Addendum to
Snake River Fall Chinook HGMPs for
Lyons Ferry Hatchery
Fall Chinook Acclimation Project
Idaho Power Company, and
Nez Perce Tribal Hatchery

July 18, 2011

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1.0 Introduction

This document was prepared by Nez Perce Tribe and Washington Department of Fish and Wildlife staff in consultation and cooperation with co-managers, Idaho Department of Fish and Game, Confederated Tribes of the Umatilla Indian Reservation, and Oregon Department of Fish and Wildlife. This document is an addendum to the Hatchery and Genetic Management Plans for Lyons Ferry Hatchery, Fall Chinook Acclimation Project, Idaho Power Company, and Nez Perce Tribal Hatchery submitted to NOAA Fisheries for consultation under Section 10(A) of the Endangered Species Act. This information is contained in an addendum rather than trying to edit and incorporate into multiple sections of the HGMP template in two separate 250 page documents. We felt providing in one document would provide for ease in review and understanding.

The information contained in this document was developed as a result of pre-consultation discussions with NOAA Fisheries regarding operation of the complex and highly integrated hatchery programs for Snake River fall Chinook. This document provides further information in response to concerns or issues raised by NOAA Fisheries and specific questions about the hatchery programs effect on Viable Salmonid Population (VSP) criteria of abundance, productivity, spatial structure and diversity (ICTRT 2007).

Organization of document

The document is organized in the following four major sections:

- Status & viability assessment – summary of NOAA Fisheries assessments
- 'Givens' associated with Snake River fall Chinook
- Research, Monitoring and Evaluation Program for Snake River fall Chinook
    - What will we learn by 2017
    - Advancing Best Available Science
- Key Uncertainties
- Approach to address those uncertainties by VSP

2.0 Status and viability assessment of Snake River fall Chinook

NOAA Fisheries has recently completed several documents which contain a status and viability assessment of Snake River fall Chinook. Those assessments are contained in the Federal Columbia River Power System Biological Opinion (BiOp) Supplemental Comprehensive Analysis Section 8.2 (NOAA Fisheries 2008) and the Section 2.2.2.2, pages 40-43 of the Umatilla Hatchery BiOp (NOAA Fisheries 2011). The following information is from these recent assessments[1].

[1] Reference to documents and reports herein does not constitute an endorsement of those documents and reports.

2.1 Abundance and Productivity

The current estimate (1999-2008 10-year geometric mean) of natural-origin spawning abundance (10-year geometric mean) of Snake River fall Chinook salmon is just over 2,200 (Figure 1). However, annual returns have declined for six of the last seven years (NOAA Fisheries 2011).

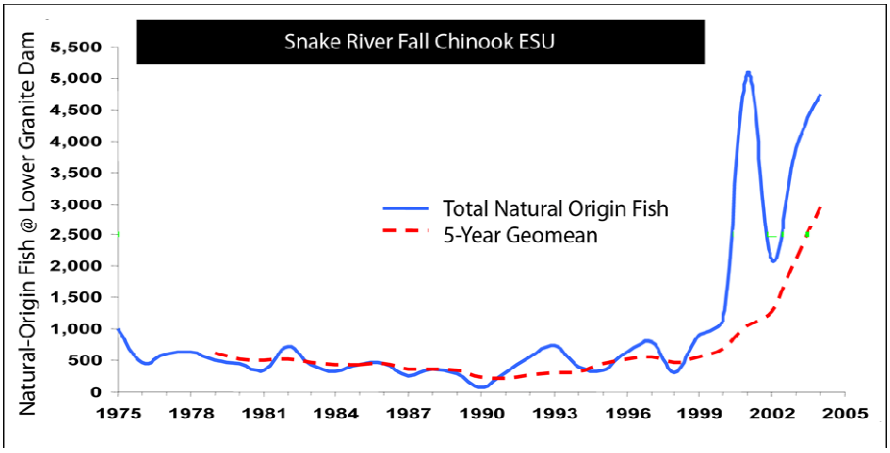

Figure 1. Figure 8.2.2.1-1 in the Supplemental Comprehensive Analysis (NOAA Fisheries 2008) - Snake River Fall Chinook Salmon Abundance Trends (adopted from Fisher and Hinrichsen 2006).

Abundance trends including hatchery-origin fish are also displayed in Table 1 below (which is Table 6. in the Umatilla Hatchery BiOp.- NOAA Fisheries 2011).

Table 1. Table 6 from Umatilla Hatchery BiOp (NOAA Fisheries 2011). Snake River Fall Chinook. Recent abundance and proportion natural origin compared to estimates at the time of listing and the previous BRT review (Ford et al. 2010).

Population	Natural Spawning Areas					
	Total Spawners (5 year geometric mean, *range*)		Natural Origin (5 year geometric mean)		% Natural Origin (5 year average)	
	Prior *(1997-2001)*	Current (2003-2008)	*Prior* *(1997-2001)*	Current (2003-2008)	*Prior* *(1997-2001)*	Current (2003-2008)
Snake River Fall Chinook	*2164* (962-9875)	11321 (7784-17266)	*1055* (306-5163)	2291 (1762-2983)	51%	22%

The overall combined hatchery and natural-origin adult abundance has been increasing significantly beginning in 2000. The 10-year average (2000 to 2009) over Lower Granite Dam has risen to 12,288 compared to the previous decade (1990 to 1999) average of 1,995. Similarly, the 10-year average (2000 to 2009) for natural-origin fish over Lower Granite Dam has risen to 2,588 compared to the previous decade (1990 to 1999) average of 509. A concern is that natural-origin returns declined from 2004 to 2009. Fall Chinook redd counts have risen from only 45 redds counted in 1990 to modern-day record counts of 3,469 in 2009 and 5,271 in 2010 for the Snake River basin upstream of Lower Granite Dam.

2.2 Spatial Structure and Diversity

The Lower Snake River fall Chinook salmon population was rated at low risk for allowing natural rates and levels of spatially mediated processes and moderate risk for maintaining natural levels of variation resulting in an overall spatial structure and diversity rating of Moderate Risk (Table 2). Given the combination of current ratings for abundance/productivity and spatial structure/diversity summarized above, NOAA Fisheries determined that the overall viability rating for Lower Snake River fall Chinook salmon population would be maintained (NOAA Fisheries 2011).

Table 2. Table 7 from Umatilla Hatchery BiOp (NOAA Fisheries 2011). Viability assessment for Lower Snake River Fall Chinook salmon population using ICTRT criteria. Updated to reflect returns through 2008 (Ford et al. 2010).

Brood years	Abundance/Productivity Metrics				Spatial Structure and Diversity Metrics			Overall Viability Rating
	ICTRT Minimum Threshold	Natural Spawning Abundance	ICTRT Productivity	Integrated A/P Risk	Natural Processes Risk	Diversity Risk	Integrated SS/D Risk	
1990-2004 1985-2004	3000	2208 (905-5163)	1.28 (0.82-1.63) 1.07 (0.93-1.75)	Moderate (Moderate)	Low	Moderate	Moderate	Maintained

2.3 Updated Risk Summary

The following is excerpted from NOAA Fisheries (2011):

> Abundance and productivity estimates for the single remaining population of Snake River Fall Chinook salmon have improved substantially relative to the time of listing. However, the current combined estimates of abundance and productivity still result in a moderate risk of extinction of between 5% and 25% in 100 years. The extant population of Snake River Fall Chinook salmon is the only one remaining from an historical ESU that also included large mainstem populations upstream of the current location of the Hells Canyon Dam complex. Natural-origin fall Chinook salmon abundance is much higher compared to 1991 when Snake River fall Chinook salmon were listed, but returns have declined every year since 2004 [although this was not the case in 2010]. Hatchery-origin spawner proportions have also increased dramatically in recent years – on average, 78% of the estimated adult spawners have been hatchery origin over the most recent brood cycle. Overall, the new information considered does not indicate a change in the biological risk category since the time of the last BRT status review (Ford *et al*. 2010).

Figure 2 displays the updated risk assessment per the four VSP criteria.

Spatial Structure/Diversity Risk

Abundance/ Productivity Risk	Very Low	Low	Moderate	High
Very Low (<1%)	HV	HV	V	M
Low (1-5%)	V	V	V	M
Moderate (6 – 25%)	M	M	M Lower Main. Snake	HR
High (>25%)	HR	HR	HR	HR

Figure 2. Figure 6 from Umatilla Hatchery BiOp (NOAA Fisheries 2011). Snake River Lower Mainstem fall Chinook salmon population risk ratings integrated across the four viable salmonid population (VSP) metrics. Viability Key: HV – Highly Viable; V – Viable; M – Maintained; HR – High Risk; Shaded cells – does not meet viability criteria (darkest cells are at highest risk) (Ford et al. 2010).

3.0 Givens associated with Snake River Fall Chinook

- Hydropower dams have blocked access and inundated approximately 85% of the historic habitat for Snake River fall Chinook. The remaining population only has access to a small proportion (15%) of the historical range for this ESU.
- Snake River fall Chinook are an Upriver Bright stock that provide an important and substantial harvest in ocean (Alaska, Canada, Puget Sound) and Columbia River (tribal and non-tribal) fisheries. These fisheries are governed by the Pacific Salmon Treaty and the *U.S v. Oregon* Management Agreement.
- Snake River fall Chinook are highly influenced by the Federal Columbia River HydroPower System (FCRPS). Juveniles emigrate later in the year than spring Chinook and steelhead and are therefore most affected by the presence or absence of summer spill. Transportation studies, to date, have not been able to determine if barging provides a survival advantage.
- The Snake River fall Chinook HGMPs describe the hatchery programs that were developed to mitigate for the effects of the FCRPS and Idaho Power Company dams. These programs were developed by the *US v. Oregon* Parties who agreed to implement per the 2008-2017 *US v.*

Oregon Management Agreement[2]. The production program is intended to supplement the natural spawning component of Snake River fall Chinook and provide for continued fisheries.

- Uncertainty exists regarding the success or impacts of supplementation.
- The size and nature of the Snake River basin imposes significant challenges in collecting data to assess the Snake River fall Chinook population VSP parameters of abundance, productivity, spatial structure and diversity.
- Sampling methods and statistical procedures used in generating escapement estimates have improved substantially over the past 10-15 years. Beginning with the 2003 return, estimates are available for the total run apportioned into natural and hatchery returns by age (and hatchery origin) with standard errors and confidence limits.
- The accuracy and precision of existing natural production demographic data is in question[3].

4.0 Research, Monitoring & Evaluation of Snake River Fall Chinook

Active monitoring of these hatchery programs have been ongoing since their inception. Section 11.1 of the HGMPs summarizes efforts to monitor metrics that have been generally adopted as indicators of the performance of supplementation programs in the Columbia Basin. Further RM&E actions within the Snake are funded by BPA and are conducted by other research entities such as the USFWS, USGS and various universities. The actions proposed herein are considered in addition to and in context of those ongoing efforts, many of which are critical to the collective knowledge base and need to continue.

4.1 State of Knowledge - What will we learn by 2017?

There is much interest to understand what improved/new knowledge will be available in 2017 to inform adaptive management decisions associated with the Snake River fall Chinook production program. As such, we start this RME section with a summary of our anticipated State of Knowledge by 2017. The details justifying this summary are provided later in the document (Section 6).

By 2017 we will have a <u>good understanding</u> of:

- total escapement upstream of Lower Granite Dam (LGR),
- abundance of natural-origin returns (NOR),
- abundance of hatchery-origin returns,
- percentage of the hatchery-origin fish in the naturally spawning population (pHOS) at the population scale,
- percentage of the natural-origin fish used in hatchery broodstocks (pNOB),

[2] Pages 70-73 and Table B4A/B of the U.S.v.Oregon Management Agreement identify the Snake River fall Chinook supplementation program juvenile production levels, release locations, and marking as well as adult collection for broodstock, run reconstruction and disposition.

[3] In 2010, the methods utilized to distinguish natural and hatchery-origin fish for run reconstruction were determined to be inaccurate. These problems will most likely require a re-do of run reconstruction to derive better numbers of natural and hatchery fish.

- genetic diversity and effective population size of natural and hatchery-origin population segments ,
- spawning distribution,
- fidelity of subyearling hatchery production groups to release site areas,
- spawning distribution upstream of LGR of Lyons Ferry Hatchery on-station released fish,
- magnitude of predation on juvenile fall Chinook by smallmouth bass and channel catfish in the Snake River,
- best management strategy for juvenile passage through hydrosystem (COE Consensus Study),
- effectiveness of harvest and live capture studies impact on number of hatchery-origin fish available to spawn naturally,
- age-at-return for natural and hatchery-origin fish,
- in-season run forecast,
- natural-origin and hatchery-origin harvest levels in mainstem and terminal area fisheries,
- relative impacts of harvest and hydro mortalities to hatchery effects, and
- relative performance of various hatchery life stage at release and release type strategies.

By 2017 we <u>may have an improved understanding</u> of:

- productivity of the naturally spawning population,
- percentage of the hatchery-origin fish in the naturally spawning population (pHOS) at spawning aggregate scales,
- relative magnitude juvenile production from some spawning aggregates,
- density dependent relationships between spawner abundance and juvenile production,
- relationship of juvenile fish growth and survival to food availability and abundance,
- range of juvenile spatial and temporal rearing patterns,
- heritability of age-at-emigration, and
- pre-season run forecasts.

By 2017 we will still <u>lack an understanding</u> of:

- relative reproductive success of hatchery and natural-origin spawners,
- magnitude of mini-jack returns and their contribution to natural spawning,
- differential use of habitats by hatchery and natural-origin fish,
- abundance of basin-wide juvenile production,
- impact of sturgeon on juvenile production (egg consumption),
- impact of avian predation on juvenile fish upstream of Lower Granite Dam, and
- ecological processes supported (or hindered) by an abundance (or scarcity) of natural spawners.

<u>Significant changes</u> to program implementation to be realized prior to 2017:

- 5.6 percent reduction in hatchery production numbers (completion of COE transportation study),
- 100% marking of hatchery production using Parentage Based Tagging (PBT),
- outplanting of hatchery–origin adults surplus to broodstock needs targeted at areas of underseeded or vacant habitat,

- exploration of live capture techniques by Nez Perce Tribe,
- promotion of local broodstock adaptation in South Fork Clearwater and Selway rivers,
- establishment of ESA recovery criteria for viable ESU with single extant population AND hatchery based mitigation requirements, and
- formal adaptive management process with pre-established management assumptions, monitoring and evaluation, formal report, and symposia conducted in 2013 and 2016.

Background associated with anticipated RME results

- Proposed new monitoring and evaluation actions would be implemented no later than 2012.
- Marking of out-of-basin fall Chinook hatchery production will continue at or above current levels.
- The current U.S.v. Oregon Management Agreement will expire with brood year 2017. Negotiations for a new agreement will begin sometime before or in 2017. Data from adult returns through 2016 will be available to inform 2017 decisions.
- Adult returns (progeny) from any given brood year are functionally complete with 5 year old returns (some 6 year olds do return but in limited numbers). Brood year 2012 production will represent the most current information during U.S.v.Oregon negotiations in 2017.
- If any as yet to be determined changes were made to BY 2011 releases with the intent to reduce pHOS, response of natural-origin juvenile production would not be quantifiable until 2016 (production from naturally spawning fish in 2015). One year of juvenile size, distribution, and survival would be available to inform U.S.v.Oregon negotiations in 2017. NOTE: Changes to BY 2011-2017 are NOT being proposed in this HGMP.
- Response of natural-origin adult productivity will be first available 10 years after any changes are made in release locations/numbers.
- We typically desire to have a minimum of 3-5 years of data to inform decisions. Ideally we would target 2015 -2019 return year data to examine adult return response and 2020 -2024 for analysis of productivity response.

4.2 Advancing Best Available Science

4.2.1 Summary of ongoing RME

A sizable effort to research, monitor, and evaluate (RME) the Snake River fall Chinook salmon ESU is underway. No less than 19 studies are currently being conducted (Table 3); some studies were initiated as early as 1982.

4.2.2 Filling in the Gaps

In 2009 and 2010, a collaborative effort by state, tribal, and federal fish managers established RME strategies and identified knowledge gaps for Columbia River anadromous fish species (Coordinated Anadromous Workshops). Key knowledge gaps associated with Snake River fall Chinook (Crawford Table 2 Chinook Strategies, Gaps, and Prioritized Funding For Each MPG, November 30, 2009) described:

1. Estimate of annual juvenile production is lacking.
2. Robust quantification of juvenile natural survival and life history diversity are needed.

3. Need timely completion of run-reconstruction and better distribution and availability of estimates.
4. Assessment of deep water redds throughout entire spawning distribution is not currently done.
5. Window counts do not provide an estimate of hatchery: natural composition.
6. Window counts currently assess 16 hours passage and fail to account for night time passage.
7. Estimates of natural pre-spawn mortality, direct removals, and direct harvest, and indirect hook and release mortality are lacking to convert escapement to spawner abundance.
8. Estimates of unmarked fish origin determinations are imprecise.
9. Impacts/contributions of hatchery origin spawners is unknown in terms of relative reproductive success or population productivity.
10. Passage of adults and juveniles relative to hydro-system operations is not well understood.

Gaps in our knowledge of population status and management action effectiveness will always exist. This results in implementation of management action under some level of risk. Adaptive management is an effort to routinely adjust management actions based on gained knowledge. In order to characterize our Snake River fall Chinook salmon state of knowledge anticipated in 2017 we describe: 1) management assumptions, 2) current assessment of assumption validity, 3) proposed RME actions to better assess assumption validity, and 4) anticipated knowledge status in 2017 (Table 4). The management assumptions were originally developed by the Ad Hoc Supplementation Work Group (Beasley et al 2008 - Appendix C) and have been modified here for specific application to Snake River fall Chinook. Assumption validity is characterized as: valid, invalid, or unknown. Invalid or unknown assessments help guide adaptive management decisions and prioritize RME activities. New RME activities proposed in the Addendum to the LFH and NPTH HGMPs contributing to assessment of each assumption's validity are identified. While all of these new activities identified by the operators are viewed as beneficial, some projects will fill critical gaps more than others. NOAA has identified a subset of five of the new RME projects set forth in the addendum as priority projects associated with the Section 10 permit. These new projects are highlighted within each of the VSP subsection tables in Sections 6.1 through 6.4 below. These priorities, technical details and feasibility, and funding sources remain subject to review and discussion through the public comment period for the Section 10 permit application. We understand that final decisions on the new RME projects to be implemented, and the responsibility for funding, will occur shortly after the public comment period closes and while NMFS develops the Section 10 permit for this program. Ongoing RME activities supporting validity assessments are NOT listed. Finally, the anticipated state of our knowledge in 2017 when the next U.S.v.Oregon Management Agreement will be developed is described (assumes newly proposed RME actions are implemented).

Table 3. Summary of ongoing project research, monitoring, and evaluation projects associated with Snake River fall Chinook.

Major Population Group	MSA	Status and Trend Monitoring				Hatchery Evaluations				Uncertainty Research			Harvest Monitoring
		Escapement to	Redd Counts	Juvenile Survival and Emigration Timing	SAR	Hatchery Compliance and Implementation Monitoring	Hatchery Regional Supplementation Effectiveness	Hatchery Project Specific Effectiveness	Hatchery Uncertainty Research	Factors influencing Life History Diversity	Predation	Passage Route Survival	
	Full Population	199801004, TAC	see specific areas below	PTAGIS, 198712700	198201301, 198201302, 198201303, 198201304	NA		199102900	Pending RPA 64 and 65 RFP Guidance	199102900, 200203200, UofI	200203200	ACOE - Passage	200206000, 198201301, 198201302, 198201303, 198201304 , LSRCP WDFW, 198335003, 199801004, TAC
Snake River Fall Chinook Spawning Aggregates	Snake River downstream Lower Granite Dam	ACOE window Counts at Lower Monumental Dam				NA				199102900			State of WA, LSRCP WDFW
	Tucannon	LSRCP -WDFW	LSRCP -WDFW	LSRCP -WDFW		NA							
	Snake River Upstream of Lower Granite Dam	199801004, LSRCP WDFW, 198335003, 200304100, COE window counts	IPC, 199102900	199102900		NA		LSRCP -WDFW, 199102900, 199801004,		IPC, 199102900			200206000, IPC - IDFG, State of WA
	Clearwater River		198335003	198335003, 199801004		NA		198335003, 199801004		198335003, 199801004, NOAA			200206000,
	South Fork Clearwater River		198335003			NA							
	Selway River		198335003			NA							
	Grande Ronde River		199801004			NA							
	Imnaha River		199801004			NA							
	Salmon River		BLM, 198335003			NA							
Hatchery Releases Groups	Lyons Ferry Hatchery	LSRCP WDFW	NA	LSRCP WDFW	LSRCP WDFW	LSRCP WDFW							
	Couse Creek	NA	NA	LSRCP WDFW	LSRCP WDFW	LSRCP WDFW							
	Captain John Rapids	NA	NA	199801004	LSRCP WDFW, 199801004	199801004, 199801005							
	Grand Ronde River	NA	NA	LSRCP WDFW	LSRCP WDFW	LSRCP WDFW							
	Pittsburg Landing	NA	NA	199801004	LSRCP WDFW, 199801004	199801004, 199801005							
	Hells Canyon Dam	NA	NA	IPC IDFG	LSRCP WDFW								
	North Lapwai Valley	NA	NA	198335003	198335003	198335003							
	Nez Perce Tribal Hatchery	198335000, 198335003	NA	198335003	LSRCP WDFW	198335003							
	Big Canyon Creek	NA	NA	199801004	LSRCP WDFW, 199801004	199801004, 199801005							
	Lukes Gulch	NA	NA	198335003	198335003	198335003							
	Cedar Flat	NA	NA	198335003	198335003	198335003							

1982-013-01	Coded Wire Tag-Pacific States Marine Fisheries Commission (PSMFC)
1982-013-02	Coded Wire Tag-Oregon Department of Fish and Wildlife (ODFW)
1982-013-03	Coded Wire Tag-US Fish and Wildlife Service (USFWS)
1982-013-04	Coded Wire Tag-Washington Department of Fish and Wildlife (WDFW)
1983-350-00	Nez Perce Tribal Hatchery Operations and Maintenance
1983-350-03	Nez Perce Tribal Hatchery Monitoring and Evaluation
1987-127-00	Smolt Monitoring by Non-Federal Entities
1991-029-00	Research, monitoring, and evaluation of emerging issues and measures to recover the Snake River fall Chinook salmon ESU
1998-010-04	Monitor and Evaluate (M&E) Performance of Juvenile Snake River Fall Chinook Salmon from Fall Chinook Acclimation Project
1998-010-05	Fall Chinook Acclimation Facilities on Snake/Clearwater Rivers
2002-032-00	Snake River Fall Chinook Salmon Life History Investigations
2002-060-00	Nez Perce Harvest Monitoring on Snake and Clearwater Rivers
2005-002-00	Lower Granite Dam Adult Trap Operations
IPC	Idaho Power Company redd counts and stranding monitoring
IPC IDFG	Idaho Power Company funding of Idaho Department Fish and Game
LSRCP WDFW	Lower Snake Compensation Plan funding of Washington Department of Fish and Wildlife
ACOE -Passage	Corps of Engineers funded Evaluating the Responses of Snake and Columbia River Basin Fall Chinook Salmon To Dam Passage Strategies and Experiences
ACOE - Window	Corps of Engineers funding window counts of adult passage
UofI	UofI otolith microchemistry study
NOAA	Juvenile life history changes in Snake River fall chinook salmon: evolution or phenotypic plasticity?

Table 4. Summary of current status and anticipated 2017 knowledge associated with Snake River fall Chinook salmon management assumptions.

Management Assumption	Current Status	New M&E Action Proposed	Anticipated 2017 Knowledge
1a. Adult progeny per parent (P:P) ratios for hatchery-produced fish significantly exceed those of natural-origin fish.	Valid. Questionable accuracy and precision associated with natural production P:P ratio.	1) PBT marking. 2) Retrospective analysis of NOR abundance using 2010 (subtraction) run-reconstruction methodology. 3) Assess sensitivity of P:P analyses to various levels of non-selective and selective harvest.	10 to 14 years of hatchery production vs natural production P:P ratios. Two years of improved natural production P:P ratio precision.
1b. Natural spawning success of hatchery-origin fish must be similar to that of natural-origin fish.	Unknown. See "Guidance to develop alternatives for determining the relative reproductive success and effects on natural-origin fish of hatchery-origin Snake River Fall Chinook Salmon" (Peven 2010).	1) PBT marking. 2) RPA 64/65 RFP.	Description of natural-origin population growth rate as increasing, decreasing, or stable. Assessment of Relative Reproductive Success is not readily achievable at this time and is the subject of FCRPS BiOp RPA 64 and 65 (even if implemented in 2012 first year results will not be obtained until 2021). RRS study feasibility will be determined prior to 2017.
1c. Temporal and spatial distribution of hatchery-origin spawners in nature is similar to that of natural-origin fish.	Unknown. Carcass sampling only possible in Clearwater River. Fidelity of yearlings to release site areas described in Garcia (2003). Fidelity of subyearling releases unknown. Relative spawn timing of natural and hatchery-origin fish unknown.	1) Radio tag study. 2) PBT marking. 3) Otolith micro-chemistry study	Two years of precise (10 plus years of imprecise) hatchery and natural origin spawner distribution data within the Clearwater River. Three to five years of subyearling fidelity to release site area data and LFH on-station release spawner distribution upstream of Lower Granite. Six years of natal spawning and rearing areas for natural origin fish.

Management Assumption	Current Status	New M&E Action Proposed	Anticipated 2017 Knowledge
1d. Productivity of a supplemented population is similar to the natural productivity of the population had it not been supplemented (adjusted for density dependence).	Unknown. Methods typically involve reference population monitoring which is problematic within an ESU with a single population (see Peven 2010). Questionable accuracy and precision associated with natural production P:P ratio.	1) PBT marking. 2) Retrospective analysis of NOR abundance using 2010 (subtraction) run-reconstruction methodology. 3) Include harvested natural-origin fish in an alternative description of natural productivity. 4) Food web study	Default monitoring is limited to natural population growth rate as increasing, decreasing, or stable. Relationship of juvenile fish growth and survival to food availability and abundance.
1e. Post-release life stage-specific survival is similar between hatchery and natural-origin population components.	Invalid - general production. Valid - surrogate production. Absolute juvenile survival estimates are lacking due to emigration during non-operation periods of juvenile bypass facilities.		Juvenile survival indices and emigration timing for general production subyearlings, general production yearlings, surrogate production, and natural production groups. Relative survival ratios various hydrosystem passage strategies.
1f. Proportion of hatchery-origin spawners (pHOS) will not exceed recently observed levels.	Unknown – predictive assumption which will be validated with data collected starting in 2011.		Trend in pHOS relative to the highest annual estimate for the proportion of hatchery-origin fish in the adult return from 2005 to 2010.
2a. Adult life history characteristics in supplemented populations remain similar to pre-supplementation population characteristics.	Unknown. Age at return of hatchery production appears to be altered; higher percentage of mini-jacks from yearling releases, jacks from yearling and subyearling releases; and reduced percentage of 5 and 6 year old returns.	1) PBT marking. 2) Collaborative study that may result from pending Age and size at maturity workshop.	~20 years of age at return trends for hatchery-origin returns. Two years of precise (10 plus years of imprecise) age structure comparisons between hatchery and natural origin fish.
2b. Juvenile life history characteristics in supplemented populations remain similar to pre-supplemented population characteristics	Invalid. Age at emigration appears to be changing; increasing number of reservoir type yearlings. May be a function of altered environmental conditions (Williams et al 2008). Mechanism is likely not solely due to the hatchery program.	1) Otolith micro-chemistry study. 2) Life cycle modeling of juvenile abundance and survival. 3) Representatively PIT tagging hatchery production (110,000 PIT tags).	Assessment of yearling age at emigration heritability (Waples). Juvenile production estimates for the basin as whole and potential spawning aggregate specific.

Management Assumption	Current Status	New M&E Action Proposed	Anticipated 2017 Knowledge
2c. Population level and within population genetic characteristics are not suppressed by supplementation.	Valid/Unknown Population appears to be maintaining differentiation from other ESUs; within population diversity is not well understood but likely homogenized given its pre-supplementation abundance bottleneck, and recent relatively high hatchery fractions, common broodstock, and widespread distribution of hatchery spawners	1) PBT marking. 2) Assessment of NOR and HOR effective population size.	Comparison of effective population size between the Snake River hatchery produced fish, Snake River natural-origin production, and the Hanford Reach natural-origin production.
3a. Genetic characteristics of hatchery-origin fish are indistinguishable from natural-origin fish.	Valid.	1) PBT marking. 2) Assess genetic diversity.	Reaffirmation of genetic similarity.
3b. Life history characteristics of hatchery-origin adult fish are indistinguishable from natural-origin fish.	Invalid.	1) PBT marking. 2) Age and size at maturity workshop.	Complete age at return data for one generation of releases of hatchery fish that includes yearling, subyearling and wild surrogate size subyearlings.
4a. Out of basin strays from a hatchery program (alone, or aggregated with strays from other hatcheries) do not comprise more than 5% of the naturally spawning fish in the Snake River population.	Valid.		
4b. Snake River hatchery production strays do not exceed 5% of the abundance of any out-of-basin natural population.	Valid. Snake River hatchery fish have a high fidelity to the Snake basin based on CWT recoveries of on-station yearlings and subyearlings less than 0.5% of the fish were recovered outside the basin in 2009.		

Management Assumption	Current Status	New M&E Action Proposed	Anticipated 2017 Knowledge
5a. Hatchery and natural-origin adult returns can be adequately forecasted to guide harvest opportunities.	Invalid. Run forecasts are commonly imprecise and often inaccurate. In-season adjustments to preseason forecasts based on PIT tag detections of returning adults passing mainstem dams are just being utilized.	1) Representatively PIT tagging hatchery production (110,000 PIT tags). 2) Retrospective analysis of NOR abundance using 2010 (subtraction) run-reconstruction methodology.	Weekly adjustments to in-season return estimates for Snake River hatchery-origin fall Chinook. Characterization of NOR abundance and productivity including fish removed via harvest.
5b. Hatchery adult returns are produced at a level of abundance adequate to support mainstem and Snake River fisheries in most years with an acceptably limited impact to natural-spawner escapement.	Valid. May not always be true and will rely on 5a forecasts.	1) PBT marking. 2) Assess terminal area selective harvest effectiveness. 3) Explore live capture techniques.	Characterization of NOR abundance and productivity including fish removed via harvest.
5c. Harvest monitoring is adequate to ensure that harvest quotas for natural and hatchery-origin adults are not exceeded.	Unknown. Currently ADCWT subyearlings released on-station at LFH are the indicator of what is going on in the fisheries. Changing the indicator hatchery group to an upstream of LGR subyearling group should be considered.		Description of annual and trends in NOR harvest rates for ocean, mainstem, terminal area fisheries. Characterization of NOR abundance and productivity including fish removed via harvest.
6a. Identify the most effective rearing and release strategies.	Unknown. Juvenile survival and SAR data for individual release groups has just become available with the completion of run-reconstruction.		Relative performance (juvenile survival, SARs, and harvest rates) comparisons for: acclimated vs direct release strategies, yearling vs subyearling age at release groups, transportation vs in-river study completion, and release locations.

Management Assumption	Current Status	New M&E Action Proposed	Anticipated 2017 Knowledge
6b. 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.	Invalid. Lower Granite Dam trapping facility is unable to operate across the entire fall Chinook return period due to high water temperatures. Lower Granite Dam trapping facility is unable to trap sufficient numbers of fall Chinook for RRS studies and target pNOB due to fish processing limitations resulting from high numbers of steelhead and limitations to fish identification from current marking strategy. Lower Granite Dam juvenile bypass facility is unable to sample across entire emigration period due to freezing conditions.	1) Support RPA 28 COE LGD trap modification process. 2) Assess terminal area selective harvest effectiveness to reduce pHOS. 3) Explore live capture techniques to reduce pHOS. 4) Run NOAA selective harvest model. 5) Radio tag study	Three to five years of subyearling fidelity to release site area data and LFH on-station release spawner distribution upstream of Lower Granite. Magnitude of potential and realized influence on pHOS from terminal area fisheries and live capture techniques.
6c. Frequency or presence of disease in hatchery and natural production groups will not increase above unsupplemented levels.	Unknown.		Annual summary disease occurrence and magnitude within hatchery production groups.
7a. Hatchery adults are adequately identifiable to allow accurate annual accounting of natural-origin adult abundance.	Invalid. Currently 24% of the Snake River fall Chinook hatchery production is released unmarked/untagged. Enumeration of NOR in run-reconstruction is based on subtracting total estimated hatchery-origin abundance from untagged fish present in the return.	1) PBT marking.	Two years of precise determination of individual fish origin for quantification of NOR abundance, pHOS, and pNOB.
7b. Describe juvenile fish production in relationship to available habitat in each population and throughout a subbasin.	Unknown.	1) Food web study 2) Otolith micro-chemistry study	Relationship of juvenile fish growth and survival to food availability and abundance. Estimate of predation impacts on subyearling survival.

Management Assumption	Current Status	New M&E Action Proposed	Anticipated 2017 Knowledge
7c. Describe annual (and 10-year geometric mean) abundance of natural-origin adults relative to management thresholds (minimum spawner abundance and ESA delisting criteria) within prescribed precision targets.	Invalid/Unknown. Accuracy of natural origin abundance estimates are suspect due to recent determination that origin classification of unmarked/untagged fish via scales is no longer valid. Use of PBT to estimate NOR harvest in fisheries will require systematic tissue sampling in mainstem and terminal area fisheries.	1) PBT marking. 2) Retrospective analysis of NOR abundance using 2010 (subtraction) run-reconstruction methodology. 3) Include harvested natural-origin fish in an alternative description of natural productivity. 4) Support RPA 28 COE LGD trap modification process.	Comparison of historical (2003-2009) natural origin abundance estimates generated via two run-reconstruction methodologies (scale pattern analysis and 2010 subtraction). Two years of validation for 2010 subtraction method relative to PBT known origin method. Description of virtual population productivity in absence of harvest actions.
7d. Adult fish utilize all available spawning habitat throughout the basin.	Invalid. Spawning ground surveys describe annual distribution of redds. Currently, the Selway, South Fork Clearwater, and Salmon rivers have substantial areas of unseeded historically used habitat.	1) Radio tag study	Spawning distribution and relative abundance of redds in all major and minor spawning areas. Radio tag study will determine fidelity of returning adults from subyearling releases to release locations and overlap with NOR.
7e. The relationships between life history diversity, life stage survival, abundance and habitat are understood.	Invalid. The physically large and spatially expansive river systems constrain typical monitoring methods. Habitat conditions are heavily influenced by hydrosystem operations. A continuum of life history strategies are expressed over 500 miles of riverine habitat.	1) Life cycle modeling. 2) Otolith micro-chemistry study. 3) Food web study.	Correlation of redd abundance and escapement. Range of juvenile spatial and temporal rearing patterns. Relationship of juvenile fish growth and survival to food availability and abundance. . Magnitude of predation on juvenile fall Chinook by smallmouth bass and channel catfish. Note: Predation by sturgeon and avian species will remain unknown.
7f. Minimum Abundance Threshold (MAT) of 3,000 fish recommended by the ICTRT is compatible with management based viability criteria.	Unknown. Management based viability criteria development pending.	1) Develop alternative Minimum Abundance Threshold (MAT).	Assessment of alternative minimum abundance thresholds compatible with pending management criteria for viability determination.

Management Assumption	Current Status	New M&E Action Proposed	Anticipated 2017 Knowledge
8a. Coordination of needed and existing activities within agencies and between all co-managers occurs in an efficient manner.	Valid. Snake River Fall Chinook Salmon coordination meetings are held twice a year.		Common understanding of ongoing management actions, ongoing monitoring and evaluation studies, monitoring gaps, and sampling constraints.
8b. Accurate data summary is continual and timely.	Invalid. Completion of run-reconstruction estimates have been conducted by an Ad Hoc group of staff from multiple entities. The process is lengthy due the complexity of assigning origin to unmarked/untagged fish.	1) PBT marking.	Similarity of run reconstruction estimates generated using multiple approaches.
8c. Results are communicated in a timely fashion locally and regionally.	Valid – Locally. Invalid - Regionally.	1) Symposia in 2013 and 2016.	Common understanding of the best available science associated with Snake River fall Chinook salmon.

5.0 Key Uncertainties

The performance measures listed in Tables 3 and 49 of the Snake River Stock Fall Chinook HGMP and the short description of activities listed above should allow adequate monitoring of populations during supplementation, however as stated above there are significant gaps that may not allow the programs to adequately describe the potential benefits, or lack of negative effects of the program, that might prevent the natural population from moving toward viability, and eventual delisting under the ESA. Snake River fall Chinook monitoring presents some significant sampling challenges in answering these questions.

Key uncertainties are:

- Accuracy of run reconstruction estimates given subsample rate and marking strategy.
- Productivity or relative reproductive success of natural origin and hatchery origin fish – separately.
- Annual production of juveniles, and juvenile production capacity for Snake River upstream of Lower Granite Dam.

6.0 Approach to address Key Uncertainties by VSP criteria

The approach described below, first in outline format and then in narrative with more specific information, is designed to address the key uncertainties while dealing with the logistical challenges identified above. Further, it is intended that this approach will inform adaptive management decisions that will shape the Snake River fall Chinook supplementation program into the future. This approach identifies some actions that currently may not be implementable however, they are addressed in some way within the HGMP. Many of the studies identified to address uncertainties are outside the purview of fisheries co-managers (WDFW, NPT, CTUIR, ODFW, and IDFG) and therefore, we expect that NOAA would be intimately involved in determining adequacy and tracking of ongoing work that affects the evaluation of this HGMP.

Outline:

6.1 Population Abundance

6.1.1 Improve accuracy and precision of natural-origin abundance via run-reconstruction:

i. Describe basic approach to run-reconstruction with impacts of trapping rates, hatchery:natural classification error/bias, and modified methods applied in 2010.

ii. Propose addition of Parentage Based Tagging (PBT). Compare cost of new method with Coded-wire Tagging (CWT)

iii. Clarify lack of alternative trapping site options at other mainstem dams.

6.1.2 Expand run reconstruction of NOR to Columbia River mouth/ocean:

i. Add NOR removed by harvest in existing ocean and mainstem fisheries. Link to existing USvOR BiOp language.

6.1.3 Quantification and management of pHOS: discussion run-reconstruction approach for estimating pHOS and limitations of Lower Granite trap to manipulate pHOS.

6.1.4 Quantification of pNOB: program goal to include NOR up to 30% of broodstock, discuss constraints of Lower Granite Trap to achieve this level.

6.1.5 Proposed actions table

6.2 Productivity

6.2.1 Improve ability to evaluate mechanisms of productivity via ecological interactions

i. Density dependence

ii. Growth and life history

6.2.2 Analyze ability of selective harvest to reduce pHOS

6.2.3 Potential actions to affect number of hatchery-origin fish escaping to spawn

i. Increased harvest and harvest activities reducing pHOS

ii. No releases of fish into Salmon and Imnaha rivers

iii. Reduced production releases after completion of transportation study

6.2.4 Proposed action table

6.3 Spatial Structure and Diversity

6.3.1 Distribution of hatchery and natural spawners: description of dispersion/fidelity rates of hatchery-origin releases between spawning aggregates and our inability to document spatial distribution of natural and hatchery spawners.

i. Fidelity of hatchery adults to release site from yearling releases.

ii. Fidelity of hatchery adults to release site from subyearling releases.

6.3.2 Population-wide vs. spawning aggregate based broodstock development: Comparison of Wenatchee spring Chinook subpopulation management approach and describe the limitations to implementing spawning aggregate based approach in Snake River basin.

6.3.3 Genetic selection and expression: description of current plans to include natural-origin spawners in broodstock, exclusion of strays, and benefits for maximizing effective population size.

6.3.4 Proposed actions table.

6.4 Population Viability

6.4.1 Summarize Snake River fall Chinook population viability provided by NOAA Fisheries in other Biological Opinion documents. This includes summary of other “H” effects (+/-) already permitted by NOAA.

6.4.2 TRT viability criteria: Summarize TRT recommended viability criteria for ESUs with a single extant population as being potentially applied to Snake River fall Chinook recovery.

6.4.3 Hatchery effects: summary of demonstrated hatchery effects (+/-) on Snake River fall Chinook population viability.

6.4.4 Proposed actions table.

6.5 Adaptive Management

6.5.1 Management assumptions and structure for making adaptive changes in Snake River fall Chinook hatchery program.

6.1 Population Abundance

6.1.1 Improve accuracy and precision of natural-origin abundance via run-reconstruction

i. Basic Approach to Run Reconstruction with impacts of trapping rates, hatchery:natural classification error/bias, and modified methods applied in 2010.

Fall Chinook salmon run reconstructions to Lower Granite Dam (LGD) began cir. 1990 to estimate the number of hatchery fish returning to the Snake River, and to above the dam. No systematic trapping occurred at the adult trapping facility during early years since fall Chinook abundance was low and nearly all hatchery releases from LFH occurred below the dam. CWT tagged fall Chinook were often out-of-basin strays during the years before 1998 and an effort was made to remove these fish from the river, often by hauling the tagged fish to LFH where the fish were euthanized and/or spawned and their origin determined from the CWT. Gametes from LFH origin fish were retained in the brood while stray fish gametes were usually discarded. Beginning in 1990 during spawning, LFH fish were separated from stray Chinook based on CWT code and the resulting LFH data were subsequently used to "reconstruct" the hatchery population that had arrived at LGD. The hatchery origin data from spawning was used with window counts to eventually derive an estimate of natural origin adults (by subtraction) arriving at, and moving above the dam. During the years until 2003 sampling and reconstruction protocols were not well established. Various approaches were used by an assortment of personnel and management agencies to estimate the number of natural and hatchery origin fish arriving at and passing Lower Granite Dam.

Beginning in 1996, releases of hatchery origin fall Chinook began at NPT operated fall Chinook acclimation facilities (FCAP) in the upper Snake and Clearwater Rivers. By mid-2000s significant increases in fall Chinook returns to the Snake River were occurring, the result of several factors: 1) yearling releases from FCAP facilities survived well, 2) ocean conditions began to improve, increasing survival for all anadromous populations including yearling and subyearling fall Chinook, 3) restrictions on downriver fisheries imposed in the mid 1990s because of ESA protections allowed more fish to escape and reach the Snake River, 4) increased returns allowed LFH to steadily increase its releases because of more abundant broodstock, including providing up to 1 million eggs to Idaho Power Company (IPC) for its Hells Canyon Mitigation program, 5) NPTH was constructed and began releasing fall Chinook into the Clearwater, 6) refinements to passage and transport through the FCRPS may have improved survival of both yearling and subyearling hatchery releases, and 7) increased spawning of hatchery fish (supplementation) within the basin presumably had resulted in increased natural production. These yearly increases of fall Chinook were concomitant with robust returns of Snake River steelhead.

As a result of the increased returns of Chinook and steelhead in the early 2000's the operational capacity of the adult trap at LGD was overwhelmed and threatened to compromise research that was

being undertaken by numerous entities. Trap capacity and personnel were not sufficient to continue diversion of CWT fish for sampling and stray removal, and increasingly the managers desired more accurate and precise estimates of numbers of natural fish moving above LGD to track their status under the ESA. Further, operation of the trap was identified in the U.S. v. Oregon Management Agreement to occur for 'broodstock collection (hatchery and natural origin), accurate run reconstruction, and for removal of non-Snake origin fish' (*U.S. v. Oregon* 2008). The run reconstruction provided important information on natural and hatchery fish composition but also an evaluation of the myriad of hatchery fish releases occurring throughout the basin to estimate return numbers and their relative performance (direct and acclimated, yearling and subyearling, early and late releases). Moreover, window counts were not considered a reliable representation of run abundance as fish numbers increased because of the incidence of fall back and re-ascent, and unclipped hatchery –origin fish.

To address these constraints and multi-purpose trapping activities a systematic, standardized trapping approach using a fixed trapping rate (or rates) to randomly sample fall Chinook and generate an estimate of the entire run composition to LGD was proposed and adopted in 2003.

Procedures 2003-2009

Preseason forecasts of fall Chinook and steelhead run sizes are used to predict what percent of the run can be reasonably handled at the LGD facility. Gates that divert fish from the ladder to the trap facility would be programmed to open four times hourly around the clock to sample at the pre-determined rate. It was assumed that if gates are open a set percentage of each hour that would provide a sample of fish passing the ladder of equal percentage. This approach served two purposes; 1) provide broodstock for the two fall Chinook hatcheries in the basin, LFH and NPTH, and 2) provide data from hatchery and natural origin fish to inform the run reconstruction. Incorporation of natural origin fish in the hatchery broodstocks is an objective determined to be a high priority by the managers to continue the connection between hatchery /natural portions of this integrated program. In addition to generating estimates of hatchery, natural and individual release groups, systematic random sampling methods used to generate the run reconstruction estimates of total returns to LGD also allowed for the calculation of precision (Steinhorst et al. 2010) and accuracy measures not attainable using window counts.

Trapping rate is based on a combination of trap capacity and broodstock needs for the hatcheries. Section 10 Permit 1530 allowed for a trapping rate of up to 20%. However, the abundance of steelhead and fall Chinook typically limited trap rates to 8 to 12%. The *U.S. v. Oregon* Management Agreement stated, 'Trapping of adult fall Chinook at Lower Granite Dam will occur at a fixed percentage rate agreed upon by the fishery managers prior to initiation of trapping…'. Once trapping begins, the intent is to transport all collected adult males and females to a hatchery. Not all jacks (based on fork length at trapping) are transported since spawning protocols limit the contribution of jacks in brood. Some jacks are scale sampled and passed; the majority of them in abundant fish years. Additional fish may enter the trap as a result of Sort by Code (SbyC) for PIT tagged returning adult fish released as part of an ongoing COE funded juvenile salmon transportation study. These fish are identified and eventually removed from the systematic sample database used for the reconstruction. Also excluded from the

data are mini-jacks, fish <30cm fork length, which are not included in window counts and are considered an anomalous life history form. Although the sample rate is intended to provide a sufficient sample of fish for the reconstruction and broodstock, pre-season predictions are often inaccurate, which may require sampling and release of some fish trapped or an adjustment of the sample rate. Untagged/unmarked fish released from the trap are measured and a scale sample collected to estimate the origin and determine age. Although the intent is to haul all CWT tagged fish to the hatcheries, if some must be released from the trap to prevent excess fish at the hatcheries, their gender and length are collected and the composition of other tagged fish taken to the hatcheries is used to represent the composition of released fish.

Fish hauled to LFH and NPTH are used for broodstock and generally all tagged fish are sacrificed and the CWTs decoded. Scales are taken from all untagged fish to provide age and in some cases origin. Hatchery and wild origin are estimated from scales by measuring the radial distance from the scale focus to the first scale check (if applicable) and to ocean entrance (OE). Fish were classified as hatchery origin if the first scale check (assumed to be a hatchery release check) occurred < .5mm, while fish were determined to be from wild origin if the first visible check occurred at or near OE and was greater then .5mm (Campbell/Marsh et al. unpublished report). After tag codes are confirmed, a combined data base of CWTs from both hatcheries is created and used for the run reconstruction.

The reconstruction process begins by expanding CWT codes by sample rate, then including associated untagged fish with each group if appropriate (e.g. – total release from a site is 400,000 fish with only 200,000 tagged with a CWT. The recovery rate of the tagged fish would be applied to the 200,000 untagged fish, thus estimates total return from the release). Not all fish releases can be directly associated with a CWT code (e.g. – different release size, date or river conditions). In that case a surrogate code from a similar release at a similar or same site but different year (or the average of several years by age class) would be used to estimate probable performance of the unassociated group. This process is used to partition all unassigned fish after CWT groups are derived. If unassigned fish remain after allocating all the unassociated groups, the remaining fish are presumed to be of LFH origin. Since few tagged stray Chinook have been identified in recent years in the basin, this seems reasonable for unmarked fall Chinook as well. Because of the error that can exist when expanding CWT groups, there may not be sufficient unassigned fish within the unassociated group to account for all the release location. When multiple groups exist the available unassociated fish are distributed proportionally among the groups. Thus, hatchery origin fish numbers were based on the presence of an adipose fin clip and/or a CWT, <u>and</u> were expanded for the unmarked/untagged portion of individual release groups.

Natural origin fish numbers for this period were based on scale pattern analysis and PIT tag recoveries of the unmarked fish.

Chinook passing Lower Granite Dam are designated fall run from August 18 to December 15. Two periods may occur during this time when sampling is not possible. The first is at the beginning of the run on 18 August each year. Water temperatures are typically in the high 60's, but once fish ladder water temperature exceeds 70 degrees, fish trapping protocols agreed upon by all the managers prevent

trapping to protect fish health[4]. Natural Chinook passing during this time are estimated by completing a post hoc estimate of the percent natural origin Chinook of total passage by week at the end of the season. The relationship is regressed over time and the slope of the line is projected back in time to estimate the % of natural Chinook passing the dam before trapping could occur. The estimated weekly % is applied to Chinook window counts to provide the estimate. The remaining fish are presumed to be hatchery origin, and the proportions of each tag code from the inclusive trapping period are applied to derive an estimate of each group passing the dam pre-trapping. The second period is late in the season when the trap closes for winter (on or before December 15) due to inclement weather and small numbers of fish. The approach described for the pre-trap period is similarly applied to fish passing the ladder at this time. The three periods are then summed by category to provide a complete run reconstruction.

Procedure for 2010

The results of a joint NOAA/WDFW study to validate age/ life history and origin (hatchery/wild) was initiated in 2008 (return years 2007-2010). The results of this study suggested a high degree of accuracy for assigning age (95-99%) and life history types (subyearling 99%, Yearling 99% and reservoir reared 97%). The results further showed a relatively high assignment accuracy of known hatchery fish (94, and 88% for 2007 and 2008 respectively, n~850) but a low assignment of known wild fish (18%, n=14) (Campbell/Marsh et al. unpublished report). Because of the low classification accuracy of known wild fish (n=14), natural or hatchery origin was not assigned by scale analysis to the return year of 2010. This high misclassification rate for PIT tagged wild fish was likely the result of several occurrences including; 1) a complex rearing program for fall Chinook that included small subyearling smolts released throughout the upper Snake basin to mimic natural origin fish (surrogates) for the COE funded transportation evaluation study, 2) the possibility that the small (n=14) wild PIT tagged fish are not representative of the wild population as a whole (scale stress checks induced by tagging/handling may mimic the hatchery scale pattern) 3) natural and hatchery subyearlings rearing for another year in the Snake River reservoirs and emigrating as yearlings, and 4) potentially complex and confusing scale patterns resulting from multiple site rearing and tagging events. Since no other reliable means of distinguishing natural and hatchery fish is presently available, the management entities responsible for run reconstruction reverted to a subtraction methodology to derive the estimate of wild fish arrival at LGD. As in the period prior to 2010, this required determining the composition for CWT fish from the hatcheries, then expanding for associated and unassociated releases. Any remaining fish arriving at the dam were presumed natural.

This approach was complicated in 2010 because of a significant discrepancy between window estimates of fall Chinook passage and the estimate derived from the systematic subsample approach used since 2004. Upon evaluation of the passage and trap data it appears that the assumption of, for example, a 10% open gate time providing a 10% population sample is being violated. Although we do not fully understand the reason for the unreliable sampling across time, the systematic method tended to

[4] FCRPS BiOp RPA 28 is already in place to consider options for reducing water temperatures in ladder/trap.

overestimate passage at the dam. The fall Chinook run reconstruction group, comprised of staff from WDFW, NPT, CRITFC and IPC, completed a preliminary analysis of the trapping at the dam (Attachment A) with the assistance of a NOAA statistician and concluded that the trapping was indeed biased high and would account for much of the discrepancy between derived estimates from trapping and window counts. The systematic method for estimating run size was therefore abandoned for 2010, but as in previous years the proportions of CWT groups were taken from the systematic sampling to derive estimates of their respective returns. Total numbers then have to be adjusted to meet window counts of jacks and adults, but no pre or post trapping adjustments have to be made to estimate natural fish numbers.

Once an estimate of hatchery and natural fish arriving at LGD is finalized, the number passed upstream is determined by subtracting fish hauled to the hatcheries for run reconstruction data and spawning. Finally, presumed spawners (escapement) that could be used for productivity analyses are determined by subtracting estimated sport and tribal harvest from the number passed at LGD.

Future Methods

Run-reconstruction generates the core data used to asses natural origin abundance and productivity. The application of various run-reconstruction methods over time raises questions about the consistency of results and sources (past and present) of potential bias. Accurate assignment of origin and fall-back rate are two key uncertainties. In conjunction with NOAA science shop (Sanford) we have started to assess comparability of window counts and random trapping (see Attachment A). This effort will support a retrospective analysis of past run-reconstruction based estimates using 2010 methods.

Fall back of fall Chinook that have ascended the LGD ladder to areas downstream of the dam does occur but the magnitude is unknown. Mini-jacks, jacks and adult fall Chinook are routinely passed downstream at LGD via the juvenile by-pass facility. In addition fish are able to pass undetected via turbines and through the locks. It is hypothesized that LFH on-station released fish may exhibit a higher tendency to fall-back than natural origin fish and hatchery-origin fish released upstream of LGD. Quantifying the rate of fall back with special attention to LFH on-station release groups will be pursued via PIT tag detection data from the juvenile bypass facility and with radio-tagged fish monitoring associated with spawner distribution described in section 6.3.

ii. Hatchery Production Marking - Parentage Based Tagging

Marking schemes for Snake River hatchery-origin fall Chinook salmon are established within the U.S. vs. Oregon 2008 - 2017 Management Agreement. At full production levels 1.4 million (24%) of the hatchery produced fish are unmarked and untagged. Identification of natural-origin from hatchery origin Snake River fall Chinook has relied on scale pattern analysis in the past. However, this method has recently been deemed inaccurate. Several marking approaches that are compatible with the U.S. vs. Oregon Agreement exist and could be used to identify 100% of the hatchery production; (1) Parentage Based Tagging (PBT), (2) thermal marking of otoliths, and (3) Oxytetracycline marking of vertebrae. Other marking approaches, inconsistent with the current US vs Oregon agreement, also exist; (1) adipose fin clipping, and (2) Coded-wire tagging.

We are proposing to utilize PBT starting with the 2011 brood year production. PBT requires a tissue sample from all fish utilized in hatchery broodstock be collected on an annual basis. Upon return as adults tissue samples from unmarked/untagged fish can be examined for matching genotypes to parents used in broodstock. Fish with genotypes that do not match potential broodstock parents can be accurately and precisely classified as probable natural origin, although out-of-basin strays that are unmarked/untagged may still be unidentifiable. Efforts to track specific hatchery broodstock parent pairings and subsequent release locations of progeny will be made, but are not required for robust analyses.

Under the current approach to utilize representative trapping and collection of marked and unmarked adults at Lower Granite Dam for both run-reconstruction and hatchery broodstock, analysis of adult returns does not require additional sampling or genetic analysis.

The current Snake River fall Chinook salmon hatchery program uses approximately 4,000-5,000 adults fish annually for broodstock. Cost to conduct the genetic analyses associated with PBT of 4,000 fish is estimated to be $160,000 - $200,000 annually (cost is expected to decrease).

Each of the marking alternatives have pros and cons in terms of initial infrastructure purchase and set up, amount of fish handling to apply and recover marks/tags, contribution to multiple purposes, and cost (initial and annual). Questions on the relative cost for a CWT approach are commonly asked; CWT tagging of the current 1.4 million unmarked/untagged fish would cost approximately $190,000 (Cost is expected to increase).

Questions regarding assignment error rates of the PBT method have be asked. Essentially, results from steelhead show that when we are able to assign parents for an individual, it should be without error unless there is a record keeping mistake in the metadata. The only scenarios where we may not be able to identify parents for a fish is if the parents were never sampled or if they failed genotyping (missing data). With careful tissue collection and storage, it is probably reasonable to assume that less than 1% of the adults used in broodstocks would not be genotyped. This number will be known and can be used to adjust unassigned progeny (assumed to be natural-origin). Overall, we expect there to be some hatchery origin-fish that we cannot assign to parents but that error rates for mis-assignments will be extremely low.

Funding to support the PBT is not currently provided for under the ongoing program. This newly proposed action within the LFH and NPTH HGMPs will require the additional annual funds.

iii. Lack of trapping sites

Fall Chinook abundance estimates have been provided since 1975 by counts at LGR Dam or through a run reconstruction process. Although other adult trapping facilities have existed in the basin in the past (Lower Monumental and Little Goose Dams), managers have agreed to the use of LGR as the most desirable point of documentation. This requires a separate estimate of spawning escapement for the Tucannon River and recognizes that some small amount of natural spawning occurs in the tailraces of the dams, which inserts some error associated with natural population abundance estimates. However,

we do not believe that the error is significant enough to recommend relocation of the primary trapping and run reconstruction effort away from Lower Granite Dam.

6.1.2 Expand run reconstruction of NOR to Columbia River mouth/ocean

i. Include NOR fish removed by harvest in descriptions of abundance:

Harvest of SR fall Chinook in certain years represent a substantial effort by both selective and non-selective fisheries (commercial and sport, both tribal and non-tribal) in the ocean and mainstem Columbia River. Locations, duration, and allowable harvest are determined by the number of forecasted NOR and HOR fish (returning to the mouth of Columbia and up the system to Lower Granite Dam), and is based on a sliding scale approach as agreed to by all parties in the 2008-2017 USvOR Agreement. These seasons are also managed in season based on real-time adjusting of the forecast utilizing fish marked representatively with PIT tags. Accounting for the removals of NOR and HOR is paramount to the efforts to manage the fisheries and to reconstruct the NOR back to the Columbia River mouth and ocean. This accounting is divided geographically into areas of the ocean and areas in the mainstem Columbia.

Run Forecasting

Annual run forecasts of fall Chinook to Lower Granite Dam (LGR) are conducted using two methods. The first run prediction of natural-origin (NOR) adult fall Chinook to the mouth of the Columbia River is completed by the US v OR Technical Advisory Committee (TAC). This prediction uses abundance estimates of Snake River adult NOR fall Chinook salmon to the mouth of the Columbia and age composition obtained from run reconstructions of fall Chinook trapped at LGR and used for broodstock at Lyons Ferry Hatchery (LFH) and Nez Perce Tribal Hatchery (NPTH). The proportion of fall Chinook salmon at each age class is applied to the estimated number of SR fall Chinook to the Columbia River mouth to generate a composite age class structure. Following brood years, each age class is plugged into a linear regression equation to generate an estimate the following years' return. For example, jack (1 ocean) returns are used to predict 2 ocean returns the following year, 2 ocean returns are used to predict 3 ocean returns the following year, etc. Predictions for each age class are summed to get a total return to the Columbia River mouth, then an average conversion rate of 0.58 from the mouth of the Columbia River to estimate the total NOR adult return to LGR.

The second run forecast is based on a simple jack to adult regression model using window counts at LGR to predict returns of total adult (hatchery-origin plus natural-origin) and NOR adult only fall Chinook salmon the following year. Total jacks passing the LGR window during the fall Chinook passage period (August 18 – December 1) are plugged into a regression equation generated from the historical relationship of jack and adult returns. This provides an estimate of the total adult returns to LGR the following year. NOR adult returns are predicted based on an estimate of NOR jacks and adults as determined by the annual run reconstruction using a similar regression analysis method.

2008-2017 US v. Oregon Management Agreement harvest sliding scale

Harvest of SR fall Chinook is predicated on the *U.S. v. Oregon* 2008-2017 Agreement Table A3. This Agreement provides a harvest rate schedule of treaty and non treaty harvest based on a sliding scale approach to manage the risk to the natural fish. This scale takes into account the expected forecast of natural and hatchery fish and the limiting factors based on the allowable mortality rate of Snake River natural fall Chinook. Thus the allowable take increases with increased predictions of natural returning fish.

Table 5. Table A3 in *U.S. v. Oregon* 2008-2017 Management Agreement. Fall Management Period Chinook Harvest Rate Schedule.

	Expected URB River Mouth Run Size		Expected River Mouth Snake River Natural Origin Run Size [1]	Treaty Total Harvest Rate	Non-Treaty Harvest Rate	Total Harvest Rate	Expected Escapement of Snake R. Natural Origin Past Fisheries
<	60,000	<	1,000	20%	1.50%	21.50%	784
	60,000		1,000	23%	4%	27.00%	730
	120,000		2,000	23%	8.25%	31.25%	1,375
>	200,000		5,000	25%	8.25%	33.25%	3,338
			6,000	27%	11%	38.00%	3,720
			8,000	30%	15%	45.00%	4,400

Footnotes for Table.

1. If the Snake River natural fall Chinook forecast is less than level corresponding to an aggregate URB run size, the allowable mortality rate will be based on the Snake River natural fall Chinook run size.

2. Treaty Fisheries include: Zone 6 Ceremonial, subsistence, and commercial fisheries from August 1-December 31.

3. Non-Treaty Fisheries include: Commercial and recreational fisheries in Zones 1-5 and mainstem recreational fisheries from Bonneville Dam upstream to the confluence of the Snake River and commercial and recreation SAFE (Selective Areas Fisheries Evaluation) fisheries from August 1-December 31.

4. The Treaty Tribes and the States of Oregon and Washington may agree to a fishery for the Treaty Tribes below Bonneville Dam not to exceed the harvest rates provided for in this Agreement.

5. Fishery impacts in Hanford sport fisheries count in calculations of the percent of harvestable surplus achieved.

6. When expected river-mouth run sizes of naturally produced Snake River Fall Chinook equal or exceed 6,000, the states reserve the option to allocate some proportion of the non-treaty harvest rate to supplement fall Chinook directed fisheries in the Snake River.

Inseason adult run adjustments using representative PIT tagging

Utilizing the preseason forecasts the managers and stakeholders are able to estimate the potential fish available for harvest, and set and manage harvest seasons accordingly. In the past 5-6 years the increased tagging levels (PIT tags), use of the separation by code (to represent run at large fish), and use of current and historic adult run timing over the dams has given the managers and stakeholders the ability to make informed real time harvest adjustment recommendations (compared to the preseaseon forecasts) during the course of the adults returning.

The recent advancement in information has been the result of the majority of the age classes of Chinook salmon returning to above LGR having a representative group of PIT tags. The detections of these run-at-large tags in returning fish at Bonneville, McNary, Ice Harbor, and Lower Granite dams are expanded by the juvenile tagging rates to generate an estimate of age 3, 4, and 5 Chinook salmon, by stock and release site, back to each dam. For releases that were not PIT tagged, a surrogate release is used to generate return estimates. These estimates are summarized weekly and utilize the historic run timing (early, average, and late) that best represents the current years run timing conditions to allow for a total year projection of returning fish. This projected estimate of the total run of fish, by dam is updated daily, and is based on run strength and timing as the season progresses. Previous years data indicate that PIT tags generally underestimate the number of untagged fish returning due to tag shedding and differential mortality (IDFG & NPT unpublished data). All PIT tag detections are corrected for interrogation efficiencies at each dam. Utilizing these minimum real time estimates compared to the preseason forecast allows managers a valuable tool for inseason harvest management and recommendations.

The Corps of Engineers funded Consensus Study Proposal Evaluating the Responses of Snake and Columbia River Basin Fall Chinook Salmon to Dam Passage Strategies and Experiences has resulted in sufficient PIT tagged returning adults to conduct in-season monitoring. Migration year 2012 represents the last year of this study. Post 2012, additional PIT tags will be needed to maintain in-season return monitoring. Representatively PIT tagging 110,000 of the hatchery production releases will cost approximately $388,000 annually. Funding to support this level of PIT tagging is not currently provided for under the ongoing program. This newly proposed action within the LFH and NPTH HGMPs will require additional annual funds.

Ocean Fisheries Impacting Snake River Fall Chinook

Snake River fall Chinook are harvested in various sport and commercial ocean fisheries from Alaska south to the central California coast. The majority of ocean fishery impacts occur in Alaskan and Canadian sport and commercial fisheries that are managed under Pacific Salmon Treaty agreements. Smaller impacts occur in sport, tribal, and non-tribal commercial fisheries north of Cape Falcon on the Oregon Coast that are managed by the Pacific Fishery Management Council (PFMC). Minor impacts occur in fisheries in the Strait of Juan de Fuca and in sport and commercial fisheries south of Cape

Falcon. There are also minor impacts to Snake River fall Chinook groundfish trawl fisheries such as the Pacific whiting fishery. NMFS monitors groundfish fisheries and tracks salmon impacts in groundfish fisheries. The allowed ESA impacts in ocean salmon fisheries impacting Snake River fall Chinook are framed as a requirement that adult equivalent exploitation rates must annually be held to at least a 30% reduction from a base period exploitation rate. The PFMC's Salmon Technical Team (STT) models proposed ocean fisheries each year to ensure planned fisheries meet ESA requirements. The PFMC STT along with the Pacific Salmon Commission's Chinook Technical Team evaluates actual ocean fisheries to determine actual exploitation rates each year. Because of conservation concerns regarding other weak stocks, ocean fishery impacts on Snake River fall Chinook have generally been significantly less than allowed ESA impacts.

Until recently, all ocean salmon fisheries impacting Snake River fall Chinook were full retention fisheries and therefore impacts to ad-clipped and non-ad-clipped Chinook were the same. Since 2005 some Strait of Juan de Fuca sport fisheries have been converted to mark selective fisheries. Beginning in 2010, part of the Washington Coastal sport fishery has been a mark selective fishery during the early summer. In future years, more ocean sport fisheries and probably at least some commercial troll fisheries will be mark selective fisheries. There will likely be some mark selective Chinook fisheries in Canada as well. This will mean that ocean fisheries will have a higher exploitation rate on ad-clipped Snake River Fall Chinook compared to exploitation rates on unclipped Chinook. The marking strategy currently in place anticipated increased application of mark selective fisheries; CWT evaluation groups are applied independently to adipose clipped and non-clipped release groups.

In-River Fisheries Impacting Snake River Fall Chinook

In-river fisheries impacting Snake River fall Chinook include the Buoy 10 sport fishery, mainstem sport fishery, Zones 1-5 commercial gillnet fisheries, Zone 6 sport fisheries, Zone 6 treaty ceremonial & subsistence fisheries, Zone 6 treaty commercial gillnet fisheries, and sport fisheries upstream of McNary Dam to the mouth of the Snake River and sport fisheries in the lower Snake River. Mainstem fisheries from the river mouth upstream along with lower Snake River fisheries upstream to Lower Granite Dam are managed under the 2008-2017 *U.S. v. Oregon* Management Agreement. Sport fisheries upstream of Lower Granite Dam are managed under a separate Section 10 permit. The Nez Perce Tribe is currently working on a harvest management plan that is expected to provide for some treaty fishery impacts to Snake River fall Chinook in the Snake River basin. Mainstem and Lower Snake river fisheries manage Snake River fall Chinook as part of the Upriver Bright (URB) stock which also includes Hanford Reach, Yakima River, and Deschutes River stocks. Since 2008, allowed total harvest rates have ranged from 31.25% to 38%. In-river fisheries have generally not harvested all of the allowed fish.

Currently, in-river mainstem fisheries are all full retention fisheries. Within the next few years, at least some non-treaty fisheries will be mark selective fisheries. WDFW is investigating alternative commercial fishing gears such as purse seines and beach seines which may be implemented as mark selective fishing gears. Sport fisheries within the Snake River basin are currently mark selective.

6.1.3 Quantification and management of pHOS: discussion run-reconstruction approach for estimating pHOS and limitations of Lower Granite trap to manipulate pHOS.

Estimation of the percent hatchery-origin fall Chinook upstream of Lower Granite Dam is derived from the run reconstruction estimates for hatchery and natural origin fish, adjusted for additional hatchery and natural fish removals (additional broodstock collection from swim-ins to NPTH, and harvest). There is currently no ability to determine pre-spawning mortality, although an estimate of hooking mortality is included in harvest, which would be needed to accurately reflect true percent hatchery origin spawners (pHOS). Managers must use percentages from the run reconstruction to represent pHOS.

Unfortunately, the accuracy and precision of the pHOS estimate from the run-reconstruction estimate (see section 6.1.1) and is currently considered suspect; scale based origin determinations of unmarked-untagged fish appear to misclassify hatchery origin fish as natural origin ~10% of the time, and misclassify natural origin fish as hatchery fish ~85% of the time (Lance Campbell –WDFW pers. Comm.). Currently pHOS is not believed to differ greatly from the run at large returning to the Snake River basin (e.g. removals at Lower Granite dam and Nez Perce Tribal Hatchery or non -selective, and selective harvest rates are relatively low).

Because there is an adult trap operating at Lower Granite Dam there is the misconception that the trap can be operated to sample a large portion of the run and to perhaps selectively remove hatchery-origin fish as they migrate over the dam. Not only is the use of the trap in this way a policy level decision but this operation has several logistical constraints. First, is the physical ability to process trapped fish; processing capacity is approximately 800 - 1,000 fish per day. During the fall, in addition to fall Chinook, Snake River steelhead are also migrating over the dam. The steelhead run has been between 100,000 and 250,000 in recent years. The capacity level of the Lower Granite trap has constrained the trapping rate in recent years to approximately 9 to 12% of the entire run of fish passing the dam. At this trapping rate all trapped fall Chinook are retained for broodstock, with the exception of some hatchery origin jacks in 2009 and 2010. In 2009 there were 3,453 males <61 cm trapped and released upstream of Lower Granite Dam In 2010, 4,363 males <65 cm were trapped and released upstream.

Increasing the trapping rate to intentionally capture and retain more marked fall Chinook will require modifications to the trapping facility to enable expanded fish handling capabilities. Issues of increased steelhead handling and disposition of fall Chinook in excess to broodstock needs would have to be addressed at a technical and policy level.

6.1.4 Quantification of pNOB: program goal to include NOR up to 30% of broodstock, discuss constraints of Lower Granite Trap to achieve this level.

<u>Utilization of Scales for broodstock allocation and origin determination.</u>

Fall Chinook salmon trapped at LGR are used for broodstock at Lyons Ferry Hatchery and Nez Perce Tribal Hatchery. Scales are collected from all unmarked and a portion of marked broodstock. In the

past, we have attempted to use scale pattern analysis to determine the proportion of natural-origin fish in the brood; in addition to age and early life history (subyearling or yearling emigrant). The utility of scale analysis for determining each of these parameters was evaluated using tagged fish of known origin. Following the evaluations, it was determined that scale analysis could reliably determine age and early life history, and could determine hatchery origin for most yearling releases and some of the subyearling releases, but not natural origin or rearing location. An analysis of scales from known hatchery- or natural-origin fish revealed that the error rate was definable and relatively consistent for hatchery fish, but because of small sample size of know natural origin fish the method is unreliable. Similarly, using scales to determine rearing location was used for a couple of years in an attempt to estimate straying of Hanford Reach or Umatilla River fall Chinook into the Snake River but an analysis using known Snake River fish demonstrated that this technique was also not reliable. Currently, broodstock age and early life history can be reliably determined using scale pattern analysis, but we cannot use scale analysis to directly determine the proportion of natural-origin fish or the presence of out of basin stray fish in the broodstock.

Access to sufficient natural fish for inclusion in brood stock.

As explained above, current facilities and staffing limits the number of fish that can be trapped and processed at the Lower Granite Dam adult trap. Recent year's trapping rates have been 9-12% of the fish. In most years, this limitation will prevent the managers from achieving the 30% NOR broodstock goal. Proposed infrastructure changes that would allow additional trapping have not been addressed in this document, but the managers will continue to discuss this action as a possible alternative to achieving the goal.

6.1.5 Proposed Actions to address improving certainty of Population Abundance

	Proposed Action	Cost
1	**100% marking of hatchery production via Parentage Based Tagging (PBT).**	**$200,000/yr**
2	**Commitment to complete retrospective analysis of past run-reconstruction based estimates of NOR using 2010 methods, including NOAA science shop (Sanford) critique .**	**$25,000**
3	**Support COE process to consider modification to ladder/trap for a) water intake to eliminate water temperature operation constraints, and b) expanded fish handling capabilities to increase pNOB (see also 3a) - Already required under RPA 28.**	**Existing staff**
4	**Include estimates for NOR harvested fish throughout the Columbia basin in population abundance assessments relative to viability thresholds. (*WDFW is concerned about the level of monitoring in fisheries because of the difficulty in full statistical creel. Could catch card estimates (post-hoc like steelhead) and expansions for wild numbers be acceptable?*).**	**Existing staff**

5	**Representatively PIT tag hatchery production at a level (110,000) that enables in-season run projections.**	**$388,000/yr**
6	**Run NOAA selective harvest model to describe potential changes in pHOS and impacts to NOR.**	**Existing staff**
7	**Evaluate fall-back of mini-jacks, jacks, and adults with focus on LFH on-station releases.**	**$25,000 one-time cost $75,000/yr**

6.2 Productivity

Recent scientific evidence (Araki et al. 2007; Chilcote 2010) suggest that in salmon and steelhead populations high pHOS from hatchery supplementation may result in reduced natural productivity. NOAA staff has recommended reducing proportion of hatchery-origin fall Chinook spawning naturally to reduce the potential risk to productivity. Further, NOAA are concerned that the current SR fall Chinook supplementation program as it is now structured may limit opportunities to evaluate the program's effects on the productivity of the ESU.

Despite these concerns, the populations of both natural and hatchery origin fall Chinook have increased significantly from the baseline period (Tables 1 & 2). It is not presently clear if the high pHOS currently within the Snake is suppressing further expansion of natural production (abundance) through reduced productivity. The lack of understanding of the current efficacy of supplementation on increasing the natural population prevents informed decisions regarding the potential need for changes to this program. Moreover, estimates of yearly productivity for the natural population depend on accurate estimates of spawning escapement from run reconstruction (discussed elsewhere). We propose several actions to improve the accuracy and precision of run reconstruction, which will improve confidence in derived estimates of the status and trend in natural fish productivity.

We also do not presently know if hatchery and natural fish are spatially distributed equally throughout the basin. Part of increasing the understanding of spatial structure within the population and interaction between hatchery and natural fish will be addressed using radio tagged fish of known release locations (see below). A study was conducted in the late 1990s that showed substantial fidelity by acclimated yearling Chinook to return to their river reach of release, but this has not been confirmed for subyearling releases either for acclimated or direct released groups. Understanding return behavior and dispersion of adults from these subyearling releases will substantially improve the manager's knowledge about true spatial spawning structure and hatchery-natural interactions. This effort may also inform a greater understanding of within population productivity, especially if asymmetrical spawning structure currently exists. Variations in actual reach level spawning pHOS may currently exist and additional actions to better understand hatchery and natural fish are necessary before substantive changes to the program are proposed.

6.2.1 Improve ability to evaluate mechanisms affecting productivity via ecological interactions

i. Density Dependence

The USFWS-USGS portion of the Snake River basin fall Chinook salmon research team began beach seining and PIT-tagging natural fall Chinook salmon subyearlings (hereafter, natural subyearlings) along the entire free-flowing Snake River upstream of Lower Granite Reservoir in 1995. Sampling and tagging have continued to the present. The following summary is based on several documents (Connor et al. 2000, 2002, 2003ab; Connor and Burge 2003; Connor and Tiffan 2010; Plumb et al. 2010). Growth in fork length measured between PIT-tagging during rearing and passage at Lower Granite Dam averaged over 1.3 mm/d and the natural subyearlings averaged over 140-mm fork length at dam passage in the 1990s. During the first 10 years of the 21st century growth decreased to an average of less than 1.0 mm/d and mean fork length was less than 98 mm. Regression analyses indicated that increases in basin-wide redd counts and hatchery smolt releases were correlated with the decreases in growth rate and size of natural subyearlings. The researchers concluded that there was preliminary evidence for intra-specific competition for food in the reservoir and that seemingly small changes in growth rate associated with density dependent mechanisms can cause large changes in smolt size. The migration rate of natural subyearlings to Lower Granite Dam has also become faster over time leading to earlier passage dates at Lower Granite Dam (e.g., median dates up to 20 days earlier after increases in redd counts and hatchery releases). The increase in migration rate and earlier passage timing were linked to increases in redd counts by use of regression analyses. These findings suggested that changes in migration rate associated with density dependent mechanisms (if actually present) can influence large changes in passage timing at Lower Granite Dam. Bioenergetics modeling supported the conclusions for increased competition for food and space as factors for decreased growth, increased migration rate, and earlier seaward migration. Apparent mortality of natural subyearlings measured between rearing and passage at Lower Granite Dam generally increased over time. The relations between apparent mortality of natural subyearlings and catch per unit effort of natural subyearlings, redd counts, and the number of hatchery fish released were clearly nonlinear and supported the existence of an asymptote. These results provided preliminary evidence for a density dependent response in apparent mortality for natural subyearlings. The researchers hypothesized that the density dependent response resulted primarily from predation in riverine habitat and possibly from predation in the reservoir.

ii. Growth and Life History

In cooperation with the Snake River fall Chinook salmon research team, the USFWS-USGS staff proposed to continue monitoring the growth and juvenile life history of natural subyearlings in the Snake River and expand on the ability to link management actions to changes in natural subyearling abundance through 2015. As part of this proposed work, two predation studies will be conducted. The first study will focus on predation by smallmouth bass in riverine rearing habitat by (1) estimating the abundance of smallmouth bass, (2) describing the diet of smallmouth bass, and (3) estimating subyearling loss to predation by smallmouth bass. This study will be conducted using methods developed by Nelle (1999) who found predation on natural subyearlings was low in riverine habitat prior to increases in production associated with increases in redd counts and the release of hatchery subyearlings. The second study will

focus on predation in Lower Granite Reservoir downstream of the confluence of the Snake and Clearwater rivers by (1) estimating abundance of channel catfish, (2) estimating abundance of smallmouth bass, (3) describing the diets of these two species, and (4) estimating subyearling loss to predation by these two species. The second study will use the methods developed by Naughton et al. (2004) who found that predation on natural subyearlings was low in the reservoir prior to increases in subyearling abundance.

Idaho Power Company (IPC), in coordination with NOAA fisheries, initiated a survey of entrapment pool areas in the upper Hells Canyon Reach of the Snake River in 2005 as part of compliance to an Interim Settlement Agreement relating to consultation for ESA species downstream of Hells Canyon Dam. A total of 45 entrapment pools have been identified at 37 site locations along approximately 60 river miles in the upper HC Reach. Entrapment pools at these sites disconnect from the river at flows ranging between 8,700 cfs and approximately 50,000 cfs with 33 of these pools disconnecting at flows within the operating range of HC Dam (flows less than 30,000 cfs). IPC plans to continue weekly fish surveys of entrapment pool sites in the upper HC reach between March 15 and June 15 (or until no Chinook are observed in pool sites), each year, to document pool use by juvenile fall Chinook salmon and steelhead. Fish in each high priority entrapment pool (18 of the 45 pools) will be enumerated by species when possible. Any observed mortalities of Chinook or steelhead associated with these sites will be documented. The thermal history of each high priority entrapment pool during the rearing period (March 15–June 15) will be collected each year. As part of this plan, Hells Canyon outflows will be adaptively managed with operational protocols to protect and minimize entrapment of juvenile fall Chinook and steelhead at high priority entrapment sites in the upper Hells Canyon Reach. This plan proposes to monitor the use and connection of entrapment pools during the rearing period and maintain a daily connection flow of at least 2 hours for any entrapment pool that is connected and disconnected from daily load following operations at HC Dam. IPC instituted the protocol of connecting entrapment pools daily during the 2005 and 2006 rearing periods. Discussions with NOAA fisheries staff further refined this protocol to that of reconnecting pools for at least 2 hours on a daily basis which was instituted in 2007. Monitoring water temperatures within pools and adaptively managing these temperatures from approaching lethal limits is critical to the protection of juvenile Chinook using entrapment sites in the upper Hells Canyon Reach. This plan proposes a protocol to reconnect entrapment pools with the main river channel at a time during the day before pool temperatures elevate to deleterious levels defined by NOAA Fisheries. This plan further proposes to salvage juvenile fall Chinook salmon and juvenile steelhead back to the river channel from any high priority entrapment pool that is disconnected and will not be reconnected again during the rearing period due to decreases in HC outflows. This practice, in consultation with NOAA fisheries, was conducted effectively from 2005 through the 2010 rearing periods as inflows decreased, leaving high elevation entrapment sites disconnected for the remainder of the rearing period.

Surveys of entrapment pool areas in the upper Hells Canyon Reach of the Snake River (HC Reach) have been conducted annually since 2005. The number of juvenile fall Chinook observed in entrapment pools each rearing season depends largely upon the number of entrapment pools disconnected/connected from Hells Canyon Dam (HC Dam) operations as well as the number and location of adult fall Chinook

redds in the upper HC Reach from the previous spawning season. Lower inflows to HC Dam result in greater power production opportunities, larger ranges of outflows from HC Dam, and thus higher numbers of entrapment pools disconnected/connected. From 2005 through 2010 the highest number of juvenile Chinook observed in entrapment pools was 26,369 in 2005. The high number of observed fall Chinook in 2005 can be attributed to a high number (1,047) of entrapment "events" and a relatively high number of adult redds (966). Conversely, 2009 had the second highest number of redds (1,129) for the six year period but had few entrapment events for the season because of high inflow conditions into the HC Reach, thus only 2,647 Chinook were observed in entrapment pools in 2009. No entrapment events were observed in 2006 as HC Dam discharge was above 30,000 cfs until June 2 after which no juvenile fall Chinook were observed in entrapment pool areas. A total of 10 juvenile fall Chinook were observed in high elevation entrapment pools (those above the operation range of HC Dam) during 2006.

6.2.2 Analyze ability of selective harvest to reduce pHOS

The cooperators will populate and run "The Selective Harvest Calculator" that was developed by Paul McElhany at the NOAA Northwest Fisheries Science Center. The Selective Harvest Calculator (SHC) is a computer program for exploring the consequences of mark-selective harvest management strategies. In the fall Chinook mark selective fisheries, hatchery fall Chinook are given an external mark (adipose fin clip) and only marked fish are to be retained. The SHC simulates the progression of a mark-selective harvest starting with an initial pool of fish with three components: 1) natural-origin fish (all unmarked), 2) marked hatchery fish, and 3) unmarked hatchery fish. The simulation proceeds with sequential encounters of individual fish with the fishing gear. Once fish encounter the gear, several fates are possible, including landing by the fishery or "hooking mortality" for unmarked fish that were released. At the end of the simulation, the fate of all the fish in the initial pool is evaluated to explore overall impacts of the fishery on the different components of the population. This model will be used to explore the impacts of sport and tribal fish harvest seasons on fall Chinook fisheries in the Columbia, Snake, and Clearwater rivers and how those changes impacts pHOS and the magnitude of the increase in NOR.

6.2.3 Potential Actions to affect number of hatchery-origin fish escaping to spawn

i. Increased harvest activities reducing pHOS

Marked increases in adult returning fall Chinook have provided the opportunity for harvest of hatchery fall Chinook in the Snake River Basin and Clearwater River Basin. The first fall Chinook fisheries in the Snake River in over 30 years were implemented in 2008. Washington, Idaho and the Nez Perce Tribe currently are growing/expanding these fisheries. To date, recreational state and Nez Perce Tribe fisheries have experienced increasing harvest success. Table 5 below describes the level of fall Chinook Snake Basin harvest (adipose fin clipped and un-clipped) by each agency which reflects the increased harvest over the last three years. The states are expanding their fishery interest and success through education and fish clinics, with an attempt to increase angler success. The end goal is for significant harvest of hatchery fall Chinook. The Nez Perce Tribe desires to grow their fisheries and fishing capacity to match fish available for Nez Perce treaty harvest year-by-year in a way that incorporates the variability of Snake River spring/summer Chinook runs. The Tribe proposes (BPA #200206000) to

investigate the use of live capture fishing methods (tangle nets, weirs, seines, etc.) to catch more fish particularly in hatchery-influenced areas that may support moderate to high harvest levels while maintaining harvest of listed natural-origin fish within acceptable levels. If properly designed and scaled to those tributaries or fisheries, where Tribe has had some difficulty catching fish, they presume that this type of strategy could increase catch and harvest of hatchery fish while maintaining conservation-focused harvest strategies on wild/natural fish.

The activities from the States and Tribes are working (Table 5) and are expected to be able to harvest a significant portion of hatchery fall Chinook in the near future as the interest and techniques continue to expand.

Table 5. Draft harvest totals for fall Chinook, natural and hatchery for Washington Department Fish and Wildlife, Idaho Department Fish & Game, and Nez Perce Tribe for 2008-2010 in the Snake River Basin.

	Chinook Harvest Totals by Agency/Tribe				
Year		WDFW	IDFG	NPT	Total Hatchery
2008	Unclipped	0	0	13	13
	Clipped	10	132	39	181
2009	Unclipped	0	0	29	29
	Clipped	46	806	65	917
2010	Unclipped	**	0	539	539
	Clipped	**	1,255	110	1,365

** will be determined from catch record cards in about 6 months

ii. No releases of fish into Salmon and Imnaha rivers

Increasing numbers of returning fall Chinook in recent years have resulted in expansion of documented spawning activity into the Salmon and Imnaha rivers (Table 16). The cooperators have agreed to no hatchery-origin fall Chinook releases into the Salmon and Imnaha rivers (see sections 1.5 of this HGMP and the Nez Perce Tribal HGMP for details). This decision will reduce the likelihood of hatchery spawners in these areas, reducing pHOS and maximizing NOS spawning in the Salmon and Imnaha rivers and other locations outside of the current juvenile releases.

iii. Reduced production releases after completion of transportation study

Releases of fall Chinook into the Snake and Clearwater rivers described in table B4B from the 2008-2017 *US vs. Oregon* Management Agreement total 5.5 million with an additional 328,000 for the COE transportation study. Releases of subyearlings for the transportation study will conclude no later than 2012 (Consensus Research Proposal, 2007). Return rates for the surrogate group and general production groups of fall Chinook are just beginning to be analyzed and draft results indicate an average smolt to adult return rate around 0.3 percent. After completion of this study this will translate into a reduction of approximately 1,000 adult surrogate hatchery returning fall Chinook (328,000 x 0.003=984) annually.

6.2.4 Proposed Actions to address improving certainty of Productivity

	Proposed Action	Cost
1	Conduct Life cycle modeling of juvenile abundance and survival	$50,000/yr
2	Conduct food web study that quantifies food availability and consumption associated with juvenile fall Chinook.	$500,000/yr
3	Analyze ability of selective harvest to reduce pHOS	Existing staff
4	Existing activities that will reduce pHOS	Existing staff

6.3 Spatial Structure and Diversity

6.3.1 Distribution of hatchery and natural spawners

i. Fidelity of hatchery adults to release site from yearling releases

Spawning aggregates are not isolated and although the fish released from the FCAP facilities have a strong fidelity to their release location there is a fair amount of interchange of fish. Garcia (2003) tracked 515 fall Chinook from 1997-2001 and determined that 32% of the supplementation fish overall spawned in other than their release reach. Specifically 11% of the males and 4% of the females from Captain Johns spawned in the Upper Snake River Reach. All of this research was done on yearling release groups.

ii. Fidelity of hatchery adults to release site from subyearling releases

Fidelity of adults to release site areas is unknown for sub-yearling release groups. As previously described sampling of carcasses is not feasible throughout most of the Snake River basin. In an attempt to understand spawner distribution associated with sub-yearling releases we propose to replicate the Garcia (2003) study using returning adults PIT tagged as juveniles under the COE consensus transportation study as the known release site fish to radio tag. Sufficient numbers of specific release site PIT tagged adults should be available over the next 3 years (2012 to 2014). Of particular interest is the spawning distribution upstream of LGD ('stray') of LFH on-station release groups. Sufficient numbers of on-station yearling releases have been PIT tagged in recent years and will be included in the 2012-2104 radio tagging. However, additional PIT tagging of the sub-yearling release group will need occur. We propose to PIT tag 20,000 on-station subyearlings from 2012-2014 and then radio-tag subsequent adults in 2014 to 2016. Implementation of this study will cost approximately $195,000 annually for three years and $35,000 for two additional years. Funding to support this level of radio and PIT tagging is not currently provided for under the ongoing program. This newly proposed action within the LFH and NPTH HGMPs will require additional annual funds.

6.3.2 Population-wide vs. spawning aggregate based broodstock development

Development of broodstocks that promote local adaptation within subpopulations (major spawning aggregates) has been suggested by NOAA and by the HSRG. The Wenatchee spring Chinook salmon hatchery program was suggested as a potential template. The Wenatchee has four major spawning aggregates; Chiwawa River, Nason Creek, White River, and Little Wenatchee River. Each spawning

aggregate has unique genetic characteristics. The program is developing segregated broodstocks for three of four spawning areas. The un-supplemented aggregate represents about 10-15% of the basins production. Segregated broodstocks are to be maintained by adult collections at Tumwater Dam, with natal stream determination via pedigree analysis. The program is targeting a pNOB of 33%. Target pHOS has yet to be established.

Application of a similar approach in the Snake River basin appears to be infeasible, with the exception of the South Fork Clearwater River. Operation of weirs and collection of carcasses in the mainstem Snake and Clearwater Rivers is not possible due to river size and morphology. Our target pNOB is 30% but is logistically not achievable at this time. Snake River genetic stock structure appears to be homogeneous.

6.3.3 Genetic selection and expression: discuss inclusion of natural-origin spawners in broodstock, exclusion of strays, gene expression vs. selection, benefits for maximizing effective population size.

Genetic selection and expression

A primary emphasis of the fall Chinook hatchery program since its inception was the maintenance of the stock's genetic integrity. Exceptional actions were taken to trap adults within the Snake basin to establish the egg bank program in the late 1970s and early 1980s. This resulted in releases of juveniles at the LFH site in the mid 1980s that were believed to be of endemic origin only one generation from natural parentage. The effort continued through the 1990s when excessive out-of-basin strays were identified in the brood. To prevent erosion of the genetics of the stock, only identifiable LFH origin Chinook were used for brood while efforts began to reduce out-of-basin straying into the Snake River through marking/tagging of hatchery populations that were identified as strays. These management efforts have been effective and the abundance of out-of-basin strays has been greatly reduced in recent years. As a result, the managers agreed to once again begin infusing naturally produced fall Chinook into broodstock; now for both LFH and NPTH. Despite these efforts there remain concerns regarding the possible expression of genes as a result of selective pressures within the hatchery environment. This selection could affect age at migration, age of return, jack rates, productivity (reproductive success), spawning success and other as yet unidentified population changes that may affect its prospects for recovery. The types of genetic risks generally associated with operation of hatcheries (Wedemeyer 1996) are widely known:

- **Extinction** – a serious concern but mainly the result of stochastic and non-genetic events,
- **Loss of Within-Population Diversity** – typically resulting from drift that can be from a founder event, inbreeding and selection, or homogenization resulting from high levels of hatchery spawners,
- **Loss of Among-population Diversity** – from immigration (straying) that results in introgressive hybridization,
- **Loss of Fitness from Hatchery Selection** – generally accepted as the result of domestication and artificial selection.

A series of actions will be pursued as part of the fall Chinook program to avoid these hazards.

Extinction

Habitat alteration and fishing likely drove Snake River fall Chinook toward extinction by the mid 1970s. We believe that conscientious hatchery actions have greatly increased population abundance (see section 2) and forestalled extinction. While supplementation has had positive results, the interaction between hatchery and natural origin fish on the spawning grounds and their relative reproductive success is unknown. Marking and tagging limitations currently in place under the US v. Oregon Management Agreement make identification of unmarked/ untagged fish difficult, complicating estimates of natural abundance and analysis of reproductive success. The managers desire a better understanding of the effective population size of natural (NOR) and hatchery (HOR) fish spawning in the natural environment to more completely understand whether or not the natural population is trending toward recovery (see Loss of Fitness below). Given the current marking limitations, conducting a genetic based monitoring of NOR and HOR effective population sizes may provide results accurate enough for these metrics to be understood. The managers propose to evaluate these survival variables through the use of Parentage Based Tagging (PBT). All fish used for hatchery broodstock would be genetically sampled and characterized through the use of SNP technology. Once a full generation of brood has been sampled, all returning adult offspring can be positively identified. As importantly, a grand parentage analysis of the 2nd generation of off spring may provide more definitive information on the relative contribution of natural and hatchery origin adults and natural effective population size. One possible approach to conducting the study was provided by Mike Ford, NOAA Fisheries and is provided in Attachment B. Implementation of the study could begin in 2011 with full DNA samples from broodstock at both hatcheries. Full sampling began at NPTH in 2009 as part of a NOAA study (see Loss of Within-Population Diversity below). Current cost estimates for SNP characterization range from $20-40/sample, giving an annual investment need of $100,000-200,000 into the foreseeable future, with first generation results (100% identification of Snake River hatchery origin) expected starting in 2017. Benefits accrue to any salmonid population by maximizing effective population size. The severe bottleneck this population experienced in the 1970s imposed substantial genetic stress. Actions taken by the hatcheries in the past by boosting population abundance significantly reduced extinction risk. Ongoing efforts begun in 2004 to identify and include natural origin fish once again in brood has functionally increased effective population size and reduced the potential for full or half sibling crosses in hatchery matings. The large size of the program and mating protocols designed to reduce the possibility of sibling crosses (size and age diversity of crosses where possible and minimization of jacks in spawning) further maintain a diverse genetic profile.

Loss of Within-Population Diversity

Propagation and release of Snake fall Chinook as yearling smolts has raised concerns about the effect on subsequent generations of hatchery and natural fish. Specifically in question is whether age at emigration is heritable and is it caused by selective pressures experienced in the hatchery. Staff at the NOAA Science Center began a heritability of age at emigration study at NPTH in 2009 by scale and DNA sampling all broodstock at the facility. This study is ongoing with the intent to determine if yearling emigration seen in naturally produced fish results from parents released as hatchery yearling smolts, thus suggesting a hatchery selection effect. Conversely the change in life history may be a response to altered habitat condition and represent gene expression and plasticity. Answers to these questions will

significantly inform managers regarding hatchery effects resulting from artificial selection or hatchery domestication. The study will require a minimum of two generations to track and detect possible changes in life history pathway selection based on parentage. The study would utilize PBT samples collected described above, but may require additional analysis for genetic expression. NOAA is funding this study.

A consistent monitoring of the genetic profile of Snake River fall Chinook has occurred since program inception. Microsatellite analysis of samples collected from marked and unmarked (presumed natural origin) fish in 2000 through 2004 showed no significant difference between the populations. Further analysis is relevant and timely to determine if there has been a loss of genetic diversity of the populations, hatchery or natural and if there has been divergence of the two. These types of analyses can be performed using PBT samples, but may require additional SNP analysis to characterize population diversity, and will require re-running samples collected in the past using SNP technology. The comparison could be completed 2011-2014 and is expected to require an additional 2,000 historical samples for comparison.

The Snake River Population appears to be maintaining differentiation from other ESUs, however within population diversity is not well understood. The ability to measure diversity has been hampered by sampling limitations on recovery of carcasses. It is likely somewhat homogenized given relatively high hatchery fractions, common broodstock, and widespread distribution of hatchery spawners. Initiation of PBT will allow for future analysis of within population diversity through juvenile sampling.

Loss of Among-population Diversity

This loss of diversity is of highest concern for Snake River fall Chinook next to extinction. Two of the original populations for this ESU are extinct, leaving only one extant population. Loss of its integrity would severely jeopardize the long term prospects for recovery under ESA. As described in the explanation of run reconstruction, natural origin adults were captured within the Snake River in the late 1970s to initiate this hatchery program. This action served to substantially reduce the risk of extinction for the remaining population. Since that time there have been steady, but adaptive, measures to reduce the impacts of out-of-basin strays escaping to spawn in the basin and for inclusion in the broodstock. Exclusion of strays from hatchery broodstocks remains a priority for both hatcheries and positively identified strays (CWT based) are eliminated to the extent possible. Errors in, or inability of, identifying strays generally contributes to strays representing less than 5% of brood stock annually. Implementation of PBT will substantially reduce potential error in stray identification.

Loss of Fitness from Hatchery Selection

As an integrated supplementation program, maintaining connection to the natural population is a priority management objective. Careful program operation initiated in the 1990s prevented any infusion of natural origin fish into broodstock because of large numbers of out-of-basin strays entering the Snake River. The problem has been substantially minimized through marking procedures and other changes in Columbia River programs and infusion of natural fish began in 2004. The intent is to now maximize inclusion of NOR (up to 30%) in broodstocks within the limitations of access to unmarked fish

at Lower Granite Dam (historically limited to 20% of fish passing the dam) and positive identification/distinction between natural fish and unmarked/ untagged hatchery returns. These efforts are documented through the spawning process at both hatcheries as each fish is uniquely numbered and eventually identified as of hatchery or natural origin. Access to and selection of natural origin fish at the LGR Dam trap are presently limited by the marking protocol adopted in the US v. Oregon Management agreement, and other identification techniques (scales) have not proven fully effective. Implementation of PBT or some other chemical or thermal marking tool will substantially improve identification of natural origin fish. Once this step has been taken, more accurate tracking of natural contribution to the brood will be possible.

RPAs 64 and 65 of the FCRPS Biological Opinion express the need to understand the affect of ongoing supplementation and high proportions of hatchery spawners on the productivity of this population. The guidance document (Peven et al. 2010) that resulted from a BPA sponsored workshop identified the challenges to answering these questions. River size and remoteness of fall Chinook spawning, difficulty in sampling the population passing LGR Dam and determining the true nature of fish spawning (proportions of hatchery and wild and whether spatial segregation is occurring), high proportions of hatchery fish returning to the river, the genetic similarity between hatchery and natural populations, legal limitations imposed on marking that increases difficulty of determining origin, and others. The guidance document concluded two things:

> 1. Based on logistical, technical, and process constraints, a pedigree-based parentage analysis to estimate RRS is not feasible for SRFCS. A promising alternative at this point appears to be a grandparental study design, but a number of details need to be worked out. Approaches such as using controlled spawning areas or surrogate populations appear far less attractive. Other approaches yielding useful but less direct RRS information are possible.
>
> 2. Evaluating the effect of the hatchery programs on natural SRFCS productivity is very challenging, and the challenge is exacerbated by inadequacies in run reconstruction. The only approach the workgroup recognized as most appropriate was a model-fitting approach similar to that of Buhle et al. (2009). Again, however, a number of feasibility and statistical power details need to be worked out. The option of using a surrogate population is highly undesirable. Other approaches yielding useful but less direct information are possible.

We agree with those conclusions and have significant concerns about attempting studies which may fail. However, no further reasonable alternatives have been offered since the BPA guidance effort. We would propose a collaborative effort by the managers and their science staffs to promulgate a study design to complete the grand parentage analysis to determine relative reproductive success as call for under RPA 64/65.

6.3.4 Proposed Actions to address improving certainty of Spatial Structure and Diversity

	Proposed Action	Cost
1	**Conduct study of subyearling release fidelity to spawning area (repeat of Garcia et al study but with subyearlings and existing PIT tagged fish). Special focus on spawning distribution in areas upstream of LGD of LFH on-station releases.**	**$195,000/yr (1012-1014) $50,000/yr (2015-2016)**
2	**Kennedy and Zabel otolith study of spawning, early rearing, and overwinter locations).**	**$75,000/yr**
3	**Completion of NOAA study heritability of age at emigration.**	**Existing staff**
4	**Promotion of local broodstock adaptation in South Fork Clearwater and Selway rivers via weir operation in SFCLWR.**	**Existing staff**
5	**Document natal spawning area of NOR fish used in respective broodstocks via otolith micro-chemistry.**	**Existing staff**
6	**Expand monitoring of genetic diversity/similarity in hatchery and natural conspecifics at sub population spatial scales once PBT marked adults are realized..**	**$60,000/yr**
7	**Conduct genetic based monitoring of NOR effective population size and HOR return effective population size.**	**$150,000/yr**
8	**Continued exclusion of strays from hatchery broodstocks.**	
9	**Maximize inclusion of NOR in broodstocks within the limitations of the current marking strategy.**	**Existing staff**
10	**Formalize and communicate conclusions on inability to conduct RPA 64 and 65.**	**Existing staff**

6.4 Population Viability

6.4.1 Summary of limiting factors and threats and VSP criteria in FCRPS BiOp

The following information is summarized from Chapter 8.2 (Snake River Fall Chinook Salmon) of the Federal Columbia River Hydropower System Biological Opinion (FCRPS BiOp) Supplemental Comprehensive Analysis (SCA) (NOAA Fisheries 2008)[5].

The key limiting factors and threats for the Snake River fall Chinook include hydropower projects, predation, harvest, degraded estuary habitat, and degraded mainstem and tributary habitat. Ocean conditions have also affected the status of this ESU. Ocean conditions affecting the survival of Snake River fall Chinook were generally poor during the early part of the last 20 years. Hatchery production is not identified as a key limiting factor.

[5] Reference to documents and reports herein does not constitute an endorsement of those documents and reports.

The FCRPS BiOp analyzed anticipated survival improvements for Snake River fall Chinook based on completed actions that are anticipated to continue into the future and proposed actions contained in the BiOp. These anticipated survival improvements are summarized in Table 6. Based on completed actions NOAA anticipates a 12% increase in survival (primarily from harvest actions) and from proposed actions NOAA anticipates an 11% to 18% increase in survival (primarily from estuary habitat improvements and expected harvest). Improvements in hydrosystem and hatchery operations were not anticipated by NOAA.

Table 6. Proportional changes in survival for Snake River fall Chinook summarized from Table 8.2.3-1 and Table 8.2.5-1 in FCRPS BiOp (NOAA Fisheries 2008). Anticipated changes from actions prior to, and as a result of proposed actions in the BiOp to improve Snake River fall Chinook survival. Factors greater than 1.0 result in higher survival (e.g., 1.225 indicates a 22.5% increase in survival, compared to average current survival); 1.0 indicates no change, and numbers less than 1.0 result in lower survival (e.g., 0.996 indicates a 0.4% reduction in survival, compared to current average survival).

ESU	Survival Improvements	Hydro	Tributary Habitat	Estuary Habitat	Bird Predation	Pikeminnow Predation	Harvest	Hatcheries	Total Survival Multiplier
Snake River Fall Chinook	Base - from completed actions and current human activities likely to continue	N/A	1.0	1.01	1.02		1.09	NA	1.12
	Prospective Actions - as a result of Action Agency projects								
	Population analysis 1990-1999 with allowable future harvest	1.0	1.0	1.09	1.01	1.01	1.0	1.0	1.11
	Population analysis 1990-1999 with expected future harvest	1.0	1.0	1.09	1.01	1.01	1.06	1.0	1.18

NOAA's summary of VSP criteria for Snake River fall Chinook in the FCRPS BiOp are summarized in Table 7 below.

Table 7. VSP information for Snake River fall Chinook summarized from Table 8.2.2-1 and Table 8.2.2-2 from FCRPS BiOp (NOAA Fisheries 2008).

ESU	Population	Abundance			R/S Productivity		Risk for Distribution	Risk for Diversity
		Most Recent 10 yr Geomean	Years included in Geomean	ICTRT Recovery Abundance Threshold	Average R/S: non-SAR adj.non-delimited	Lower and Upper C.I.		
Snake River Fall Chinook	Lower Mainstem Fall Chinook 1977-	1,273	1995-2004	3,000	0.81	0.46 - 1.21	Moderately High' (large portion of historical habitat is inaccessible and the distribution of the extant population makes it vulnerable to variable environmental conditions and large disturbances)	Moderately High' (Loss of diversity associated with extinct populations and significant hatchery influence for the extant population)
	Lower Mainstem Fall Chinook 1990-	1,273	1995-2004	3,000	1.24	0.93-1.66		

Based on the above information NOAA Fisheries (2008) determined that:

- It is likely that the Snake River fall Chinook salmon ESU will trend toward recovery,
- It is likely that the species will have a short-term extinction risk,

- The Snake River fall Chinook ESU is expected to survive with an adequate potential for recovery, and
- That the affected designated critical habitat is likely to remain functional... , and
- Concluded that the FCRPS RPA is not likely to jeopardize the continued existence of the Snake River fall Chinook ESU….

6.4.2 TRT recommended viability criteria for ESUs with a single extant population as being applied to recovery.

Snake River fall Chinook present a significant challenge for recovery under the ESA since only one of the three original MPGs within the ESU remain; two populations or MPGs that existed above Hells Canyon Dam are extinct. The ICTRT (2007) recommended criteria for recovery[6], or more accurately for a population to be a low risk:

An MPG meeting the following five criteria would be at low risk:

1. ***At least one-half of the populations historically within the MPG (with a minimum of two populations) should meet viability standards.***

2. ***At least one population should be classified as "Highly Viable."***

3. ***Viable populations within an MPG should include some populations classified (based on historical intrinsic potential) as "Very Large", "Large" or "Intermediate" generally reflecting the proportions historically present within the MPG. In particular, Very Large and Large populations should be at or above their composite historical fraction within each MPG.***

4. ***All major life history strategies (e.g. spring and summer run-timing) that were present historically within the MPG should be represented in populations meeting viability requirements.***

5. ***Populations not meeting viability standards should be maintained with a) sufficient productivity so the overall MPG productivity does not fall below replacement (i.e. these areas should not serve as significant population sinks) and b) sufficient spatial structure and diversity demonstrated by achieving Maintained standards.***

Further, the ICTRT addressed the greater concern for ESUs that contained only one MPG historically or that currently include only one MPG. As expected the criteria are more stringent. They maintained that those with only one remaining MPG:

"(that the MPG)… for proper function should meet the following criteria:

• A single MPG should meet all the requirements to be at low risk (see above). In addition:

[6] Reference to TRT recommended criteria herein does not constitute an endorsement of those criteria by co-managers. A Snake River fall Chinook recovery plan has not been completed and recovery criteria have not been adopted.

1. ***Two-thirds or more of the historical populations within the MPG should meet viability standards; AND***

2. ***At least two populations should meet the criteria to be "Highly Viable."***

The managers are uncertain as to how to meet these criteria for Snake River fall Chinook given the significant challenges of either reconnecting historic habitat above the Hells Canyon Complex (HCC) or reestablishing a self sustaining population somewhere above the HCC that could functionally meet these recovery criteria. The managers have therefore not specifically addressed this recovery aspect within this document.

6.4.3 Summary of demonstrated hatchery effects (+/-) on SR population viability.

Snake River fall Chinook population viability as discussed on previous sections is very difficult to calculate, in addition demonstrating hatchery effects both positive and negative is also extremely challenging. The initiation of the fall Chinook program was out of necessity to prevent this population from demographic extirpation. Adult returns were perilously low and harvest was drastically diminished or eliminated throughout the historic range. The HGMP and this addendum document discuss the recent increase of this population (both natural and hatchery) from extreme levels, partially remedied by this program. This moderate increase in the population (nowhere near historic levels) does demonstrate some effects and a partial list of those hatchery effects are:

- Dramatic increase in adults returning
- Decreased extinction risk
- Recolonization of areas in the recent past devoid of fall Chinook (Salmon, Grande Ronde, Imnaha, and tributaries to the Clearwater rivers) increasing the spatial distribution of spawners
- Influx of marine derived nutrients providing countless ecological benefits
- Harvest opportunities increased in ocean and mainstem fisheries and opening of upstream fisheries previously absent for greater than 40 years

These benefits have been realized and will continue into the future. This program also highly coordinated amongst the States, Tribes, and Federal entities and through continuing dialogue and adaptive management this program is expected to prosper.

6.4.4 Proposed Actions to assess Viability

	Proposed Action	**Cost**
1	**Develop management criteria for viable ESU with single extant population AND hatchery based mitigation requirements.**	**Existing staff**
2	**Assess options for management based minimum abundance thresholds.**	**Existing staff**
3	**Model sensitivity of SR fall production to climate change conditions (increased temperatures and increased frequency of high flow events).**	**$40,000**
4	**Support NOAA effort to describe relative impacts of all H's on Snake River fall Chinook consistent with U.S. vs. Oregon Management Agreement Section III.E.**	**Existing staff with NOAA staff**

6.5 Adaptive Management

6.5.1 Management Objectives

As an alternative to establishing a static suite of performance standards that could trigger re-initiation of consultation, an adaptive management framework will be followed.

Fisheries co-managers collect and utilize research and monitoring data to inform a variety of management decisions (CSMEP 2008). Pre-labeling core management decision points and the basic information used to guide those decisions is central in maintaining transparent and efficient management of resources. Establishing predetermined thresholds where management decisions are hard-wired is not readily embraced by managers or functionally possible given a complex environment and adaptive management framework.

The information used to inform the hatchery operation decisions is complex. Maintaining effective communications between policy, management, and research level positions is essential in assuring accountability and linking actual project performance into a formal fisheries management decision processes (policy level and management level). Establishing a decision framework, including timeframes, prior to management action implementation is desirable. This decision framework guides regular consideration to continue, terminate, modify specific management actions, or re-initiate ESA consultation. The hatchery management assumptions described below provide the technical link to a decision framework with both base expectations and basic data requirements. If any of the assumptions are proven to be false or suspect, either by direct project findings or literature, the project's ability to achieve management goals will be formally re-considered. Routine assessment for change in program scope (continuation) and direction will be applied as necessary, at a minimum every five years. The next formal assessment of Snake River fall Chinook salmon hatchery program performance is schedule to occur in 2013 as part of a Lower Snake River Compensation Program review. In addition we expect to conduct a program review in 2016 as this aligns better with US v OR negotiations for the new management plan and it fits the standard 5 yr check in that we have promoted in other ESA consultations

The following management objectives and assumptions, taken from the Ad Hoc Supplementation Work Group final report (Beasley et al 2008), have been recommended for application to select hatchery programs. The assumptions were developed through co-management meetings, recommendations and review of monitoring and evaluation literature. They have been slightly modified for application to Snake River fall Chinook.

Management Objective 1: Maintain and enhance natural production in supplemented population.

1a. Adult progeny per parent (P:P) ratios for hatchery-produced fish significantly exceed those of natural-origin fish.
1b. Natural spawning success of hatchery-origin fish must be similar to that of natural-origin fish. (Assessment of this assumption is not readily achievable at this time and is the subject of FCRPS BiOp RPA 64 and 65. Default monitoring may be limited to natural population growth rate).

1c. Temporal and spatial distribution of hatchery-origin spawners in nature is similar to that of natural-origin fish.
1d. Productivity of a supplemented population is similar to the natural productivity of the population had it not been supplemented (adjusted for density dependence). (Methods typically involve reference population monitoring which is problematic within an ESU with a single population. Consider default monitoring of natural population growth rate as stable or increasing to be sufficient).
1e. Post-release life stage-specific survival is similar between hatchery and natural-origin population components.
1f. Proportion of hatchery- origin spawners (pHOS) will not exceed recently observed levels.

Management Objective 2: Maintain life history characteristics and genetic diversity in supplemented and unsupplemented populations.
2a. Adult life history characteristics in supplemented populations remain similar to pre-supplementation population characteristics.
2b. Juvenile life history characteristics in supplemented populations remain similar to pre-supplemented population characteristics.
2c. Genetic characteristics of the supplemented population remain similar (or improved) to the unsupplemented populations

Management Objective 3: Operate hatchery programs so that life history characteristics and genetic diversity of hatchery fish mimic natural fish.
3a. Genetic characteristics of hatchery-origin fish are indistinguishable from natural-origin fish.
3b. Life history characteristics of hatchery-origin adult fish are indistinguishable from natural-origin fish.

Management Objective 4: Effects of hatchery programs on non-target (same species) populations remain within acceptable limits.
4a. Strays from a hatchery program (alone, or aggregated with strays from other hatcheries) do not comprise more than 5% of the naturally spawning fish in the Snake River population.
4b. Snake River hatchery production strays do not exceed 5% of the abundance of any out-of-basin natural population.

Management Objective 5: Restore and maintain treaty-reserved tribal and non-treaty fisheries.
5a. Hatchery and natural-origin adult returns can be adequately forecasted to guide harvest opportunities.
5b. Hatchery adult returns are produced at a level of abundance adequate to support fisheries in most years with an acceptably limited impact to natural-spawner escapement.
5c. Harvest monitoring is adequate to ensure that harvest quotas for natural and hatchery-origin adults are not exceeded.

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

6a. Identify the most effective rearing and release strategies.
6b. 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.
6c. Frequency or presence of disease in hatchery and natural production groups will not increase above unsupplemented levels.

Management Objective 7: Understand the current status and trends of natural-origin

7a. Hatchery adults are adequately identifiable to allow accurate annual accounting of natural-origin adult abundance.
7b. Describe juvenile fish production in relationship to available habitat in each population and throughout a subbasin.
7c. Describe annual (and 10-year geometric mean) abundance of natural-origin adults relative to management thresholds (minimum spawner abundance and ESA delisting criteria) within prescribed precision targets.
7d. Adult fish utilize all available spawning habitat in each population and throughout a subbasin.
7e. The relationships between life history diversity, life stage survival, abundance and habitat are understood.
7f. Minimum Abundance Threshold (MAT) of 3,000 fish recommended by the ICTRT is compatible with management based viability criteria.

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

8a. Coordination of needed and existing activities within agencies and between all co-managers occurs in an efficient manner.
8b. Accurate data summary is continual and timely.
8c. Results are communicated in a timely fashion locally and regionally.

Management Assumptions 1a, 1b, 1d and 1f directly address aspects of productivity of naturally spawning hatchery and natural origin fish. Monitoring associated with Management Assumption 7c addresses the ability to describe natural origin fish abundance. Validity of each assumption is checked by hypothesis testing, comparison to pre-established thresholds, and trend monitoring.

The NMFS has stressed a desire to identify a metric that would signal a negative hatchery effect amidst the demographic and other variability the Snake River fall Chinook ESU experiences. Currently we believe there is no metric possible for this ESU that would be a certain indicator of hatchery effects only.

However, the most appropriate metric available to us is the proportion of hatchery-origin fish (pHOS[7]) in the total run of adult (excluding jacks) fall Chinook salmon in the Snake River above Lower Granite Dam (LGD), as a relative indicator of natural-origin fall Chinook salmon abundance (see Management Objective 1f). The underlying premise for this metric is that annual hatchery returns to Lower Granite Dam will be from relatively constant smolt release levels as hatchery fish production targets have been achieved and should remain stable. If the number of natural-origin fish relative to the number of hatchery-origin fish declines this would be detected as an increase in pHOS. Therefore, an increase in pHOS of sufficient magnitude would be counter to our management assumption and may indicate possible negative impacts of the hatchery program on the ESU. This metric then could be considered an 'early warning' value that would signal a potential decrease in productivity.

The early warning value used to test our management assumption would be the highest annual estimate for the proportion of hatchery-origin fish in the adult return from 2005 to 2010[8]. The test metric to compare against this value would be the median proportion of hatchery fish in the run of fall Chinook above LGD for the most recent three year time period. To exclude base period values from this calculation, the first year this test metric could be calculated (check-in) would be 2013.

Should natural population abundance reach this early warning metric, the co-managers would work with NMFS to analyze the supplementation program compared to other actions and conditions that influence SR fall Chinook abundance, productivity, spatial structure and diversity, as well as legal principles, included by not limited to the Tribes' treaty rights, the States' interests, the Secretarial Order on ESA and Tribal Treaty rights, the conservation necessity principles and the ESA.

We believe that the suite of expanded RM&E proposed in this addendum will substantially improve the understanding of natural population status and trend and provide the basis for examining the effects of the supplementation program

6.5.2 Proposed Actions to address improving certainty of Productivity

	Proposed Action	Cost
1	**Develop management criteria for viable ESU with single extant population AND hatchery based mitigation requirements.**	**Existing staff**

[7] Estimate of pHOS will account for removals of hatchery and natural origin fish upstream of Lower Granite Dam for broodstock collection, harvest, pre-spawn mortality, etc and represent our best estimate of available adult spawners.

[8] Identification of natural-origin fish has relied partially on scale patterns from 2006 onward, and this technique has been shown to be inaccurate, probably underestimating the number of natural-origin fish. WDFW and NPT biologists are currently revising the counts using methods in place before the 2006 changeover. These revised estimates will be used in the calculations for the hatchery fraction of fall Chinook returning to LGD. Implementation of downstream mark selective fisheries would have the potential to change the relative ratio of natural to hatchery fish relative to the levels observed in recent years and therefore would need to be accounted for in establishing a specific test metric.

2	**Commitment to formal adaptive management process with pre-established management assumptions, monitoring and evaluation, formal report, and symposium conducted in 2016.**	**$15,000**
3	**Support NOAA effort to describe relative impacts of all H's on Snake River fall Chinook consistent with U.S. vs. Oregon Management Agreement Section III.E.**	**Existing staff**

Attachment A.

Snake River Fall Chinook Salmon Trapping at Lower Granite Dam

by

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April 6, 2011

Fall Chinook salmon run reconstructions to Lower Granite Dam (LGD) are performed each year using a set trapping rate (or rates) to randomly sample fall Chinook and generate an estimate of the entire run composition to LGD. In addition to generating estimates of hatchery, natural and individual release groups, sampling methods used to generate the run reconstruction estimates of total returns to LGD allow for the calculation of precision and accuracy measures superior to that obtained using window counts. These measures are only useful if the trapping methods are truly random and the composition of the sample can be accurately determined. This memo provides a brief summary of data and analysis obtained from fall Chinook salmon run reconstruction estimates (2006-2010) and the recent observations of bias in the abundance estimates.

Standardized and effective LGD trapping protocols providing adequate accuracy and precision estimates have only been around since 2004; prior to that the trapping protocols were not well established. Since 2004 a comparison of total fall Chinook returns obtained by window counts and run reconstructions revealed a consistent bias, with the run reconstruction estimate greater than window counts in all but one year (Figure 1). Looking only at adults, the run reconstruction estimates were always greater than that determined by window counts (Figure 2). Recently the divergence between the estimates has increased, approaching 20% greater estimates from run reconstructions compared to window counts.

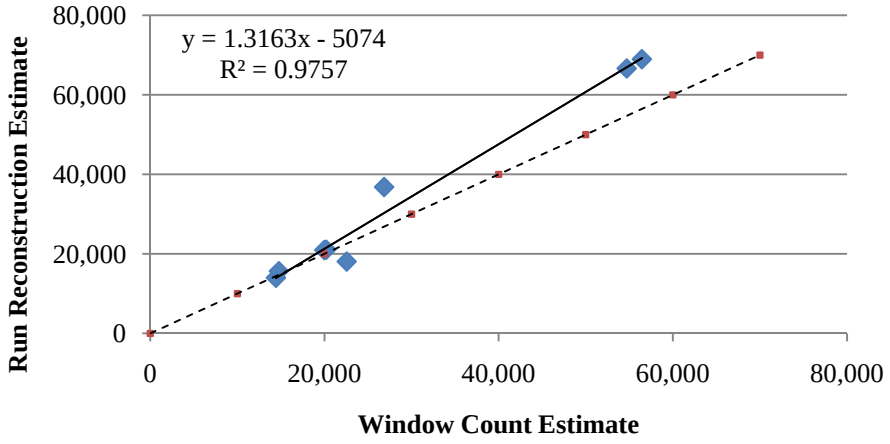

Figure 1. Relationship between the total fall Chinook salmon (jacks and adults) to Lower Granite Dam obtained from window counts and run reconstruction. The solid line indicates the data trend line and the dashed line indicated the expected 1:1 trend line.

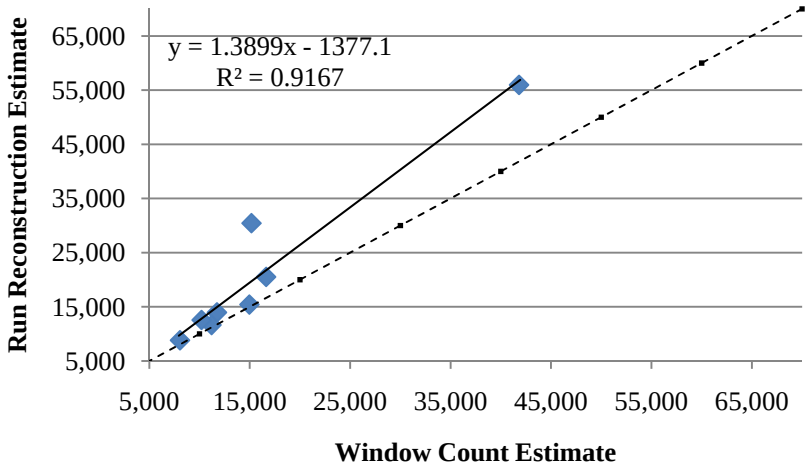

Figure 2. Annual comparison of the number of adult fall Chinook salmon to Lower Granite Dam obtained from window counts and run reconstruction. The solid line indicates the data trend line and the dashed line indicated the expected 1:1 trend line.

If we assume that a bias exists, it is likely that the methods used for the calculation of one of these estimates (window count or run reconstructions) produced the observed bias. Potential bias from window counts could have arisen from how the counts were conducted. Actual counting is performed for 50 out of 60 minutes per hour for 16 hours per day early in the fall Chinook passage period, then is reduced to 10 hour counts late in the season. Both of these factors were accounted for in the final estimates. Hourly estimates were expanded to account for

the time period that no counts occurred (expanded by 0.83). Similarly, in our analysis night passage was estimated based on an analysis performed by the fish passage Center that demonstrated approximately 3.2% of fall Chinook salmon pass the ladders at night as determined by the detection of PIT tagged fish (http://www.fpc.org/documents/FPC_memos.html). Finally, window counts were completed on each of the four lower Snake River dams, and total fall Chinook salmon abundance estimates were similar at each facility, suggesting that the counting methods were consistent across the facilities. We are not suggesting that window counts are highly accurate or completely represent fall Chinook abundance, but we can see no factor that leads to a bias in the data.

Run reconstruction estimates were based on trapping a random sample of fish across the return then expanding the sample by the trapping rate. Generally trapping rates ranged from 10% – 20% of the fish passing the ladder, with the rate set before the season at a rate adequate to collect broodstock for ongoing hatchery programs at Lyons Ferry Hatchery and Nez Perce Tribal Hatchery. Depending on the size of the return of both fall Chinook and steelhead and broodstock needs, the trap rate may have changed during the season, usually reduced, as broodstock needs are met or total numbers exceed what is manageable at the adult facility.

Functionally, the trap consists of a set of two gates in the fish ladder, each set to open four times per hour, 24 hours per day for a set amount of time depending on the trapping rate. The gates are computer controlled and a report is generated that provides the exact amount of time that the gate was open down to the second. In addition, the gates are programmed to open when it detects specific PIT tagged fish (sort-by-code fish) so they can be captured outside of the trapping times. This additional time is added to the set trap rate to generate the adjusted trap rate (set trap rate plus sort-by-code time). The adjusted trap rate number is used to expand the sample and come up with a total number of fish passing the trap each day and for the season. Sort-by-code fish are identified by their unique PIT tag at the LGD trap or hatchery and are removed from the sample prior to run reconstruction analysis so that they did not inflate the estimate.

Based on the trapping report and communications with Doug Marsh (NOAA-Fisheries), there does not appear to be any issues with the trap function that would indicate a bias. However, when the number of fish trapped per day is compared to the window counts, it appears that the trap captures a higher percentage of fish than would be expected given the trapping rate. This discrepancy between window counts and trap rate was observed in 2008, 2009, and 2010. With no bias you would expect the number of fish captured by the trap to approximately equal the trapping rate multiplied by the number of fish that passed the trap (or window). For example, if the trap is set to open 10% of the time and 100 fish pass through the ladder on a given day, you would expect to capture 10 fish. On any given day the total fish captured would deviate greater than or less than the expected due to chance, but over multiple days the deviation from the trap rate should equal zero. Detecting anomalies or bias in the trapping rate should be possible by calculating the deviation between the number of fish counted at the window and the number of fish captured in the trap. For this analysis we calculated the daily deviation in trap rate as the difference between the observed and expected trapping rate using these two variables (number of fish counted at the window and number of fish trapped). The observed trapping rate was calculated as the number of fish in the trap divided by the number of fish that passed the window each day (# trapped fish/# fish passing the window). The expected trapping rate was calculated

as the adjusted trapping rate multiplied by the number of fish passing the counting window each day (trap rate x # fish passing the window). Given no bias the daily deviation should be evenly distributed around zero with a mean of zero.

An examination of the expected and observed trapping rates and the deviation from the expected trapping rate at the LGD trap from 2005 through 2010 revealed significant deviations between the observed and expected trapping rates in 2008, 2009 and 2010 (Table 1). For every year except 2009 we only used the 80% passage window for this calculation to avoid issues related to small sample sizes early and late in the season. In 2009 only 4 days were available in the early passage period (12% trapping rate) so we included all days with greater than 100 fall Chinook passages during the 12% trapping period. Generally deviations were low early in the trapping period then diverged as the trapping rate was changed (lowered). This was especially evident in 2008, when the trap rate changed twice and the magnitude of the deviation increased each time until it was nearly 12%.

When we plotted the daily deviation in trap rate verses date (Figures 3, 4, 5, 6, 7), a consistent positive bias is revealed only in those years when the trapping rate changed during the season (2010, 2008), but did not occur in those years when the trap rate didn't change (2007, 2006). A closer examination of Figures 3 and 5 revealed that the bias didn't arise until the trap rate changes, prior to that time it appeared to be randomly distributed around zero. Because the trap rate change occurred unusually early in 2009 there was not enough data to conclude anything about the trap rate change observed in Figure 4. However, data from Table 1 suggested that a bias was present after the trap rate changed.

Table 1. Year, trapping start and end dates, expected and observed trapping rates and the deviation from the expected trapping rate at the Lower Granite Dam ladder from 2005 – 2010. Observed and expected trapping rates were calculated from the 80% window passage for all years except 2009, where the entire early trapping period was used in this calculation.

Year	Trapping start date	Trapping end date	Expected trapping rate	Observed trapping rate	Deviation from expected trapping rate
2005	9/6	11/16	13%	10.24%	-2.76%
2006	9/1	11/21	13%	13.43%	0.43%
2007	9/1	11/20	20%	19.88%	-0.12%
2008	8/24	9/12	20.04%	19.78%	-0.26%
	9/13	9/26	12.07%	17.01%	4.93%
	9/27	11/21	10.01%	21.87%	11.86%
2009	8/18	9/8	12.06%	12.73%	0.67%
	9/9	11/15	9.11%	11.56%	2.45%
2010	8/22	9/18	12.11%	12.78%	0.67%
	9/19	11/18	10.07%	13.00%	2.93%

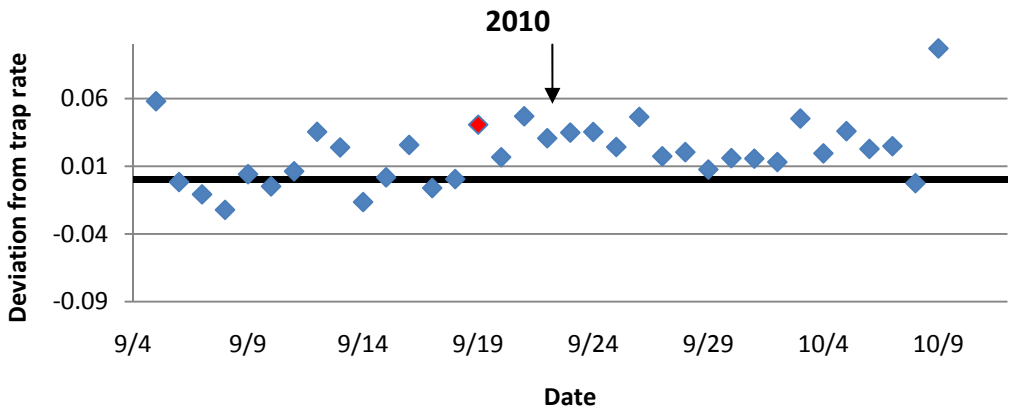

Figure 3. A graph of the daily deviation between the observed and expected trapping rate at the LGD fish ladder for the 80% passage window in 2010. The observed trapping rate was calculated by dividing the number of fish in the trap by the number of fish that passed the counting window that day. The expected trapping rate was the proportion of time that the automatic gates were programmed to open each day plus the number of seconds the gate is open to capture sort-by-code fish, calculated per day then averaged over the trapping period. Window counts were expanded to account for 50 minute observations per hour and night passage. The bold line represents zero deviation. The red data point and arrow represent the day that the set trapping rate changed.

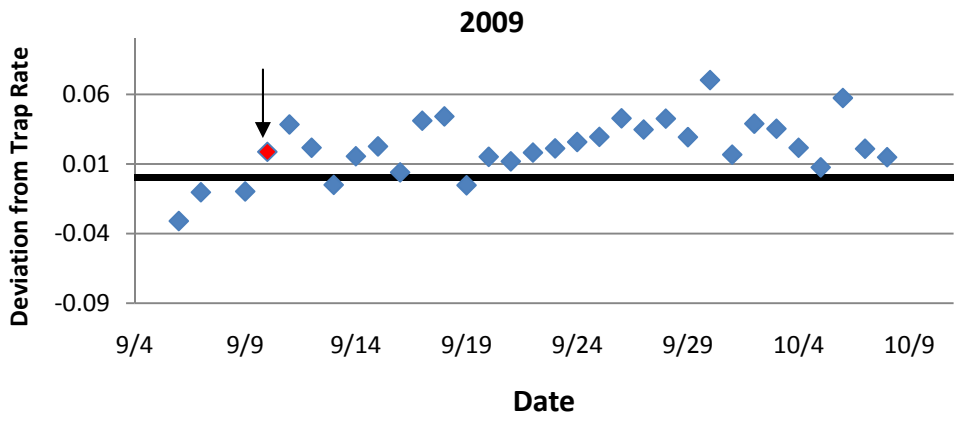

Figure 4. A graph of the daily deviation between the observed and expected trapping rate at the LGD fish ladder for the 80% passage window in 2009. The observed trapping rate was calculated by dividing the number of fish in the trap by the number of fish that passed the counting window that day. The expected trapping rate was the proportion of time that the automatic gates were programmed to open each day. Window counts were expanded to account for 50 minute observations per hour and night passage. The bold line represents zero deviation. The red data point and arrow represent the day that the set trapping rate changed.

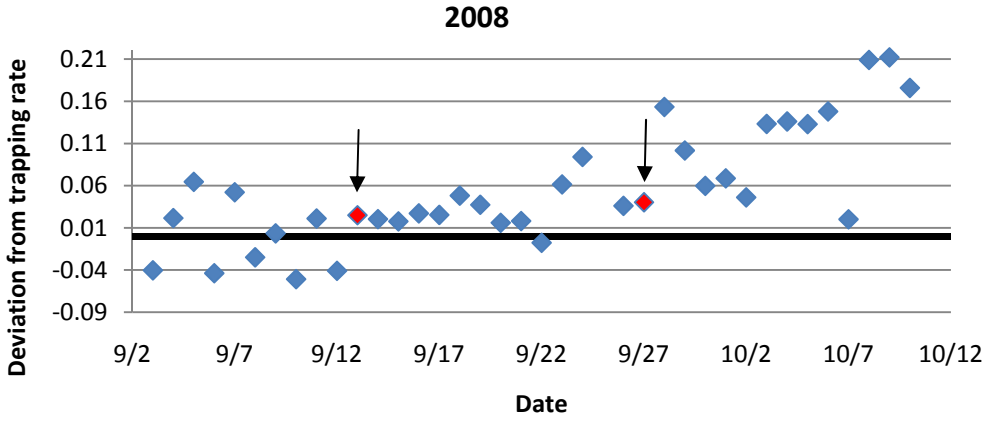

Figure 5. A graph of the daily deviation between the observed and expected trapping rate at the LGD fish ladder for the 80% passage window in 2008. The observed trapping rate was calculated by dividing the number of fish in the trap by the number of fish that passed the counting window that day. The expected trapping rate was the proportion of time that the automatic gates were programmed to open each day. Window counts were expanded to account for 50 minute observations per hour and night passage. The bold line represents zero deviation. The red data points and arrows represent the days that the set trapping rate changed.

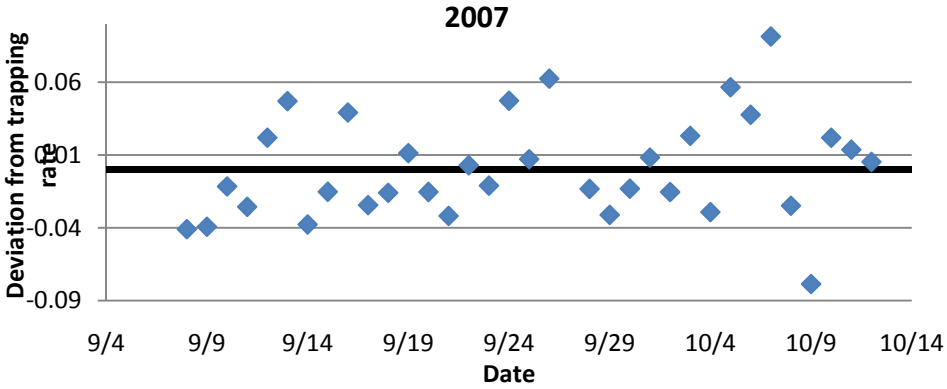

Figure 6. A graph of the daily deviation between the observed and expected trapping rate at the LGD fish ladder for the 80% passage window in 2007. The observed trapping rate was calculated by dividing the number of fish in the trap by the number of fish that passed the counting window that day. The expected trapping rate was the proportion of time that the automatic gates were programmed to open each day. Window counts were expanded to account for 50 minute observations per hour and night passage. The bold line represents zero deviation.

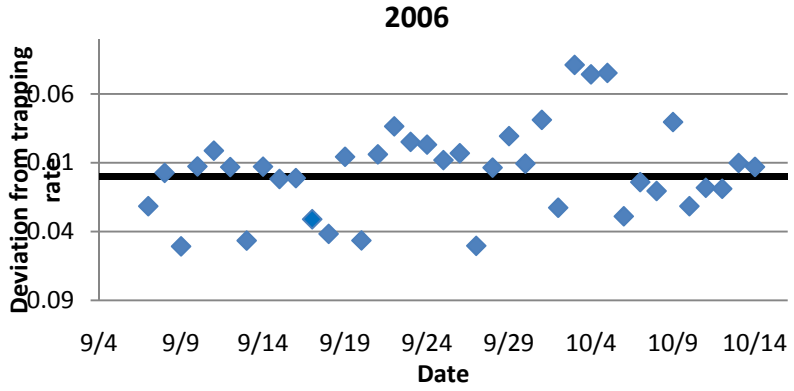

Figure 7. A graph of the daily deviation between the observed and expected trapping rate at the LGD fish ladder for the 80% passage window in 2006. The observed trapping rate was calculated by dividing the number of fish in the trap by the number of fish that passed the counting window that day. The expected trapping rate was the proportion of time that the automatic gates were programmed to open each day. Window counts were expanded to account for 50 minute observations per hour and night passage. The bold line represents zero deviation.

These analyses rely on accurate and unbiased window count estimates and we have not ruled out the possibility that window counts are flawed. However, the apparent increase in observed trapping rate that occurred each time the trap rate was changed suggests that it was more of a trap issue. Ben Sandford (NOAA Fisheries) completed a preliminary statistical analysis of the data from 2008 through 2010. Data from 2009 could not be analyzed because not enough days were available prior to the trap change. Results from 2008 and 2010 were mixed. Ben's summary: 2010 shows the odd effect where a change in the "specified trap rate" seems to have led to a bias. Data from 2009 can't be evaluated due to very early change date. Data from 2008 shows more of a general temporal trend (bias increased linearly over time) in bias but perhaps a finer-scale analysis could be done as there are unique patterns to the data. He recommends a more careful analysis in the future.

Recommendations

1. Install a high resolution video camera to monitor/validate the by-catch associated with sort-by-code fish entering the trap. Recently, the number of sort-by-code fish has increased significantly (>2,600 fish in 2010), so the trap opens much more frequently outside of the set trapping times. If Chinook salmon group together then the trap opening for a single sort-by-code fish may have a higher probability of trapping additional fish compared to the random possibility associated with the gate opening. Previously a video camera was placed over the gate to account for the trapping of sort-by-code and other fish trapped outside the trapping times. Frequent openings for short periods of time also relates to #2.

2. Investigate how the length of time the trap opens influences the trapping rate. Generally the trap is opened four times an hour and the length of those openings is set based on the

overall rate. It is possible that as the trap rate decreases, the four openings are no longer sufficient to provide a representative sample. In both 2008 and 2010 the discrepancy between the observed and expected trap rate is amplified once the trap rate is set below 12 percent. This conclusion is supported by the data from 2006 and 2007, in which the trap rate was held constant at 13 and 20 percent respectively, and the discrepancy between the expected and observed trap rate was low. Further evidence for this explanation was observed in 2009 when the trap was held at a constant 9 percent for nearly the entire season, and yet the expected and observed trap rates were similar to the discrepancies observed in 2008 and 2010 after the rate was decreased. Because there is no reason to doubt the function of the trapping mechanism, and there is little evidence to suggest that the window counts are exceedingly inaccurate, a reduction of the trapping rate below 12 percent may be related to the inaccuracies that have been observed. One possible solution would be to reduce the number of times the trap is opened per hour to ensure that the trap is open for a sufficient amount of time to collect a representative sample.

3. Conduct a thorough review of the window counting protocol could identify potential sources of bias in window count abundance estimates. Our analysis assumed that the window counts are accurate, which may not be the case. Representatives from the window counting and run reconstruction groups should meet and discuss potential counting challenges.