Independent Scientific Review Panel

Review of the
Lower Snake River Compensation Plan
Fall Chinook Program

ISRP 2014-4
April 17, 2014

ISRP

Independent Scientific Review Panel

for the Northwest Power & Conservation Council
851 SW 6th Avenue, Suite 1100
Portland, Oregon 97204
www.nwcouncil.org/fw/isrp

ISRP Members

J. Richard Alldredge, Ph.D., Emeritus Professor of Statistics at Washington State University

Robert Bilby, Ph.D., Ecologist at Weyerhaeuser Company

David Heller, M.S., Aquatic Habitat Management and Restoration Consultant, formerly Fisheries Program Leader for the Pacific Northwest Region, USDA Forest Service

R. Scott Lutz, Ph.D., Associate Professor of Wildlife Ecology, University of Wisconsin

Alec Maule, Ph.D., Fisheries Consultant and former head of the Ecology and Environmental Physiology Section, United States Geological Survey, Columbia River Research Laboratory

Robert J. Naiman, Ph.D., Emeritus Professor of Aquatic and Fishery Sciences at University of Washington

Greg Ruggerone, Ph.D., Fisheries Scientist for Natural Resources Consultants

Dennis Scarnecchia, Ph.D., Professor of Fish and Wildlife Resources, University of Idaho

Steve Schroder, Ph.D., Fisheries Consultant and former Fisheries Research Scientist at the Washington Department of Fish and Wildlife

Carl Schwarz, Ph.D., Professor of Statistics and Actuarial Science at Simon Fraser University, Canada

Chris C. Wood, Ph.D., Emeritus Scientist at the Pacific Biological Station, Department of Fisheries and Oceans, Nanaimo, British Columbia, Canada

Scientific Peer Review Group Contributors

Eric J. Loudenslager, Ph.D., Consulting Fisheries Scientist and Adjunct Professor of Fisheries Biology, Humboldt State University, California

William Smoker, Ph.D., Emeritus Professor of Fisheries at the University of Alaska Fairbanks, School of Fisheries and Ocean Sciences.

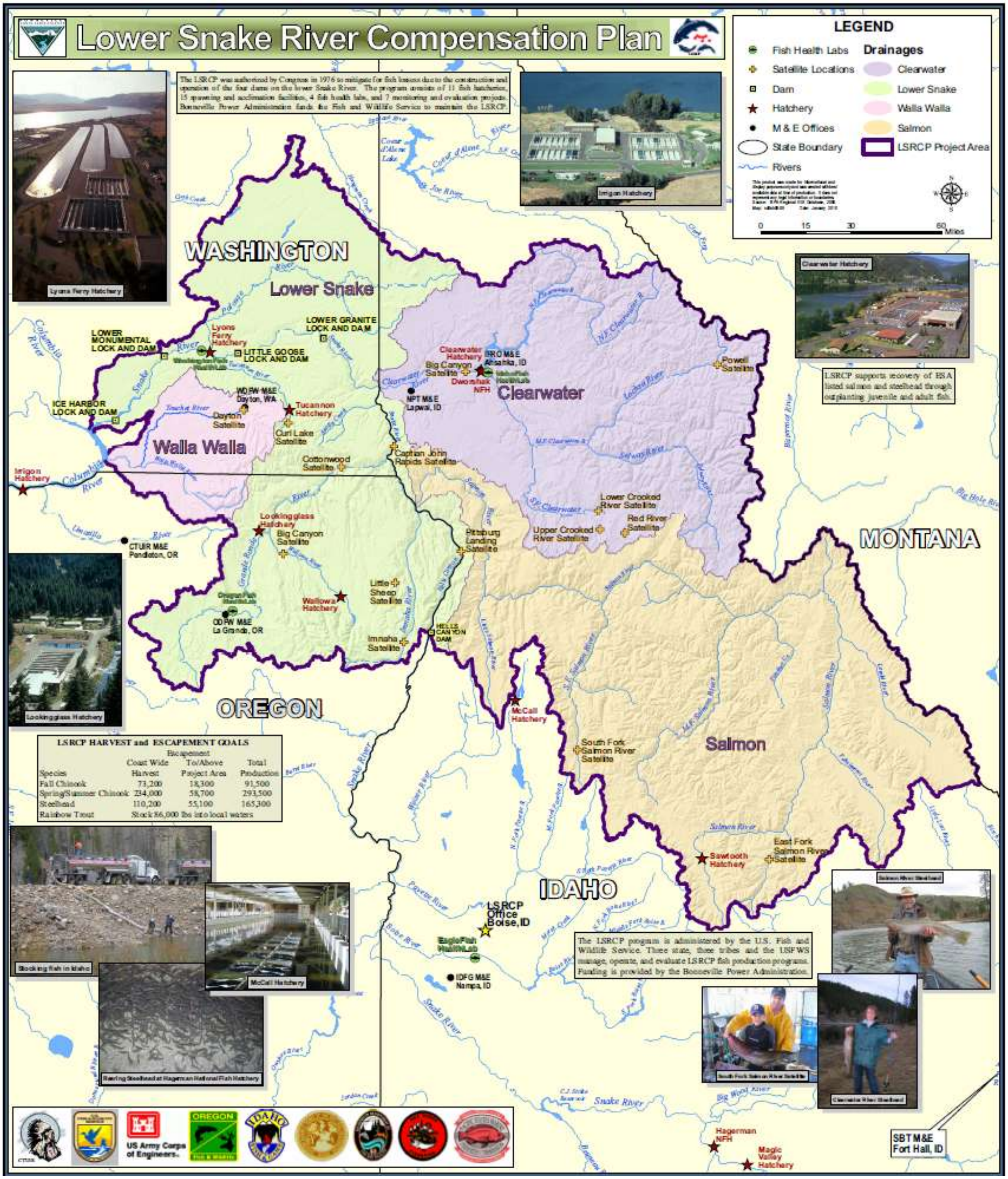
Staff

Erik Merrill, J.D., Manager, Independent Scientific Review Program, Northwest Power and Conservation Council

Cover graphic: background photo of fall Chinook redds from LSRCP fall Chinook symposium presentation: History and Status of Snake River Fall Chinook Redd Surveys, Phil Groves and Brad Alcorn.

ISRP Review of the Lower Snake River Compensation Plan (LSRCP) Fall Chinook Program

Contents


Lower Snake River Compensation Plan
LEGEND
Fish Health Labs
Satellite Locations
Dam
Hatchery
M & E Offices
State Boundary
Rivers
Drainages
Clearwater
Lower Snake
Walla Walla
Salmon
LSRCP Project Area
0 15 30 60 Miles
The LSRCP was authorized by Congress in 1976 to mitigate for fish losses due to the construction and operation of the four dams on the lower Snake River. The program consists of 11 fish hatcheries, 15 spawning and acclimation facilities, 4 fish health labs, and 7 monitoring and evaluation projects. Bonneville Power Administration funds the Fish and Wildlife Service to maintain the LSRCP.
LSRCP supports recovery of ESA listed salmon and steelhead through outplanting juvenile and adult fish.
The LSRCP program is administered by the U.S. Fish and Wildlife Service. Three state, three tribes and the USFWS manage, operate, and evaluate LSRCP fish production programs. Funding is provided by the Booneville Power Administration.
WASHINGTON
OREGON
IDAHO
MONTANA
Lower Snake
Walla Walla
Clearwater
Salmon
LOWER MONUMENTAL LOCK AND DAM
LITTLE GOOSE LOCK AND DAM
LOWER GRANITE LOCK AND DAM
ICE HARBOR LOCK AND DAM
HELLS CANYON DAM
Lyons Ferry Hatchery
Tucannon Hatchery
Irrigon Hatchery
Lookingglass Hatchery
Wallowa Hatchery
Clearwater Hatchery
Dworshak NFH
McCall Hatchery
Sawtooth Hatchery
Hagerman NFH
Magic Valley Hatchery
WDFW M&E Dayton, WA
CTUIR M&E Pendleton, OR
ODFW M&E La Grande, OR
NPT M&E Lapwai, ID
IDFG M&E Nampa, ID
SBT M&E Fort Hall, ID
LSRCP Office Boise, ID
Dayton Satellite
Curl Lake Satellite
Cottonwood Satellite
Big Canyon Satellite
Little Sheep Satellite
Imnaha Satellite
Captain John Rapids Satellite
Pittsburg Landing Satellite
Powell Satellite
Lower Crooked River Satellite
Red River Satellite
Upper Crooked River Satellite
South Fork Salmon River Satellite
East Fork Salmon River Satellite
Lyons Ferry Hatchery
Irrigon Hatchery
Clearwater Hatchery
Lookingglass Hatchery
Trucking fish in Idaho
McCall Hatchery
Rearing Steelhead at Hagerman National Fish Hatchery
Salmon River Steelhead
South Fork Salmon River Satellite
Clearwater River Steelhead
US Army Corps of Engineers
LSRCP HARVEST and ESCAPEMENT GOALS
Species | Coast Wide Harvest | Escapement To/Above Project Area | Total Production
Fall Chinook | 73,200 | 18,300 | 91,500
Spring/Summer Chinook | 234,000 | 58,700 | 293,500
Steelhead | 110,200 | 55,100 | 165,300
Rainbow Trout | Stock 86,000 lbs into local waters

ISRP Review of the Lower Snake River Compensation Plan (LSRCP) Fall Chinook Program

I. Executive Summary

The Independent Scientific Review Panel (ISRP) conducted a review of the Lower Snake River Compensation Plan (LSCRP) fall Chinook program at the request of the Northwest Power and Conservation Council and U.S. Fish and Wildlife Service (USFWS). For the review, the ISRP used materials from the two-day Fall Chinook Symposium (see agency and tribal program summaries), project annual reports, Hatchery Genetic Management Plans (HGMP) for Lyons Ferry and Nez Perce Tribal Hatcheries, and the Biological Opinion produced for the program by NOAA Fisheries. The ISRP believes that the data, evaluations, and conclusions provided by the LSRCP and its partners are applicable beyond the Columbia River and Pacific Northwest. Therefore, we encourage the investigators to use the summary reports as a foundation for one or more scientific papers that assesses the within-hatchery and post-release performance of the program's fall Chinook salmon.

The fall Chinook hatchery program is a well-coordinated and integrated multi-agency effort. Two principal facilities are involved, the Lyons Ferry and Nez Perce Tribal hatcheries. Broodstock for the hatcheries are obtained at Lower Granite Dam and at fish ladders at each of the facilities. Sub-yearling and yearling fall Chinook are released at Lyons Ferry Hatchery and also distributed to three acclimation sites. Two acclimation sites are located on the Snake River and one on the Clearwater River. Eyed eggs from Lyons Ferry Hatchery are also transferred to three hatcheries, Oxbow, Irrigon, and Umatilla, where they are reared to the sub-yearling stage prior to release into the Snake River. Only sub-yearling fall Chinook are produced and released at the Nez Perce Tribal Hatchery. Three acclimation sites also receive fish from the Nez Perce hatchery. One site is located in the lower Clearwater River and the other two are situated in the upper Clearwater. The combined annual release goals for the Lyons Ferry and Nez Perce Tribal hatcheries are 900,000 yearling and 4.6 million sub-yearling salmon. Three million of the sub-yearlings undergo some form of acclimation while the remaining 1.6 million fish are released without acclimation below Hells Canyon, in the Grande Ronde River, and elsewhere in the Snake River. In aggregate, the program is distributing juveniles throughout the parts of the Snake River basin that are still accessible to fall Chinook.

Both hatcheries have consistently met their green-egg-to-smolt survival goals. Objectives for size-at-release have been reliably met for yearling Chinook. Changes in hatchery infrastructure and rearing protocols made in 2004 significantly improved fish growth and health. Since 2004, sub-yearling size-at-release objectives have been met. Difficulties in obtaining broodstock initially prevented the program from regularly attaining its juvenile release goals. However, recent increases in adult abundance have allowed egg take and smolt release targets to be met from 2009 to present.

Information obtained on juveniles produced by the program included their migration rates and dates of arrival and survival to Lower Granite and other downriver dams. Some of this information has been used to determine how environmental conditions in the Snake and Clearwater rivers influence juvenile migration rates and how likely hatchery-reared juveniles are to interact with natural origin fall Chinook juveniles.

Numbers of program fish harvested by commercial and recreational fisheries in the ocean and lower Columbia River are estimated, and the remaining hatchery and natural origin adults are counted as they migrate past Lower Granite Dam. An annual harvest goal of 73,200 fish was established for the program, with 54,900 fish being identified for commercial harvest and 18,300 fish for recreational harvest. Adult abundance targets above Lower Granite Dam are 24,750 hatchery adults and 14,360 natural origin recruits.

The program has been responsible for significant increases in the abundance of Snake River Fall Chinook. In 1990, about 350 fall Chinook adults ascended past Lower Granite Dam. By 2009, that number increased to 47,000 fish. Since 2009, the annual management escapement goal of 24,750 hatchery origin adults above Lower Granite Dam has been met every year. Natural origin recruits have also dramatically increased over the past fifteen years, and the escapement goal of 14,360 for these fish was exceeded in 2012 (and most likely in 2013 although final counts are not yet available). Moreover, the minimum viability threshold of 3,000 adults, instituted for natural origin fall Chinook in the Snake River basin, has been surpassed every year since 2001. However, the overall harvest target of 73,200 fish has never been reached. From 2009 through 2012, yearly commercial and recreational harvest levels increased and have averaged 21,100 fish (range 14,649 to 30,920). These totals include fish harvested in ocean fisheries extending to Southeast Alaska.

A number of adaptive management actions may have contributed to the dramatic increase in Snake River fall Chinook abundance. Steps have been taken to reduce disease episodes and improve juvenile quality at the hatcheries by altering raceway configurations, changing cleaning methods, increasing flows, and reducing rearing densities. Fish health has been improved by treating prospective brood fish with antibiotics prior to spawning, disinfecting fertilized eggs with iodophor, and culling eggs from females with high bacterial kidney disease titers. Mating protocols, that reduce the occurrence of younger fish in the broodstock, have been implemented to limit the occurrence of fish maturing at a young age. Bird predation has been reduced by placing netting over rearing vessels. Additionally, some releases of fish are made during darkness to reduce immediate predation by fish and birds. Increases in the number of acclimation sites and number juveniles released have increased over the past decade. Hydrosystem operations have been altered. Increased summer spill at Dworshak and from upper Snake River dams has been implemented to cool water temperatures in the lower Clearwater River and Snake River reservoirs. Additionally, flow stabilization is now practiced during spawning and incubation periods.

Looking ahead, the ISRP notes that the program faces a number of challenges. One of these will be to separate the relative contribution that factors such as modifications to hatchery procedures, changing ocean conditions, altered hydrosystem operations, and supplementation have had on the upsurge of fall Chinook abundance. Understanding the role that each of these factors have played will influence how the program is managed in the future. The program also needs to address two key questions. First, how effective has the hatchery program been in establishing locally adapted and self-sustaining spawning aggregations of fall Chinook? Existing data suggest that the natural spawning population is not viable as the return-per-spawner index of productivity is typically well below replacement. The low productivity of natural fall Chinook is a critical concern in an otherwise successful program. And, second, what risks does the hatchery program pose to natural populations?

To help answer these questions and achieve other program objectives the ISRP provides the following recommendations:

1) Integrate the LSRCP fall Chinook program goals, objectives, and implementation with the recovery plan for natural Snake River fall Chinook. LSRCP production numbers were based on anticipated post-release survival rates and harvest rates that have yet to be achieved. Harvests have been constrained in response to Endangered Species Act (ESA) listings. Consequently, there are substantial numbers of hatchery adults returning to the Snake River basin in recent years. However, the productivity (recruits per spawner or R/S) of the natural population is typically not above 1.0, which is needed for a self-sustaining natural population. The spawning escapement of hatchery-origin adults appears to exceed the capacity of the available habitat, and many of the natural adults are likely first filial progeny of hatchery parents. The LSRCP fall Chinook program needs to be

balanced with the recovery plan, which will evaluate the risks and trade-offs of alternative hatchery production and harvest levels to natural fall Chinook abundance, productivity, diversity, and spatial distribution.

2) Evaluate hatchery/wild salmon interactions and develop biologically based spawning goals for natural fall Chinook salmon. Currently, total adult returns to the Snake River are meeting program goals but largely because harvest rates have been cut for conservation purposes. Reductions in harvest to protect Snake River fall Chinook result in spawning escapements of hatchery fish to the Snake River Basin that likely exceed reasonable levels. The effects of hatchery fish on the productivity of natural spawning populations of Snake River fall Chinook, however, is not known and needs to be investigated. The proportion of hatchery and wild females in spawning aggregations should be recorded each year because available data indicate females are much less abundant than males. Escapement goals based on habitat characteristics should be developed for specific regions within the Snake River basin. Additionally, brood tables for natural and hatchery origin fish should be developed and updated annually. To complete brood tables, estimates of ocean and mainstem harvests and returns to the Columbia and Snake rivers will need to be included. These tables will facilitate the development of spawner-recruitment relationships which the co-managers can use to evaluate the viability (Recruits/Spawner) of natural spawning populations.

3) A persistent problem for the program has been the identification of unmarked hatchery origin adults; therefore, the ISRP recommends that visible marks be placed on 100% of the hatchery juveniles produced by the program. This would help: (a) establish the origin of fish used as broodstock, (b) refine estimates of naturally spawning hatchery fish and their spawning ground distributions, and (c) improve the estimates of the proportion and number of hatchery and natural origin fish returning to Lower Granite Dam. Marking of hatchery fish could also facilitate additional selective harvest in the Snake River Basin as a means to control characteristics of the spawning escapement. Alternatively, the co-managers have decided to use Parent Based Tagging to identify unmarked hatchery fish. This method relies on pedigree analyses to assign origins. Since there is substantial likelihood that natural-origin individuals are direct descendants of hatchery fish, such assignments may be subject to an unknown amount of error. Thus, it is important to establish the amount of assignment error this method may have by crafting and performing validation studies.

4) Additional standards for in-hatchery performance should be considered, including acceptable survival levels for (a) broodstock held at Lyons Ferry Hatchery, (b) green egg-to-eyed egg survival at Lyons Ferry and Nez Perce Tribal hatcheries, and (c) eyed egg-to-fry and fry-to-release survival at all hatcheries and acclimation sites. Such standards will help the co-managers determine fish culture performance that may need improvement or identify successful procedures that could be exported to other parts of the fall Chinook program. If not already done, within-hatchery performance data should be assembled into multi-year databases that are available to all fall Chinook partners.

5) Recent modifications to the mating procedures may have unintended consequences. If not already in place, a monitoring program should be developed that tracks demographic (e.g., age and size at return, fecundity, egg size, maturation dates) and genetic trends (e.g., changes in effective population size) in hatchery fish. Continued consultation with regional genetic expertise is also recommended.

6) Evaluate factors affecting the survival, migration rate, and arrival timing of hatchery smolts traveling from their release locations to Lower Granite Dam. Some analyses have explored correlations between migration rate and river flow and temperature. These tests were performed in 2005 and should be performed again with additional data. Furthermore, the importance of size-at-release, river flow, temperature, turbidity and release time-of-day (e.g. diurnal v. nocturnal) on survival should be examined. How survival rates to Lower Granite Dam and other lower Columbia River dams may affect smolt-to-adult survival should be evaluated. Results from these analyses may help managers refine when fish should be released to maximize survival and minimize potential interactions with natural origin fall Chinook and other ESA-listed species.

7) Continue to evaluate ecological and disease interactions of hatchery and wild juvenile salmon. Some of the potential ecological and demographic effects of hatchery fall Chinook on natural origin juveniles and other fishes in the Snake River basin have been examined. The co-managers have identified several areas where further investigation is warranted. One of these is an assessment of the possible transfer of pathogens from hatchery fish to natural origin juvenile fall Chinook at dams and during downstream transport in barges and trucks. Another is an evaluation of the competitive interactions between hatchery and natural fall

Chinook juveniles in reservoirs created by the lower Snake River dams. These are worthwhile studies, but more should be done. For example, predaceous and competitive interactions among juvenile hatchery fish and ESA-listed salmonids in the basin are assumed to be minimal due to habitat preferences. This assumption should be tested. The effects of large releases of hatchery fish on food abundance in the river as well as on possible demographic and aggregative numerical responses of bird, mammal, and fish predators should be examined as both could affect natural origin conspecifics and other fishes.

8) Continue to evaluate and document adequacy of the run reconstruction methodology. Run reconstruction is being employed to estimate total abundance of fall Chinook returning to Lower Granite Dam and to ascertain the composition of the run. Interpolation is used to help estimate abundance when fish counts at Lower Granite Dam cannot be made. The ISRP recommends that the annual percentage of the run determined by interpolation be reported. If significant portions of the run are estimated by interpolation, it may be advisable to investigate correlation relationships as a way to estimate missing values. It would also be helpful to document the percentage of the population that was sampled for origin, age, and sex. Since the methods used in the run reconstruction process have recently changed, it may be useful to fabricate a set of returns and then pass these data on to the reconstruction team to see if they can reconstruct the simulated dataset. This approach would help assess the reliability of the new approach.

9) Continue to discuss and evaluate the re-introduction of fall Chinook into historical habitats. The original decline of Snake River fall Chinook was caused by a variety of anthropogenic impacts, including the creation of dams on the Snake River that prevented fish from reaching ancestral spawning grounds. By the mid-1970’s approximately 85% of the historical spawning and rearing areas used by fall Chinook were no longer available. At the Fall Chinook Symposium, it was suggested that efforts should be made to extend the existing range of Snake River fall Chinook into areas that are currently inaccessible, including prime spawning and rearing areas above Hells Canyon Dam (Carmichael 2013).

10) Additional recommendations are presented in the remaining portions of this review.

II. ISRP Review Charge

The ISRP was created by the 1996 amendment to the 1980 Northwest Power Act and directed to review projects proposed for funding by the Bonneville Power Administration (BPA) to implement the Northwest Power and Conservation Council's (Council) Fish and Wildlife Program. In 1998, the Senate-House Conference Report for the fiscal year 1999 Energy and Water Development Appropriations bill expanded the ISRP responsibilities to include review of projects in federal agency budgets that are reimbursed by BPA. The LSRCP is a BPA-funded, reimbursable program. The ISRP reviews proposals using four standard criteria: that the project is based on sound science principles; benefits fish and wildlife; has clearly defined objectives and outcomes; and has provisions for monitoring and evaluation of results.

This ISRP report is the final part of a periodic review of the LSRCP. Specifically, the Council, BPA, ISRP, and the U.S. Fish and Wildlife Service (USFWS) agreed that ISRP review of LSRCP projects be incorporated in a multi-year rolling programmatic review organized by species. The ISRP's first review was of the LSRCP Spring Chinook Program in 2010 and 2011 (ISRP 2011-14). The second review covered the Steelhead Program in 2012 and 2013 (ISRP 2013-3). In 2002, before this new three part review process, the ISRP reviewed 26 individual LSRCP proposals as part of the Columbia Plateau, Blue Mountain, and Mountain Columbia provincial reviews (ISRP 2002-6).

In addition to individual project proposal reviews, the 1996 amendment directs the ISRP to conduct a review of project results. The Council's 2009 Fish and Wildlife Program instructs the ISRP to focus retrospective reviews on the measurable benefits to fish and wildlife made through projects funded by BPA and previously reviewed by the ISRP. The current ISRP review is an evaluation of the managers' self-assessment of the LSRCP fall Chinook program performance against the LSRCP goals and Fish and Wildlife Program artificial production principles.

For the LSRCP reviews, the USFWS was especially interested in obtaining ISRP feedback on potential LSRCP program gaps, the appropriateness of underlying scientific assumptions guiding program activities, and the quality of the data collected and analyzed at the program and project levels. The ISRP believes that these are important topics to cover in the fall Chinook program review.

III. Columbia River Basin Hatchery Program Assessment

Since 1998, Congress has directed multiple reviews of salmon hatchery production programs through the Fish and Wildlife Program (NWPCC 1999-4, 1999-15, 2004-17, 2005-11) and Hatchery Scientific Review Group (HSRG 2004, 2009, 2011) that established a scientific framework for implementing and evaluating hatchery programs. ISRP and Independent Scientific Advisory Board (ISAB) reviews also have provided guidance on specific monitoring and evaluation metrics and analyses consistent with this scientific framework (ISAB 2000-4, ISAB 2003-3, ISRP/ISAB 2005-15, ISRP 2008-7).

Assessing hatchery programs requires information and performance measures for fish culture practices in three subject areas: 1) inside the hatchery, 2) hatchery-produced fish after release, and 3) effects of hatchery-produced fish on wild stocks and other hatchery fish outside the hatchery (ISAB 2000-4). Information and assessment in these three areas is required to establish benchmarks for survival in the hatchery environment; understand how practices in the hatchery influence post-release survival and performance; establish post-release survival benchmarks for harvest management; and establish quantitative estimates for benefits and risks to natural populations.

In this report, the ISRP is evaluating the following questions, which are consistent with the ISAB hatchery monitoring guidelines and the Council's criteria for reviewing artificial production (NWPCC 1995-15):

1. How are the project fish performing in the hatchery?

- Are there unambiguous performance indicators and quantitative objectives for those indicators?
- Are performance indicators for fish in the hatchery environment adequately measured, reported, and analyzed?
- Are programs able to achieve the goals as planned?
- Is fish culture performance within standards expected for salmonids?

2. How are hatchery juveniles performing once released?

- Are there unambiguous performance indicators and quantitative objectives for those indicators?
- Are performance indicators for fish after release from the hatchery environment adequately measured, reported, and analyzed?
- Are they able to achieve the goals of the projects as planned?

3. What are the demographic, ecological, and genetic impacts of the programs on wild fish?

- Are there unambiguous performance indicators and quantitative objectives for those indictors for natural and hatchery fish?
- Is performance for ecological and genetic impacts adequately measured, reported, and analyzed?
- Are they adequately evaluating supplementation (for example using the Ad Hoc Supplementation Work Groups'[1] recommendations)?

4. How are programs being modified when problems are encountered in meeting objectives?

IV. Lower Snake River Compensation Plan Fall Chinook Program Background

The Lower Snake River Compensation Plan (LSRCP) hatchery program for anadromous fish was authorized in 1976 as part of the Water Resources Development Act of 1976 (90 Stat. 2917). A major component of the plan was to replace lost adult salmon and steelhead resulting from the construction and operation of four hydroelectric dams on the Lower Snake River in Washington. The LSRCP fall Chinook program is highly integrated with other programs and mandates. The fall Chinook program's background is well described in summary documents prepared for the fall Chinook program review: Lower Snake River Compensation Plan 2013 Snake River Fall Chinook Salmon Program Review Summary and Future Direction, LSRCP Hatchery Mitigation, and Synergy and Hatchery Program Overview. Excerpts from these summaries are provided below.[2] See the summaries for full details and graphics.

Collaborators. Snake River fall Chinook salmon hatchery program implementation and evaluation has been an integrated and collaborative effort by the Washington Department of Fish and Wildlife, Nez Perce Tribe, Idaho Power Company, U.S. Fish and Wildlife Service, Confederated Tribes of the Umatilla Indian Reservation, U.S. Geological

---

[1] AHSWG: Ad Hoc Supplementation Work Group, Galbreath 2008.
[2] Most of the information in this background section is excerpted directly from the three summary documents or is slightly edited. Quotations are not used for ease of reading.

Survey, University of Idaho, NOAA Fisheries, Idaho Department of Fish and Game, Columbia River Inter-tribal Fish Commission, U.S. Army Corps of Engineers, and Oregon Department of Fish and Wildlife. Funding support has been provided by the U.S. Fish and Wildlife Service's LSRCP, Bonneville Power Administration, Idaho Power Company, U.S. Army Corps of Engineers, U.S. Bureau of Land Management, and Pacific Salmon Commission.

Mandates and agreements. Multiple legal mandates and agreements influence the implementation of the Snake River Fall Chinook Salmon hatchery programs.

- 1855 Treaties between the U.S. government and the Nez Perce, Umatilla, Yakama and Warm Springs Tribes
- Lower Snake River Compensation Plan – Public Law 94-587, 99-662, 103-316
- Idaho Power Company (IPC)Hells Canyon Settlement Agreement (Federal Energy Regulatory Commission)
- Nez Perce Tribal Hatchery Agreement
- Pacific Northwest Electric Power Planning and Conservation Act 16 U.S.C. § 839-839h
- U.S. vs. Oregon 2008-2017 Management Agreement
- Columbia Basin Treaty Tribes Accords
- Federal Columbia River Power System (FCRPS) Biological Opinion
- ESA/Hatchery Genetic Management Plan
- Pacific Salmon Treaty (Pacific Salmon Commission – PSC)
- Magnuson Act (Pacific Fishery Management Council – PFMC)

LSRCP Goals. The fall Chinook program mitigation goals are 18,300 fish returning to the Snake River, plus 18,300 fish for sport harvest and 54,900 fish for commercial harvest below the Snake River project area, totaling 91,500 adult and jack salmon. This equates to a 4:1 downriver harvest to escapement ratio. The LSRCP goals focus on both hatchery and natural origin fall Chinook salmon. In contrast, the escapement goal for natural origin fall Chinook salmon returning to the Snake River Basin is 14,360 fish and the Interior Columbia Technical Recovery Team minimum viability threshold is 3,000 natural origin fall Chinook salmon returning to the Snake River Basin (Hesse 2013).

Historical and present abundance. Historical abundance of natural origin fall Chinook in the Snake River has been estimated as high as 500,000 fish for the pre-1940s time period and as low as 78 fish in 1990. Contemporary returns of hatchery and natural origin fish have increased significantly to about 70,000 in 2013. The four hatchery programs target a return of 24,750 hatchery-origin fish back to the Snake River basin. This goal has been exceeded for the past four years (2009-2012).

Harvest. From 2005 to 2012, approximately 40% of the adults and jacks produced from the LSRCP fall Chinook program were harvested. Almost all (> 99%) the fish were caught below the Snake River. Fall Chinook (including Snake River fish) provide very important fisheries for the Treaty Tribes in the Columbia River in Zone 6 (Bonneville Dam to McNary Dam) and to non-treaty fishers below Bonneville Dam. Fall Chinook produced by the program were also harvested in Puget Sound and along the coasts of Canada and Southeast Alaska.

Production. Hatchery objectives and production targets have changed over time. Originally the program was an egg-bank mitigation effort overseen by a single agency. As new hatchery facilities came on line, the project evolved into a multi-agency mitigation and supplementation endeavor (Table 1). Three programs contribute fish to the Snake River hatchery production goal. The Nez Perce Tribal hatchery (NPTH) contributes 23.8%, the Idaho Power Company (IPC) program accounts for 18.2%, while the LSRCP is responsible for 58% of the fish. The hatchery program is complex, with adult broodstock being collected at multiple locations, spawning occurring at two facilities, and eggs and fry being transferred to different hatcheries and acclimation sites for rearing. Fish are released at 12 locations. Some are released from hatcheries, others are transferred to acclimation sites, reared and then released (acclimated releases) or transported and released directly (direct releases) into the environment. At hatcheries and acclimation sites, fish may be allowed to volitionally exit their rearing environments (volitional release) or they can be forced to leave all at once (forced release). Since 1985 (28 years), project targets for numbers of fish released have only been met four times, three of those years occurred in the last four years. The most recent 5-year average release number is 5,772,708.

Approximately 5.5 million juvenile fall Chinook are released annually by the project. Contributing to this total are 1.0 million sub-yearlings produced by the Idaho Power Company to mitigate for the effects of its three Hells Canyon dams. The effects of the four lower Snake River dams are mitigated by releases of 2.2 million sub-yearlings and 900,000 yearlings from the Lyons Ferry Hatchery (LFH) along with 1.4 million sub-yearlings from the Nez Perce Hatchery. The hatchery facilities are operated in a highly integrated and coordinated manner.

Table 1. Past and present Snake River fall Chinook hatchery operations. Source: Hesse (2014).

Category	Past Condition	Current Situation
Hatchery Facilities	Lyons Ferry	Lyons Ferry Fall Chinook Acclimation Project Nez Perce Tribal Irrigon/Oxbow/Umatilla
Purpose	Egg Bank/Mitigation	Supplementation & mitigation
Release Location	Downstream of Lower Granite Dam (program limited by broodstock availability)	Upstream and Downstream of Lower Granite Dam
Broodstock	Mostly Hatchery Origin (limited by high number of strays)	Hatchery & Natural Origin Adults (up to 30% natural origin)

2013 Fall Chinook Workshop. Over two days in August 2013, the LSRCP and cooperators including Federal and State agencies, Tribal governments, and Idaho Power presented the successes and challenges faced in implementing the LSRCP's fall Chinook program as part of the larger Snake River fall Chinook effort. Five ISRP reviewers participated in the workshop.

V. ISRP Findings, Conclusions, and Recommendations

Report Card: Summary of Progress toward Meeting Goals

The Report card was filled out by ISRP members using data contained in project annual reports, HGMPs for the Lyons Ferry and Nez Perce Tribal Hatcheries, and information presented at the Fall Chinook Symposium held in August 2013 at Clarkston, WA.

Metric	Hatchery Program				
	Lyons Ferry	**FCAP[a]**	**IPC**	**Irrigon LSRCP**	**Nez Perce (NPTH)**
Within-Hatchery Performance					
Broodstock Collection Goals	1400 Females	[b]			526 Females
Years Achieved	2/10[c]				1/8
Pre-spawning Mortality Goal	No[d]				10%
Years Achieved					6/7
Egg Collection Goal	4.4M		1.3 M		1.98 M
Years Achieved	6/18		6/13		4/10
Egg to Smolt Goal	80%		No	No	70%
Years Achieved	16/20				6/8
Smolt Release Goal (0+)	400 k	1.4 M	1.0 M	400 k	1.4 M
Years Achieved	10/10	10/10	4/9	5/10	4/9
Smolt Release Goal (1+)	450 k	450 k			
Years Achieved	10/10	9/10			
Post-Release Performance					
Survival to Lower Granite Dam Goal	No	No	No	No	No
Smolt-to-Adult Survival Goal	No	No	No	No	No
Lower Col and Ocean Harvest Goal (Commercial)	54,900				
Years Achieved	0/8				
Recreational Harvest Goals	18,300				
Years Achieved	0/8				
Smolt-to-Adult Recruit Goal	No	No	No	No	No
Snake River Adult Abundance Goal	18,300				
Years Achieved	5/28				

Metric	Hatchery Program: Lyons Ferry	FCAP	IPC	Irrigon LSRCP	Nez Perce (NPTH)
Post-Release Performance (continued)					
Lower Monumental Dam Adult Abundance Goal	9,988		2,290	Included in LFH	3,750
Years Achieved	4/8	4/8	4/8	4/8	4/8
Natural Spawning Escapement Goals	No	No	No	No	No
Interaction Performance					
Age Structure	Yes				Yes
Documentation of Run Timing	Yes				Yes
Natural Origin Recruit Abundance	Yes				Yes
Natural Origin Recruit Productivity	No	No	No	No	No
Before After Control Impact Assessments	No	No	No	No	No
Other Supplementation Effectiveness Evaluation	Yes[e]	Yes	Yes	Yes	Yes
Relative Reproductive Success Assessment	No	No	No	No	No
Other Genetic Assessment	Yes	Yes	Yes	Yes	Yes

[a] FCAP or Fall Chinook Acclimation Project is managed by the Nez Perce Tribe. Sub-yearling and yearling Chinook obtained from the Lyons Ferry Hatchery are transported and reared at three acclimation sites.
[b] Shaded blocks indicate that the metric is not applicable for a hatchery program. For example, no broodstock are collected at the FCAP, IPC, or Irrigon hatcheries.
[c] The number of years the goal was met is placed over the years examined.
[d] "No" means that no standards have been established for this performance criterion
[e] A new joint study between the Washington Department of Fish and Wildlife and Nez Perce Tribe [Snake River Fall Chinook Monitoring and Evaluation (#2012-013-00)] will examine homing fidelity of hatchery fall Chinook.

1. How are the project fish performing in the hatchery?

Are there unambiguous performance indicators and quantitative objectives for those indicators?

Hatchery performance data for salmonids can be evaluated in three life cycle periods: adult, egg-to-fry, and fry-to-smolt or fry-to-release. Standard metrics for the adult period include number of broodstock collected, pre-spawning survival, proportions of the broodstock consisting of natural and hatchery origin adults, and demographic traits such as fecundity, egg size, age, weight, length, and pathogen profiles. Information on eggs typically consists of the total number of eggs collected, green egg-to-eyed egg and eyed egg-to-fry survival rates. Sometimes information on fry weight, length, developmental condition at yolk absorption and the occurrence of abnormalities are also obtained. During the rearing period, data on growth, rearing densities, health, and survival are usually collected. When fish are released, other data are also often recorded, including mean weight and length; numbers released per location; rearing history (e.g. transfers to out-of-basin rearing locations during potential imprinting periods); dates; type of release (e.g., volitional, forced from acclimation ponds or direct from trucks); and health status.

A number of hatchery programs are being used to recover and supplement Snake River fall Chinook. Briefly, broodstock are held and spawned at Lyons Ferry (LFH) and Nez Perce Tribal hatcheries (NPTH). At LFH, some of the eggs obtained are incubated to the eyed stage and then transferred to Oxbow, Umatilla, and Irrigon hatcheries where they are reared, transported, and directly released as sub-yearlings into the Snake River. Sub-yearlings and yearlings are produced from the eggs that are retained at LFH. A portion of both types of juveniles are distributed to three acclimation sites, two in the Snake River and one in the Clearwater River. Fish at acclimation sites are reared for an additional three to six weeks prior to release. Yearlings and sub-yearlings that remained at LFH are released from the hatchery into the lower Snake River. All the eggs collected at the NPTH are retained and fry are reared for several months before some are trucked to three acclimation sites for additional rearing before being released into the Clearwater River basin. Juveniles kept at the hatchery are reared for several additional months before they are released from the hatchery into the Clearwater River.

Performance standards for various aspects of the Snake River fall Chinook hatchery program have been created. LFH and NPTH have established goals for the number of females needed to meet egg-take targets and aim to achieve a pNOB (percent natural origin brood) of 30% in their broodstocks. NPTH has also set a criterion for no more than

10% pre-spawning mortality. Additionally, data from health screenings performed on maternal parents are used to cull eggs from fish when bacterial kidney disease (BKD) ELISA[3] values exceed 0.250. Eggs from out-of-basin adults also are culled if they exceed 5% of the eggs obtained at a hatchery. Target rearing densities for hatchery ponds and acclimation sites are also in place. Objectives have been established for the number of fish that should be freed from each hatchery's acclimation sites and direct release locations. Separate, green egg-to-sub-yearling survival objectives, 80% for LFH and 71% for NPTH, are in place along with goals for the size of sub-yearlings and yearlings at release.

The above criteria are important, but additional standards should be established for the LFH and NPTH hatcheries and their satellite facilities. For example, no pre-spawning mortality objective is in place for LFH. Survival goals for green egg-to-eyed egg, eyed egg-to-fry, and fry-to-sub-yearling have been not been created even though data on these values are routinely collected. A green egg-to-yearling survival standard for LFH is also lacking. Objectives for eyed egg-to-smolt survival for Oxbow, Irrigon, and Umatilla hatcheries are absent. Similarly, survival goals for sub-yearlings and yearlings at the program's acclimation sites are missing.

Ascertaining discrepancies between expected performance and observed project values provide managers with knowledge that can be used in two ways. If observed values are lower than accepted standards, specific problem areas can be identified, making it possible to improve existing conditions. Conversely, if detected performance exceeds a standard, it may provide an opportunity to export successful methods to other parts of the program.

> *Are performance indicators for fish in the hatchery environment adequately measured, reported, and analyzed?*

As mentioned above, the proponents have not established performance metrics for many of the lifecycle stanzas that occur in artificial culture. The ISRP requests that missing standards be created in the future. The HGMPs for LFH and NPTH, annual

---

[3] ELISA or enzyme-linked immunosorbent assays use antibodies and color changes to detect the presence of antigens. Kidney tissue samples from hatchery broodstock are commonly analyzed by ELISA to detect *Renibacterium salmoninarum*, the bacteria that causes bacterial kidney disease.

reports for these hatchery programs, and data presented at the Fall Chinook Symposium indicated that adequate information was being collected to evaluate an array of within-hatchery metrics. However, these data are not in a single location and easily accessible. If not already completed, the ISRP recommends that records of within-hatchery performance for LFH and NPTH, and their associated satellite facilities, be assembled into multi-year databases and made available to all the fall Chinook partners. This repository of information would be further enriched if details about the methods and analytical approaches employed to produce reported metrics were attached and briefly explained.

Are programs able to achieve the goals as planned?

Both the LFH and NPTH have undergone operational and infrastructural changes designed to improve the quality and survival of the fall Chinook juveniles they rear. Bird predation at LFH was a significant problem but is now controlled by placing wires over rearing ponds and by using hazing methods. Outbreaks of BKD and bacterial gill disease (BGD) were common at LFH. BKD episodes became less frequent after adult females used as broodstock were injected with oxytetracycline and erythromycin and rearing densities were reduced to 0.08 to 0.14 lbs/ft^3/inch.[4] In a further effort to suppress BKD, yearlings are fed medicated feed for 28 days before being released. BGD at LFH was contained by altering the configuration, flows, and rearing densities in rearing ponds. Challenges also occurred at LFH acclimation sites. All of these sites rear fish with pumped river water. Because of their close proximity to hydropower dams they are subjected to large changes in river stage and flow. Both can impact the efficiency of water intakes and water quality. Power outages and pump failures at the sites commonly occurred, but backup systems, coupled with experienced and dedicated staff, have kept the acclimation sites operational.

The fall Chinook program at NPTH has also evolved to overcome fish culture difficulties. Power surges and outages during the 2002 and 2003 incubation-season created water temperature spikes which induced high incidences of coagulated yolk disease. Changes in the hatchery's infrastructure have prevented further incidences of this

[4] This measure of rearing density was developed by Piper (1972) who used English units. It is calculated by dividing the total pounds of fish in a rearing vessel by the volume of the rearing vessel in cubic feet times the length of the fish in inches.

environmentally induced problem. A flash flood in 2005 blocked the water intake structure of the hatchery and forced the early release of 869,000 sub-yearling fall Chinook. The intake structure was subsequently modified to avoid future blockages. Pump failures, electrical outages, warm water temperatures and low dissolved oxygen levels have occurred at the NPTH acclimation sites. At one acclimation site, an earlier release date was created to protect reared fish from experiencing low dissolved oxygen levels and high water temperatures. Additionally, backup pumps, electrical systems, and supplemental oxygen capabilities are now in place at an off-station rearing location and two additional acclimation sites located in the upper Clearwater River.

The managers and staff that operate the LFH and NPTH facilities have demonstrated that they are capable of responding successfully to unexpected challenges. That competency, along with the aforementioned operational and infrastructure improvements and the increased availability of adults that can be used as broodstock, have allowed green-egg-to-smolt survival and release number goals to be accomplished by both the LFH and NPTH programs over the past five years.

Is fish culture performance within standards expected for salmonids?

Collecting and maintaining broodstock is often challenging. Adults may be held for a month or longer at LFH and NPTH before reaching maturation. In well-run hatchery programs mortality rates of 10 to 15% for adults, held for this length of time, are expected. Survival of broodstock at NPTH is often greater than 90% and survival of adult females at the hatchery has ranged from 91 to 99% from 2003 to 2010. Procedures are being implemented at LFH and NPTH to decrease pre-spawning mortalities to accepted standards. Moreover, both LFH and NPTH programs have consistently met their green-egg-to-smolt release goals. Eyed eggs transferred from LFH to Irrigon, Oxbow, and Umatilla hatcheries have also experienced high egg-to-fry (~97%) and fry-to-release (~94%) survival rates. Rearing densities at all the facilities are at the low end of conventional rates, which has helped control episodes of BGD and BKD. Survival rates of yearlings and sub-yearlings placed into acclimation sites are excellent. For example, yearlings placed into LFH sites have averaged 98% for yearlings and 99% for sub-yearlings. Survival rates of sub-yearlings at NPTH acclimation sites are comparable, averaging about 99%. Size-at-release targets have been consistently met for yearlings (10 fish per pound; fpp) and generally attained for sub-yearlings (50 fpp).

Broodstock scarcity has prevented the project from meeting its smolt release objectives. Recent increases in adult abundance, however, have allowed components of the LFH program to meet juvenile release objectives. For instance, numbers of fish released at

LFH acclimation sites have met program aspirations since 2006, targets for the Idaho Power Company program have been realized since 2008, and releases at LFH have met expectations since 2003. Similarly, release goals for NPTH locations have been fulfilled since 2009.

All of the above indicate that the hatchery programs are performing at or above recognized standards.

2. How are hatchery juveniles performing once released?

> *Are there unambiguous performance indicators and quantitative objectives for those indicators?*

Performance indicators for post-release hatchery fish fall into three categories: smolt performance, adult performance, and fishery benefits. No goals have been established for smolt performance. Yet, data on the survival of hatchery smolts to Lower Granite Dam (LGD) and to dams in the lower Columbia are collected annually. Yearly information is also obtained on the migration rates (Rkm/day) of juvenile hatchery fish as well as their arrival timing to LGD.

Adult metrics should include total adults produced per broodyear, return timing to LGD and hatchery racks, age and size at maturity, escapement to LGD (i.e., Smolt-to-Adult Recruits or SAR), smolt-to-adult survival to the mouth of the Columbia River (SAS), recruits per spawner (R/S), escapement to spawning grounds and straying rates. Data on some of these attributes are routinely collected, and a mitigation goal of annually returning 18,300 adults, to the Snake River, is in place. No performance standards have been created for any of the other possible adult metrics.

Fishery benefits can be appraised by estimating the number of project fish caught by commercial and recreational gear below and above LGD. Presently the Snake River fall Chinook program has three post-release performance standards, two linked to harvest and one to adult abundance in the Snake River. A number of other standards would be worthwhile, including standards for straying rates and adult escapement to spawning areas. In the meantime, the ISRP encourages project managers to continue to monitor and collect basic fishery statistics, such as abundance and harvest by origin (hatchery or natural), age composition by sex, length at age, fecundity by age, and spawning escapement.

Are performance indicators for fish after release from the hatchery environment adequately measured, reported, and analyzed?

The ISRP suggests that more analyses could be conducted with the survival, migration rate, and arrival timing data collected on smolts as they migrate from their release locations to LGD. Annual project reports show that river flows and water temperature data have been assembled each year releases have been made. Some analyses using these data have explored correlations between migration speed, river flow, and temperature. In another case, arrival dates at LGD coupled with estimates of migration speed were used to compare how long fish released from acclimation sites and those directly released from trucks resided in the Clearwater River before reaching LGD. More of these analyses should be conducted. In addition, the effects of flow, temperature, size-at-release, and turbidity on survival to LGD should be examined. Results from the above analyses may help managers refine when project fish should be released to maximize survival and minimize possible interactions with natural origin fall Chinook juveniles.

The number of fish harvested in the ocean and lower Columbia River can only be imprecisely estimated at present because only a portion of the hatchery fish receive CWTs and are adipose clipped (ad). Other fish receive CWTs but are not adipose clipped and some project fish (~24%) receive no marks or tags. Project managers are updating harvest numbers by using capture rates on ad-clipped/CWT fish to estimate how many unclipped CWT fish might have been caught in Alaska and British Columbia. Greater precision in estimates of harvest could be achieved if the percentage of hatchery-reared fish with both adipose clips and CWTs were increased. Managers are now considering this option. Parent Based Tagging (PBT) may help improve and refine harvest rate estimates in the future.

Straying rates of hatchery fish have been assessed. Over the past eight years, less than 0.4% of the adults produced from the project were recovered in out-of-basin locations. Thus project fish appear to have a high fidelity to the Snake River and it is assumed that strays produced by the project have not significantly impacted other populations of fall Chinook. SAS and SAR values were also estimated. These survival estimates were highly variable from year to year; however, annual variations were typically consistent among fish releases suggesting that shared environmental conditions in the ocean and river affected all project fish similarly. Exploitation rates estimated from LFH fish have averaged 44% in the ocean and lower Columbia River. Very few (0.3%) have been caught in the Snake River basin because commercial and recreational fisheries in this area have not yet been established.

Are they able to achieve the goals of the projects as planned?

The project has achieved its adult abundance goal of 18,300 fish returning to the Snake River basin from 2009 to present. Furthermore, survival of project fish has exceeded the 0.2% SAR goal that was put forth in the LSRCP agreement. Ocean and lower Columbia River harvest goals, however, have not been reached. Harvest rates have been constrained for conservation purposes, and this has resulted in escapements of hatchery fish into the Snake River Basin that may be exceeding the capacity of the habitat to support spawners and/or their progeny, as shown by the return per spawner metric that is typically below replacement (1.0). Consequently, the number of fish being released (900,000 yearlings and 4.6 million sub-yearlings), and the harvest and adult return goals of the fall Chinook hatchery program may need to be re-evaluated. Nonetheless, the project has made significant contributions to fisheries and is now providing adult fall Chinook to the Snake River basin. The abundance of Snake River Chinook in recent years has reduced the need to restrict downstream in-river harvests on more abundant fall Chinook stocks.

3. What are the demographic, ecological, and genetic impacts of the programs on wild fish?

Are there unambiguous performance indicators and quantitative objectives for those indictors for natural and hatchery fish?

Interactions between hatchery and natural origin Snake River fall Chinook can have ecological and demographic effects at the juvenile life stage and may also have genetic consequences at the adult stage. Formal performance indicators should be developed to quantify these possible effects. Project managers have thought about such interactions and have performed some work in an effort to estimate possible effects. A recent study (Rosenberger et al. 2013) examined the temporal and spatial overlap of natural origin and recently released hatchery juveniles in the reservoirs created by Lower Granite, Little Goose, and Lower Monumental Dams. How hatchery fish were released was found to influence their residency in the reservoir. Those that were directly released into the Clearwater River took longer to reach LGD than individuals released from acclimation sites. Juveniles directly released were therefore more likely to interact with naturally produced fish. It was hypothesized that large numbers of migrating hatchery fish could cause premature migration of natural fish via the “pied piper” phenomenon. Competition for feeding stations, direct competition for food and transfer of pathogens were also recognized as potential effects. Hatchery releases may also prime predators and coincidentally increase predation rates on natural origin fish. Field studies need to be performed to ascertain the likelihood and potential impact of these, and other possible interactions, between hatchery and natural origin juvenile fall Chinook.

Commercial and recreational harvests focused on hatchery fish can depress the abundance of natural origin adults because hatchery populations can tolerate a higher harvest rate than natural populations. Also the presence of hatchery fish on spawning grounds can lead to competition for spawning sites among females and for mates among males. High instantaneous spawning densities are known to increase egg retention rates in females. Moreover, if females arrive on spawning grounds over several weeks, redd superimposition is likely to occur. Recent redd surveys in the Snake River Basin have shown that superimposition does increase with adult abundance. The impact of multiple females using the same spawning areas on juvenile production should be evaluated. Relative reproductive studies should also be instituted to see if the inclusion of spawning hatchery adults reduces the productivity of natural origin spawning aggregations. Habitat-based escapement goals should be developed for naturally spawning fall Chinook.

The possible effects of interactions between project fish and other fish species in the Snake River basin were considered at length in the HGMPs for LFH (WDFW et al. 2011) and NPTH (NPT 2011) as well as in the BiOp (NOAA 2012) developed for the two projects. The likelihood of deleterious impacts due to interactions between hatchery juveniles and ESA-listed juvenile steelhead, spring Chinook, and sockeye were considered to be low. It was hypothesized that the only time hatchery fish would encounter these species would be as emigrating smolts. At that time, all the fish would have similar body sizes, which would presumably limit possible predatory interactions. Hatchery broodstock collection could, however, impact adult steelhead since some of them migrate into the Snake River with maturing fall Chinook; however, care is taken to limit stress when handling steelhead incidentally caught at LGD.

> *Is performance for ecological and genetic impacts adequately measured, reported, and analyzed?*

Some studies are addressing this issue, but more needs to be done. Clearly, quantifying the effects of hatchery fish on natural populations is difficult. A recent genetic study indicates little or no genetic differentiation between hatchery and natural origin fall

Chinook, apparently because the proportion of natural spawners consisting of hatchery fish is very high. Although the hatchery program has a broodstock goal of 30% natural origin fish (pNOB) as a means to reduce domestication and other hatchery-related effects, the observed pNOB is much lower and the goal has not been achieved. If the LSRCP has not already decided on a framework for accomplishing this goal, the ISRP suggests that the protocols established by Todd Pearsons and colleagues might provide a good starting point (Pearsons et al. 1998; Pearsons and Hopley 1999; Ham and Pearsons 2001; Pearsons et al. 2002).

Are they adequately evaluating supplementation (for example using the Ad Hoc Supplementation Work Groups' recommendations[5])?

Proportions of adult hatchery and natural origin Chinook salmon are estimated at Lower Granite Dam by run reconstruction techniques, but these estimates are uncertain due to the high proportion of unmarked/untagged hatchery salmon. However, no estimates of the proportion of hatchery fish on spawning grounds are apparently made. Proportion of hatchery fish in the return is estimated at Lower Granite Dam using the run reconstruction methodology. If stock composition estimates cannot be made on the spawning grounds, then run reconstruction data should be used to estimate spawning escapement and composition (hatchery/natural origin, % females) after removing fish returning to the hatcheries. A brood table for natural spawners should be maintained and updated each year. Stock-recruitment relationships have been developed for the natural population. These analyses should also evaluate the appropriateness of the current escapement goal of 14,360 natural origin fish to see if it is too large given the low productivity (R/S) observed in recent large returns.

4. How are programs being modified when problems are encountered in meeting objectives?

Operations and procedures at the LFH, NPTH, at acclimation sites, as well at the Oxbow, Umatilla and Irrigon Hatcheries have evolved over time. Many of these changes were responses to events that could have caused significant mortalities, such as power outages, pump failures, clogged water intakes, disease outbreaks, and bird predation.

[5] AHSWG: Ad Hoc Supplementation Work Group, Galbreath 2008.

Others were prompted by project reviews conducted by the Hatchery Scientific Review Group (HSRG) and the USFWS's Hatchery Review Team (HRT), both of which proposed a number of operational changes to improve the hatchery programs. All proposed changes were given careful consideration, and some were implemented. When the HGMPs for both hatcheries were being developed, NOAA requested in a pre-consultation that research, monitoring, and evaluation (RM&E) measures be developed to address some of the project's outstanding information needs. An addendum to the HGMPs was produced that contained a number of RM&E efforts which were later prioritized (NOAA 2012). The eight highest priorities were to: 1) use parentage-based tagging to identify project fish, 2) continue to refine run-reconstruction methods, 3) study fall back behavior at LGD, 4) determine release-site fidelity of hatchery fish, 5) ascertain spawning, rearing, and over-wintering locations for natural origin fall Chinook, 6) develop juvenile life-cycle models, 7) identify the genetic structure of putative sub-populations of Snake River fall Chinook, and 8) hold a symposium in 2016 to share the results of completed studies. Some of this work has already taken place or is ongoing and will be used to modify the hatchery programs in the future.

VI. Summary of Results and Comments on Program Components

1. History of the Fall Chinook Production Program

Over the past hundred years the abundance of natural origin Snake River fall Chinook has declined significantly, largely due to anthropogenic factors. Exploitation rates for Columbia River Chinook in the early to middle Twentieth Century were as high as 80% and Snake River fall Chinook were undoubtedly affected. Spawning and rearing areas were degraded by sedimentation, increases in water temperature, and habitat modification primarily due to farming, grazing, and logging. Water withdrawals, for irrigated agriculture and river alterations, caused by gold dredging operations, also impacted fall Chinook habitat. Additionally, the construction of Swan Falls Dam (1901) on the mainstem Snake River and Lewiston Dam (1927) on the Clearwater River, blocked fall Chinook from gaining access to core spawning and rearing areas. Completion of the lower four dams on the Snake River and three additional upstream dams, in the Hells Canyon section of the Snake, further restricted access to traditional spawning areas. By 1975, 85% of the rearing and spawning areas, historically used by Snake River fall Chinook, were no longer accessible. The constriction and degradation of habitat, high exploitation rates, and poor ocean conditions reduced annual returns of Snake River fall

Chinook abundance to less than a thousand adult fish in the early 1990s. This decline led to their being listed in 1992 as a threatened species under the Endangered Species Act (Schuck 2014).

Four interconnected hatchery programs are currently releasing fall Chinook salmon into the Snake River Basin. The first to be implemented was the Lower Snake River Compensation Plan (LSRCP) which was started in 1975. Initially, the LSRCP was an egg banking effort. Adult fall Chinook were collected at Ice Harbor Dam and their eggs and subsequent progeny were reared in several locations before being released back into the Snake River. In 1984, the Lyons Ferry Hatchery was established on the lower Snake River. It became the spawning, incubation, rearing, and release location for LSRCP fall Chinook. At the inception of the LSRCP program, there was a conscious effort to maintain the genetic integrity of the Snake River Fall Chinook population. The occurrence of strays in the broodstock was monitored and found to be increasing over time, eventually reaching 43% in 1989. None of the adults originating from that brood year were used as broodstock because of the high incidence of out-of-basin fish. Several additional actions were taken to reduce the incorporation of strays into the program. From 1990 through 2002, for example, only adults from the Lyons Ferry hatchery were used as broodstock. Additionally, in 1990 two new adult collection sites were used; one at the Lyons Ferry Hatchery and another at Lower Granite Dam. Also, starting in 1993, Ice Harbor Dam was no longer used as a collection site because out-of-basin fish were often captured at this location. Finally, a series of measures were taken in 2003 and 2004 to broaden the genetic composition of the fish being used for broodstock. One of these was to establish a sub-sampling procedure at Lower Granite Dam (LGD) that allowed Lyons Ferry Hatchery fish, as well as unmarked or untagged females from the entire run, to be collected and used as broodstock.

Initially, the main objective of the LSRCP fall Chinook program was to mitigate for the lost production of fish caused by the construction and operation of the four lower Snake River dams. The addition of the Fall Chinook Acclimation Program (FCAP) in 1996 broadened the scope of the hatchery effort. The FCAP program, operated by the Nez Perce Tribe, calls for 1.4 million fall Chinook juveniles produced by the Lyons Ferry Hatchery to be transferred and released at three acclimation sites in the Snake River basin. Two sites are located on the mainstem of the Snake River while the third is situated on the lower Clearwater River. The primary goals of the FCAP program are to supplement natural production and provide additional harvest opportunities. A third hatchery program was implemented by the Idaho Power Company (IPC) to mitigate for the impacts of its three Hells Canyon Dams on Snake River fall Chinook. The 1980 mitigation agreement called for the release of one million sub-yearling fall Chinook below Hells Canyon Dam. A lack of available eggs from the Lyons Ferry Hatchery prevented the program from starting until 2000. Currently, the Idaho Department of Fish and Game receives approximately two hundred thousand eyed eggs from Lyons Ferry and rears them to the sub-yearling stage at IPC's Oxbow Hatchery. Another eight hundred thousand eyed eggs are shipped to ODFW's Umatilla Hatchery where they are reared to the sub-yearling stage for the IPC. Usually both groups are directly released below the Hells Canyon Dam. On several occasions, however, some of program's sub-yearlings have been acclimated and released from Pittsburg Landing, a FCAP acclimation site located several miles downstream of the dam.

The fourth hatchery program began in 2002 when the Nez Perce Tribal Hatchery (NPTH) located on the Clearwater River was completed. Adults captured at LGD and the Nez Perce Hatchery are used as broodstock. Sub-yearling fall Chinook, produced by the facility, are released at the hatchery and also transferred to acclimation sites located on the lower Clearwater, South Fork Clearwater, and Selway rivers. These releases are made to supplement natural fall Chinook production as well as increase harvest opportunities. A final component of the Snake River fall Chinook hatchery program began in 2005 when, for logistical reasons, WDFW began shipping eyed eggs from Lyons Ferry to ODFW's Irrigon Hatchery. At Irrigon, the fish are reared to the sub-yearling stage, then transported and directly released into the Grande Ronde River to supplement fall Chinook in this portion of the Snake River basin.

When combined, the hatchery programs are scheduled to make annual releases of 900,000 yearlings and 4.6 million sub-yearlings. Yearlings are released from the Lyons Ferry hatchery and from three acclimation sites. Two of these locations, Pittsburg Landing and Captain John Rapids, are situated on the Snake River while the remaining one, Big Canyon, is in the Clearwater Basin. Three million of the sub-yearlings also undergo some form of acclimation prior to being freed. Some are released from Lyons Ferry (two hundred thousand) and the Nez Perce Tribal (five hundred thousand) hatcheries. Others are released from the same three acclimation locations used for yearlings and from three additional sites all situated in the Clearwater basin. The remaining 1.6 million sub-yearlings are directly released into the Snake River at various places including below Hells Canyon Dam and the Grande Ronde River.

2. Broodstock Collection and Mating

A. Broodstock Collection

An enduring challenge for all the hatchery programs has been the acquisition of enough broodstock to meet egg take requirements. At present, broodstock is obtained by systematic sampling at LGD and by volunteer recruitment back to the Lyons Ferry and Nez Perce hatcheries. Additional adult collection sites, including a weir located on the South Fork of the Clearwater River and the Oxbow Hatchery on the Snake River may become operational in the future. The primary site for broodstock collection for both LFH and NPTH is at Lower Granite Dam (LGD). Approximately 70% of the adults collected at the dam are transferred to LFH and about 30% go to NPTH. The LGD fish trap is operated by NOAA-Fisheries and funded by Bonneville Power Administration through the Northwest Power and Conservation Fish and Wildlife Program. This trapping site provides the opportunity to collect natural origin fall Chinook adults for inclusion in the hatchery population and reduces the likelihood of unintentional capture of Columbia River fall Chinook.

Constraints on trapping rates at LGD, to limit incidental take of Snake River steelhead, can restrict the number of adult fall Chinook salmon collected at LGD, necessitating additional collection at LFH and/or at NPTH. Hauling of fish from the LGD adult trap begins after August 18 and generally ends the third week in November. Broodstock collection at the LFH adult trap starts September 1. Trapping at LFH is adjusted to assure that fish are trapped throughout the entire run.

Adult collection goals, presented at the Fall Chinook Symposium, in the LFH/NPTH BiOp and LFH HGMP differed from one another. The symposium report states that the current broodstock goal is 1,200 adult females; in contrast the LFH HGMP states that 1,400 to 2,000 females are needed for broodstock and that 3,500 to 5,000 fish are collected and retained at LGD for broodstock and run-reconstruction purposes (Attachment #6, LFH HGMP Lyons Ferry Complex Annual Operations Plan page 9). The LFH/NPTH BiOp states that up to 7,500 fall Chinook might be collected for broodstock and run re-reconstruction (section 2.6.1, page 118). The LGD trap protocol does not indicate numerical objectives for fish collection. The LFH HGMP states that 4.75 million eggs are needed to fulfill the United States v Oregon production priorities. It is not clear whether this includes the 1.3 million eggs for Idaho Power Company (IPC) production at Oxbow and Irrigon Hatcheries.

The NPTH presentation, at the fall Chinook symposium, and NPTH HGMP (NPT 2011) indicated that 1,052 adults (526 females and 526 males) are needed for hatchery propagation to achieve the release target of 1.4 million sub-yearling fall Chinook based on 3,762 eggs per female (1.98 million eggs in total) and 71% survival from green egg to juvenile release. Consequently, it is possible to assess the extent to which the NPTH program component has been able to collect sufficient broodstock, but it is more difficult to assess this for the LFH component.

Table 2 provides estimates of the total annual collections of Snake River fall Chinook salmon for these programs. Tables 3 and 4 provide a summary of the collected broodstock, spawning populations, and egg take at LFH and NPTH.

Table 2. Fall Chinook salmon collected for broodstock and run-reconstruction at Lower Granite Dam, Lyons Ferry Hatchery and Nez Perce Tribal Hatchery (Table 17, LFH/NPTH BiOp, NOAA 2012).

	Fall Chinook Salmon collected at LGD and LFH			Fall Chinook Salmon Collected at NPTH			Total
Year	Female	Male	Jack	Female	Male	Jack	
1991	269	238	148				655
1992	293	185	154				632
1993	126	125	140				391
1994	168	243	510				921
1995	349	505	1884				2738
1996	499	609	501				1609
1997	485	381	769				1635
1998	815	1274	1201				3290
1999	1448	1371	934				3753
2000	1112	1757	1332				4201
2001	1519	2200	455				4174
2002	1856	1858	811				4525
2003	1164	1428	1596	131[a]		68	4387
2004	1681	2298	710	163	388	175	5415
2005	1783	1468	7014	78	66	51	10460
2006	882	1331	1690	23	42	76	4044
2007	1867	2518	2328	53	62	2061	8889
2008	1607	2782	2042	211	497	571	7710
2009	1471	1833	1302	278	229	5111	10224
2010	1496	1546	213	0	0	0	3255
2011	1598	916	587	137	129	257	3624

[a] A total of 131 adult fall Chinook entered the fish ladder and were retained as possible broodstock at NPTH in 2003. The sex of these fish was not reported.

Table 3. Fall Chinook adults and jacks collected at NPTH and LGD, number of fish spawned, egg take, and fecundity 2003-2010 (Table 20. NPTH HGMP, NPT 2011)

Brood Year	Collected Adults						Spawned Adults			Green Eggs[a]	Average Fecundity
	LGD			NPTH							
	Female	Male	Jack	Female	Male	Jack	Female	Male	Jack		
2003	0	0	0	131[b]		68	98	46	4	307,735	3,140
2004	289	447	57	163	388	175	360	385	23	1,306,229	3,628
2005	202	227	29	78	66	51	278	200	31	958,536	3,448
2006	196	209	239	23	42	76	213	155	54	852,632	4,003
2007	253	322	313	53	62	2,061	290	315	16	1,101,127	3,797
2008	402	563	102	211	497	571	532	495	37	**2,105,802**	3,958
2009	400	525	904	278	229	5,111	494	278	12	**1,814,541**	3,673
2010	545	562	72	0	0	0	496	408	53	**1,940,243**	3,912

[a] Bold entries are years when the egg take achieved at least 90% of the 1.98 M goal
[b] A total of 131 adult fall Chinook entered the fish ladder and were retained as possible broodstock at NPTH in 2003. The sex of these fish was not reported.

Table 4. Combined Fall Chinook adults and jacks collected from LG and LFH and used in spawning at LFH (Table 30. LFH HGMP, WDFW *et al.* 2011)

Brood Year	Collected Adults			Spawned Adults			Eggs Collected[a]
	Female	Male	Jack	Female	Male	Jack	
1991	269	238	148	260	183	118	906,411
1992	293	185	154	276	161	1	901,232
1993	126	125	140	115	102	24	400,490
1994	168	243	510	164	164	47	583,871
1995	349	505	1,884	333	371	81	1,056,700
1996	499	609	501	464	465	60	1,433,862
1997	485	381	769	375	255	206	1,184,141
1998	815	1,274	1,201	663	518	228	2,085,155
1999	1,448	1,371	934	1,305	874	528	3,980,455
2000	1,112	1,757	1,332	1,037	729	369	3,576,956
2001	1,519	2,200	455	1,338	1,150	188	**4,734,234**
2002	1,856	1,858	811	1,322	1,089	171	**4,910,467**
2003	1,164	1,428	1,596	794	619	234	2,812,751
2004	1,681	2,298	710	1,331	1,178	156	**4,625,638**
2005	1,783	1,468	7,014	1,518	1,099	96	**4,929,630**
2006	882	1,331	1,690	786	693	88	2,819,004
2007	1,867	2,518	2,328	1,569	1,432	125	**5,143,459**
2008	1,607	2,782	2,042	1,345	1,264	17	**4,957,300**

[a] Bold entries are years when the egg take achieved at least 90% of the 4.75 M goal

Based on “green” egg take objectives, the NPTH has achieved at least 90% of its egg production goal in three of eight years from 2003 to 2010. LFH has met 90%, or more, of its egg production goal six times in eighteen years from 1991 to 2008. In the years when egg production goals were not realized, abundance of returning fall Chinook was the limiting factor.

B. Spawning and Mating

The location of broodstock collection at Snake River dams, age-structure, and size-at-age of the returning fish, and desire to integrate hatchery production with the natural population and use the hatchery fish for supplementation has produced mating protocol challenges. These include avoiding out-of-basin (non-native) fall Chinook in Snake River fall Chinook propagation, establishing limits on the incorporation of 0- and 1-ocean fish (mini jacks and jacks), and incorporating sufficient natural origin fall Chinook into the hatchery population.

C. Avoiding Out-of-Basin fall Chinook

From the late 1970s through 1991 broodstock were collected at Ice Harbor Dam and LFH (Milks and Arnsberg 2014). The fish collected included a substantial proportion of strays from Columbia River fall Chinook hatchery programs that enter, even if temporarily, the Snake River. Often these fish migrate into the lower portion of the Snake River and then return to the Columbia to spawn in their natal river or hatchery. When captured at Ice Harbor they are unable to return and inadvertently become incorporated into the broodstock. In the 1989 broodyear, fish from the Umatilla and Bonneville fall Chinook hatchery programs, represented 43% of the LFH broodstock (Bugert *et al*. 1990).

In response to concerns about the risk from incorporating non-native fish in the broodstock, all 1989 progeny were tagged and no returns were used for subsequent releases in the Snake River. Trapping was moved up-river to LGD to reduce the capture of strays. Beginning in 1990, trapping at LGD diverted all coded wire tagged (CWT) fall Chinook and tags were read before mating. Only fish with LFH CWT codes were used in the Snake River fall Chinook program. This practice resulted in the near-complete exclusion of CWT tagged fall Chinook from passage above LGD.

Since 2000 broodstock have been randomly sampled by opening and closing the trap several times per hour, untagged fish are included in the broodstock. Eggs from matings are segregated so that those involving tagged, non-Snake River fish can be removed. Up to 5% of the total number of fish used for mating can be of out-of-basin origin. For the past eight years the level of strays incorporated into the broodstock has been well below this upper limit (Table 5).

Table 5. Percentage of trapped fish consisting of out-of-basin strays and percentage of Snake River fall Chinook hatchery production at LFH from strays (Table 21 LFH/NPTH BiOp)

Return Year	Strays as a proportion of trapped fish	Strays as a proportion of production
2004	5.4	0.0
2005	6.3	0.0
2006	3.3	0.4
2007	2.3	0.0
2008	3.5	0.1
2009	1.3	0.1
2010	5.4	0.3
2011	2.5	1.2

D. Incorporation of 0- and 1-ocean fish (mini jacks and jacks)

Initial spawning protocols at LFH and NPTH permitted jacks to be included in the broodstock up to 15%, with individuals classified as jacks or adults based on length (Milks and Arnsberg 2014). In 2009, fish age was determined using CWT and scale pattern analysis and compared to ages based on length. This approach revealed that jacks (1-ocean males) and jills (1-ocean females) were substantially underestimated, and that a large portion of the production from 2000 through 2009 involved 0- (mini-jacks) and 1-ocean parentage (Table 6).

The concern with breeding substantial levels of younger age fish into the population is that it will alter the age-structure and longer term evolutionary trajectory of the natural and propagated population components. Younger fish have lower reproductive potential, so brood stock age is especially important for a hatchery population that is used to supplement natural spawning.

In response to the determination that a substantial fraction of the matings for LFH involved 0- and 1-ocean parents, mating protocols have been adopted to reduce the frequency of using younger males. The current protocol mates a given female with a larger male and permits using a male to fertilize eggs from multiple females if needed. The protocol has reduced the frequency of 0- and 1-ocean parents in 2010-2012 (Milks and Arnsberg 2014, Table 6).

However, the reuse of males results in a reduction in the effective population size and that could increase genetic risks (LFH/NPTH BiOp 2012). There is no correct response to this problem; using larger numbers of parents with attendant increase in younger age parents or using only older age parents but reducing the effective population size both have risks with unknown consequences. The program should incorporate monitoring to evaluate the consequences of the breeding protocol and continue to involve regional genetic expertise to test and adopt best emerging practices.

Table 6. Number of matings of mini-jacks, jacks, and jills contributing to broodstock at LFH, 2000-2012 (Milks and Arnsberg 2014, Table 4)

Year	0-salt (mini-jack)	1-salt jack	1-salt jill	Number of matings containing jack x jill mating	% of total matings with 0 and/or 1-salt parentage
2000	195	609	157	127	80.4
2001	9	875	67	47	67.6
2002	5	348	6	4	31.8
2003	3	527	78	63	74.5
2004	34	941	254	204	77.6
2005	13	610	58	26	45.3
2006	1	525	123	94	70.6
2007	0	1136	477	405	82.9
2008	0	348	78	31	30.2
2009	1	547	513	152	70.3
2010	0	38	2	0	3.2
2011	0	23	36	2	4.6
2012	0	2	3	0	0.4
2000-2009 Average	26	647	181	115	63.1
2010-2012 Average	0	21	16	1	2.7

E. Incorporating natural origin fall Chinook into the hatchery population

In addition to the absolute numbers of broodstock collected, since 2003 there has been an objective to incorporate natural origin fall Chinook into the hatchery broodstock. A rate of 30%, with a limit of no more than 20% removal from the natural origin population, is the current goal. The documents reviewed do not establish a scientific rationale for having 30% of the hatchery broodstock be of natural origin, or, a rationale for removing up to 20% of the natural population to achieve this objective. Only 70 to 80% of the hatchery production receives marks or tags making the identification of natural origin fish problematic. In the past, scale pattern analyses were used to determine the proportion of natural origin fish in the brood. However, a recent evaluation of this method disclosed that scale analysis could be used to estimate age but could not be used to determine the proportion of natural origin or out-of-basin fish in the broodstock (WDFW et al. 2011). Parent Based Tagging should help resolve this problem in the future (*see* p 71 for details on this method). The number of natural origin fall Chinook included in the broodstock and the proportion of the natural population collected are presented in Table 7.

The proportion of natural origin fall Chinook in the LFH hatchery broodstock averaged 6% from 2003 through 2008, and 13% in the NPTH broodstock, both substantially below the 30% target (Table 19 and 20 LFH HGMP, WDFW *et al.* 2011). The co-managers state that a lack of sufficient sampling and holding infrastructure at LGD, warm water temperatures when fish are being collected, plus the fact that not all hatchery fish are visibly marked, makes it unlikely that the 30% pNOB goal can be achieved.

Even with considerable uncertainty regarding the distribution and natural spawning of hatchery-origin fall Chinook, it is likely that the natural spawning population includes more than 50% hatchery-origin parents (LFH/NPTH BiOP, NOAA 2012). The hatchery and natural population components are genetically indistinguishable (Small and Marshall 2010). The PNI[6] of the Snake River fall Chinook population is currently estimated at 0.06 (WDFW *et al*. 2011). A substantial portion of the natural origin population is expected to

[6] PNI is the proportional mean fitness of an integrated population (i.e., one consisting of natural- and hatchery origin salmonids) relative to a pure natural population. PNI can be estimated by dividing pNOB by pNOB + pHOS; where pNOB equals the proportion of hatchery broodstock composed of natural origin adults and pHOS equals the proportion of natural spawners composed of hatchery origin adults. The HSRG has established a minimum PNI for integrated populations of > 0.50.

be progeny of hatchery-origin parents. This circumstance is generally inconsistent with recommended hatchery practices (ISAB 2003; HSRG 2009). The ISRP recommends that co-managers develop monitoring to evaluate the demographic and fitness consequences of the current management regime. A critical part of such an evaluation will be estimating separate R/S values for naturally spawning natural- and hatchery-origin fish.

Table 7. Estimated numbers of Snake River natural origin fall Chinook salmon collected for broodstock and the percentage of the run at large collected (Table 18. LFH/NPTH BiOp 2012).

Brood	Total estimated Natural origin fall Chinook collected at LGD			LGD Total	Total estimated Natural origin fall Chinook salmon collected at LFH			LFH Total	Total estimated Natural origin fall Chinook salmon collected at NPTH			NPTH Total	Total	Est Nat Run Size	% of Natural Run Removed
Year	Female	Male	Jack		Female	Male	Jack		Female	Male	Jack				
2003					4	5	2	11	1			1	12	3868	0.31
2004	226	46	19	291	10	1		11	12	45		57	359	5115	7.02
2005	145	241	11	397	1	3		4		5		5	406	3110	13.05
2006	172	129	1	302	5	7	1	13		1		1	316	2749	11.50
2007	119	159	-	278	1	3	1	4	1			1	283	2045	13.83
2008	173	127		300					2			2	302	2155	14.01
Average															9.95

3. Lyons Ferry Hatchery

A. Background and Hatchery Production Summary

Lyons Ferry Hatchery (LFH) spawns Snake River fall Chinook, incubates eggs and rears sub-yearling and yearling smolts for the Lower Snake River Compensation Plan, Fall Chinook Acclimation Project (FCAP) and Idaho Power Company (IPC) Hells Canyon Agreement obligations.

U.S. v. Oregon establishes smolt production targets, tagging/marking numbers, and the release plan for Snake River fall Chinook. There are seventeen prioritized groups of sub-yearling and yearling smolts that are released at various locations in the Snake River basin (Table 8, WDFW et al. 2011). Some of the production is transferred as eyed eggs for final incubation and juvenile rearing at Irrigon and Umatilla hatcheries in Oregon operated by the Oregon Department of Fish and Wildlife and to the Oxbow Hatchery operated by Idaho Department of Fish and Game. Portions of the juveniles reared at Lyons Ferry are transferred as sub-yearling and yearling pre-smolts for acclimation and release above Lower Granite Dam by the FCAP project, and a portion of the production is also reared to sub-yearling and yearling smolts at LFH and released primarily at the hatchery. Additionally, as part of a U.S. Corps of Engineers study, sub-yearlings were released into Couse Creek and the Grande Ronde River. They served as natural origin surrogates to determine travel time and survival through the hydrosystem. Table 9 summarizes the LFH production schedule as mandated by the 2008-2017 U.S. v. Oregon agreement (adapted from Table 4 and 43, LFH HGMP, WDFW et al. 2011)

Table 8. Lyons Ferry Hatchery (LFH) fall Chinook production components

Program	Rearing Site	Release Site	Transfer Age	Transfer Goal	Release Goal	Size (fish per pound)	Age
LSRCP	LFH	LFH			200,000	50	0+
	Irrigon	Grande Ronde	Eyed Eggs	421,000	400,000		0+
	LFH	Couse Ck			200,000	50	0+
	LFH	LFH			450,000	10	1+
FCAP	LFH	Cap John	0+	500,000	500,000	50	0+
	LFH	Big Canyon	0+	500,000	500,000	50	0+
	LFH	Pittsburg Landing	0+	500,000	400,000	50	0+
	LFH	Cap John	1+	155,000	150,000	12	1+
	LFH	Big Canyon	1+	155,000	150,000	12	1+
	LFH	Pittsburg	1+	155,000	150,000	12	1+
IPC	Oxbow	Hells Canyon	Eyed eggs	211,000	200,000	42	0+
	Umatilla/ Irrigon	Hells Canyon	Eyed eggs	842,000	800,000	42	0+
TOTAL	Sub-Yearlings		3,200,000 (Not Including Transportation Study)				
	Yearlings		900,000				

Table 9. Releases of LFH fall Chinook LSRCP, FCAP, and IPC production Brood Year 1996-2009 in thousands (adapted from Table 45, 46, and 47. LFH HGMP, WDFW et al. 2011).

Program	Release Location[a]	Age	Release Year												
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
LSRCP	LFH	0+			204	196	3.9	194	200	201	200	202	200	200	200
	CC	0+						29	100		434	411		230	201
	GRR	0+									482	409		303	441
	LFH	1+		418	432	456	338	432	518	446	453	450	503	459	455
FCAP	Cap John	0+			323	892	501	998	804	501	505	506	514	513	524
	Big Can	0+	253		347	891	857	1010	506	474	510	505	507	520	475
	Pit Land	0+				400	374	399	390	363	398	398	401	402	416
	Cap John	1+		133	157	131	101	160	152	151	0	151	158	154	141
	Big Can	1+		61	229	131	113	159	145	106	140	130	155	149	154
	Pit Land	1+		142	143	135	104	160	140	145	151	150	147	150	152
IPC	HC Dam	0+					115	171	541	10	583	523	125	962	1000
	PLAP									165	398	397			

[a] CC: Near Couse Creek; GRR: Grande Ronde River, HC Dam: Hells Canyon Dam; PLAP: Pittsburg Landing Acclimation Project

The symposium reports, provided by hatchery and M&E staff, establish the ability of the various production facilities associated with the LSRCP fall Chinook program to rear both sub-yearling and yearling fish for release.

In the last five years, the production goals have been met. This is in contrast to the production levels in the 1990s (Figure 1). Achieving the production targets in the recent five years is primarily a function of being able to obtain enough female broodstock, owing to increases in adult abundance. There is general consensus among co-managers, and the ISRP concurs, that the cause for improvements in both hatchery and natural origin adult abundance is largely unknown. Factors that may contribute include improved hydrosystem survival, reduced harvest rates, and improved ocean conditions. The ISRP cautions that salmon population abundance varies enormously, often abruptly, and that recent success does not justify an assumption that in the future production targets can be met in most years.

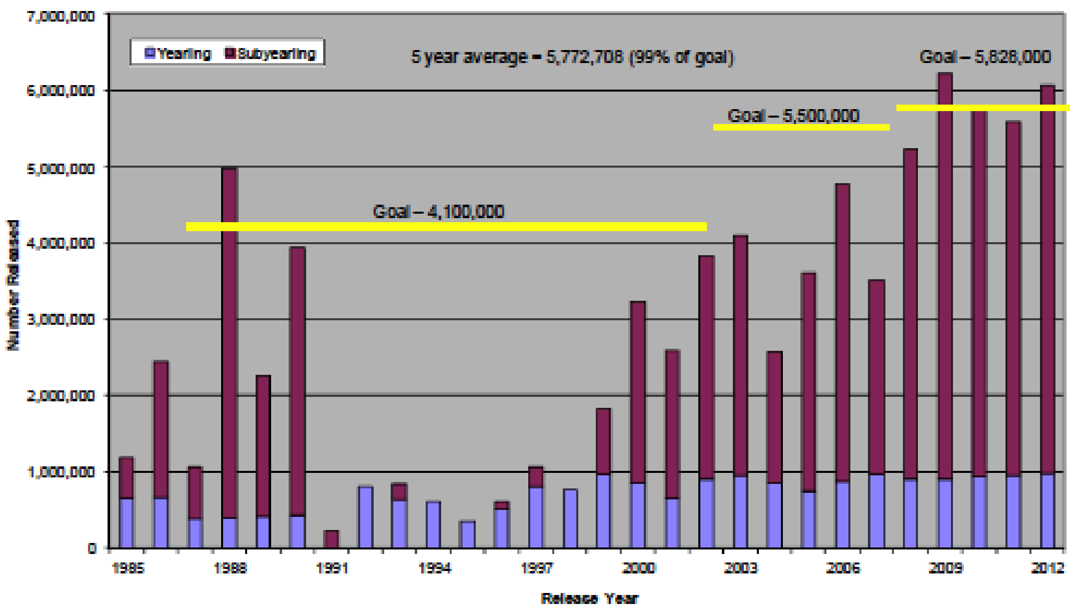


Figure 1. Snake River fall Chinook hatchery releases relative to production targets (from Hesse 2014)

B. Performance of Lyons Ferry Hatchery LSRCP Operations

B.1. Egg Incubation

The original LSRCP hatchery objectives anticipated 80% survival from green eggs-to-smolt releases for sub-yearlings. Originally, no yearling releases were planned, so no green egg-to-yearling smolt (or release) survival objective was developed. The estimates of egg to sub-yearling and yearling smolt releases are reasonable. There are egg losses shown in Table 10 that were not explained in the HGMP. However, the LSRCP Lyons Ferry fall Chinook Annual Report(s) (Milks et al. 2013) indicates that the balances represent eyed egg transfers. For example in 2004, 4.63 million eggs were collected at spawning, but only 3.41 million eyed eggs were retained. The rest were transferred to Irrigon Hatchery for the LSRCP Grande Ronde River sub-yearling releases or to Oxbow and Umatilla hatcheries for IPC sub-yearling production.

Table 10. Egg numbers in millions and egg-to-fry survival at LFH for the 1991-2007 brood years.

Brood Year	Green Eggs	Eyed Eggs	Fry Ponded	Release Age	% Survival		
					Green Egg to Ponding	Ponding to Smolt	Green Egg to Smolt
1991	.906	.828	.808	1+	89.1	94.1	83.8
				0+			
1992	.901	.856	.835	1+	92.7	96.5	89.5
				0+	92.7	98.4	91.2
1993	.400	.363	.352	1+	88	99	87.1
				0+			
1994	.583	.553	.542	1+	92.7	99.3	92.1
				0+			
1995	1.05	1.02	.960	1+	90.8	94.8	86.1
				0+	90.8	99.0	89.9
1996	1.43	1.38	1.36	1+	95	76.6	72.8
				0+	95	89.5	85
1997	1.18	1.13	1.10	1+	93	92.5	86
				0+	93	97.6	90.8
1998	2.10	1.98	1.93	1+	92.4	94.8	87.6
				0+	92.4	95.1	87.9
1999	3.98	3.60	3.87	1+	92.4	66.3	61.3
				0+	92.4	95.2	87.9
2000	3.58	3.25	3.16	1+	92.8	91.3	84.8
				0+	92.8	94.9	88.1
2001	4.73	4.23	4.10	1+	93.6	79.5	74.5
				0+	93.6	97.7	95.8
2002	4.91	3.54	3.48	1+	95.3	86.8	82.8
				0+	95.3	94.8	90.3
2003	2.81	2.48	2.44	1+	95.5	75.7	72.3
				0+	95.5	95.1	90.8
2004	4.63	3.41	3.29	1+	93.0	96.8	90.1
				0+	93.0	97.6	90.8
2005	4.93	3.38	3.28	1+	92.2	99.3	91.5
				0+	92.2	104.9	96.7
2006	2.82	2.60	2.60	1+	95.7	95.4	91.3
				0+	95.7	100.2	95.5
2007	5.14	2.85	2.83	1+	95.8	95.4	91.4
				0+	95.8	100.3	95.5

B.2. Juvenile Production

This section summarizes LFH hatchery production for LSRCP releases from LFH and Couse Creek in the Snake River. LSRCP Grande Ronde River, FCAP, and IPC releases, following egg and pre-smolt transfers, are also presented.

The 450 K fall Chinook yearling release at LFH is the first production priority in the U.S. v. Oregon agreement, and was accomplished seven out of the eleven years shown in Table 9. Releases of sub-yearlings from LFH and into Couse Creek are priorities 5 and 11, respectively, in the U.S. v. Oregon production schedule. In the early years of the program, low numbers of brood stock resulted in inconsistent releases from year-to-year. Brood stock collection has been more consistent since 2007 as a result of higher adult returns. Consequently, program goals have been met for the on-station and Couse Creek sub-yearlings releases since 2008 (see Table 9 above and Milks *et al.* 2013). Size goals (50 fish per pound or fpp) for sub-yearlings and 10 fpp for yearlings) for the LFH releases have been consistently met.

C. LSRCP, Fall Chinook Acclimation Project, and Idaho Power Company Post Transfer Hatchery Performance

C.1. LSRCP

Egg Incubation

The LFH HGMP reports that eyed eggs transferred from LFH to Irrigon Hatchery for release in the Grande Ronde River, had survival rates of 99% from eyed egg to ponding and 98% from ponding to release for the years represented in Table 9. Survival for individual years was not provided. Irrigon Hatchery summaries indicate that eyed-egg-to-release survival, for brood years 2009 through 2012, was 94, 89, 96, and 90% respectively; for more details see www.fws.gov/lsnakecomplan/Reports/ODFWreports.html.

Smolt Production and Releases

LSCRP releases into the Grande Ronde River were initiated in 2005 from brood year 2004 and have occurred every year except 2007, from brood year 2006. Since 2008, release numbers have been within 5% of the 400 K target (Table 9). There is no reported size target for these fish. Size has ranged from 79.5 fpp in 2011 to 42 fpp in 2010, averaging 53.9 fpp across eight releases. The ISRP understands these releases are intended to provide data on migration timing and survival through the hydrosystem.

C.2. Fall Chinook Acclimation Project (FCAP)

In 1994, through U.S. vs. Oregon, an agreement was reached to replace natural production losses from adults trapped and removed at Lower Granite Dam, with LFH production which was to be acclimated and released upstream of the dam.

The U.S. Congress provided funding and instructed the U.S. Army Corps of Engineers (USACE), through the LSRCP, to construct final rearing and acclimation facilities for fall Chinook in the Snake River basin. This was to complement USACE activities and efforts in compensating for fish lost due to construction of the lower four Snake River dams. The NPT assumed responsibility for operation and maintenance of the facilities. The LSRCP was directed to fund the operations and maintenance of facilities constructed under the plan. However, in 1997, this decision was changed, and BPA was directed to fund operations and maintenance (O&M) and monitoring and evaluation (M&E) of the facilities through the Council's Fish and Wildlife Program.

The acclimation project began in 1996 when 115,000 yearling fall Chinook were released from the Pittsburg Landing site. Fish were first reared and released from Big Canyon in 1997 and from the Captain John Rapids[7] site in 1998. The current program goal is to annually release 150,000 yearlings from each acclimation location. The annual, sub-yearling release target varies by location. The objective for two of the sites, Big Canyon and Captain John Rapids is to rear and release 500,000 sub-yearlings per year while the goal for the Pittsburg Landing site is an annual release of 400,000 fish. The project's 1.85 million juveniles represent approximately 58% of the total Snake River fall Chinook juvenile production from Lyons Ferry Hatchery. An interim goal for the project is to return 5,800 hatchery origin adults above Lower Monumental Dam and also to contribute approximately 29,000 fish to commercial and recreational fisheries. The project's long-term mitigation objectives are to produce 10,614 fish above Lower Monumental Dam and provide 42,500 fish to commercial and recreational fisheries (WDFW et al. 2011).

Performance of hatchery fish

The Big Canyon and Pittsburg Landing acclimation sites are temporary facilities; each having sixteen aluminum tanks that are 20' in diameter by 4' deep. A permanent 50' by 150' earthen pond is used at the Captain John Rapids location. The rearing vessels at the two temporary sites and the pond at the Captain John Rapid location are supplied with pumped river water. Daily fish culture activities at the sites include obtaining dissolved oxygen readings, removal of

[7] This site has sometimes been called Captain John's Rapid. In this report it is referred to as Captain John Rapids.

mortalities, feeding, and maintaining the pumps and other infrastructure. Rearing density goals of 0.12 lbs/ft^3/inch for yearlings and 0.14 lbs/ft^3/inch for sub-yearlings were established for the circular tanks. At Captain John Rapids, the targets for rearing densities equaled 0.04 for yearlings and 0.05 for sub-yearlings. The project's rearing density targets are lower than the 0.20 value recommended by Piper (1972) and were instituted for fish health reasons. Rearing density targets have generally been achieved. For example, densities from 1999-2012, for yearlings, averaged 0.09 at the Big Canyon and Pittsburg Landing locations. During these same years, end of rearing period densities for sub-yearlings averaged 0.08. Additional information collected at each rearing location, just prior to release, included estimates for 1) the number of juveniles released, 2) mean fork lengths, body weights and K (Fulton's Condition Factor) values (Ricker 1975), 3) mark and tag retention rates, 4) number of tagged and marked fish released, 5) duration of acclimation period, 6) dates the fish were released, and 7) a general health profile. Fish health was characterized by ELISA screenings for BKD and by performing standardized autopsy-based assessments (Goede and Barton 1990).

Average dates, when yearling and sub-yearling fish are placed into each acclimation site and how long they are reared, are shown in Table 11. Entrance and exit dates, and duration of holding, have remained relatively consistent from one year to the next. Yearlings are typically transported to Big Canyon and Pittsburg Landing in early March and are usually released after 40 days. Acclimation of yearlings at the Captain John Rapids site often starts in early February, a month sooner than the other two locations, and results in a sixty day acclimation cycle. This is done to free up rearing space at the LFH. Yearlings from all the sites are characteristically released in early to mid-April. Sub-yearlings are transported to each acclimation site in early May and are held for about three weeks before release (Table 11).

The project's goal of annually releasing 450 thousand yearlings and 1.4 million sub-yearlings has been met when the sites are supplied with full quotas of juveniles. Low egg takes or early mortality of juveniles, due to disease outbreaks at LFH, has on occasion reduced the number of juveniles available for the project. For instance, in 2005, no yearlings were transferred to Captain John Rapids because of their low abundance at LFH (*see* Table 9). The average number of yearlings and sub-yearlings released by the project from 1999 to 2012 is shown in Table 11. Disparate numbers of sub-yearlings (~300 thousand to ~2.4 million) were released from 1996 to 2002. Throughout this same period, yearling numbers were less variable and ranged between 300,000 and 500,000. Since 2006, numbers of both types of juveniles released have not varied appreciably, averaging approximately 1.4 million for sub-yearlings and 450,000-500,000 for yearlings. These releases are consistent with the project's current objectives.

The project established goals for fish size at the end of acclimation. For yearlings, it is 10 fpp pound or 45 grams per fish, while for sub-yearlings it is 50 fpp, or 9 grams. During the first eight years of the project, the target size has usually been met for yearlings but not for sub-yearlings (Table 11). The principal reason for this difference was the small size and poor health of the sub-yearlings transferred to the acclimation sites. Improvements in combating BGD and BKD were made at Lyons Ferry and have significantly reduced the incidence of both diseases. As a result, since 2004 the size-at-release goal for sub-yearlings has been frequently reached. Each year, one-way ANOVA analyses are used to determine if fish from the various acclimation sites have different lengths, weights, and condition factors at release. Minor differences have been observed and attributed to divergences in rearing conditions, flow, water exchange rates, and feeding methods.

Table 11. Average number released, survival, size, dates of acclimation and number of days reared for the juvenile fall Chinook salmon used in the FCAP program from 1999-2012. Data were obtained from the annual reports for project NPT 1998-01-005.

Acclimation Site	Type of Juvenile	Number Released	Survival During Acclimation			Fish Size (Fpp)		Rearing Period Dates		Number Of Days Reared
			Mean	Min	Max	At Arrival	At Release	Arrival	Release	
Big Canyon	Yearling	139,688	97.7%	95.8%	99.3%	12.5	10.0	Mar 5	Apr 13	39.3
Captain John Rapids	Yearling	148,006	99.1%	97.4%	99.9%	12.9	9.6	Feb 6	Apr 8	61.0
Pittsburg Landing	Yearling	148,106	98.4%	95.7%	99.7%	12.4	9.9	Mar 1	Apr 12	41.6
Big Canyon	Sub-Yearling	477,884	99.2%	98.3%	99.9%	91.1	66.8	May 10	May 31	20.8
Captain John Rapids	Sub-Yearling	478,546	99.2%	90.0%	99.9%	90.6	63.8	May 9	May 31	22.3
Pittsburg Landing	Sub-Yearling	397,037	99.3%	97.2%	99.9%	97.6	62.8	May 4	May 25	20.5

Survival of yearlings and sub-yearlings, while at the acclimation sites, is uniformly high, averaging 98% for yearlings and 99% for sub-yearlings (Table 11). The majority of the mortalities experienced by yearlings are attributed to high incidences of BKD. Mortalities in sub-yearlings are predominately caused by BGD. From 2005 on, the incidence of both diseases at the acclimation sites was significantly reduced due to fish cultural changes made at the Lyons Ferry Hatchery. Over the past nine years, goals for size-at-release, release numbers, and survival during the rearing period have been met or exceeded, indicating that this is a well-run hatchery program. Releases from each site occur during darkness and, when possible, under rising flow conditions to limit bird and fish predation. Another factor the operators may wish to consider, when planning release dates, is turbidity as releases under semi-turbid conditions may provide increased visual cover and protect the fish from immediate post-release predation.

C.3. Idaho Power Company (IPC)

Eyed eggs transported from LFH are incubated and juveniles reared at Oxbow Fish Hatchery, operated by Idaho Department of Fish and Game (IDFG) and Umatilla and Irrigon fish hatcheries operated by the Oregon Department of Fish and Wildlife (ODFW). IPC does not have formal, in-hatchery or post release survival thresholds, or, specific adult mitigation targets.

An agreement between IPC and the USCAE stipulated that IPC would share in the construction cost of the Lyons Ferry Hatchery to ensure sufficient broodstock holding and egg incubation capacity to provide approximately 1.3 million eyed fall Chinook salmon eggs annually. The agreement further states that IPC would not be entitled to any eggs in any year until such time that LFH had obtained 80% of its annual quota of eggs. Because of this qualifier, IPC did not receive any fall Chinook salmon eggs to meet its mitigation obligation until December 7, 2000.

Egg Incubation

The numbers of eggs received each year for Oxbow and Umatilla hatcheries and survival to ponding and smolt release are given in Table 12 below.

Table 12. Survival rates (%) for eyed eggs transferred to Oxbow and Umatilla hatcheries for the IPC production (from Table 33. LFH HGMP, WDFW *et al*. 2011)

Brood Year	Rearing Hatchery	Eyed Eggs	# of Fry Ponded	Survival to Pond	# of Smolts	Survival to Smolt	Release Location[a]
2000	Oxbow	122,514	121,032	98.8	115,220	94.0	HC Dam
2001	Oxbow	178,409	175,408	98.3	171,463	96.1	HC Dam
2002	Oxbow	230,000	226,392	98.4	209,246	91.0	HC Dam
	Umatilla	336,967	334,544	99.3	332,226	98.6	HC Dam
2003	Oxbow	200,000	197,669	98.8	9,957	87.7	HC Dam
					165,438		PLAP
2004	Oxbow	211,000	207,387	98.3	189,119	89.6	HC Dam
	Umatilla	842,278	826,916	98.2	394,055	93.6	HC Dam
					397,085	94.4	PLAP
2005	Oxbow	210,000	206,760	98.5	191,135	91.0	HC Dam
	Umatilla	378,064	351,726	93.0	332,165	87.9	HC Dam
		451,532	421,808	93.4	397,085	87.9	PLAP
2006	Oxbow	127,564	126,664	99.3	124,539	97.6	HC Dam
2007	Oxbow	205,000	202,668	98.9	192,471	93.9	HC Dam
	Umatilla	810,000	792,793	97.9	770,350	95.1	HC Dam
2008	Oxbow	210,000	206,154	98.2	202,839	96.6	HC Dam
	Umatilla	823,000	805,966	97.6	803,485	97.6	HC Dam

[a] HC Dam: Hells Canyon Dam; PLAP: Nez Perce Tribal Pittsburg Landing Acclimation Ponds

Survival from eyed eggs to release, for both Oxbow and Umatilla hatcheries, exceeds the planned objective in the LSRCP.

Smolt Production

Oxbow Fish Hatchery – Following hatching, fall Chinook salmon are moved outside to the juvenile raceways, usually in early February. Fry are ponded directly into the concrete juvenile raceways but are initially restricted to a small section of the raceways with a water flow of 70 gpm. Approximately every 30 days, rearing space is increased by moving the screens further down the raceways and gpm are increased to maintain target flows. Density and flow indices are maintained to not exceed 0.30 lbs/ft^3/in and 1.00 lbs/gpm/in, respectively. Fish are reared in the raceways until their release as sub-yearling smolts.

Umatilla Fish Hatchery – In February fall Chinook salmon fry are ponded in Oregon[8] raceways and then transferred to Michigan raceways for final rearing when their total weight is approximately 2,800 pounds. Current production protocols at Umatilla Fish Hatchery are to rear fall Chinook salmon in Michigan style raceways with a final density index of approximately 0.64 lbs/ft^3/in, a flow index of 1.5 lbs/gpm/in, and a water exchange rate of 3.4 times per hour.

Releases of fall Chinook sub-yearling juveniles from IPC mitigation is summarized in Table 13 below.

---

[8] The Umatilla Hatchery has 10 Oregon raceways. They are 91' long by 18.75' wide by 3.67' deep. The raceways are operated in pairs with an upper and lower unit. Water flows from the upper unit and then moves into the lower unit. The hatchery also has 24 Michigan raceways which are narrower and shallower (91' long by 9' wide by 2.75' deep) than the Oregon raceways. Michigan raceways are operated in sets of three, with water moving from an upper raceway before passing through the remaining two raceways. Each Michigan raceway has a submersible pump that delivers 950 gpm of water to oxygen contact columns located at the head end of each raceway. At this point, oxygen is introduced and unwanted saturated gas is removed. Each pond has its own oxygen supply line and supplemental oxygen is delivered from a bulk liquid tank on site (ODFW and CTUIR 2010)

Table 13. Year, release dates, numbers, smolt size, and release location for IPC mitigation from Oxbow and Umatilla hatcheries (from Table 47, WDFW et al. 2011)

Brood Year	Release Year	Release Dates	Release Numbers	Average Size (fpp)	Release Location
2000	2001	May 16	113,770	42.0	HC Dam
		June 19	1,450	23.0	HC Dam
2001	2002	May 21	171,463	42.0	HC Dam
2002	2003	May 15/16	333,226	41.4	HC Dam
		May 22	209,246	46.6	HC Dam
2003	2004	May 24	165,438	54.0	PLAP
		May 28	9,957	48.0	HC Dam
2004	2005	April 28	189,119	61.5	HC Dam
		May 10/12	394,055	59.4	HC Dam
		May 25/26	397,704	50.4	PLAP
2005	2006	May 2	191,135	80.3	HC Dam
		May 9/10	332,165	57.9	HC Dam
		May 1,3,5	397,085	52.5	PLAP
2006	2007	May 8	124,539	55	HC Dam
2007	2008	May 6	192,471	51.4	HC Dam
		May 20/22	770,350	44.0	HC Dam
2008	2009	May 8	202,839	54.8	HC Dam
		May 12/14	803,485	60.2	HC Dam
Averages			555,389	51.4	

The numbers of smolts released by the IPC mitigation is constrained by the availability of eggs from Lyons Ferry Hatchery, which in-turn reflects Snake River fall Chinook adult abundance at Lower Granite Dam. The first releases began in 2001 and in 8 of 13 brood years, from 2000 to 2012, at least 90% of the project goal of releasing 1 million sub-yearlings has been met. The project's established goal, for sub-yearling smolt size (42 fpp), has not been regularly achieved.

D. Juvenile Post Release Survival

D.1. LSRCP

The LFH production and release presentation and report from the August 2013 Clarkston symposium and WDFW LFH fall Chinook evaluation reports, available at the Lower Snake River Compensation Plan website, do not provide explicit performance metrics for juvenile post-release survival. Three of the LFH evaluation reports (2009, 2010, and 2011 annual reports, published in 2011, 2012, and 2013) provide juvenile travel time from release to various Snake and Columbia river dams for yearlings from Brood Year (BY) 2008 and 2009, and for sub-yearlings for BY 2009 and 2010. Although post-release survival estimates are available for the projects, the reports state that the data are not suitable for estimating hydrosystem survival using the Survival Under Proportion Hazards or SURPH model.[9]

The LFH annual reports indicate that direct sub-yearling releases at Couse Creek on the Snake River are being used for comparison and evaluation of acclimated releases from Captain John Rapids (see comments on the Rosenberger et al. 2013 Acclimation report below).

Juvenile migration and survival of LFH and other LSRCP fall Chinook warrant more robust evaluations of survival under varying environmental conditions (flow, spill, and transport) and under alternative rearing approaches (sub-yearling versus yearling; acclimated versus direct release; and release locations). Comments below, included in the FCAP component, apply generally to evaluation of LFH fall Chinook production.

[9] SURPH is an analytical tool for estimating survival using release-recapture data as a function of environmental and experimental effects. These effects may apply to a population (such as ambient temperature) or an individual (such as body length). The tool was developed by J. Lady, P. Westhagen and J.R. Skalski from the School of Aquatic and Fisheries Sciences, University of Washington. For more information go to: www.cbr.washington.edu/analysis/apps/surph

D.2. Fall Chinook Acclimation Project (FCAP)

Four post-release performance metrics are measured: 1) survival of juveniles from their acclimation sites to lower river dams including Lower Granite (LGD), McNary and Bonneville, 2) migration rates of juveniles to LGD, 3) cumulative arrival timing of juveniles from each acclimation site to LGD, and 4) the number of adults returning to LGD by return year from each acclimation site. The survival of yearlings to LGD from 1996 to 2005 was documented in annual reports and averaged 86% (Table 14). Additional data from 2006 through 2012, obtained on yearlings, revealed similar high survival rates (mean of 90%) to LGD during those years. Survival of sub-yearlings to LGD appeared to be slightly lower than achieved by the larger yearling fish that were released earlier in the year (Table 14). Formal analyses, however, that compare the survival of different release groups have not been performed. River flow, temperature, size-at-release and other factors could potentially affect post-release survival rates. No analyses were presented examining the role that these and other factors (e.g., health status at release) might have on survival to LGD or to lower dams. However, river flow and water temperature information from the Snake and Clearwater rivers were used to see if these factors influenced how rapidly yearlings migrated to LGD. Migration rates of yearlings released from Pittsburg Landing were positively correlated with Snake River flow rates ($r = 0.930$; $p<0.001$) but were not influenced by temperature ($r = -016$; $p = 0.659$). Similarly, the migration rates of yearlings released from the Big Canyon site into the Clearwater River were positively associated with flow rates ($r = 0.821$;$p =0.007$) and were also negatively related to river temperatures ($r =-0.792$; $p=0.011$).

A few examples of the cumulative arrival timing of yearling and sub-yearling smolts to LGD indicated that yearlings appear to emigrate quickly, arriving at the LGD within 10 to 15 days after being released. The cumulative arrival timing of sub-yearlings seems to be more variable. Some groups arrive at LGD as rapidly as yearlings, while in other cases fish from a release group may arrive at the dam over a month or more. These possible tendencies could be confirmed by a comprehensive analysis that compares the cumulative arrival timing of yearlings and sub-yearlings over multiple release years.

Table 14. Survival of juvenile fall Chinook released from FCAP acclimation sites to Lower Granite and McNary Dams. Data obtained from annual reports for project NPT 1998-01-004.

Release Year	Acclimation Site					
	Big Canyon		Captain John Rapids		Pittsburg Landing	
	Age of Juvenile		Age of Juvenile		Age of Juvenile	
	0+	1+	0+	1+	0+	1+
ESTIMATED PERCENT SURVIVAL TO LOWER GRANITE DAM						
1996	-	-	-	-	-	98.8
1997	74.8	93.4	-	-	-	92.2
1998	-	73.4	-	77.0	-	88.6
1999	69.7	88.9	93.1	94.1	-	90.0
2000	70.3	89.6	71.7	95.2	62.1	87.0
2001	53.3	74.4	70.5	85.2	27.8	74.9
2002	43.9	89.5	55.0	97.0	43.5	88.6
2003	76.9	83.1	87.9	91.7	67.0	86.4
2004	61.4	74.7	75.2	88.1	66.3	78.5
2005	68.9	82.0	84.6	-	81.1	86.7
ESTIMATED PERCENT SURVIVAL TO McNARY DAM						
1996	-	-	-	-	-	41.3
1997	29.5	78.5	-	-	-	81.8
1998	-	38.4	-	50.5	-	55.7
1999	35.7	62.4	70.5	71.3	-	62.1
2000	36.4	67.9	63.8	84.0	37.3	66.6
2001	12.9	39.5	17.8	48.5	6.2	37.9
2002	19.8	54.3	29.5	63.5	26.6	70.5
2003	36.6	59.9	69.3	69.4	32.3	62.3
2004	33.2	52.1	53.9	50.8	44.6	45.2
2005	56.7	56.3	51.3	-	49.3	67.3

D.3. Idaho Power Company

Passive integrated transponder (PIT) tagging upriver of Lower Granite Dam (LGD) and the detection of tagged fish at dams have been used to estimate juvenile survival rates from release to LGD beginning in brood year 2002. Survival rates have fluctuated from 43.8 % to 81.8% and in most years are comparable to other fall Chinook salmon releases in the Snake River Basin (Figure 2).

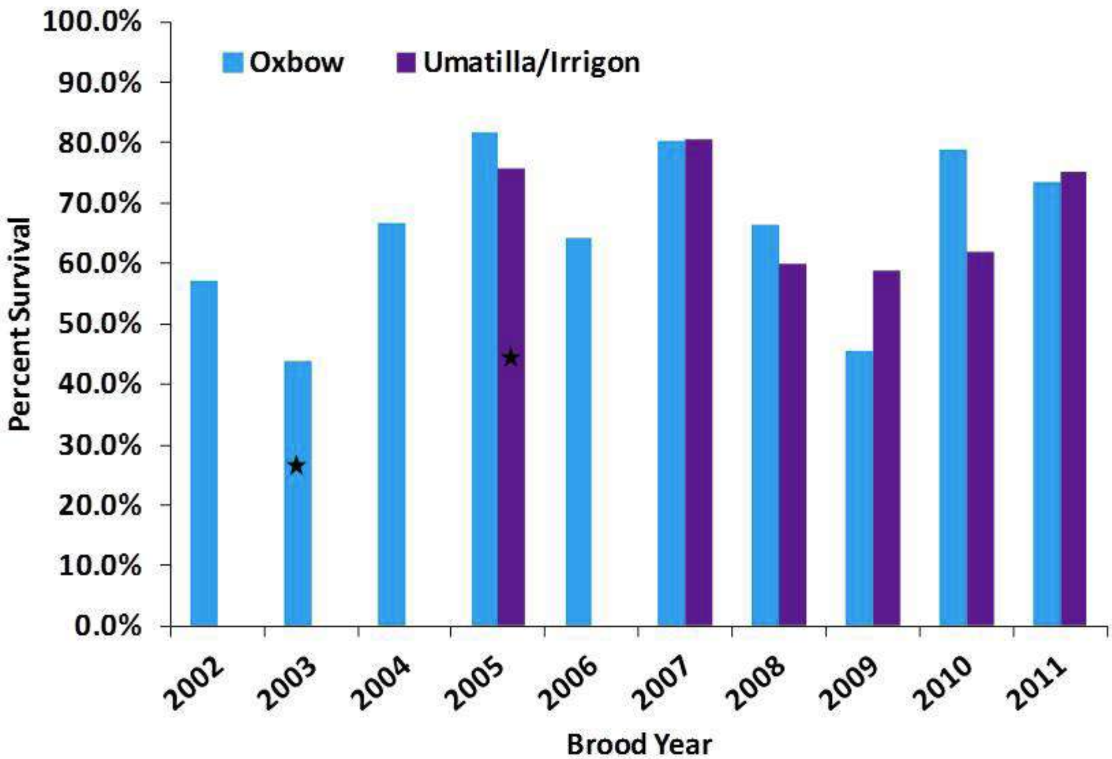


Figure 2. Juvenile survival rates of fall Chinook salmon reared at Umatilla/Irrigon and Oxbow hatcheries, released below Hells Canyon Dam, and recovered at Lower Granite Dam, 2002-2011 brood years. Stars indicate years in which a portion of the hatchery production was released at Pittsburg Landing (from Rosenberger 2014).

4. Nez Perce Tribal Hatchery (NPTH)

A. Background and Hatchery Production Summary

Fall Chinook salmon were extirpated from the Clearwater River shortly after the Lewiston Dam was built in 1927. The dam, located close to the Clearwater's mouth, blocked the upstream migration of adult fall and spring Chinook salmon. Even though it was removed in 1973, few fall Chinook salmon re-colonized the Clearwater River. The LSRCP began a fall Chinook reintroduction and supplementation effort in the Clearwater River Basin in 1997. That was the first year that annual releases of yearling and sub-yearling fall Chinook were made from Big Canyon Creek, a lower Clearwater River acclimation site. Fall Chinook supplementation was expanded in 2002 when the NPTH was constructed on the lower Clearwater River.

When first planned, the green egg take goal for fall Chinook at the NPTH was 3.96 million eggs which were expected to produce 2.8 million sub-yearlings. Upon review it was decided to partition the project into two phases. In Phase I, a green egg take goal of 1.978 million was established along with a 1.4 million sub-yearling goal. The egg take and sub-yearling abundance goals for fall Chinook in Phase II are those that were originally proposed. To advance to Phase II, sufficient hatchery origin adults need to return to the NPTH to generate 500,000 sub-yearling smolts. Additionally, through its supplementation efforts the hatchery should create enough natural origin recruits (NORs) that mature early in the spawning season to produce an additional 100,000 hatchery sub-yearlings. Besides these objectives, the NPTH program has annual interim and long-term goals of producing 2,290 and 3,750 hatchery adults above Lower Monumental Dam. It is also anticipated that the NPTH will supplement natural abundance, eventually helping to establish a self-sustaining natural origin population of 2,175 fall Chinook in the Clearwater River. If these long-term goals can be realized it will help contribute to the delisting of Snake River fall Chinook.

The NPTH was built to accommodate the project's Phase I objectives and is thus programmed to annually release 1.4 million sub-yearling fall Chinook (Table 15). Releases occur at four different acclimation locations. Two of them, the hatchery itself and an acclimation site located in the North Lapwai Valley, are situated in the lower Clearwater River. Both are scheduled to annually release five hundred thousand juveniles. The remaining two sites are farther upstream: one on the South Fork of the Clearwater (Lukes Gulch) and the other on the Selway River (Cedar Flats). Each of these locations has a release goal of 200,000 sub-yearlings (Table 16). From 2006-2008 juvenile Chinook were transferred directly from the NPTH to Lukes Gulch and Cedar Flats for final rearing and acclimation. Beginning in 2009, fish destined for these locations were transferred to Sweetwater Springs in late February and reared for approximately two months before being transferred to their designated acclimation locations for an additional two months of rearing.

Table 15. Annual Nez Perce Hatchery fall Chinook production goals.

Spawning & Incubation Location	Rearing Location	Release Site (Acclimation Site)	Transfer Age	Release Goal	Release Size (fpp)	Release Age
NPTH	NPTH	NPTH	0+	500,000	50	0+
NPTH	NPTH	North Lapwai Valley	0+	500,000	50	0+
NPTH	Sweetwater Springs	Lukes Gulch	0+	200,000	50	0+
NPTH	Sweetwater Springs	Cedar Flats	0+	200,000	50	0+
Total Sub-yearlings				1,400,000		

Table 16. Releases of NPTH sub-yearling fall Chinook for broodyears 2002-2011. Data are from Table 26 in the HGMP for the Nez Perce Tribal Hatchery (NPT 2011)

Release Location	Release Year								
	2003	2004	2005	2006	2007	2008	2009	2010	2011
NPTH	314,596[a]	169,596	869,300	432,097	491,424	495,937	628,815	536,999	813,348[b]
North Lapwai Valley	191,382	-	-	199,746	164,105	168,623	495,569	465,949	509,520
Lukes Gulch	-	-	-	25,391	24,955	100,368	209,878	198,969	207,482
Cedar Flats	-	-	-	25,774	24,988	100,294	200,098	188,411	205,556
Yearly Totals	505,978	169,596	869,300	683,008	705,472	865,222	1,534,360	1,390,328	1,735,906

[a] Two releases of sub-yearlings were made at NPTH in 2003, one of 199,632 and another of 114,964 fish.

[b] Two releases of sub-yearlings were made at NPTH in 2011, one of 526,761 and another of 286,587 fish.

B. Performance of Nez Perce Tribal Hatchery Operations

B.1. Broodstock

Lower Granite Dam and a ladder at the NPTH are the two principal locations used to collect broodstock for the NPTH program. At LGD, electronic controls are employed each hour, 24 hours per day, to shunt 9 to 20% of the fish passing over the South shore ladder into a holding facility. Pre-season forecasts are utilized to set sub-sampling rates at LGD to ensure that enough adults are collected to meet broodstock and run reconstruction purposes. Fish entering the fish ladder at NPTH are also collected and used by the project for broodstock. When the project first began, fall Chinook returning to Dworshak National Fish Hatchery and weirs on Potlatch River and Lapwai Creek were also used. Since 2006, however, only adults collected at LGD and NPTH have been incorporated into the broodstock.

Broodstock collection at LGD generally takes place from late August through October. Warm river water temperatures will often delay when the fish are first collected and broodstock acquisition ends once target numbers have been reached. The fish ladder at NPTH typically collects adults from late August through November.

Broodstock for the NPTH are held at the facility in ponds until reaching maturation. Potentially, adult fish can be held at NPTH for several months before spawning because arrival timing at LGD and NPTH is not correlated with maturation timing. Injuries, stress, and disease are expected to cause some adult mortality. Precautions have been taken to keep adult mortalities at 10% or less prior to spawning. To reduce mortalities caused by BKD, all females are injected with erythromycin prior to being placed into the hatchery's holding ponds. Beginning in 2010, a protocol of injecting females with a second dose of erythromycin just prior to spawning was started. In addition, every-other-day formalin treatments have been carried out to control *Saprolegnia* and other possible fungal infestations. These measures have generally helped the facility meet its pre-spawning survival goal of 90%. From 2003 to 2010 mortality rates for females ranged from a low of 1.4% in 2006 to a high of 9.3% in 2009. Mortality rates in males from 2005 to 2010 were higher, varying from a low of 7.8% in 2010 to a high of 26% in 2006. In the future, hatchery managers may wish to consider injecting males with erythromycin to see if this prophylactic treatment would help reduce mortality rates.

The proportion of the broodstock consisting of fish transported from LGD has varied over the years. When the project first began in 2002, as well as in 2010 and 2012, 100% of the broodstock came from fish captured at LGD. Conversely, in 2003 just 17% were obtained from LGD. During the other years when adults from both sources were spawned, about 70% (range 58 to 83%) of the fish originated from fish collected at LGD (Table 17). An important goal of the hatchery is to have 30% of the broodstock be of natural origin, i.e., have a pNOB value of 0.30. The origin of all the adults spawned at NPTH is determined via tags, marks, and scale pattern analyses and in the future will likely be ascertained by using Parent Based Tagging methods. Almost all the fish captured at NPTH are of hatchery origin while those captured at LGD appear to be more representative of the entire Snake River fall Chinook population.

The percentage of natural origin fish in NPTH broodstock has ranged from 0.01 to 22% (Table 17). The occurrence of NORs in Snake River fall Chinook during the same time period (2003-2008) has ranged from 10.7% in 2008 to 32.5% in 2004. Yearly percentages of NORs in Snake River fall Chinook are higher than their occurrence in fish selected for NPTH broodstock. If NORs could be rapidly identified, it might become possible to increase pNOB values to the 30% goal. At present, there is no way to rapidly screen potential broodstock to determine if they are NORs because a significant portion of the hatchery production is not visibly marked. The marking and tagging proportions applied to hatchery origin juveniles have been negotiated as part of the U.S. v. Oregon agreement; this agreement would have to be revised before 100% of project's fish could be visibly marked. The ISRP encourages the co-managers to consider this option of visibly marking all hatchery production fish not only for broodstock selection but also to help quantify the fishery and natural spawning contributions made by the project.

Table 17. The proportion of adults spawned at NPTH that were collected at LGD along with estimated pNOB values for hatchery broodyears 2003 - 2012

Broodyear	Percent From LGD[a]	Estimated pNOB value[a]
2003	16.9	0.01
2004	58.2	0.17
2005	73.1	0.14
2006	64.8	0.22
2007	83.0	0.14
2008	70.9	0.08
2009	74.3	0.05
2010	100	0.05
2011	67.2	0.06
2012	100	0.06

[a] Data are from NPT (2011) and from materials presented at the Snake River Fall Chinook Symposium held at Clarkston Washington, August 2013.

B.2. Egg takes, incubation and juvenile rearing

Spawning operations at the hatchery occur over a six to seven week period from mid-October to early December. Starting in 2007, some late maturing females were injected with salmon gonadotropin releasing hormone analog (sGnRHa) sold under the name Ovaplant™ to induce maturation. Green egg-to-eyed egg survival rates of injected and non-injected females were compared in 2008-2010. No differences were found, and this treatment has become a routine practice at the facility. When spawning, single male by single female matings are made and eggs from each female are kept separate from one another. After fertilization, eggs from each female are water hardened for one hour in a solution of iodophor. Eggs from a single female are then placed into an "isolation bucket" and held there until disease screenings have been completed. Eggs are culled if ELISA values for BKD are greater than 0.250 or the parental fish are later identified as strays. After disease screening, the eggs from each female are shocked, counted and placed into their own "Heath-Style" incubation tray until yolk absorption. Early rearing occurs in troughs located in the hatchery building. Eventually, fingerlings are transferred to larger outside ponds or transported to the Sweetwater Springs rearing facility for further rearing.

Annual reports for the NPTH indicate that juveniles, destined for the North Lapwai Valley acclimation site, are moved there in mid-April where they are held for three to four weeks before being released. Warm water temperatures and low dissolved oxygen levels in the two rearing ponds at this location have shortened the amount of time fish can be reared at this site. Juveniles assigned to the Lukes Gulch and Cedar Flats were also transported from the main hatchery to their respective acclimation sites in mid-April. Once there, they were reared and acclimated for about 50 days before release. This approach was changed in 2009, When fish allocated for these two locations were taken to Sweetwater Springs in late February, reared there for two months, then conveyed to their final acclimation locations and reared for an additional 50 days.

The project was initially designed with a 70.1% green egg-to-sub-yearling survival objective. Operational and infrastructural improvements since the project's inception have resulted in the survival objective being raised to 78%, which equals the average survival of green eggs to sub-yearlings from 2006 to 2009. The project has met its original survival objective in most years (Table 18). High incidences of coagulated yolk disease caused by mechanical system failures during the 2003 and 2004 incubation seasons lowered green egg-to-fry survival rates. The occurrence of this non-infectious condition was largely responsible for the low survival rate in the 2003 broodyear. In most years, however, green egg-to-eyed egg survival appears to be a little low; a reasonable goal for this period is around 93% although the BiOp (NOAA 2012) states that an acceptable survival rate for this period is 85%. Nevertheless, the proponents may wish to consider using “backup” males during the mating process, as that often raises fertility rates by several percentage points. Eyed egg-to-fry survival rates are respectable even with the inclusion of the 2003 broodyear. Rearing densities used by the project range from 0.3 lbs/ft^3/inch for fish <200 fpp and 0.1lbs/ft^3/inch for individuals > 180 fpp. The latter density is about half of what is recommended for juvenile Chinook, and it is being implemented to increase the health and quality of the fish being raised. When first ponded, fish are fed three percent of their body weight per day and food is delivered by hand six to seven times daily. As the fish grow, decreases in percent body weight fed and feeding frequency are implemented until the last month of culture when percent body weight fed increases (see Table 24 in NTP 2011 for additional details).

Table 18. The green-egg-to-sub-yearling survival of NPTH fall Chinook for broodyears 2002-2009. Data are from Table 26 of the HGMP for the NPTH hatchery (NPT 2011).

Broodyear	No. Of Green Eggs Taken	No. Of Eyed Eggs	Survival From Green to Eyed Egg	No. Of Fry Produced	Survival From Eyed Egg to Fry	No. Of Sub-yearlings Released	Survival From Fry To Sub-yearling	Green Egg To Sub-yearling Survival
2002	528,000	510,048	96.6%	509,626	99.9%	505,911	99.3%	95.8%
2003	355,560	270,353	76.0%	211,629	78.3%	169,596	80.1%	47.7%
2004	1,306,229	1,193,763	91.4%	1,035,856	86.8%	869,300	83.9%	66.6%
2005	958,536	885,783	92.4%	854,838	96.5%	683,008	79.9%	71.3%
2006	852,632	751,700	88.2%	733,240	97.5%	704,798	96.1%	82.7%
2007	1,101,127	936,728	85.1%	910,268	97.2%	865,222	95.1%	78.6%
2008	2,105,802	1,819,528	86.4%	1,781,899	97.9%	1,534,360	86.1%	72.9%
2009	1,814,541	1,646,713	90.8%	1,491,037	90.5%	1,390,328	93.2%	76.6%
Totals	9,022,427	8,014,616	88.8%	7,528,393	93.9%	6,722,523	89.3%	74.5%

Daily fish culture activities include monitoring flow rates in the rearing vessels, checking oxygen levels, cleaning rearing vessels, and removing mortalities. Given the amount of handling the fish receive, the overall conversion of green eggs to sub-yearlings is indicative of a well-run program, particularly from 2006 to the present. Mortality of the fish reared at the three acclimation sites is quite low plus the number of acclimation days and average sub-yearling size at release (50 fpp) generally meet project objectives. Sub-yearlings released at the North Lapwai Valley location seldom meet the project's 50 fpp goal because of the relatively short time fish can be reared at this location (Table 19). The NPTH program has met its annual release goals from 2008 to present.

Table 19. Mortality, length of acclimation period, and size at release for fall Chinook juveniles transferred to the three NPTH acclimation sites from 2006-2010. Data are from Table 26 of the HGMP for the NPTH (NPT 2011) and annual reports for BPA projects 1983-350-003 and 1983-350-00.

Acclimation Site	Release Year	No. Of Days Reared	Size At Release (fpp)	Percent Mortality During the Acclimation Period
North Lapwai Valley	2006	26	72.3	1.40
	2007	35	50.9	2.57
	2008	41	73.4	0.22
	2009	23	85.3	0.02
	2010	24	81.2	0.02
Cedar Flats	2006	57	32.9	0.95
	2007	54	47.3	0.47
	2008	49	59.3	1.56
	2009	45	57.9	1.14
	2010	41	48.3	0.76
Lukes Gulch	2006	56	36.6	2.47
	2007	47	37.2	0.96
	2008	48	46.0	2.32
	2009	43	51.6	1.18
	2010	49	44.4	0.64

C. Post Release Performance

Four post-release performance metrics are measured: 1) survival of juveniles from their acclimation sites to Lower Granite (LGD) and McNary dams, 2) migration rates of juveniles to LGD, 3) cumulative arrival timing of juveniles from each acclimation site to LGD, and 4) the number of adults returning to LGD by return year from each acclimation site. Survival rates of migrants seem to vary in concert and appear to be strongly affected by release year (Table 20). These patterns suggest that environmental conditions the fish encounter influence in-river survival rates. River-flow and water temperature data from the Clearwater are routinely collected. The proponents may wish to determine the role that these and other factors (e.g., size at release, health status, lunar phase, etc.) may have on survival of project sub-yearlings as they migrate to LGD. Such knowledge could provide insights into when project fish should be released.

How rapidly fish released from the project migrate to LGD is apparently determined for each release group. But very little of these data are reported. In some of the annual reports, though, it is hypothesized that river flow and water temperatures influence the migration speed of project fish. Analyses performed by the FCAP program showed that migration speed of yearling fall Chinook, released from the Big Canyon Acclimation site, was positively associated with flow rates and negatively affected by water temperature. Data collected by the NPTH program could be used to explore the importance that these factors, along with fish size, have on sub-yearling migration rates.

A few examples of the cumulative arrival timing of project fish to LGD were provided. It is likely that such data exists for all the project’s releases that contained PIT tagged fish. If that is the case, the proponents might consider performing analyses similar to those reported by Rosenberger et al. (2013) that examined the degree of temporal overlap between hatchery and natural origin juvenile fall Chinook in lower Snake River reservoirs. Results could indicate whether project fish are likely to co-mingle and possibly impact NOR juveniles.

Table 20. The estimated survival of NPTH sub-yearling fall Chinook to Lower Granite Dam. Data were obtained from NPT Annual Reports for BPA projects #1983-350-00 and #1983-350-003 and extrapolated from materials provided during the LSRCP Fall Chinook symposium held at Clarkston, Washington in August 2013.

Release Year	Release Location			
	Nez Perce Tribal Hatchery	North Lapwai Valley	Lukes Gulch	Cedar Flats
ESTIMATED PERCENT SURVIVAL OF NEZ PERCE TRIBAL HATCHERY SUB-YEARLINGS TO LOWER GRANITE DAM				
2003	89	85	-	-
2003[a]	32	-	-	-
2004	62	-	-	-
2005	-	-	-	-
2006	69	-	79	75
2007	49	60	63	65
2008	71	73	75	69
2009	73	69	73	63
2010	75	64	73	54
2011	80	84	87	88
2012	63	69	83	67
ESTIMATED PERCENT SURVIVAL OF NEZ PERCE TRIBAL HATCHERY SUB-YEARLINGS TO MCNARY DAM				
2003	64	43	-	-
2003[a]	11	-	-	-
2004	32	-	-	-
2005	-	-	-	-
2006	39	-	54	51
2007	33	38	44	31

[a] There were two releases of sub-yearlings in 2003.

5. Program Modifications

A. Lyons Ferry Hatchery

Previously mentioned operational and infrastructural changes have occurred at LFH to improve the survival and quality of the fish reared at the facility. Operations at Oxbow, Umatilla, and Irrigon Hatcheries are also under constant scrutiny. All of these facilities have backup pumps, electrical systems and alarms. To date, no major mortality event has occurred at any of these three hatcheries. Changes have also been instituted at the FCAP acclimation sites. New pumps, sand/water separation devices, alarms, and backup systems have been put in place to ensure that the acclimation sites meet their release and survival goals. Maintaining acclimation sites in remote locations can be challenging. The FCAP program should be commended for its efforts to rear fish under difficult conditions.

B. Nez Perce Tribal Hatchery

Like LFH, the NPTH program has undergone some modifications since its inception. For example, coagulated yolk disease was an issue during the first two years eggs were incubated at the facility. Power failures and electrical spiking caused temperature alterations that were responsible for the occurrence of this environmentally induced disease. Mechanical and electrical repairs were made at the hatchery and the problem was resolved. In addition, pumps have been replaced and supplemental oxygen systems installed when needed at the project's acclimation and rearing locations. Some changes in how adults are processed have also taken place. Beginning in 2007, females that were immature at the tail end of the spawning season were injected with Ovaplant® to induce ovulation. The green egg-to-eyed egg survival rates of injected females were measured and found to be similar to those obtained from non-injected fish. This procedure is now routinely used and in some years more than half the females may receive this treatment. Starting in 2010, male and female broodstock were put into separate ponds to reduce handling stress. This is now a standard procedure. Also in 2010, the practice of injecting females with a second dose of erythromycin was instigated in an effort to further suppress the incidence of BKD. Finally, the release date for sub-yearlings at the North Lapwai Valley acclimation site was changed to early May instead of early June to account for unfavorable water temperature and dissolved oxygen conditions the site experiences later in the spring.

C. HSRG and HRT Reviews

The Lyons Ferry and Nez Perce Tribal Hatchery programs were recently reviewed by the HSRG and HRT. Both groups made suggestions for how the programs could be modified. Their recommendations and the proponent's responses to them are presented in the HGMPs (WDFW et al. 2011; NPT 2011) for each project. Both groups suggested that some of the broodstock for the NPTH and LFH should be collected in the Clearwater River to promote spatial and genetic diversity. The HSRG felt this could be accomplished by deploying seines or other non-lethal methods to collect adults. The co-managers, however, felt that such methods would be expensive to employ and also inflict unacceptable amounts of stress and harassment on naturally spawning fish. Currently, plans are underway to establish a weir on the South Fork of the Clearwater which will be used for broodstock collection for the Lukes Gulch and Cedar Flats acclimation sites. In the meantime, the co-managers state that their broodstock selection methods at LGD are providing a diverse source of fish for their program. The HRT recommended that current broodstock trapping and sorting capabilities be improved at LGD. The co-managers agree but emphasize that LGD cannot be used like a weir to regulate the abundance of hatchery and natural origin recruits entering the Snake River Basin. Three reasons were given: 1) the potential harassment of ESA-listed steelhead that are also ascending LGD when fall Chinook are present, 2) lack of infrastructure to hold, sort, retain, and release adult salmonids at the dam, and 3) the potential lethal effects of stress and warm water temperatures on adult salmonids handled at the dam.

The HRT also recommended that escapement goals for fall Chinook should be established for the region between Lewiston and Hells Canyon on the Snake River and for the Clearwater River. They proposed that the number of project fish released into these areas should be correlated with escapement goals. Specific management goals for the Clearwater and the mainstem Snake River below Hells Canyon are being developed by the co-managers. Redd surveys, performed by project personnel, have indicated that the distribution of spawning fish has expanded and that abundance in core spawning areas has increased. Increases in fall Chinook have also been observed in tributary habitat; e.g., in the Clearwater, Grande Ronde, Salmon, and Imnaha Rivers. Given these results, the co-managers are not willing to reduce the number of hatchery fish released by both hatcheries. Nevertheless, future modifications to the Snake River fall Chinook program will have to occur to meet its recovery objectives. These might include increased harvests of hatchery fish in the Snake River, a reduction in number of hatchery fish released, or other options. A fall Chinook recovery plan is being developed by the co-managers and the ISRP assumes that the plan will consider how to balance harvest opportunities with recovery goals.

Another HRT recommendation was to develop harvest goals that are simultaneously linked to current release strategies and to natural origin escapement goals. Managers in the basin have placed a high priority on harvest. However, large returns to the Snake River Basin have just recently occurred and there is a desire to develop and implement a variety of harvest scenarios prior to establishing more specific harvest goals.

The HSRG suggested a BKD control strategy be developed to reduce its prevalence in hatchery fish. Managers feel that prevailing protocols at NPTH and LFH have responded to this recommendation. Before spawning, females are injected with oxytetracycline and erythromycin plus recently spawned eggs are disinfected with iodophor to control disease outbreaks. Moreover, the ELISA standards used at the hatcheries are more stringent than those recommended by the HSRG. BKD appears to be under control at both hatcheries and at their satellite rearing and acclimation locations. Consequently, the HRT recommended discontinuing the preventative use of medicated feed on yearlings reared at acclimation sites. No plans, however, are in place to stop this prophylactic treatment as survival benefits appear to outweigh the risks of using this protocol.

The HRT also suggested the program should consist entirely of sub-yearlings as this would allow more juvenile production. Data collected on returning adults has indicated that yearlings survive at higher rates and contribute more individuals to fisheries than sub-yearlings, though Milks et al. (2013) provide exceptions to this generalization, e.g., Big Canyon. When SAR values were calculated after removing jacks and mini-jack, sub-yearlings had slightly higher survival than yearling releases. Given the greater desire by fishermen for adult salmon, project managers are considering a shift to greater production of sub-yearling versus yearlings (Milks et al. 2013).

A final suggestion from the HRT was to mark or tag 100% of the fish produced by the project. Standing agreements in U.S. v. Oregon have established the numbers and types of marks or tags that project fish will receive. This agreement would have to be revised before any change in marking or tagging frequency can take place. Additionally, a Parent Based Tagging program is underway at Lyons Ferry which will, in theory, identify hatchery fish based on their genetic profiles. Nevertheless, a serious discussion about placing visible marks on 100% of the hatchery juveniles released by all the Snake and Clearwater fall Chinook hatchery programs seems like a worthwhile endeavor. It would help 1) establish the origin of fish used as broodstock, 2) refine estimates of naturally spawning hatchery fish and their spawning ground distributions, and 3) improve the estimates of the proportions and numbers of hatchery fish and natural origin adults making it back to the LGD.

As the Snake River fall Chinook mitigation and supplementation program continues, the ISRP expects that additional infrastructure modifications and procedural changes will occur to meet new challenges. The high survival of juveniles while they are under culture indicates that this is a carefully run hatchery program.

D. Parental Based Tagging

A primary limitation for all fall Chinook analyses is ambiguity when partitioning returning adults into natural- and hatchery-origin components, and assigning hatchery origin estimates to individual projects (Lyons Ferry, FCAP, NPTH IPC; sub-yearling versus yearling). The difficulty arises because only a portion of the released juveniles are tagged or marked. The estimation method currently used is described in the run-reconstruction report. Tagging or marking all hatchery juveniles would solve the dilemma to a large extent, and this has been a recommendation of the HSRG, HRT, and the ISRP (in this review).

Several approaches seem worthwhile. For example, all project fish could be ad clipped and thermal marks could be applied to their otoliths that correspond to hatchery and release origins (Volk et al. 2005). The solution being proposed by the co-managers is the use of parental-based-tagging (PBT). Tissue samples, obtained from all the adults spawned at a hatchery, are used to genotype each fish. Comparable tissue samples from potential adult offspring are collected and similarly analyzed. Pedigree analyses are then performed to determine if a sampled adult fish is the offspring of hatchery parents or is a natural origin recruit. Because hatchery yearlings and sub-yearlings originate from different sets of parents, PBT can be used to identify hatchery adults produced from yearling and sub-yearling releases. Additionally, if juveniles from specific matings are assigned to different release locations the method could also identify adults produced from each release location. It is important to understand that while the methodology is conceptually sound, it remains untested. In the case of Snake River fall Chinook, the ISRP is concerned that genetic similarities between hatchery- and natural-origin population components could reduce the precision of adult origin assignments. NOAA (2012) concludes that there is a substantial likelihood that natural origin individuals are the direct progeny of hatchery-origin individuals. This means both groups may have similar genotypes which could reduce the accuracy of group assignments. The ISRP believes it is important to establish the level of assignment error by crafting appropriate experimental evaluations to assess rates of “false positives” (individuals not belonging to an assignment category, being incorrectly assigned to that category) and “false negatives” (individuals belonging to a category, being assigned to another).

6. Impacts of Hatchery Fish on Wild Fish

A. Non-harvest Impacts

Some of the possible ecological, demographic, and genetic interactions that LFH and NPTH fish might have with wild fish are addressed in the HGMPs for both hatcheries (NPT 2011; WDFW 2011) and in the Snake River fall Chinook BiOp recently released by NOAA (NOAA 2012). The HGMPs covered possible interactions that project fish may have with ESA-listed steelhead, spring Chinook, bull trout, and sockeye salmon. One potential impact the project is expected to have will occur during broodstock collection at LGD. Listed steelhead co-mingle with adult Snake River fall Chinook and some will probably be captured and handled when fall Chinook broodstock are collected. Predaceous and competitive interactions between yearling and sub-yearling project fish, with juvenile spring Chinook, steelhead, bull trout, and sockeye may also occur but are not expected to be significant mainly because of when and where hatchery fish are released, their size at release, and their short tenure in the Snake River. However, the ISRP recommends that field studies be conducted to confirm this assumption. Competitive interactions with natural origin fall Chinook juveniles and other fishes may occur with hatchery sub-yearlings that remain in the river and migrate as yearlings. How important this might be should also be evaluated. Additionally, the possibility of numerical responses, both aggregative and demographic, of potential bird, mammal, and fish predators, due to releases of hatchery fish should be examined. Such responses may be more deleterious to natural origin juveniles because of their longer tenure in the river.

The possible transfer of pathogens from hatchery fish to natural origin conspecifics, and other salmonids, needs further investigation. An overlap in the migration timing of natural origin and hatchery juveniles occurs and both types are known to migrate together through the lower four Snake River Dams. Some of these fish will use bypass systems at the dams. Those that do may be routed directly back into the river. Some, however, may be diverted into holding and loading facilities that are used to collect migrants that will be barged or trucked and later released below Bonneville Dam. Opportunities exist for pathogen transfer at the holding facilities and in barges and trucks. Whether this occurs, and how important it may be, has not yet been determined.

Significant interactions between adult hatchery and natural origin fall Chinook can occur on spawning grounds. Influxes of numerous hatchery fish onto spawning aggregations may increase intra-sexual competition among females for spawning locations and among males for prospective mates. Additionally, high instantaneous spawning densities are known to increase egg retention rates in females and increases in overall spawning density may lead to high rates of redd superimposition. Redd surveys in the Snake River Basin have shown that superimposition does increase with adult abundance. The impact of multiple females, using the same spawning areas, on juvenile production should be evaluated. Results from such evaluations could be used to help establish spawning escapement goals. Relative reproductive studies (RRS) should also be instituted to see if the productivity of natural origin spawning aggregations is reduced because of the presence of hatchery adults. We suspect that RRS would likely reflect ecological rather than genetic issues because genetic data indicate the hatchery and natural populations are presently quite similar, as expected given the high percentage of hatchery fish on the spawning grounds.

B. Harvest Impacts

Commercial and recreational fisheries focused on the project's hatchery fish can depress the abundance of natural origin adults if both types are harvested in the same fisheries. Recruit/spawner (R/S) ratios in hatchery fish are greater than what can be achieved by natural origin recruits because they are protected from significant mortality events during incubation and juvenile rearing. Initially, the principal purpose of the LSRCP fall Chinook program was to mitigate the effects of the lower four Snake River dams on harvest opportunities. Now the program is also being used to supplement and recover fall Chinook in the Snake River Basin. The establishment of self-sustaining, subpopulations of fall Chinook in the basin will only occur if enough natural origin recruits return to their natal areas to reproduce successfully. A balance between harvest and protection of natural origin fish must be realized before the project can achieve both of its goals.

Mixed-Stock Harvest Goals. The LSRCP program has mitigation goals for adult fall Chinook salmon (combined hatchery and natural) returning to the Snake River Basin (18,300 hatchery and natural origin fish) and for harvest in downstream fisheries (73,200 hatchery and natural origin fish). This mitigation goal equates to a harvest rate of 80%. This is an exceptionally high harvest rate target for a stock that includes ESA-listed fall Chinook salmon. An average harvest of 80% is unlikely to be sustainable for any wild Chinook salmon population over the long-term.

Harvest rates in ocean and in-river fisheries have declined in recent decades and are much less than the 80% harvest rate goal. The escapement goal of 14,360 natural origin fish was not achieved until large runs in 2012 and likely in 2013. The minimum viability threshold of 3,000 natural origin fall Chinook salmon in the Snake River Basin has been achieved each year beginning in 2000.

C. Viability of the Natural Population

The increasing abundance of natural origin fall Chinook salmon during the past 15 years and the relatively large runs in recent years might suggest to some stakeholders that the Snake River fall Chinook salmon ESU should be delisted from the ESA. Although abundance is one important and desirable metric for evaluating population viability, productivity (survival) is also a key metric. The natural spawning population must be sustainable without continual supplementation with hatchery fish, if the population is to be deemed viable. The return per spawner, ratio of natural origin Chinook salmon, exceeded 1.0 during only one of the past nine years (brood years 2000-2008), and R/S was typically near 0.5 (Figure 3 below; Cooney 2013). A return per spawner ratio of less than one indicates that the natural run could not sustain itself at that spawning abundance. A key factor contributing to the low R/S is high spawning abundance (>5,000 spawners), which appears to exceed the carrying capacity of the Basin that is still accessible to fall Chinook (Cooney 2013).

The increasing abundance of natural origin adults, returning to the Basin in recent years, appears to be the result of many hatchery fish spawning in the wild (73% of natural spawners are of hatchery origin, on average; Hesse 2013). These hatchery fish produce large numbers of natural origin adults even though their R/S is less than one. Therefore, while the increased abundance of natural and hatchery origin fall Chinook returning to the Snake River Basin has contributed to greater harvests in recent years, the natural run is not likely viable and would probably diminish rapidly if supplementation was to cease.

The fall Chinook supplementation program intentionally encourages hatchery fish to spawn in the rivers as a means to reduce demographic risk of extinction. The Snake River fall Chinook program appears to have reduced this risk. However, given the abundance of hatchery fish on the spawning grounds, an important question for the supplementation program, raised by T. Cooney, NOAA Fisheries, is: “at what point do genetic and ecological risks outweigh demographic benefits, such that hatchery supplementation should be scaled back?” If spawning escapements are found to be exceeding the capacity of the system, then methods for selectively harvesting hatchery fish with less impact on natural origin fish should be considered.

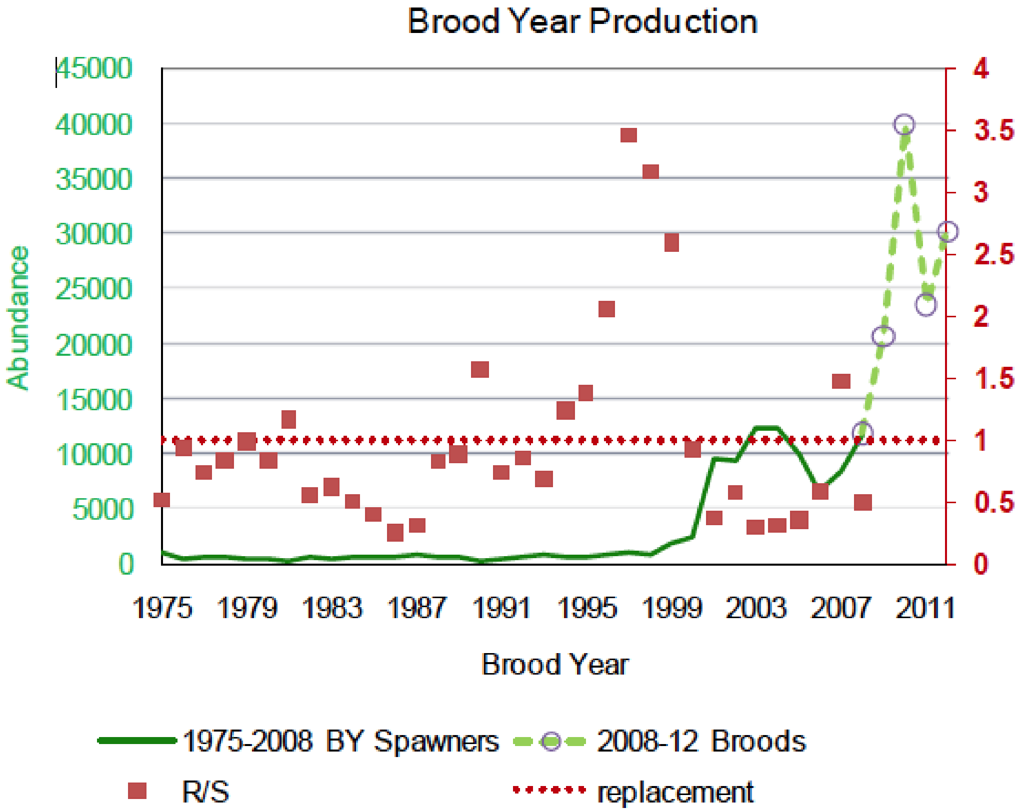


Figure 3. Spawning abundance (green line) and return per spawner (R/S; right Y-axis) of natural Snake River fall Chinook salmon. R/S values below 1 (replacement) reflect a declining natural population. Source: Cooney 2013.

7. Adult Production from Hatchery Programs

A. Adult Abundance above Lower Granite Dam

Data on the number of adults produced by the project returning to LGD from 2004 to 2012 indicated that the NPTH project met its interim goal of providing 2,290 adults above LGD from 2008 to 2012. Moreover, from 2009 through 2012 the long-term project goal of producing 3,750 adults was achieved each year. Similarly, adult return goals from 2009 to 2012 for the LFH programs were met (Table 21). SAR and SAS values for the IPC, LSRCP, FCAP and NPTH programs for broodyears 1994-2007 were calculated by Milks et al. (2014). Both values included jacks. SAS estimates combined Snake River SARs and Columbia River harvest estimates and included all CWT tagged fish regardless of whether they had been adipose clipped or not (Table 22). Milks et al. (2014) state that the SAS values should be regarded as minimums because the potential harvest of unmarked project fish caught in Alaskan and Canadian fisheries have not yet been incorporated into their calculations.

Table 21. Returns of Snake River Hatchery fall Chinook adults and jacks to the Snake River. Returns in bold indicate the years that the in-basin abundance goals were met. IPC – Idaho Power Corporation; LSRCP + FCAP – Lower Snake River Compensation Plan plus Fall Chinook Acclimation Project; NPTH – Nez Perce Tribal Hatchery. (Table from Milks et al. 2014)

	Return Year							
Program A+J	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
IPC subyrl	35	118	895	766	8915	8309	2980	3175
LSRCP subyrl	457	478	2138	2564	**4905**	**4366**	**3310**	**4930**
LSRCP yrl	3418	2615	5927	3544	**11863**	**6548**	**6029**	**3492**
NPT subyrl	153	181	1837	2224	5283	5598	4188	7100
LSRCP FCAP subyrl	3070	1043	2643	3856	**10262**	**10112**	**6479**	**9519**
LSRCP FCAP yrl	803	704	2470	1607	**4726**	**3567**	**3985**	**3346**
Surrogates subyrl	0	106	431	1130	**1459**	**2614**	**2266**	**3024**
Total	7937	5245	16342	15692	47412	41114	29237	34585

Table 22. Average percent (%) Smolt-to-Adult Return (SAR) to Snake River and Smolt-to-Adult Survival (SAS) including Columbia River and ocean harvest estimates from brood years 1994-2007. IPC – Idaho Power Corporation; LSRCP – Lower Snake River Compensation Plan; FCAP - Fall Chinook Acclimation Project; NPTH – Nez Perce Tribal Hatchery. (Table from Milks et al. 2014)

Program	Yearling		Sub-yearling	
	SAR%	SAS%	SAR%	SAS%
IPC	-	-	0.67	1.02
LSRCP	0.94	1.65	0.40	0.60
FCAP	0.33	0.64	0.41	0.59
NPTH	-		0.42	0.54

B. Harvest

The LSRCP presenters provided the ISRP with excellent PowerPoint presentations and written summaries of Snake River fall Chinook harvest management. This summary is largely based on those presentations.

Combined commercial and sport harvests of Snake River fall Chinook averaged 13,303 fish during 2005 to 2012 (Figure 4). These values, which were based on CWT recoveries, include nearly all harvests in ocean fisheries extending from northern California to Southeast Alaska (SEAK) and in-river fisheries downstream of the Snake River. The average harvest, which includes some fish produced by the Nez Perce Tribe and Idaho Power Company, was only 18% of the LSRCP/FCAP goal of 73,200 Chinook salmon. Less than 1% of the total harvest occurs in the Snake River Basin.

Slightly more than 50% of the harvest in recent years occurs in ocean fisheries. This harvest reflects a 30% reduction in harvest rates in ocean fisheries (relative to the 1988-1993 base period) that began in 1996, as required when many Chinook stocks became listed under the Endangered Species Act. For example, exploitation rates on Snake River fall Chinook in ocean fisheries (SEAK to California, including British Columbia) averaged 46% prior to ESA listing in 1992 (1986-1991), and 31% during 1992-2006 (NMFS 2008 PST Agreement). In 2008, an amended Pacific Salmon Treaty led to additional reductions in harvest rate along the west coast of Vancouver Island (WCVI) and in Southeast Alaska. Historically, among harvests north of Washington State, most Snake River fall Chinook had been taken along outer Vancouver Island.

In the Columbia River, Snake River fall Chinook are managed as part of the upriver bright (URB) Chinook stock. URB Chinook include all fall Chinook originating upstream of McNary Dam plus natural origin fall Chinook returning to the Deschutes River. This stock is the largest in the Columbia Basin, averaging approximately 250,000 fish entering the Columbia Basin. Large URB runs occurred in 1987 (420,000 fish) and in 2013 (784,000 fish; WDFW 2014 memo). In 2013, URB Chinook salmon represented approximately 60% of the exceptional return of 1.27 million fall Chinook entering the Columbia Basin. The pre-season forecast for 2014 is 1.6 million fall Chinook salmon, including 973,000 URB Chinook salmon. The fall run forecast would be the largest run since 1938, if it materializes.

Management of the fall salmon fisheries is based on abundance of Chinook salmon beginning August 1. Fishery harvests are adjusted in-season based on updated run sizes and the allowed catch identified in the pre-determined harvest rate schedule for mainstem fisheries. For example, when the expected URB run size (at the Columbia mouth) is <60,000 fish and the Snake River fall natural run is forecasted to be <1,000 fish, then the total allowed harvest rate is 21.5% (of which 93% is allocated to Treaty harvests). If the URB run is >200,000 and the Snake River fall natural run is forecasted to be 5,000 fish, then the total allowed harvest rate is 33.25% (of which 75% is allocated to Treaty harvests). Snake River natural Chinook abundance is a key controlling factor. If the Snake River natural fall Chinook forecast is less than corresponding level of the aggregate URB run size, then the allowable mortality rate is based on the Snake River natural fall Chinook run size.

In these two abundance/harvest scenarios, the spawning escapement of natural Snake River Chinook was expected to range from 784 fish to 3,720 fish, respectively, for the small and relatively abundant salmon scenarios. These managed escapement levels are low compared with the natural origin goal of 14,360 Chinook and the Interior Columbia Technical Recovery Team minimum viability threshold of 3,000 Chinook salmon. Mainstem Columbia harvest rates averaged 32% during 2008-2012. Since 1986, the escapement goal for natural Chinook salmon was met in 2012 and most likely in 2013 (Figure 5). The viability criterion (3,000 fish) has typically been met since 2000.

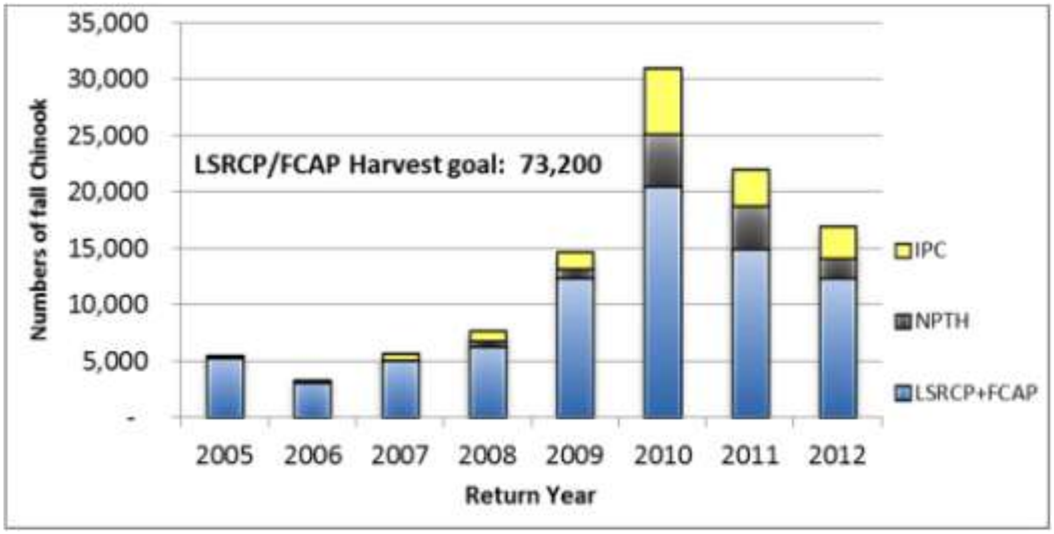


Figure 4. Estimated combined commercial and sport harvest of Snake River Hatchery fish outside of the Snake River basin, 2005-2012. Values include ocean fisheries. IPC – Idaho Power Corporation; LSRCP + FCAP – Lower Snake River Compensation Plan plus Fall Chinook Acclimation Project; NPTH – Nez Perce Tribal Hatchery. Source: Milks et al. 2014.

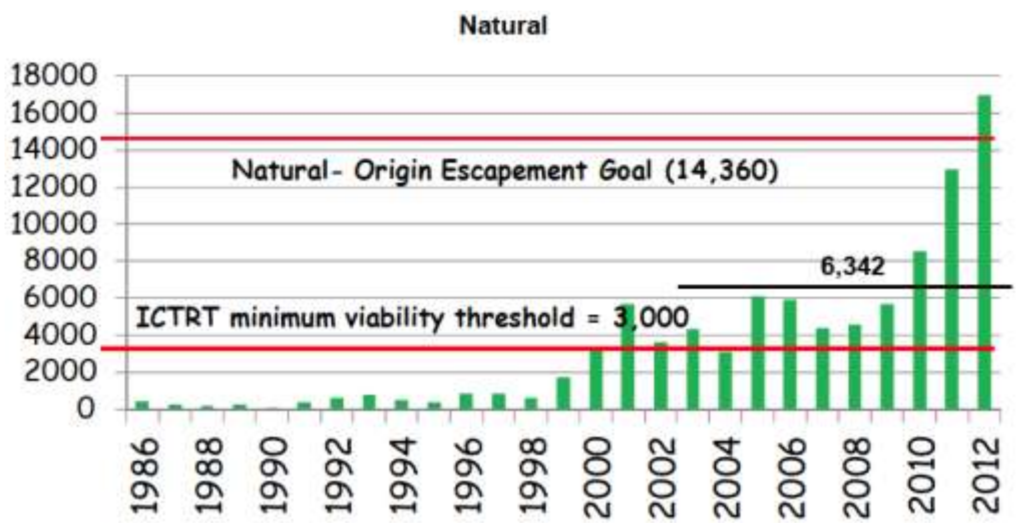


Figure 5. Natural origin returns to Snake River basin relative to natural escapement goal of 14,360 and Interior Columbia Technical Recovery Team minimum viability threshold of 3,000. Harvests of these fish in the Snake River Basin are low, indicating most of the fish contribute to the spawning escapement goal. Source: Hesse 2013.

8. Research, Monitoring and Evaluation

A. Snake River Fall Chinook Salmon Run Reconstruction

Presentation: Run-Reconstruction Adult Abundance, Age Structure (1,798kb), W. Young, D. Milks, S. Rosenberger, B. Sandford, and S. Ellis
Summary: Snake River Fall Chinook Salmon Run Reconstruction

Summary of Findings

The objective of the run reconstruction effort, which was funded by the LSRCP, BPA and IPC, is to estimate abundance and population composition at and upstream of Lower Granite Dam (LGD), e.g., abundance by origin (hatchery, natural), age, and gender. During 2005-2012, run reconstruction involved systematic sampling at Lower Granite Dam, whereby a predetermined fraction of the population was trapped in the fish ladder (9-20% depending on year) then sampled for tags, marks, gender, length, and age (freshwater and marine age from scales). Window counts of salmon were expanded counts from the subsample to reach a total count. Hatchery mark and tag data were expanded as a means to reconstruct natural and hatchery origin abundance.

Abundance estimates. Abundances of natural and hatchery origin Chinook were presented and based on a new run reconstruction approach (subtraction approach). The ten-year geometric mean for natural origin fish was estimated to be 6,342 fish of which 5,323 were considered "adults" (fish spending more than one winter at sea). This abundance level was 2x the interim abundance goal set by the Interior Columbia River Technical Recovery Team. The new reconstruction approach led to ~50% greater overall abundances of natural fall Chinook salmon. The investigators looked for potential bias and reported that the new approach may be overestimating the natural component in response to factors such as lost or missed CWT.

Age and sex composition. The run reconstruction revealed that hatchery Chinook matured at an earlier age (2.8 years) than natural Chinook (3.4 years), as is common. Most of the difference in age resulted from residence in the ocean where natural Chinook spent 0.5 years more, on average. The percentage of natural Chinook spending four years at sea (i.e., big, fecund fish) was ~4%. The percentage of jacks (fish spending only 1 year at sea) was ~55% and 35% for hatchery and natural Chinook, respectively. The proportion of mini-jacks in the hatchery return to the dam was ~13%, i.e., fish maturing without going to sea (note: mini-jack production is higher than this estimate to the extent that some do not migrate below Lower Granite Dam where they are detected and counted as they migrate upriver). The female proportion of total returns averaged only 27% and 34% for hatchery and natural Chinook, respectively.

Hatchery Fraction and Stray Rate. The percentage of the total fall Chinook return represented by hatchery fish averaged 74% during 2000-2012, ranging from a low of 56% in 2005 to a high of 89% in 2009. The percentage of out-of-basin hatchery strays ranged from 0.3% in 2012 to 7% in 2003. Most of the out-of-basin strays originated from the Umatilla and Klickitat rivers. Some stray hatchery fish originated from distant rivers, such as the Elwha River in the Strait of Juan de Fuca and the Trinity River in Northern California. The proportion of natural spawners originating from hatchery releases was not reported, but other investigations suggest it is similar to the ratio recorded at Lower Granite Dam, i.e., near 74%.

Run Timing. Migration timing at Ice Harbor Dam was compared from 1962-1968, when most fish were natural origin, to that during 2008-2012 when most fish were hatchery origin. Migration timing has become about 5 days earlier, on average, and more compressed. Jack salmon tend to return later than “adult” salmon.

Critique and Recommendations

The ISAB (2013-5A) reviewed the fall Chinook run reconstruction as part of the review of NOAA Fisheries life cycle models review (2013-5). Please see comments within the ISAB report. A few additional comments and recommendations are presented here.

The run reconstruction involved two parts: 1) estimating total abundance of fall Chinook salmon returning to LGD dam, and 2) composition of the return. Estimation of total abundance is fairly straight-forward as all returning salmon must swim up the ladder and past a viewing window. Simple adjustments for passage during the night are made when no monitoring of the window is conducted (PIT data show relatively few migrate at night). Some daytime counts are missed due to “technical or logistical problems,” and interpolation is used to estimate missing data. The ISRP recommends reporting of the annual percentage of the run determined by interpolation. If a significant portion of the run is estimated via interpolation, then it may be worthwhile to investigate correlation relationships as a means to estimate missing values. The percentage of the population sampled for origin, age, and gender should be reported.

The run reconstruction summary and presentation provide a detailed explanation of the new process by which the total abundance is apportioned into various components. This is based on a complex apportionment of fish captured by the adult trap on the ladder into various components based on visible marks, known proportions of CWT/PIT in release groups, age/length keys from sub-samples taken for brood stock and/or scale samples. The number of natural origin fish is obtained by subtraction – after removing estimates of hatchery fish from total abundance.

The written description of the process describes an apportionment that seems reasonable. The key assumptions are described, but it is impossible to know if the actual code has implemented the apportionment correctly given the information in the brief summary. Also, the report notes that fallback without re-ascension does not affect the estimated return to LGD, but this could have a significant impact to the estimates of the abundance and composition of spawner escapement above LGD. More information is needed to explain why the current accounting of fallbacks could have a significant effect on spawner escapement above LGD.

Figure 4 (see the report) shows that estimates of natural origin Chinook abundance were ~50% higher when based on the new versus old methodology during 2005-2009. The report should provide information on why the differences are so large. For example, are the differences caused by different assumptions being made in the two methods or are they artifacts because the estimates are imprecise? The report did not describe the old run reconstruction methodology.

One way to potentially validate the new reconstruction method is to create a simulated set of returns (choosing reasonable values for the parameters used to generate these fake data) and then passing these data to the reconstruction team to see if they can reconstruct the simulated dataset. This approach may provide some comfort that the computer code implements the methods correctly, and it may facilitate an evaluation of how sensitive the reconstruction method is to violations of assumptions.

The estimates of natural production in Figure 4 are missing a measure of precision, e.g., a standard error. The reconstruction process is very complex so trying to get a measure via analytical methods is likely not practical, but a relatively straightforward bootstrap should be fairly easy to implement. All composition figures should also have a measure of precision to guide the reader in interpreting how these values change over time.

When comparing age at return of natural versus hatchery origin fish, it was not clear how the chi-square statistics would be computed. The natural origin fish are obtained by subtraction and are apportioned to age based on complex methods. The final numbers cannot be used in the statistical test directly without accounting for this complex process. The data are also pooled over several years, which violate the assumption of a chi-square test. A stratified version of the chi-square is more appropriate, such as the Cochran-Mantel-Haenszel chi-squared test.

When comparing the proportion of females in the natural versus hatchery return, it was not clear if this analysis used a paired t-test (given that sex ratio data were available for each year and a paired test could be used).

Some hatchery Chinook salmon are released with an adipose fin clip but without a CWT. When salmon receive adipose clips, a fraction will have just a portion of the fin clipped. These partially clipped fins can regenerate, and at the adult stage such a fish may be classified as an unclipped natural fish. It was not clear from the brief report whether adjustments were made to account for the proportion of hatchery fish that received partial fin clips (was juvenile sampling conducted at the hatchery?). When relating CWT to untagged CWT-associated fish, why was tag loss, which is usually small but reported by PSMFC, not incorporated into the analysis? Was loss of PIT tags incorporated into the analysis?

Given the issue with error associated with expanded CWT counts, it may be prudent to evaluate whether more accurate abundance estimates could be achieved if a higher fraction of the hatchery population was marked or tagged. The ISRP encourages the use of parentage-based-tagging as discussed in the report, assuming issues can be resolved (see comments on parentage-based-tagging above in section V.5.D.).

Length was sometimes used to identify jack versus adult Chinook salmon. Length is an imprecise measure of jack versus adult salmon because there is considerable overlap depending on year of return, gender, and freshwater life history (yearling or sub-yearling). The ISRP encourages the investigators to use scales or tags to estimate age rather than length whenever possible. Presentation of length-at-age frequency distributions for each gender and freshwater life history type would help identify error associated with the length approach for identifying jacks.

The female proportion of total returns averaged 27% and 34% for hatchery and natural Chinook, respectively. The ISRP recommends that managers consider the relatively low percentage of females among natural origin spawners when developing spawning escapement targets. Male salmon often spawn with multiple females, so female abundance on the spawning grounds, especially older and larger more fecund fish, is key to potential future returns.

The ISRP encourages the investigators to develop and report a brood table for natural origin and hatchery origin fall Chinook. Percentage of natural versus hatchery fish in the spawning population and in the hatchery brood stock should be included in the tables. These tables would facilitate development of spawner-recruitment relationships, which are needed to evaluate viability (R/S) of the natural run. Estimates of mainstem and ocean harvests should be incorporated. Multiple tables might be developed to reflect returns to the Snake River basin, Columbia River mouth, and total return (ocean fisheries).

The run reconstruction group plans to evaluate the data collection methods from earlier years to determine if these methods could be applied, or modified in some way, to account for data collection/handling discrepancies in prior years. The ISRP believes this task is very important.

Editorial comments

There are several references to Figure 6 that likely should refer to Figure 2.

The diagram in the PPT presentation corresponding to Figure 2 shows more clearly how the PIT and other associated counts are removed. The authors might consider replacing the current Figure 2 with a cleaned-up version of the PPT figure.

B. Snake River Fall Chinook Salmon Run Reconstruction as a Basis for Multistage Stock Recruitment Modeling with Covariates

Presentation: Juvenile Life History and Multistage Stock-Recruitment Modeling with Covariates (2,754kb), W.P. Conner, W. Young, R. Perry and K.F. Tiffan

Summary: SRFC Salmon Run Reconstruction as a Basis for Multistage Stock Recruitment Modeling with Covariates

The Independent Scientific Advisory Board (ISAB), sharing many of the same members as the ISRP, evaluated a more detailed documentation of this project as part of NOAA Fisheries' Life Cycle Model compilation (ISAB 2013-5). The ISAB's summary comments are extracted and included below, but the ISAB's detailed, editorial comments are not shown here.

1) Clarity of model goals

The Introduction clearly describes why a two-stage model with covariates (hatchery production or other management actions) that can account for density dependence would be advantageous in assessing the effectiveness of management actions such as supplementation or habitat restoration. This paper describes the methods used to develop the abundance estimates for a two-stage model. The model will partition the life cycle to habitats above and below Lower Granite Dam. The above LGD stage requires reconstruction of the natural origin adult run to estimate the adult return as well as the reconstruction of juvenile passage to estimate the number of smolts produced in the next generation.

2) Soundness of methods and conceptual approach

The text is methodical in taking into account the series of complicating factors that must be considered in reconstructing estimates of natural origin adult and juvenile abundance of fall Chinook at Lower Granite Dam. The figures are helpful, in general, in explaining the conceptual approach for the reconstruction, but the text lacks sufficient detail to evaluate the implementation. For example, the reconstruction of the adult run involves adjusting data on fish passage at LGD to account for less than complete sampling and other artifacts (Figure 5). These expanded counts and information from CWT and fin clips are then used to apportion the adult run into components of natural, hatchery, or unknown origin. While the accounting exercise seems to be carefully thought out, it is presented using a "written description" rather than a set of equations. This makes it difficult to assess if the model is valid as the written descriptions are “approximations” of what was done. The accounting exercise for the juvenile run reconstruction is also presented in general form using written descriptions rather than equations. Again, this makes it hard to audit the model without knowing the internal steps.

More explanation of the equation for estimating collection probability would be useful. For example, it was helpful to read that a decrease in turbine allocation will decrease collection probability because decreased turbine allocation means increased spill. But wouldn’t a decrease in river flow decrease spill, in which case shouldn’t the terms river flow and turbine allocation have opposite signs in the numerator of the equation?

The authors indicate that the reconstructions have been programmed into an Excel spreadsheet. Excel spreadsheets are difficult for performing audits on the model, so the conversion to computer code (see *Last Steps* section) is welcome.

Methods of estimating confidence intervals (p. 23) will use a bootstrap, but it is not clear how all sources of uncertainty will be accounted for in the bootstrapping. For example, how will the proportions of hatchery fish marked with CWTs (used in the expansions) be bootstrapped? How will the missing window counts be bootstrapped? It is also not clear why an estimate of precision is needed when the estimates are used in a future model where process noise may overwhelm sampling noise.

3) Data use, availability, and gaps

It appears that a wide variety of data are used to reconstruct various runs that cannot be measured directly. It is not clear however, which data are most crucial for each step and the relative “confidence” in the various types of data. For example, the actual count in the 50 minutes is likely “correct.” The expansion factors to account for times not sampled depend on accurate recording of when counting is done and not done – how well is this recorded? It would be helpful to create a matrix showing which data are used in which part of the run-reconstruction and the “confidence” in each type of data. If some data have very low “confidence,” this would imply that additional effort should be expended to improve collection of this data type.

Can PIT-tag information be used to help estimate total counts for days with partial or missing daily information as well? For example, is there a relationship between PIT-tag counts and actual window counts that can be used to adjust either count and improve the apportionment? Or are several different relationships needed because of differing fractions of different runs that are PIT tagged?

Some funding (p. 25) was requested for radio tagging work, but it is not clear if this will provide estimates for the most critical parts of the reconstruction model. Some sensitivity analysis of the final model is needed to see which information is most critical for obtaining information about the run reconstruction.

The model as described makes it difficult to incorporate data that only indirectly provides information about the component parts. For example, page 10 describes how missing data on days without window counts will be imputed based on the previous and following two days, but other information, for example from other dams, may also provide information about the missing data. Bayesian methods would be ideal to incorporate multiple sources of information about a particular component.

4) Clarity of descriptions of methods, assumptions, uncertainty, accuracy, and precision

The Introduction and most of the section on reconstructing the adult run are clearly written, but other parts could be improved, especially the section on reconstructing juvenile abundance. For example, the definitions of CH0 and CH1 are confusing – yet critical to understanding the rest of the analysis.

Because details of the bookkeeping are complicated, the text is often difficult to follow in places. If the chapter is intended to document methods and to make them repeatable by others, then equations are needed to provide greater precision. If that requirement is to be fulfilled elsewhere (e.g., through documents available upon request), then the text could be greatly simplified to improve readability and conceptual clarity.

Readability and clarity is also compromised by some missing labeling or explanation in figures (variables and units on y-axes of figures 3 and 4; abbreviations in the flow charts in figures 6-8 that have not yet been defined, e.g., SbyC).

The authors do a commendable job of identifying assumptions and uncertainties, although they do not discuss the implications of these uncertainties or the sensitivity of reconstructed estimates to the assumptions. As noted earlier, it would be helpful to have a matrix showing which data are used in which part of the model and the degree of confidence in each piece of data.

5) Model complexity, usefulness for comparisons, and sensitivity analyses

It is not clear from the report if a more complex model is warranted in place of a pure statistical approach where, for example, counts at LGD are regressed against the final adult counts and this simple relationship is "good enough." Adding complexity does not always improve a model's predictions, especially if the intermediate steps rely on data that is not well known or if the intermediate steps have substantial "noise" in the relationships.

Model outputs or sensitivity analyses are not described – the ISRP hopes that results will be included in the document scheduled for May 2014.

6) Adaptive management

The Introduction sets the stage for future use in adaptive management, but this report only looks at the reconstruction of abundance above LGD (adults and juveniles). Presumably, the modeling below LGD (juvenile to adult) is done elsewhere? Even with this accounting, there is no development of the relationship between adults returning and juveniles produced as a function of program enhancement (e.g., more habitat produced). So this model appears to develop only the inputs to the actual model of interest.

C. LSRCP Hatchery Mitigation

Presentation: SAR and SAS Comparisons (1,492kb), D. Milks, W. Young, J. Hesse and B. Arnsberg
Summary: LSRCP Hatchery Mitigation (944kb)

ISRP Summary of Findings

The report evaluated the LSRCP programs success in meeting its mitigation goals. The mitigation goals are 18,300 fish to the Snake River, plus 18,300 fish for sport harvest, and 54,900 fish for commercial harvest, totaling 91,500 adult and jack salmon. The LSRCP mitigation goal of 18,300 fish returning to the Snake River was met in the last four years (Figure 6), but the harvest goals have yet to be achieved. Nearly all harvests occur downstream of the Snake River. The investigators noted that increased returns during 2008-2012 may be due to the new U.S. and Canada Pacific Salmon Treaty agreement, leading to reduced harvests by salmon trollers off the west coast of Vancouver Island.

LSRCP smolt to adult returns (SARs) during brood years 1994-2007 averaged 0.94% for yearling and 0.40% for sub-yearling fall Chinook salmon. Smolt-to-adult survival (i.e., SAS values that count ocean harvested fish as survivors) during this period averaged 1.65% for yearling and 0.60% for sub-yearling Chinook. The investigators note that these values may be biased somewhat low because some unclipped CWT Chinook may have been underestimated in the mark-selective fishery monitoring.

During brood years 1994-2007, approximately 44% of the returning LSRCP fall Chinook salmon were harvested in ocean and Columbia River mainstem fisheries. Only 0.3% of the return was harvested in the Snake River Basin. FCAP Chinook experienced similar exploitation rates (45%), but the Idaho Power Company (IPC) and Nez Perce Tribal Hatchery (NPTH) harvest rates were much lower (20-26%, respectively). The investigators noted that this observation needs further evaluation.

Survival (SAR) of yearling Chinook to the Snake River was typically higher than survival of sub-yearling Chinook at each release site, except Big Canyon where survival of sub-yearling fish was higher. However, if jack salmon are excluded, then survival of sub-yearling salmon was higher. This pattern reflects the larger proportion of jack salmon produced by yearling releases and the fact that jack salmon experience less risk of mortality at sea because they mature early. There is a desire among the co-managers in the basin to move the program away from yearling production and towards greater sub-yearling production, as a means to reduce mini-jack and jack production and to increase “adult” production. Older/larger “adult” Chinook salmon are more desirable to anglers. The agencies are investigating numbers of sub-yearling releases needed to offset the contribution of yearling releases to the fisheries.

Critique and Recommendations

This report provides important summary results about survival of hatchery fall Chinook salmon, including harvests in the ocean and mainstem river. The observed higher production of “jack” salmon by yearling versus sub-yearling releases highlights the need to use actual age composition rather than length when reconstructing fall Chinook salmon abundances at Lower Granite Dam (see above comments on run reconstruction report). The ISRP encourages the investigators (and hatchery programs) to review ongoing research by Don Larsen (NOAA Fisheries) and colleagues on hatchery rearing approaches (e.g., feeding history) that may reduce production of jacks and mini-jacks while increasing production of “adult” salmon. If more hatchery fall Chinook salmon are to be released as sub-yearling versus yearlings, then age and scale patterns of returning fish should be examined to identify the proportion of sub-yearling releases that hold-over in freshwater for a year. PIT-tagged fish may also be used to identify holdovers. Potential competition with natural fall Chinook by these holdovers should be evaluated. Mini-jack production should be included in the evaluation since they do not contribute to fisheries and they may compete with native fishes and sneak-mate with female fall Chinook. The investigators should identify a target goal for production of adult, jack, and mini-jack production.

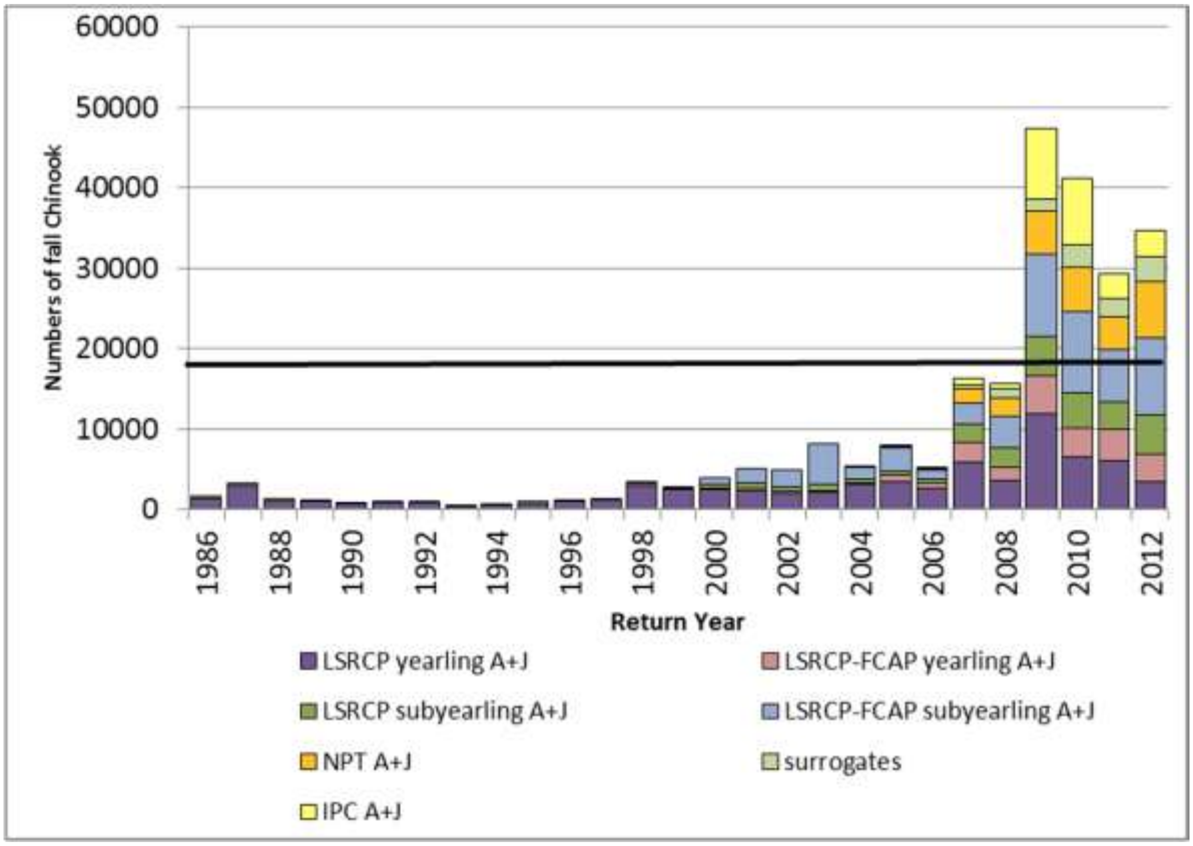


Figure 6. Estimated numbers of Snake River hatchery fall Chinook returns to the Snake River, 1986-2012. Black line represents the in-basin mitigation target of 18,300 fish. IPC – Idaho Power Corporation; LSRCP + FCAP – Lower Snake River Compensation Plan plus Fall Chinook Acclimation Project; NPTH – Nez Perce Tribal Hatchery

D. Acclimation Enhances Post-release Performance

Presentation: Acclimated vs Direct Release, S. Rosenberger, W.P. Connor, C.A. Perry, D.J. Milks, M.L. Schuck, J.A. Hesse, and S.G. Smith
Summary: Acclimation Enhances Post-release Performance

Background

The possible use of direct releases of sub-yearlings to assist the supplementation and recovery of fall Chinook in the Snake River basin mentioned in the Lyons Ferry Hatchery HGMP (WDFW et al. 2011) was being considered as a management strategy for a number of reasons. First, newly implemented rearing density criteria for fall Chinook at LFH will reduce the number of juvenile fall Chinook that the hatchery can rear unless some of the fish are transferred out of the hatchery's rearing ponds as sub-yearlings. Second, under existing Fall Chinook Acclimation Program protocols sub-yearlings from LFH are transferred to acclimation sites only after yearlings have been released. Thus, sub-yearlings are typically placed into their acclimation sites in late May and are released after a three-week acclimation period in late June. Fish released at this time of year may face challenging environmental conditions such as low flow rates and warm water temperatures. Direct releases could be made without such logistical restraints. Instead, fish at optimal sizes and health could be released under favorable flow and river temperature regimes. And third, acclimation sites are expensive to create and maintain; by comparison direct releases are a cost effective option. Yet, the value of this approach may be limited if physiological stresses caused by the procedure reduce the immediate or long-term survival of fish experiencing such a release.

A study was designed by the USFWS, NPT, and WDFW to compare the migration rates and survival of sub-yearling fall Chinook released from acclimation sites to those undergoing direct releases (WDFW et al. 2011). The study, which ran from 2005 to 2010, compared sub-yearlings released from the Captain John Rapids acclimation site to hatchery sub-yearlings that were transported from the hatchery and released directly into a nearby Snake River location. A recently published paper by Rosenberger et al. (2013) presents results obtained from the last three years of the study. They compared 1) the downstream migration rates of acclimated hatchery sub-yearlings, directly released sub-yearlings, and naturally produced sub-yearlings; 2) the arrival timing of these three groups of juveniles to Lower Monumental Dam; and 3) the survival of directly released and acclimated sub-yearlings to Lower Monumental Dam. Data collected on naturally produced fish were used to determine if direct or acclimated release methods affected how long hatchery and wild fish may interact with one another in the Snake River. Interactions between hatchery and naturally produced fall Chinook juveniles will likely be limited in riverine habitats because of different habitat preferences. In reservoirs, however, concentrations of both types of fish may occur. Rosenberger et al. (2013) suggest that migrating hatchery fish may induce early migration in wild fish due to the so called "pied piper" effect and engage in competition for preferred feeding locations or directly compete for food. Additionally, as the fish migrate past dams some will travel down bypasses and be routed to raceways where they will be collected and loaded onto barges or trucks. The transmission of pathogens and the likelihood of physical aggression between hatchery and wild fish may be increased if both are held and transported together. Thus, dam passage dates of wild and hatchery fish can reflect the potential level of interaction these fish experience during migration (Rosenberger et al. 2013).

Methods

PIT-tagged fish were used to estimate the migration rates and arrival timing to Lower Monumental Dam by the three types of juveniles. Survival rates of direct release and acclimated hatchery sub-yearlings were also estimated by PIT tag detections at the dam. No survival estimates were made for natural origin fish. Hatchery fish receiving both release treatments were tagged at Lyons Ferry Hatchery prior to placing some of the fish into the Captain John Rapids acclimation site. Natural origin fish were captured and tagged over a prolonged period of time so that the full extent of their migration period over Lower Monumental Dam could be documented. Migration rates were determined by dividing the channel distance between a fish's release point by the elapsed time between its release and detection at Lower Monumental Dam. Differences in mean migration rates among each hatchery release type and that observed for natural fish were ascertained by subtracting the mean migration rate of natural fish from the mean migration rate of a hatchery release type. The difference was divided by the mean migration rate of natural origin fish. The quotients equaled percent differences in migration rates. The likelihood of direct interactions between fish from a hatchery group and natural fish decreases as the percent difference in their migration rates increases. Arrival timing at Lower Monumental Dam was another factor used to estimate the probability that direct interactions between natural fish and fish originating from different hatchery release types would encounter and interact with one another. The arrival dates of fish from each group were assembled into frequency distributions. Then the amount of overlap between the distribution for natural fish and the distributions for each hatchery release type were calculated. The greater the amount of overlap the more likely the two types of fish would interact with one another. Three survival comparisons between the two types of hatchery fish were performed, one for each release year. The length distributions of the fish at the time of tagging were incorporated into these analyses to account for any affect size may have had on survival.

Results

Acclimated hatchery sub-yearlings had faster migration rates than direct release sub-yearlings during each of the three study years. Annual percent differences in the migration rates of acclimated fish compared to natural migrants were also greater than those observed on direct release fish. Additionally, the detections for acclimated fish at Lower Monumental Dam were less protracted than those for direct release and natural origin juveniles. The combination of greater migration speed and compact arrival dates at Lower Monumental Dam meant that the amount of overlap in the migration timing of acclimated juveniles with natural fish was less than that observed for direct release fish. Acclimated fish also survived to Lower Monumental Dam at higher rates than direct release fish. Annual reports for the FCAP project state that releases from their acclimation sites are made at night. When direct releases during the Rosenberger et al. (2013) study were made is not mentioned. Some of the survival differences seen between direct release and acclimated fish might have occurred if direct releases occurred during daylight hours. However, the hour of release would not significantly influence migration rates or arrival dates to Lower Monumental Dam.

Discussion and Conclusions

Three reasons are provided to help explain the differences observed between acclimated and direct release fish. First, acclimated fish could have been larger at release than direct release fish and such a size differential could explain observed variances in survival and migration characteristics. Second, a pond is used to acclimate and rear fish at the Captain John Rapids location. Natural features in the pond, including lower rearing densities, may give fish a survival advantage over conventionally reared fish after release into the natural environment. And third, direct release fish experience stress at collection, transport, and release. Acclimated fish experience lower levels of stress, and this may enhance their swimming speed and stamina. Regardless of what might be causing differences between acclimated and direct release fish, the study indicates that fish released from acclimation sites survive at higher rates and will have fewer interactions with wild fish than those that are directly released. However, the apparent higher survival rates of acclimated fish may simply be indicative of how rapidly they migrated to Lower Monumental Dam. Comparisons should be made between the daily survival rates of fish directly released and those freed from acclimation sites.

The ISRP agrees with the authors' three recommendations for future work. Their first recommendation was that further investigation is needed to determine how hatchery and wild fish interact in large river reservoirs, like those caused by the Lower Snake River Dams. The authors were largely concerned with the possible effects of interactions between natural origin juveniles and hatchery fish when both types were simultaneously present in the same habitats. However, the presence of hatchery juveniles in reservoirs prior to the arrival of natural origin juveniles may also affect the survival of natural origin fish. Hatchery juveniles could reduce available food and also support and attract predators. These possibilities should be investigated. The authors also recommended that the physiological, immunological, and pathogenic responses of wild sub-yearling fall Chinook subjected to transport by barge or truck need to be investigated. This work would help quantify the effects of mixing wild and hatchery fish together while being artificially transported. Their third recommendation was that fish used in the study could be used to determine if the early survival advantage achieved by acclimated fish persists to the adult stage. Continuing this evaluation to ascertain how acclimation and direct release strategies influence survival to the adult stage, homing /straying, and contributions to fisheries would produce valuable information. The cost effectiveness of each type of release should also be considered by the co-managers.

The LSRCP is not required to evaluate the effects of hatchery fish on natural populations. It was established to produce hatchery fish for harvest mitigation purposes. Nevertheless, LSRCP personnel and their partners have begun such efforts. This work should be expanded to include how artificial production of fall Chinook influences the survival and productivity of the basin's steelhead, spring/summer Chinook, sockeye, bull trout, and coho salmon. Finally, the ISRP commends the authors for publishing this well-conceived study. Its results will provide important guidance to managers when they consider the role that direct and acclimated releases should play in the recovery and supplementation of Snake River fall Chinook.

E. Snake River Fall Chinook Salmon Age and Size at Return: Then and Now

Presentation: Age and Size at Return, W. Young, D. Milks, M. Schuck, and B. Arnsberg
Summary: Snake River Fall Chinook Salmon Age and Size at Return: Then and Now

ISRP Summary of Findings

The investigators compared historical demographic parameters in Snake River fall Chinook to more recently gathered data to examine whether 1) the proportions of fish $\geq$57 cm returning to the Snake River had changed over time, 2) the length frequency distributions of contemporary fish were comparable to those measured on natural origin (NOR) fish returning to the river in 1976, 3) length-at-age in hatchery and NOR males and females had changed from what was observed during 1984-1987, 4) the age at maturity had changed from what was observed in 1984-1987, and 5) the number years fish reared at sea had changed over time during 1984-1987. Snake River fall Chinook salmon were mostly natural origin prior to the start of hatchery program in 1980.

The investigators state that the scarcity of long-term data hampered their ability to investigate changes in age and size especially for natural origin fish. Using available data they concluded that the proportions of fish $\geq$57 cm (i.e., an estimate of so called “adult” salmon) had not changed from what it had been historically. When they compared length frequencies of natural origin fish sampled in 1976 at Little Goose Dam to lengths obtained from natural origin fish sampled at Lower Granite Dam in 2005-2006 they found no discernible differences in female length frequencies. But there seemed to be a higher proportion of smaller males in 2005-2006 than in 1976.

Length-at-age of hatchery origin broodstock collected during 1984-1987 was compared with hatchery and natural origin Chinook captured in 2008-2010. Separate comparisons were made for yearling and sub-yearling Chinook salmon. Slight variations in size at ocean age were observed, but overall sizes were similar for historical and contemporary hatchery fish. There was some indication that contemporary natural origin fish were longer than contemporary hatchery fish at a given age (e.g., among 2-salt to 4-salt sub-yearling migrant Chinook) but the analyses were not conclusive. Statistical tests were not performed on the limited datasets.

Age composition of hatchery Chinook salmon was reported for brood years 1984-1987 and 1994-2004; data were not available for natural origin returns. Average ocean age of both sub-yearling (~2.5 to 1.8 yrs) and yearling Chinook salmon (~1.6 to 1.4 yrs) decreased over time. This pattern was related to ~100% increase in jacks (i.e., ~20% to 40% of the population for both migrant types) and a ~50% decrease in fish spending three years at sea. Sub-yearling

Chinook produced approximately twice the percentage of Chinook spending three winters at sea, i.e., relatively old fish.

Throughout the report the investigators stress that the results should be viewed with caution. Multiple factors, such as hatchery influence, size-selective fisheries, and limited data availability, may have confounded the evaluations. They state that larger data sets encompassing a greater number of years would be required to fully evaluate whether demographic changes have occurred to Snake River fall Chinook.

Critique and Recommendations

The investigators provided the ISRP with a good PPT presentation and summary narrative of what is known about Snake River fall Chinook salmon age and size at return. Monitoring demographic traits such as size and age at maturity of hatchery populations to determine if they are changing from the original population is an essential part of a hatchery evaluation plan (Hard 1995; Goodman 2005; Knudsen et al. 2006). These data are important because greater size typically implies greater reproductive potential. Length at age and age at maturity are influenced by both population genetic characteristics and environmental conditions, including factors that affect body growth. However, an important finding for Snake River fall Chinook salmon is that changes in key salmon population metrics cannot be evaluated unless there is a robust monitoring effort each year. Unfortunately, basic fisheries data (length-at-age, age composition, hatchery or natural origin) were not collected until recently, therefore significant questions about supplementation effects on natural salmon are difficult to examine at this time. The investigators recognize these limitations.

The ISRP recommends that the investigators continue to collect length at age by gender and stock origin (hatchery and natural). Estimates of “adult” salmon based on length is worthwhile to the extent that this metric has been collected for many years, but new data collection must use accurate age determination methods such as scales, otoliths, and tags in order to improve data accuracy. Aging techniques should be validated with tagged fish. Types of data collected on fish spawned at the Lyons Ferry Hatchery and other hatcheries should be expanded to include egg mass weight, egg size, fecundity, relative fecundity[10] and gonadosomatic index

[10] Relative fecundity represents the number of eggs per unit change in body weight. It is calculated by dividing a female's fecundity by her total weight including eggs. It is often expressed as eggs/kilogram of body weight.

values. Additionally, the influence of yearling and sub-yearling life histories on ocean age of maturing salmon should continue to be monitored and evaluated for both hatchery and natural origin salmon. These data will provide metrics for assessing the effects over time of the hatchery program on Snake River fall Chinook salmon.

When evaluating trends related to fish size and age, it would have been worthwhile to provide sample size on the figures.

F. Snake River Fall Chinook Redd Surveys: A Summary of 22 Years (1991-2012)

Presentation: History and Status of Snake River Fall Chinook Redd Surveys (7,092kb), P. Grove, B. Alcorn and B. Arnsberg
Summary: Snake River Fall Chinook Redd Surveys: A Summary of 22 Years (1991-2012) (4,353kb)

For the past 22 years, annual fall Chinook redd surveys have been conducted in the Snake, Clearwater, Grande Ronde, Imnaha, Salmon and Tucannon Rivers. Surveys are done by foot in the Tucannon while aerial methods are used in the other rivers. In the Snake, underwater video is also used to detect redds located in deep water portions of the river. The surveys, which take place throughout the spawning season are being performed to 1) enumerate the number of fall Chinook redds present in the Snake River basin, 2) define habitat characteristics associated with fall Chinook spawning areas including velocity, substrate, and water depth, 3) determine the temporal and spatial distribution of fall Chinook spawning in the Snake Basin, and 4) identify areas in the river where redds may be susceptible to dewatering due to hydropower operations. Temporal and spatial data were also collected on spawning fall Chinook. It was found that fish returning to the Clearwater River start spawning in late September while fall Chinook returning to other portions of the basin start spawning in mid-October. The peak spawning period for all the populations, however, is in early November and spawning typically ends during the first week of December. Additionally, the distribution of fall Chinook throughout the basin has remained fairly constant since the surveys were started. Approximately 54% of the fish spawn in the Snake River, 27% in the Clearwater, 10% in the Tucannon, 8% in the Grande Ronde, 2% in the Imnaha, and 1% in the Salmon River. Little variation was seen in the percentage of fish using deep and shallow spawning habitats; about 70% of the redds are consistently found in shallow water areas.

Results of this work have shown that redd numbers increase with adult escapement above LGD. However, with increasing abundance the redd-to-adult relationship has tended to plateau. The data may be interpreted to suggest that there is a limitation in the available area for redds, i.e., that spawning habitat is limited. However, the co-managers contend that this is unlikely for several reasons. First, with increasing adult abundance it also becomes more difficult to make accurate redd counts. This occurs because gravel disturbance in high density spawning areas makes it challenging to distinguish individual redds. Also later arriving females may superimpose redds on existing ones, again making it difficult to differentiate one redd from another. Second, environmental measurements made in spawning areas showed that fall Chinook may spawn in locations that have water depths up to 10 meters and velocities as high as 2.1 m/s. Models based on these observed habitat preferences were developed to estimate the number of redds that could be established in the Snake River. The most recent model predicts that the redd capacity for fall Chinook in the Snake River is approximately 4,500 with 3,000 of those being in shallow water with an additional 1,500 situated in deep water areas (Groves et al. 2013). The greatest number of redds counted in the Snake River since the inception of the LSRCP has been 2,944 – about 1,500 below its theoretical maximum. Thus, it does not appear to Groves et al. that the adult carrying capacity for the Snake River has been reached if predictions from the model are close to reality. This issue needs more investigation. Whether or not spawning habitat is being saturated, as Figure 2 suggests, is an important question, as saturation would indicate that supplementation could be inhibiting natural production. Although the investigators contend that it is not, the program should continue to be concerned about the possibility. As numbers of spawners increase with increases in population, it is important to document how the spawners will spread out onto the spawning areas spatially and temporally. Those patterns may change with the total number of spawners and with the numbers of spawners on the spawning grounds at a given time, which will affect rate of superimposition. The ISRP notes that other data suggest the capacity of the river to support fall Chinook salmon may have been exceeded in recent years given the low return per spawner (<1; when spawning abundance has increased (Figure 3 above; Cooney 2013)).

Would it be feasible to sample redds for evidence of superposition mortality or of dewatering mortality (redds are deep and dewatering of the river bed may not affect embryos, especially post hatch)? Fry per redd censuses of putatively superposed redds could reveal spawner density effects on fry production. It is also important to understand how the density issue depicted in some of the slides will translate to numbers of emigrants by age and to returns.

Does the term "adult escapement" as used in the written summary include jack males? It seemed that it did in that there were 1.5 males per female. Would this analysis be more effective by just including females, especially since the jack percentage varies annually?

The possibility of counting redds by using small unmanned air systems (sUAS) or drones is being explored and deserves further investigation. The development of new robotic technology for these surveys promises higher quality, less expensive data for the future. Such devices would allow for more frequent surveys which could increase the accuracy of redd counts in these remote areas. They can also be programmed to fly specific routes at standard heights helping to further reduce counting errors. They provide obvious safety advantages over the traditional use of helicopters. It would be desirable to confirm, and compare, the reliability of the drone-generated data versus that from other methods. Does variation in the water level and clarity each year affect redd counts?

In general, this program seems on track and has produced a number of peer-reviewed publications. Possible future information needs the program may wish to address include 1) estimating the degree of redd superimposition at different adult abundance levels, 2) assessing whether superimposition significantly reduces juvenile production, 3) determining the distribution and abundance of hatchery origin adults on spawning grounds, and 4) relating redd counts and potential superimposition estimates to natural origin returns.

G. Spatial Structuring of an Evolving Life-History Strategy under Altered Environmental Conditions

Presentation: Understanding Juvenile Life History Trade-offs Using Otolith Microchemistry and Stage Structured Modeling (3,245kb), J.C. Hegg, B.P. Kennedy, P.M. Chittaro, and R.W. Zabel
Summary: Spatial Structuring of an Evolving Life-History Strategy Under Altered Environmental Conditions (2,955kb)

A core spawning area for Snake River fall Chinook salmon was in a 49-km stretch of the river close to Marsing, Idaho (Connor et al. 2005). Stream temperatures and productivity in this portion of the upper Snake River allowed the fish to grow rapidly and migrate to the ocean as sub-yearlings (Connor et al. 2002). After the Hells Canyon dams were completed in the 1950s and 60s, Snake River fall Chinook no longer had access to this section of the river. Spawning and rearing locations that were still available had cooler temperatures during incubation and were less productive. An exception to this general tendency was habitat in the upper Snake River adjacent to the Hells Canyon dams. This region has water temperatures and productivity characteristics similar to those that existed at the Marsing site.

In 1992, when Snake River fall Chinook were listed under the Endangered Species Act, it was assumed that all fall Chinook juveniles produced by the basin entered the Columbia River estuary as sub-yearlings. Subsequent field work revealed that some spent their first winter in Snake or Columbia river reservoirs before migrating to the sea as yearlings (Connor et al. 2005). Two factors were hypothesized to be responsible for the expression of the yearling life history strategy. One was that the relatively cool water regimes and low productivity found in many of the currently accessible spawning areas slowed down development and growth. Second, early growth was further affected by releases of cool waters from Dworshak Reservoir which along with releases of cool water from reservoirs located above Hells Canyon decreased water temperatures the fish experienced while rearing in the Lower Granite Dam reservoir. The combined effect was to reduce growth and cause some of the fish to delay their seaward migration (Connor et al. 2005).

One of the objectives of the Hegg et al. (2013) paper was to determine if natal spawning and rearing locations influence the frequency of the yearling life history strategy in Snake River fall Chinook. To address this question, the authors collected water samples in regions of the Snake River basin where fall Chinook salmon spawn and rear to determine if different areas possessed distinct $^{87}Sr/^{86}Sr$ ratios. This seemed likely as the Snake River Basin is geologically complex, containing Mafic, Felsic, sedimentary, carbonates and metamorphic rocks. Each rock type has its own characteristic profile of minerals and elements. Mafic rocks, for example usually contain heavier elements such as magnesium and iron. Felsic rocks, on the other hand, have a lower percentage of heavier elements and are typically enriched with silicon, oxygen, aluminum and potassium. Results of water chemistry analyses showed that different regions of the Snake River basin possessed identifiable $^{87}Sr/^{86}Sr$ ratios. This information was used to group the parts of the basin available to fall Chinook into four separate regions, each with its own distinctive $^{87}Sr/^{86}Sr$ ratio. One included the Clearwater and Salmon rivers (CWS). Another was the upper Snake (USK) region that represented the free flowing river between Hells Canyon Dam and the confluence of the Salmon River. The third region referred to as the lower Snake (LSK) started at the confluence of the Salmon River and stretched downstream to the beginning of the impounded portion of the river near the mouth of the Clearwater River. The last region represented the Grande Ronde, Tucannon, and Imnaha Rivers (TGI).

Salmonid otoliths continually incorporate soluble elements and thus provide a history of the water chemistry a fish has encountered during its life cycle. A variety of mass spectrometry tools have been used to reveal the chemical composition of otoliths. Hegg et al. (2013) chose a multi-collector inductively coupled plasma mass spectrometer coupled with a laser ablation sampling system (LA-multi collector ICPMS). This combination gave them the ability to quantify isotopic ratios and, via laser ablation, ascertain changes in elemental and isotopic composition in specific regions of the otoliths they examined. Otoliths from 120 natural origin adult fall

Chinook salmon collected at Lower Granite Dam and spawned at Lyons Ferry Hatchery were collected and analyzed. Data from specific regions of each otolith were used to determine 1) entry age into saltwater, 2) natal or incubation location, 3) freshwater rearing location, and 4) if the fish used the yearling strategy where it overwintered. They found the proclivity to adopt the yearling strategy was affected by a fish's natal location. Fish incubated in the Clearwater had the highest probability of employing this strategy while those incubated in the Upper Snake were the least likely to produce yearlings. They also discovered that juveniles rearing in the Upper Snake or Tucannon/Grande Ronde/Imnaha regions rarely if ever became yearlings. Conversely, 58% of the juveniles rearing in the Lower Snake River and 76% in the Clearwater used the yearling strategy.

These results showed that otolith microchemistry has the power to retrospectively provide important life history information. One of the challenges the LSRCP fall Chinook program has faced is the identification of fish produced from its hatchery programs. Although many project fish are tagged or marked significant numbers have been released without marks or tags. The authors suggest that the inclusion of isotopic ratios from additional elements detected in otoliths could be used to identify hatchery fish and also further refine their assignments of natal origin, rearing, and overwintering locations for natural origin fish. The ISRP agrees. Isotopic data on a suite of elements are collected when using LA-multi-collector ICPMS. Fish produced from the Lyons Ferry Hatchery may be particularly apt targets for microchemistry identification. The HGMP (WDFW et al. 2011) for Lyons Ferry Hatchery revealed that the wells supplying the facility have high concentrations of dissolved manganese and that iron is also present. Their occurrence could provide a unique chemical signature to fish incubated and reared at the hatchery. This possibility could be tested by collecting otoliths from known Lyons Ferry hatchery adults and comparing their chemical signatures with those obtained from fall Chinook incubated at the NPTH or other known locations using methods similar to those described by Hegg et al. (2013).

A main thesis of the Hegg et al. paper is that environmental conditions precipitated by dams in the Snake River Basin have led to the rapid development of a novel yearling strategy in Snake River fall Chinook. It is quite possible, however, that the strategy existed historically and its recent prevalence is due to conditions favoring its expression in parts of the Clearwater and Snake Rivers. There is an ongoing debate about what proportions of sub-yearling and yearling hatchery juveniles should be released by the LSRCP and NPTH. Results from this study could be used by managers to make adjustments to these ratios at different release locations. Survival comparisons, for instance, between hatchery yearlings and sub-yearlings released from upper Clearwater acclimation sites could shed further light on this question (see Milks et al. 2013).

The authors used otoliths collected from fish assumed to be of natural origin at the Lyons Ferry Hatchery. Because significant portions of hatchery fish are not marked, it is possible that some of their samples originated from hatchery origin adults. The natal location of these fish would have been identified as the lower Snake River. This might help explain why the natal location for a number of the fish sampled was identified as the lower Snake River. Nonetheless, the study clearly indicated that fish produced from the Clearwater were the predominant source of individuals that migrated as yearlings. If possible, the ISRP recommends that otoliths from natural origin adults spawning in different portions of the Snake River basin be recovered and analyzed. Results could be used to buttress conclusions in the present study or provide new insights into regions of the basin that are prone to produce yearling smolts.

Literature Cited

Bugert, R., P. LaRiviere, D. Marbach, S. Martin, L. Ross, and D. R. Geist. 1990. Lower Snake River Compensation Plan Salmon Hatchery Evaluation Program. 1989 Annual Report. USFWS, LSRCP, Boise, Idaho.

Connor, W. P., H. L. Burge, R. Waitt, and T. C. Bjornn. 2002. Juvenile life history of wild fall Chinook salmon in the Snake and Clearwater rivers. North American Journal of Fisheries Management 22: 703–712.

Connor, W.P., J.G. Sneva, K.F. Tiffan. R.K. Steinhorst, and D. Ross. 2005. Two alternative juvenile life history types for fall Chinook salmon in the Snake River basin. Transactions of the American Fisheries Society 134:291-304.

Goede, R.W., and B.A. Barton. 1990. Organismic indices and an autopsy-based assessment as indicators of health and condition in fish. Pages 93-108 *in* S.M. Adams, editor. Biological indicators of stress in fish. American Fisheries Society, Symposium 8, Bethesda, Maryland.

Goodman, D. 2005. Selection equilibrium for hatchery and wild spawning fitness in integrated breeding programs. Canadian Journal of Fisheries and Aquatic Sciences 62:374-389.

Groves, P.A., J.A. Chandler, B. Alcorn, T.J. Richter, W.P. Connor, A.P. Garcia, and S. Bradbury. 2013. Evaluating salmon spawning habitat capacity using redd survey data. North American Journal of Fisheries Management 33:707-716

Ham, K.D., and T.N. Pearsons. 2001. A practical approach for containing ecological risks associated with fish stocking programs. Fisheries. 26:15-23

Hard, J. 1995. Genetic monitoring of life-history characters in salmon supplementation: problems and opportunities. Pages 212-225 *in* H.L. Schramm, Jr. and R.G. Piper editors. Uses and effects of cultured fishes in aquatic ecosystems. American Fisheries Society, Symposium 15, Bethesda, Maryland.

Hesse, J. 2014. Lower Snake River Compensation Plan 2013 Snake River fall Chinook program review summary and future direction. 2013 LSRCP fall Chinook Symposium, Clarkston, Washington 17p.

Hegg, J.C., B.P. Kennedy, P.M. Chittaro, and R.W. Zabel. 2013. Spatial structuring of an evolving life-history strategy under altered environmental conditions. Oecologia 172:1017-1029.

HSRG. 2004: Hatchery Scientific Review Group: Mobrand, L. (chair), J. Barr, L. Blankenship, D. Campton, T. Evelyn, T. Flagg, C. Mahnken, R. Piper, P. Seidel, L. Seeb, and W. Smoker. 2004. Hatchery reform: Principles and Recommendations of the HSRG. Long Live the Kings, 1305 Fourth Avenue, Suite 810, Seattle, WA 98101 (available from www.hatcheryreform.us).

HSRG. 2009. Hatchery Scientific Review Group: Paquet, P. (chair), A. Appleby, J. Barr, L. Blankenship, D. Campton, M. Delarm, T. Evelyn, D. Fast, T. Flagg, J. Gislason, P. Kline, G. Nandor, L. Mobrand, and S. Smith. 2009. Report to Congress on Columbia River Basin hatchery reform.

ISAB. 2003. Independent Scientific Advisory Board: Review of salmon and steelhead supplementation. ISAB 2003-3. Northwest Power and Conservation Council, Portland, Oregon. www.nwcouncil.org/fw/isab/isab2003-3

ISAB. 2013. Independent Scientific Advisory Board: Review of NOAA Fisheries' life-cycle models of salmonid populations in the Interior Columbia River Basin (June 28, 2013 draft). ISAB 2013-5. Northwest Power and Conservation Council. www.nwcouncil.org/fw/isab/isab2013-5

Milks, D. and B. Arnsberg. 2014. Adaptive Snake River broodstock management: Snake River fall Chinook. 2013 LSRCP fall Chinook Symposium, Clarkston, Washington. 10p.

Milks, D, A. Grider, and M. Schuck. 2011. Lyons Ferry Hatchery evaluation fall Chinook salmon annual report: 2009. U.S. Fish and Wildlife Service Lower Snake River Compensation Plan Office, Boise, Idaho. (http://www.fws.gov/lsnakecomplan/Reports/WDFW/Eval/2009%20LFH%20EvalFallChnk%20AR.pdf)

Milks, D, A. Grider, and M. Schuck. 2012. Lyons Ferry Hatchery evaluation fall Chinook salmon annual report: 2010. U.S. Fish and Wildlife Service Lower Snake River Compensation Plan Office, Boise, Idaho. (http://www.fws.gov/lsnakecomplan/Reports/WDFW/Eval/2010_LFH_EvalFCH_AnnualReport_FINAL.pdf)

Milks, D, A. Grider, and M. Schuck. 2013. Lyons Ferry Hatchery evaluation fall Chinook salmon annual report: 2011. U.S. Fish and Wildlife Service Lower Snake River Compensation Plan Office, Boise, Idaho. (http://www.fws.gov/lsnakecomplan/Reports/WDFW/Eval/2011_FCH_AnnualReport%20(1).pdf)

Milks, D.A., W. Young, J. Hesse, W. Arnsberg. 2014. LSRCP hatchery mitigation: Snake River fall Chinook. 2013 LSRCP fall Chinook Symposium, Clarkston, Washington. 14p.

Marshall, A. R., and M. Small. 2010. Evaluating relative reproductive success of natural and hatchery-origin Snake River fall Chinook salmon spawners upstream of Lower Granite Dam. Project 2003-060-00, Contract 00048811. Final Report. Bonneville Power Administration, Portland, Oregon.

Nez Perce Tribe. 2011. Nez Perce Tribal Fish Hatchery Snake River fall Chinook Hatchery Genetic Management Plan (HGMP), Lapwai, Idaho. 155p

NOAA. 2012. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation. Snake River Fall Chinook Salmon Hatchery Programs, ESA section lO(a)(l)(A) permits, numbers 16607 and 16615. 166p.

Oregon Department of Fish and Wildlife and the Confederated Tribes of the Umatilla Indian Reservation. 2010. Hatchery and genetic management plan: Umatilla fall Chinook program. 70p.

Paquet. P.J. and 15 others. 2011. Hatcheries, conservation, and sustainable fisheries - achieving multiple goals: results of the Hatchery Scientific Review Group's Columbia River Basin Review. Fisheries 36:547-561.

Pearsons, T.N., G.A. McMichael, K.D. Ham, E.L. Bartrand, A.L. Fritts, and C.W. Hopley. 1998. Yakima species interactions studies progress report 1995-1997. Submitted to Bonneville Power Administration, Portland Oregon (DOE/BP 64878-6).

Pearsons, T.N. and C.W. Hopley. 1999. A practical approach for assessing ecological risks associated with fish stocking programs. Fisheries. 24(9):16-23.

Pearsons, T.N., G. Temple, M. Schmuck, C. Johnson, and A. Fritts. 2002. Yakima River species interactions studies. Project No. 1995-06424. BPA Report DOE/BP-00004666-9. 73 electronic pages.

Piper, R.G. 1972. Managing hatcheries by the numbers. Am. Fishes and U.S Trout News 17:25-26.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board Canada 191:1-382.

Rosenberger, S., P. Abbott, and J. Chandler. 2014. Idaho Power Company's fall Chinook salmon hatchery program. 2013 LSRCP fall Chinook symposium, Clarkston, Washington. 8p.

Rosenberger, S.J., W.P. Connor, C.A. Peery, D.J. Milks, M.L. Schuck, J.A. Hesse, and S.G. Smith. 2013. Acclimation enhances post release performance of hatchery fall Chinook salmon subyearlings while reducing the potential for interaction with natural fish. North American Journal of Fisheries Management 33:519-528.

Schuck, M. 2014. Snake River fall Chinook: A primer 1900-1975. 2013 LSRCP fall Chinook Symposium, Clarkston, Washington. 9p.

Volk, E.C., S.L. Schroder, and J.J. Grimm. 2005. Otolith thermal marking. Pages 447- 463 *In* S.X. Cardin, K.D. Friedland, and J.R. Waldman (eds) Stock Identification Methods, Elsevier Press.

Washington Department of Fish and Wildlife, Nez Perce Tribe, Idaho Department of Fish and Game, and Oregon Department of Fish and Wildlife. 2011. Snake River Stock Fall Chinook Lyons Ferry Hatchery, Fall Chinook Acclimation Program, and Idaho Power Company. Hatchery and Genetic Management Plan (HGMP). 330p.