Independent Scientific Review Panel

Summary of ISRP Reviews of Steelhead and Spring and Fall Chinook Salmon Programs of the Lower Snake River Compensation Plan

ISRP Summary Review of the LSRCP 2011- 2014

ISRP 2014-6
June 18, 2014

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

Authors and contributors to the three ISRP reviews of the LSRCP programs

Current 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 (ISRP chair).

Dennis Scarnecchia, Ph.D., Professor of Fish and Wildlife Resources, University of Idaho, an expert in large river fisheries population dynamics, and salmon, trout and char.

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.

Past ISRP and Scientific Peer Review Group contributors

All three reviews

Eric J. Loudenslager, Ph.D., Hatchery Manager and Adjunct Professor of Fisheries Biology, Humboldt State University, California, an expert in genetics and fish culture

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

Steelhead and Spring Chinook reviews 2013 and 2011

Colin Levings, Ph.D., Emeritus Research Scientist and Past Section Head Marine Environment and Habitat Science Division, Department of Fisheries and Oceans, Canada.

Spring Chinook review 2011

Peter A. Bisson, Ph.D., Senior Scientist at the Olympia (Washington) Forestry Sciences Laboratory of the U.S. Forest Service's Pacific Northwest Research Station.

Charles Henny, Ph.D., Emeritus Research Scientist at the U.S. Geological Survey in Corvallis, Oregon, an expert in wildlife and environmental toxicology.

Katherine Myers, Ph.D., Principal Investigator of the High Seas Salmon Research Program at the School of Aquatic and Fishery Sciences, University of Washington.

Thomas P. Poe, M.S., Consulting Fisheries Scientist, an expert in behavioral ecology of fishes, formerly with the U.S. Geological Survey.

Bruce Ward, Fisheries Scientist, formerly with the Ministry of Environment, Aquatic Ecosystem Science Section, University of British Columbia, Vancouver, B.C., Canada.

Richard Williams, Ph.D., Affiliated Research Scientist, Center for Salmonid and Freshwater Species at Risk, University of Idaho, an expert in population and evolutionary genetics, ecology.

Staff

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

ISRP Summary Review of the LSRCP 2011- 2014

Contents

ISRP Summary Review of the LSRCP 2011- 2014

Executive Summary

This report summarizes the Independent Scientific Review Panel's (ISRP) review of the Lower Snake River Compensation Plan's (LSRCP) three hatchery programs. The ISRP completed a review of the spring Chinook program in 2011 (ISRP 2011-14), the steelhead program in 2013 (ISRP 2013-3), and the fall Chinook program in 2014 (ISRP 2014-4). The reviews were requested by the Northwest Power and Conservation Council and U.S. Fish and Wildlife Service.

Scientific foundation: The ISRP found that the LSRCP's hatchery programs for steelhead and spring and fall Chinook salmon are largely consistent with the scientific foundation, artificial production strategy, and artificial production principles contained in the Council's Fish and Wildlife Program. Each hatchery program has objectives, including targets for broodstock abundance, egg-to-smolt survival rates, smolt size-at-release, and contributions to fisheries and, in the case of supplementation programs, to natural spawning populations. Adequate monitoring and evaluation programs are in place to ascertain if these objectives and outcomes are realized. Data produced from project experiments are being used to refine how fish are reared, released, and identified. Interactions between hatchery and wild fish are being examined, and methods used to estimate the survival and contribution of project fish to fisheries and natural spawning populations are being employed and refined. Data gaps have been identified, and program activities designed to address these issues are either underway or planned in the future. The hatchery programs have provided substantial fish and wildlife benefits. These have ranged from preventing extinction of natural populations via supplementation and captive broodstock programs to providing valuable recreational and commercial fishery opportunities. Materials presented at symposiums and associated reports covering LSRCP activities demonstrated that the cooperators are dedicated, innovative, and collaborative. The ISRP compliments them for their fine technical performance.

In-hatchery performance standards for broodstock abundance, pre-spawning survival of broodstock, egg-to-smolt survival, and numbers of released smolts were established for many of the LSRCP hatcheries. Currently, adequate numbers of broodstock are being collected, and mortality prior to spawning has been low. While under artificial culture, fish will experience some mortality during incubation and rearing. Since 1995, egg-to-smolt survival rates in hatcheries have averaged 84% for steelhead and 70 to 80% in Chinook. These high survival rates are indicative of well-run hatchery programs. Goals for smolt size at release have been set, and with some exceptions, the hatchery programs have met these objectives. Each hatchery is programmed to release a fixed number of smolts. Over the past decade, LSRCP hatcheries for spring Chinook, steelhead, and fall Chinook reached their juvenile release goals 36%, 60%, and 70% of the time, respectively. Failure to reach release goals occurred for a variety of reasons, including the desire for reduced rearing densities and greater size at release. In a few instances, water shortages and scarcity of broodstock also limited fish production.

Post-release performance of hatchery fish was evaluated by examining survival of smolts from release to Lower Granite Dam, calculating smolt-to-adult survival prior to removal from fisheries (SAS) and smolt-to-adult return (SAR) to Lower Granite Dam. Additionally, the number of recruits produced per fish spawned (R/S) was estimated along with harvest numbers and frequency of straying. The survival of smolts to Lower Granite Dam varied from one year to the next but typically ranged from 60 to 70%. Standards for SAS and SAR rates were established for the steelhead and Chinook hatchery programs. Considerable annual variation in SAS and SAR values was observed. Substantial differences in these values occurred among hatcheries rearing the same type of fish; however, they tended to increase or decrease in a synchronous fashion. Consequently, survival of smolts to the adult stage appears to be shaped by conditions the fish experience in the mainstem and ocean. To be self-sustaining, a hatchery needs on average to consistently achieve R/S values that are equal to or greater than 1, and this has been accomplished by all the hatcheries in LSRCP program. One of the primary objectives of the LSRCP was to restore fisheries in areas below and above the project area. Harvest goals for the ocean and mainstem Columbia River originally envisioned for the LSRCP have never been reached. Lower than expected SAS values and the need to constrain fisheries to protect Endangered Species Act (ESA)-listed species are largely responsible. Nevertheless, the hatchery programs have significantly increased the total abundance of spring and fall Chinook and steelhead, and thus the programs have contributed to important commercial and recreational fisheries.

Potential demographic, ecological, and genetic impacts of the hatchery programs were assessed. Chinook reared in hatcheries produced more early maturing males and fewer older maturing fish than wild counterparts. Age data were collected over time on hatchery and natural populations of spring Chinook, and no identifiable trend toward an increasing number of younger fish was detected in either group. This result suggests that changes in age observed in hatchery populations were mainly caused by environmental conditions the fish experienced during artificial culture. Nevertheless, naturally spawning hatchery fish influence the age structure of natural populations because they currently represent a high proportion of natural spawners. The ISRP encourages LSRCP cooperators to continue to test and evaluate changes in age structure, including genetic linkages, and its effect on productivity. The migration timing of adult hatchery and natural-origin salmon and steelhead was examined and found to differ in some projects.

New research is examining the spawning distribution of hatchery and natural-origin fish in streams; some hatchery fish formed spawning aggregations adjacent to release locations. Straying of hatchery fish was evaluated annually, and it varied by year and species. In a few cases, straying percentages for project steelhead to out-of-basin watersheds exceeded 20%. After this degree of straying was identified, the LSRCP implemented a number of strategies, including the use of endemic broodstocks and the wide-scale use of acclimation ponds, which reduced the incidence of straying. However, transport of juveniles in barges around the dams remains a key factor contributing to the straying of steelhead. Potential interactions between juvenile hatchery and wild fish were considered and some protocols have been implemented to minimize disease transmission and the possible occurrence of competitive and predaceous interactions.

The effects of supplementation on adult abundance and productivity of natural populations are also being investigated. Results of these studies have been mixed. Spring Chinook supplementation programs have increased the total abundance of spawners in their rivers (hatchery plus wild) but have not produced an increase in natural-origin adults. Fall Chinook supplementation has likely contributed to the recent increases in natural-origin fish abundance in the Snake River Basin, but the productivity of the natural-spawning population remains very low. Clear evidence for density dependence has been observed in supplemented populations, especially in spring Chinook, and this ecological response may inhibit desired increases in abundance and productivity. In fall Chinook, there has been a marked increase in natural-origin fish, and it is reasonable to believe that a number of these represent the progeny of naturally spawning hatchery fish. For logistical reasons, assessing the role of supplementation versus improvements in survival and harvest reductions is not complete. Additional research is needed to understand how genetic and environmental factors, including habitat restoration, affect the consequences of supplementation on natural populations. The LSRCP's supplementation programs offer important opportunities for such work.

Monitoring and evaluation programs established by the LSRCP have allowed its three hatchery programs to make informed changes to hatchery infrastructure, broodstock sources and collection locations, mating protocols, and rearing and release procedures. Ongoing refinements to run reconstruction procedures are helping to quantify harvest numbers and to estimate natural escapements of project fish. Parentage based tagging will be used in the future to identify all the hatchery steelhead and spring and fall Chinook produced by the LSRCP. Accurate identification of hatchery origin fish will allow additional refinements to 1) the contribution rates of hatchery and natural origin fish to harvests and spawning escapements and 2) estimates of natural origin productivity and abundance.

After Snake River spring and fall Chinook and steelhead were listed by the ESA, the LSRCP recognized the need to assist in the recovery of these species in addition to meeting original program objectives. The ISRP encourages the LSRCP to continue collaborative efforts with ESA recovery planning while also providing the harvest opportunities originally sought by the LSRCP. Overall, the hatchery component of the LSRCP is scientifically sound. It has established goals, quantitative targets, and objectives for research, monitoring, and evaluation. Finally, as indicated above, it has demonstrated the ability to be managed adaptively as new challenges develop.

I. Introduction

The ISRP recently completed a review of the current status and progress of the LSRCP. This review was facilitated by three symposiums organized by the U.S. Fish and Wildlife Service for spring/summer Chinook (November 30 through December 2, 2010), steelhead (June 20-21, 2012) and fall Chinook (August 6-7, 2013). The ISRP produced species-specific reviews based on information presented at the symposiums, project summaries prepared for the ISRP reviews, and discussions at the symposiums among program managers, researchers, decision makers, and the ISRP (ISRP 2011-14, 2013-3, and 2014-4). The report presented here, a synthesis of ISRP findings, describes substantial progress made by the LSRCP in terms of increasing abundance and harvests of salmon while also identifying key challenges facing the program at present and in the near future.

II. Background: Lower Snake River Compensation Plan[1]

In 1945 Congress authorized the construction of four dams on the lower Snake River, and funds to build the dams were appropriated in 1954. The dams were built from 1961 to 1975. Adult fish ladders and some other minor modifications to the dams were funded to alleviate impacts the dams were expected to have on Snake River salmon and steelhead. The U.S. Fish and Wildlife Service, National Marine Fisheries Service, and state agencies evaluated the need for additional mitigation for fish and wildlife losses due to the construction and operation of the Snake River dams. This assessment described the immediate and anticipated long-term impacts of the four dams. The report was provided to the Army Corps of Engineers in 1972, and the Corps used it to produce the Lower Snake River Compensation Plan (LSRCP) which was submitted to Congress in 1975. A year later the LSRCP was authorized by Congress as part of the Water Resources Act of 1976.

An important part of the LSRCP called for the design and construction of fish hatcheries to compensate for losses of adult steelhead and Chinook salmon returns to the Snake River associated with the construction and operation of the four lower dams. To mitigate for estimated losses, in an "in kind and in place" manner, the hatcheries were distributed throughout the Snake River Basin. Construction of the first facility was completed in 1980 and the last hatchery was built in 1991. The overall size of the hatchery programs was determined

[1] Information and text for this overview were obtained from: 1) LSRCP web site www.fws.gov/snakecomplan/aboutus.html, 2) invitations to the LSRCP spring and summer Chinook and steelhead symposiums, 3) Herrig D. 1998. Lower Snake River Compensation Plan Background. 6 pp. 4) Marshall, S.L. 2010. A brief history of the Lower Snake River Compensation Plan hatchery program for spring and summer Chinook. 6 pp., 5) Marshall, S.L. 2011. A brief history of the Lower Snake River Compensation Plan program for steelhead. 10 pp. 6) Johnson, B. 2013. Snake River fall Chinook synergy and hatchery program overview. 7 pp. 7) Hesse, J.A. 2013. Lower Snake River Compensation Plan 2013 Snake River fall Chinook salmon program review summary and future directions. 17 pp., and 8) Milks, D, W. Young, J.A. Hesse, and B. Arnsberg. 2013. LSRCP hatchery mitigation Snake River fall Chinook. 14 pp.

by using a three-step process. First, the numbers of adult Chinook and steelhead migrating back to the Snake River prior to dam construction were estimated. Next, the numbers of steelhead and Chinook adults lost because of the dams were estimated. And lastly, catch to escapement ratios of 4:1 for Chinook and 2:1 for steelhead were employed to estimate foregone losses in commercial and recreational fisheries due to dam-related mortality. It was assumed that fisheries below the four dams would continue as they had in the past, and thus adult return goals were based on adult escapements to the project area. Harvest goals for fish, produced by the LSRCP, were also established for each species. Once these goals had been determined, expected smolt-to-adult return rates were used to calculate the number of smolts that the hatcheries would have to release to achieve desired adult run sizes. The plan recognized that adults escaping to the project area would be used as hatchery broodstock. No other priorities for these fish were mentioned in the enabling legislation or supporting documents.

The mitigation goal established for spring/summer Chinook (hereafter referred to as spring Chinook) was to return 58,700 adult fish above Lower Granite Dam after providing 234,800 adults to fisheries in the ocean and Columbia River. Spring Chinook for the LSRCP are reared at six hatcheries and acclimated and released at eight other satellite facilities. In aggregate, the production goal for the hatcheries is 6.75 million smolts. For steelhead, a mitigation goal of 55,100 adult fish returning back to the project area was established after downriver harvests of 37,000 and 73,200 steelhead by commercial and recreational fishermen, respectively. The program was projected to generate 130,000 angler days of recreational fishing. Juvenile steelhead are reared in five hatcheries and acclimated and released at 11 satellite facilities. The smolt production goal for this species was originally set at 11 million but was subsequently reduced to 5.35 million. The spring Chinook and steelhead hatcheries are owned by the U.S. Fish and Wildlife Service which also administers the LSRCP. State, federal, and tribal fish and wildlife agencies, in the region, operate the facilities and evaluate program success.

The Fish and Wildlife Service, Nez Perce Tribe, Idaho Power Company, Washington Department of Fish and Wildlife (WDFW), Oregon Department of Fish and Wildlife (ODFW), Idaho Department of Fish and Game (IDFG) and other partners have joined to create a well-integrated program for fall Chinook. This program has a mitigation goal of 18,300 adults above the project area. The fall Chinook program is also expected to contribute 54,900 adults to ocean and lower Columbia River commercial fisheries and another 18,300 adults to recreational fisheries. Two hatcheries and ten satellite facilities are used to rear, acclimate, and release project fish. Release goals of 900,000 yearling and 4.6 million sub-yearling smolts were established for this program.

Major unforeseen factors have impacted the LSRCP since it was authorized in 1976. First, smolt-to-adult survival rates (SAS) for natural Chinook and steelhead populations have been less than originally projected, leading to listing Snake River spring and fall Chinook as threatened under the Endangered Species Act in 1992. Steelhead were listed as threatened in 1997. The need to reduce harvest rates in mainstem Columbia River fisheries, to protect natural-origin fish, caused a higher proportion of the annual hatchery runs to return to the project area than projected at the time the program was authorized. Finally, the United States v. Oregon court-stipulated

Fishery Management Plan established specific hatchery production agreements among the states, tribes, and federal government. This agreement diversified the steelhead and Chinook hatchery programs by adding new off-station release sites and stocks designed to meet short term conservation objectives. The effect has been to change the LSRCP from a strict harvest mitigation effort to one that supplements and conserves natural populations as well as provides harvest opportunities.

An internal review of the LSRCP's hatchery programs occurred in 1998, and the ISRP reviewed 26 LSRCP proposals in 2002 as part of the Columbia Plateau, Blue Mountain, and Mountain Columbia provincial reviews (ISRP 2002-6). New developments and scientific advances have occurred since then. For example: (a) new information is available regarding the roles that hydrosystem operations, barging of smolts, predation, climate and ocean conditions play in determining SAS rates,[2] (b) a new Columbia River Fishery Management Plan[3] was approved to guide harvest and production through 2017, (c) an updated Biological Opinion[4] for the Federal Columbia River Power System was approved to guide system operations and offsite mitigation, and (d) two scientific reviews (Hatchery Scientific Review Group[5] and Hatchery Review Team[6]) were conducted of LSRCP hatchery programs.

III. ISRP Review Charge, Criteria, and Approach

ISRP review charge: The ISRP was created by the 1996 amendment to the 1980 Northwest Power Act and instructed by the U.S. Congress to review projects proposed for funding by the Council through BPA's fish and wildlife budget. 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 was directed to review the reimbursable program projects using the same criteria as used to review projects in the Council's Fish and Wildlife Program and to *"make any recommendation that the Panel considers appropriate to make the project, program, or measures meet the criteria."*

ISRP review criteria: The ISRP is directed by Congress to evaluate whether projects 1) are based on sound scientific principles, 2) benefit fish and wildlife, 3) have clearly defined objectives and outcomes, and 4) have provisions for monitoring and evaluation of results.

---

[2] Williams et al. 2005. Effects of the Federal Columbia River Power System on Salmonid Populations. NOAA Tech. Memo., NMFS-NWFSC-63

[3] U.S. v. Oregon 2010 – 2017

[4] See 2010 Supplemental Biological Opinion for the 2008 FCRPS Biological Opinion

[5] HSRG 2009 – Columbia River Basin system-wide review: www.hatcheryreform.us

[6] HRT: U.S. Fish and Wildlife Service (USFWS). 2011. Hatchery Review Team, Pacific Region. U.S. Fish and Wildlife Service, Portland, Oregon. Available at: http://www.fws.gov/Pacific/fisheries/hatcheryreview/reports.html

ISRP retrospective review: The 1996 amendment also directs the ISRP to conduct a retrospective review of project accomplishments. The Council's 2009 Fish and Wildlife Program directs 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 ISRP's reviews of the three LSRCP programs are retrospective evaluations of the collective fish and wildlife benefits produced from individual LSRCP projects. In addition to the Council's request, the Fish and Wildlife Service was 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.

ISRP hatchery review approach: The approach used by the ISRP to review the LSRCP stems from previous hatchery reviews directed by Congress and implemented through the Fish and Wildlife Program (NWPCC 1999-4, 1999-15, 2004-17, 2005-11) and the Hatchery Scientific Review Group (HSRG 2004, 2009[7]). These reviews established a scientific framework for implementing and evaluating hatchery programs. Independent reviews have also provided guidance on specific monitoring and evaluation metrics and analyses consistent with this scientific framework (ISAB 2000-4, ISRP/ISAB 2005-15, ISRP 2008-7).

Assessing hatchery programs requires information and performance measures for fish culture practices in three areas: 1) inside the hatchery, 2) for hatchery-produced fish after release, and 3) the effect 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, to understand how practices in the hatchery influence post-release survival and performance, to create post-release survival standards for harvest management, and to estimate quantitative benefits and risks to natural populations.

Consequently, in the review of the LSRCP programs, the ISRP evaluated whether the written reports and presentations adequately addressed the following questions:

1) How are the project fish performing in the hatchery?
2) How are hatchery juveniles performing once released?
3) What are the demographic, ecological, and genetic impacts of the programs on wild fish?
4) How are the programs being modified to achieve objectives?

[7] HSRG 2004: Hatchery Scientific Review Group: Mobrand, Lars (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.

IV. ISRP Findings, Conclusions, and Recommendations[8]

Results of Past LSRCP Reviews

In its review of LSRCP proposals in 2002, the ISRP found that, in general, the set of proposals, augmented by responses, demonstrated that the LSRCP program was implemented in a scientifically sound manner. However, the ISRP noted that in most years the LSRCP's hatchery program and mitigation efforts had not met goals for harvest, adult returns above Lower Granite Dam, broodstock, and juvenile production. The ISRP also agreed with the conclusions reached in an internal review made by the LSRCP in 1998, that the abundances of Snake River hatchery and natural origin spring and fall Chinook and natural steelhead were precarious. As a result, some of the production-oriented programs envisioned in the authorization legislation for the LSRCP were changed to supplementation and conservation efforts due to the depressed status of the natural stocks.

Additionally, ISRP members expressed uncertainty about whether the sum of the work presented in the proposals they reviewed would produce scientifically sound programs. They questioned whether the programs would suffer from redundancy and possibly from a lack of standardized protocols and procedures for data acquisition and analysis. They wondered if the introduction of hatchery fish would cause deleterious effects on wild fish production. It was also recognized that the LSRCP was subject to multiple Congressional mandates. The primary mandate was to produce fish via artificial culture to mitigate for the effects of the four lower Snake River dams. After Snake River Chinook and steelhead were listed for protection under the ESA another primary facet of the LSRCP was to protect and recover ESA-listed Chinook and steelhead. It was not clear how these and other mandates would be coordinated, not just within the LSRCP, but also across the Snake River Basin. The ISRP suggested that many of their questions and concerns could be addressed if the LSRCP were to hold a symposium on its projects so that all parts of the program could be presented, discussed, and evaluated at one time.

[8] This summary of Findings, Conclusions, and Recommendations is based primarily on the following documents plus materials provided to the ISRP as a result of the LSRCP Symposiums on Spring Chinook (Nov-Dec 2010), Steelhead (Jun 2012) and fall Chinook (Aug 2013). 1) ISRP. 2002-6. Lower Snake River Compensation Plan: Final proposal review for the Columbia Plateau, Blue Mountain and Mountain Snake Provinces. 24pp. 2) Schuck, M. 2010. 2010 LSRCP Spring/Summer Chinook Symposium: Symposium summary. 36pp. 3) Marshall, S. 2010. LSRCP response to ISRP Report 2011-14. 4pp. 4) Leth, B. 2012. LSRCP steelhead program review symposium: Roll-up presentation. 15 pp. 5) Hesse, J.A. 2013. Lower Snake River Compensation Plan 2013 Snake River fall Chinook salmon program review summary and future directions. 17 pp. 6) ISRP. 2011-14. Review of the Lower Snake River Compensation Plan's spring Chinook program. 69 pp. 7) ISRP. 2013-3. Review of the Lower Snake River Compensation Plan steelhead program. 73 pp. and 8) ISRP. 2014-4. Review of the Lower Snake River Compensation Plan fall Chinook program. 112 pp.

LSRCP Symposiums in 2010, 2012, and 2013

General Conclusions

As described above, the ISRP's reviews were organized around three LSRCP symposiums – one for spring Chinook in 2010, a second for steelhead in 2012, and a third for fall Chinook in 2013 – resulting in three ISRP reports (ISRP 2011-14, 2013-3, and 2014-4). To complete the reviews, the ISRP considered presentations and reports generated for the symposiums, annual project reports, hatchery genetic management plans, and peer-reviewed papers originating from LSRCP projects.

The information generated from the symposiums indicated that the LSRCP programs for Chinook and steelhead were typically consistent with the scientific framework and artificial production principles contained in the Council's Fish and Wildlife Program. Data produced from project experiments are being used to refine how fish are reared, released, and identified. Interactions between hatchery and wild fish are being examined, and methods used to estimate the survival and contribution of project fish to fisheries and natural spawning populations are being employed and refined. Data gaps have been identified, and program activities designed to address these gaps are planned for the future. Significant fish and wildlife benefits have also been derived from each project. These have ranged from preventing extinction of natural populations via supplementation and captive broodstock programs to providing valuable recreational and commercial fisheries. Each program has objectives for broodstock abundance, origin and survival, egg-to-smolt survival rates, smolt size-at-release, and contributions to fisheries. Monitoring and evaluation is conducted to ascertain if these objectives and outcomes are being realized. The adequacy of existing monitoring and evaluation methods has been assessed, and improvements to these procedures have periodically occurred.

The LSRCP has contributed to the abundances of natural origin salmonids in the Snake River Basin, especially fall Chinook, but productivity of the natural populations continues to be low. A continuing challenge for the Program will be to further integrate the LSRCP with ongoing recovery efforts for spring and fall Chinook and steelhead, all of which are ESA-listed.

The symposiums and reports demonstrate that the LSRCP cooperators are dedicated, innovative, and collaborative. The ISRP compliments them for their fine technical performance. The ISRP also believes the data, evaluations, and conclusions provided by the LSRCP programs are applicable beyond the Columbia River Basin and Pacific Northwest. LSRCP cooperators are encouraged to use their program summary reports and presentations as foundations for scientific papers that assess within hatchery and post-release performance of project steelhead and Chinook.

Specific Comments and Conclusions

The major emphasis of recent ISRP reviews of the LSRCP is to assess in-hatchery and post release performance of project fish. This report's appendix provides tabular performance summaries for each steelhead and Chinook hatchery in the LSRCP program. Data in the tables should be regarded as snap-shots taken at the time of the ISRP reviews. Additionally, symposium presentations and reports, and annual project reports were reviewed to ascertain what is currently known about possible demographic, genetic, and ecological effects of project fish on natural origin salmonid populations in the Snake River basin. A final point of interest is to see how the programs have been modified and whether these modifications have helped to achieve project goals.

In-Hatchery Performance

Performance standards for various aspects of the LSRCP hatchery programs have been established. Some minor differences in the standards exist among the spring Chinook, steelhead, and fall Chinook hatchery programs. Four standards were established for the spring and fall Chinook programs: broodstock abundance, pre-spawning mortality of broodstock, egg-to-smolt survival, and number of smolts released. Only two in-hatchery standards were universally assessed in steelhead hatcheries: egg-to-smolt survival and smolt release numbers. These last two indicators, which were measured in all the hatchery programs, encompass within-hatchery performance. By themselves, however, they cannot be used to determine the causes and timing of mortality while eggs and juveniles are under artificial culture. Scientifically based adjustments to hatchery practices are not possible without such knowledge. The HGMPs and annual reports for the hatchery programs, however, indicate that additional survival and growth data are routinely collected on eggs and fish as they progress from one life history stage to the next. Performance standards should be established for each of these life history stages, for example, green egg-to-eyed egg, eyed-egg-to-fry, and so forth. These new standards would allow managers to ascertain discrepancies between expected performance and observed project values. If observed values are lower than accepted standards, specific problem areas can be identified, making it possible to improve existing conditions. Conversely, if performance exceeds a standard, it may provide an opportunity to export successful methods to other parts of the program. Additionally, if it does not already exist, the ISRP recommends that in-hatchery performance metrics for fish cultured in LSRCP hatcheries be imported into a centralized database where data from all of the hatcheries could be housed and made available to the cooperators.

Broodstock Collection and Survival: Adequate numbers of broodstock are typically collected for the spring Chinook mitigation hatcheries and for the spring Chinook supplementation programs that have been in operation for a number of years. Some recently implemented spring Chinook supplementation programs have had difficulty in acquiring broodstock due to low numbers of returning adults. However, recent increases in spring Chinook abundance have helped to alleviate this problem. With some exceptions, broodstock availability has not limited juvenile production at any of the steelhead hatcheries. Broodstock abundance and the occurrence of out-of-basin fish in fall Chinook broodstock collections did affect this program when it first began. Those issues were resolved by altering where broodstock were collected, by careful screening of prospective broodstock to ensure they were of Snake River origin, and by substantial increases in fall Chinook returning to the Snake River Basin over the past seven years.

Once broodstock have been collected it can be challenging to maintain them until maturation. This is especially true for the fish being used in the LSRCP hatchery programs that may be held for one or more months prior to spawning. As the fish reach maturation, hatchery staff sort through them, selecting those that are ripe for immediate spawning. Sorting can subject immature fish to stressors that could lead to premature death. Nevertheless, over the past decade, the pre-spawning survival goals for the spring ($\geq$80%) and fall Chinook ($\geq$ 90%) programs have been met around 90% of the time. During two years, warm water temperatures caused higher than expected mortality to occur in spring Chinook. Also, in a few instances, male fall Chinook experienced higher mortality than expected at the Nez Perce Tribal Hatchery (NPTH). Recently, the NPTH has started holding adult male and female salmon in separate ponds to reduce handling stress. This approach, plus the hatchery's use of antibiotics and formalin treatments on its broodstock should further enhance the facility's already acceptable pre-spawning survival rate. The ISRP was unable to find any information on the survival of steelhead broodstock in the reports and data we received. This information most likely exists in the HGMPs for the steelhead hatcheries. It would be useful to extract it from these documents and place it in a single table or document that could be shared with LSRCP cooperators.

Survival in the Hatchery: From fertilization to release as yearling smolts, spring Chinook, steelhead, and yearling fall Chinook will be under hatchery conditions for 17 to 20 months. Sub-yearling fall Chinook will experience about 6 to 7 months of artificial culture. During their tenure in the hatchery, the fish will experience some mortality during incubation (typically 5 – 10%) and rearing. Egg-to-smolt survival goals of 70% for spring Chinook, 65 to 70% for steelhead, and 70 to 80% for sub-yearling fall Chinook were established. Disease episodes at the hatcheries have occasionally occurred but have not been a major factor in any of the programs. The LSRCP's spring Chinook hatcheries met their egg-to-smolt survival goal over 90% of the time during the past decade. Standards for egg-to-smolt survival in steelhead ranged from 65 to 70% and were met 76% of the time from 2000-2009. The 70 to 80% egg-to-smolt survival standards for fall Chinook sub-yearlings were achieved about 80% of time. These overall survival values are indicative of well-run hatchery programs.

Smolt Size: The hatchery programs have established goals for smolt size at release that are usually expressed as fish per pound. In some instances these have changed over time. When the steelhead program first began, a goal of 8 fish per pound or 57 g/fish was established. As the program matured this size standard was changed to 5 to 4.5 fish per pound (91-101 g/fish). This doubling in smolt size was instituted to increase post-release survival and reduce residualism or the tendency to remain and rear in freshwater. With some exceptions, the Chinook and steelhead hatchery programs typically meet their smolt size objectives.

Release Numbers: Each hatchery is programmed to release a set number of smolts. Over the past decade, the nine hatcheries producing spring Chinook, have reached their release goals 36% of the time. Three factors have constrained smolt production, difficulty in obtaining broodstock, reductions in program production to meet newly established rearing density criteria, and inadequate water supplies at some of the hatcheries. The twelve hatcheries producing steelhead smolts achieved their release goals about 60% of the time over the past ten years. Reductions in steelhead smolts occurred for four reasons. First, more hatchery adults returned to the project area than expected because harvest rates downstream of the project area were curtailed to protect ESA-listed steelhead. Thus, fewer smolts are needed to reach current harvest levels. Second, because the size of the program's steelhead smolts had almost doubled, it was necessary to reduce the number of fish being reared to maintain desired rearing densities. Third, decreases in water availability at Magic Valley and Hagerman hatcheries diminished their capacity to rear steelhead. And lastly, a shift in production goals from steelhead to spring Chinook along with a water shortage at the Clearwater Hatchery limited steelhead production at this facility. Efforts are underway to increase water supplies at the Magic Valley, Hagerman, and Clearwater hatcheries. When these supplies come on line, steelhead smolt production is expected to increase. The smolt release goals for the two fall Chinook hatcheries have been reached about 70% of the time over the past decade. When release goals were not met, scarcity of broodstock was largely responsible. Recent increases in Snake River fall Chinook abundance have alleviated this problem, and the program has recently been able to consistently meet project goals for smolt release numbers.

Post-Release Performance

Performance indicators for fish released from LSRCP hatcheries fall into three categories: smolt performance, adult performance, and fishery benefits. Smolt performance was measured by estimating survival and migration speed (rkm/day) from release sites to Lower Granite Dam and by assessing their dates of arrival to the dam. Adult metrics included total adults produced; return timing to hatcheries or other collection points; age and size at maturity; escapement to Lower Granite Dam (smolt-to-adult returns or SAR); SAS; straying rates; and adult recruits per spawner (R/S). Fishery benefits were appraised by estimating harvest numbers and rates above and below Lower Granite Dam, including harvests in the ocean (e.g., fall Chinook). Not all of these indicators were examined by each program, but key metrics such as SAR, SAS, and harvest rates above and below Lower Granite Dam were universally examined. Specific goals were established for some indicators such as total adults reaching the project area, but in other instances, standards were not established.

Smolt Survival to Lower Granite Dam: Data on annual survival, arrival timing, and migration speed of hatchery spring and fall Chinook and steelhead smolts to Lower Granite Dam are routinely collected. Survival rates can be quite variable. For example, over a 19-year period they ranged from 53 to 79% for steelhead smolts. Survival of fall and spring Chinook to Lower Granite Dam usually ranges from 60 to 70%. Analyses were performed to examine the effects of river flow, water temperature, and how fish were released (acclimated vs. direct release) on their migration speed and arrival dates to Lower Granite Dam. Additionally, the effect of travel distance on survival was evaluated. More of this type of work needs to be performed. The effects of flow, temperature, size-at-release, and turbidity on survival to Lower Granite Dam should be examined. Results from such analyses may help managers refine when project fish should be released to maximize their survival and minimize possible interactions with natural origin juveniles.

Smolt-to-Adult Survival (SAS): Smolt-to-adult survival objectives were established for spring Chinook and steelhead. They ranged from 3.25% to 4.35% for the eight spring Chinook hatcheries. These survival objectives have never been met. Instead, with a few exceptions, SAS values for LSRCP spring Chinook were less than 1% in most years. No SAS goals were established for the fall Chinook hatcheries. Average SAS values for brood years 1994-2007 for yearling and sub-yearling fall Chinook smolts were 1.65% and 0.6%, respectively. These values are likely a bit low as the harvest of un-marked project fish in Alaska and Canada have not yet been incorporated into these estimates. The SAS goals for the 12 steelhead hatcheries vary from 1.5% to 2.6%. Over the past decade these hatcheries reached their SAS objectives about 38% of the time. Observed SAS values for spring Chinook and steelhead are quite variable. For instance from 1980 through 2005, steelhead SAS values ranged from 0.26% to 2.8%, a tenfold difference. When SAS values for all the spring Chinook hatcheries were examined, it became apparent that there were strong year effects. That is, even though within year differences in SAS values occurred among the hatcheries, SAS values tended to vary in a synchronous fashion across all the hatcheries. A similar trend was seen in the steelhead SAS values. Consequently, conditions that the fish experienced in the mainstem Columbia River and ocean strongly impacted their survival to adults.

Smolt-to-Adult Return (SAR): SAR goals were established for all LSRCP hatcheries. The fall Chinook program, for instance has a SAR goal of 0.2% which has been dependably reached. A SAR value of 0.87% was put in place for spring Chinook, and the project's hatcheries have met this goal about 20% of the time. SAR values are affected by ocean (fall Chinook) and mainstem fisheries. Virtually no spring Chinook fisheries, however, occurred from 1975 through 1995 and current harvest rates on these fish below Lower Granite Dam are less than 10%. Thus, harvest does not appear to be an important factor affecting SAR values for spring Chinook. SAR goals ranging from 0.5% to 0.87% are in place for the 12 steelhead hatcheries. These goals were met from 1998 through 2005 when SAR values were consistently over 1%. Substantial annual differences in SAR values occurred among hatcheries rearing steelhead and spring Chinook. Within each species, they tended to increase or decrease in a synchronous fashion much like SAS values. Thus, SARs for Chinook and steelhead appear to be strongly affected by mainstem and ocean conditions.

There is some level of uncertainty associated with the program's SAS and SAR values because not all the project fish are marked or tagged. Expansions of coded-wire tag (CWT) recoveries, or PIT tag detections, have been used to make such estimates in the past. Recently, the LSRCP has decided to use parentage based tagging (PBT) to identify project fish. This genetically based method is designed to determine whether a sampled fish originated from hatchery parents. It is a very promising approach and may substantially refine future estimates of SAR, SAS, and other project metrics, for example, straying proportions. The ISRP encourages LSRCP cooperators, however, to continue to apply additional marks and tags on project fish. Recoveries of these known origin fish could be used to help validate origin assignments and provide error rates to PBT determinations.

Recruits per Spawner: Parent to progeny or recruits per spawner (R/S) data have been collected on each of the hatchery programs. To be self-sustaining, a hatchery program needs to, on average, obtain a 1 or higher R/S value. All three LSRCP hatchery programs have typically achieved this target, largely because mortality in the hatchery environment is low. All five spring Chinook hatcheries have normally achieved R/S values greater than 1. Maximum values for several of these hatcheries (e.g., Imnaha) exceeded 20 fish per parent. Even greater overall R/S values were observed in the steelhead program, where an average of 17 recruits per spawner from 1981 through 2005 occurred. During the past ten years, R/S values in hatchery fall Chinook have also been greater than 1. Like SAS and SAR values, differences in R/S values occurred among the hatcheries rearing the same type of fish, and there was also considerable variation from one year to the next.

Harvest: A primary objective of the LSRCP is to restore and maintain fisheries, including harvest. Prior to the LSRCP, approximately 26,000 steelhead were harvested in the project area. That yield was maintained after the project began until 1999. From 1999 to the present, an average of 62,000 steelhead have been caught annually. Annual angling effort for steelhead in the project area has also increased from 130,000 angler-days, prior to the LSRCP, to approximately 475,000 angler-days. Increases in catch and effort coincided with the ESA listing for steelhead which reduced harvest rates below the project area and allowed more fish to be harvested in the project area.

Harvest benefits have also been produced by the LSRCP fall Chinook program. In 1990, approximately 600 fall Chinook adults returned to Lower Granite Dam. Beginning in 1996, fall Chinook supplementation began in the Snake River basin and numbers of fall Chinook returning to the basin increased over time to approximately 76,000 fish in 2013. This increase has supported significant ocean and lower Columbia River fisheries, in part by reducing the constraint on harvests of relatively abundant runs of naturally produced fall Chinook salmon that co-mingle with ESA-listed fall Chinook salmon. In recent years, greater returns of fall Chinook to the Snake River basin have also resulted from reduced exploitation rates in ocean fisheries.

The spring Chinook program has also supported fisheries. Adult returns were small during the first twelve years of the spring Chinook program as there were only two years when adult returns to the project area exceeded 10% of the above project abundance goal of 58,700 fish. Over the past ten years, however, abundance of spring Chinook has increased, and annual returns have averaged around 49% of the above project goal. Recreational and tribal fisheries began in the above project area in the late 1990s and harvest opportunities have grown as abundance continues to increase. Some harvest takes place below the project area, but it is largely constrained by the need to protect and recover ESA-listed spring Chinook. Even though the hatchery programs for Chinook and steelhead have failed to provide below project fishery benefits at levels envisioned when the LSRCP was first established, they have increased the total abundance of spring and fall Chinook and steelhead, and contributed to important commercial and recreational fisheries.

Demographic, Ecological and Genetic Impacts

Age at Maturation and Spawning Ground Distribution: Some demographic, ecological, and genetic impacts to hatchery and naturally produced fish attributable to the LSRCP hatchery programs have been detected. An increase in the proportion of early maturing males (three-year-olds) and a corresponding reduction in the proportion of late maturing fish (age five and older) were observed in hatchery spring Chinook. However, no change was detected in the proportion of the predominant age class (four-year-olds). LSRCP managers suggested that few mini-jacks were produced in the hatcheries, whereas NOAA-Fisheries scientists estimated high numbers of mini-jacks (e.g., 52% in Lookingglass Hatchery). Similarly, in hatchery fall Chinook, there was an increase in the proportion of early maturing males including mini-jacks and a corresponding decrease in the proportion of older maturing five and six-year-old individuals when compared to naturally produced fish. Changes in the age structure at maturation commonly occur in hatchery programs and evidence suggests early maturation is related in part to environmental factors the fish experience while under artificial culture. Arrival timing to Lower Granite Dam and spawning ground distribution patterns of hatchery fish were also compared to those expressed by natural origin adults. Natural origin spring Chinook were inclined to arrive at Lower Granite Dam over a more protracted period than hatchery fish. Hatchery spring Chinook also had less diverse spawning ground distributions as they tended to aggregate and spawn in areas adjacent to hatchery release locations.

Straying: Straying frequencies of LSRCP steelhead and spring and fall Chinook are annually evaluated. Very few fall Chinook from the LSRCP have been recovered outside the Snake River Basin. Over the past eight years, for instance, the average proportion of strays for fall Chinook was less than 0.5%. The proportions of strays within the steelhead and spring Chinook programs are greater and varied by hatchery and year. The percentage of returning adults from spring Chinook hatcheries that strayed ranged from near zero to 8% from 2000 to 2006 and the proportion of steelhead strays averaged 9%. In some instances, 20% or more of the steelhead produced from a hatchery were identified as strays. The cooperators indicate that these proportions are probably lower than the actual straying occurrence because not all fisheries or potential spawning areas where strays might be detected are sampled.

Factors responsible for straying included the disruption of imprinting on natal waters caused by handling stresses at hatcheries or in barges and trucks if juveniles were artificially transported downstream. Additionally, warm water temperatures experienced by returning adults forced some fish to seek cold-water refugia in streams located below the project area. In some cases, these fish would resume their upstream migrations after water temperatures had cooled, but many stayed and apparently spawned in their new watersheds. In one instance, cooperators found that a substantial number of Snake River steelhead from the LSRCP hatcheries strayed into the John Day and Deschutes Rivers.[9] In 2007, it was estimated that 13% of the steelhead spawning in the John Day River were hatchery strays. Coded-wire tags recovered from these fish showed that most of them had originated from Snake River hatcheries. These out-of-basin strays may have been responsible for a recent decline in the productivity of John Day steelhead according to the investigators.

Efforts to reduce straying are being implemented by the LSRCP. They include the extensive use of acclimation sites, use of localized broodstocks, and consolidation of release locations. Reductions in the occurrence of strays have been observed since these and other measures were put in place. More refined estimates of straying will be possible in the future as the LSRCP plans to increase the use of PIT tags and employ PBT to identify the origin of fish recovered on spawning grounds and harvested in fisheries. These undertakings to reduce and monitor straying are commendable and should be coordinated with ongoing efforts to reduce straying caused by current fish barging and trucking practices.

Hatchery-Wild Interactions: Interactions between hatchery and natural origin Snake River Chinook and steelhead can have ecological and demographic effects at the juvenile life stage and may have genetic consequences at the adult stage. It is clear that the LSRCP cooperators have carefully considered these interactions when planning and developing their hatchery programs. The HGMPs for the steelhead and Chinook hatcheries as well as the BiOp developed by NOAA Fisheries, for the fall Chinook program, reviewed existing literature on disease transmission, behavioral changes, and competitive and predaceous interactions between hatchery and natural origin juvenile salmonids. Potential risks were identified, and some measures have been implemented to minimize their occurrence. In the steelhead program, these measures include 1) some release locations for hatchery fish are located below areas of natural spring Chinook production, 2) release dates are scheduled around expected Chinook fry emergence periods to minimize predation, and 3) acclimation ponds and volitional release strategies are used to reduce straying. Additionally, hatchery steelhead juveniles expected to residualize in freshwater are removed from release groups to prevent out-breeding with native rainbow trout and reduce competitive and predaceous interactions with other freshwater fishes. Furthermore, areas in watersheds have been set aside for natural steelhead production, and traps and weirs are used to remove hatchery origin adults from spawning areas to minimize potential genetic effects. Nonetheless, LSRCP co-managers acknowledge that pursuing steelhead and Chinook harvest using artificial production while simultaneously implementing recovery actions for listed steelhead and Chinook salmon is new territory for fisheries management. Whether this can be successfully accomplished is unknown. The ISRP believes this is a critical adaptive management challenge for the LSRCP.

---

[9] Ruzycki, J. R., and R. W. Carmichael. 2010. Summary of out-of-basin steelhead strays in the John Day River Basin. Report to the Independent Scientific Advisory Board. Oregon Department of Fish and Wildlife, La Grande, Oregon. 10pp.

Supplementation: All three LSRCP hatchery programs have implemented supplementation programs in an effort to increase the abundance of natural origin fish or in some cases to prevent the extinction of endemic populations. Supplementation occurs when natural-origin adults are artificially spawned and their subsequent offspring are raised in hatcheries before being released into the natural environment. Typically, hatchery-origin adult fish produced from these releases are allowed to spawn naturally. This approach is intended to increase the abundance of natural-origin adult fish returning in the next generation. Even though increasing harvest opportunities were prioritized in the LSRCP's steelhead program, supplementation efforts are occurring in a few locations to increase the abundance of natural-origin steelhead. Supplementation efforts for Chinook have been more extensive. Spring Chinook supplementation programs have increased the total abundance of spawners in their rivers (hatchery plus wild) but have not produced an increase in natural-origin adults. Fall Chinook supplementation has likely contributed to the recent increases in natural-origin fish abundance in the Snake River Basin, but the productivity of the natural-spawning population remains very low.

Supplementation remains a controversial strategy. Uncertainty exists on whether a boost in total adult abundance in a population caused by an infusion of hatchery-origin spawners will lead to an eventual and sustained increase in natural-origin adults. One factor that may affect the success of supplementation is the ability of hatchery-origin fish to spawn and produce offspring under natural conditions. Density dependence or other environmental factors can also affect the success of supplementation programs, as evidenced by monitoring results in the Snake River basin. For example, reduced growth and survival of juvenile spring Chinook salmon in response to increasing population density has been documented in a number of Snake River watersheds.[10] Total abundance of natural origin fall Chinook salmon has increased in recent years in association with increasing numbers of natural spawning by hatchery fish (~73% of spawners are hatchery fish[11]) but R/S values have typically been less than 1 suggesting that the capacity to support large numbers of spawners has been exceeded.[12] These recent findings of density-dependence provide impetus for integration and coordination of the LSRCP with other hatchery programs, habitat restoration efforts, harvest management, and ESA recovery efforts.

[10]Walters, A.W., T. Copeland and D.A. Venditti. 2013. The density dilemma: limitations on juvenile production in threatened salmon populations. Ecology of Freshwater Fish. 22:508-519

[11]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.

[12]Cooney, T. 2013. Snake River fall Chinook population status update. 2013 LSRCP fall Chinook Symposium, Clarkston, Washington 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.

Studies have been conducted in the Snake River Basin to evaluate supplementation of spring Chinook and steelhead.[13] The experimental methodology to test whether supplementation can boost natural populations without disrupting their genetic composition is complex. Data from the Idaho Supplementation Studies and Yakima River supplementation program should be available in the next few years. Hopefully results from these efforts will help co-managers make decisions about the utility of supplementation. Ultimately, sustainable population growth of natural Chinook and steelhead in the Snake River basin will depend on restoration efforts to increase productivity and capacity of the habitat in the basin in addition to improved survival when migrating through the hydrosystem and estuary.

Supplementation efforts in the Snake River Basin offer important opportunities for further research. A significant portion of the monitoring and research on supplementation taking place in the basin is directly funded by BPA and therefore is not formally a part of the LSRCP. Nonetheless, the LSRCP is supporting this work either through partial funding or via participation of some of its cooperators. The ISRP encourages the LSRCP to continue its involvement and contributions to these studies. Results from such work will benefit the salmon resources in the Snake River Basin and will likely offer important insights on salmon recovery and management throughout the Pacific Northwest.

Program Modifications

Adaptive Management: The monitoring and evaluation programs established by the LSRCP have allowed its three hatchery programs to make informed changes to hatchery infrastructure, broodstock sources and collection locations, mating protocols, and to rearing and release procedures. Ongoing refinements to run reconstruction procedures are helping to estimate harvests and natural escapements of project fish. Parentage based tagging will be used to identify all of the hatchery fish produced by the LSRCP. Once this is fully implemented, additional refinements to straying rates and harvest and escapement numbers will be possible.

---

[13] Berntson, E.A., R.W. Carmichael, M.W. Flesher, E.J. Ward, and P. Moran. 2011. Diminished reproductive success of steelhead from a hatchery supplementation program (Little Sheep Creek, Imnaha Basin, Oregon) Transactions of the American Fisheries Society. 140:685-698.

Carmichael, R.W., T. Hoffnagle, J. Feldhaus, D.Eddy and N. Albrecht. 2013. Imnaha River spring/summer Chinook salmon hatchery program review. http://www.fws.gov/lsnakecomplan/Meetings/2010%20Spring%20Chinook%20Symposium/Written%20Reports%20&%20ISRP%20Comments/Imnaha%20River%20SpringSummer%20Chinook%20Salmon%20hatchery%20Program%20Review%20.pdf

Hess, M.A., C.D. Rabe, J.L. Vogel, J.J. Stephenson, D.D. Nelson, and S.R. Narum. 2012. Supportive breeding boosts natural population abundance with minimal negative impacts on fitness of a wild population of Chinook salmon. Molecular Ecology. 21:5236-5250.

Matala, A.P., S.R. Narum, W. Young and J.L. Vogel. 2012. Influences of hatchery supplementation, spawner distribution, and habitat on genetic structure of Chinook salmon in the South Fork Salmon River, Idaho. North American Journal of Fisheries Management. 32:346-359

Communication among the cooperators within the LSRCP is extensive. During harvest periods, weekly teleconferences are routinely held and coordination meetings are convened twice a year. Annual Operating Plans for the hatcheries are developed, information gaps have been identified and prioritized, and an adaptive management process with given management assumptions and monitoring and evaluation goals are in place. Several management and legal agreements that affect the LSRCP will be up for renewal or renegotiation prior to 2018, for example, the U.S. v. Oregon Management Agreement and the Federal Columbia River Power System Biological Opinion and its related Accords with States and Tribal governments. In anticipation of this process, LSRCP cooperators are gathering project data to help guide and determine future adaptive management options and opportunities.

The above are operational adaptations, and the LSRCP has done an excellent job of incorporating emerging data into operational protocols. However, the LSRCP spring and fall Chinook and steelhead programs have not yet achieved full mitigation, especially with regard to harvests. The next adaptive management step that the LSRCP needs to take is more encompassing. It will require coordination across legal jurisdictions, management regimes, and tributary, mainstem river, estuary and ocean environments, necessitating an All-H approach to establishing program goals, objectives, and strategies.

All-H Approach: The ISRP recognizes that the LSRCP is just one part of salmon and steelhead management in the Snake River Basin. Actions that are independent of the LSRCP hatchery programs, but are strongly linked to it, include the establishment and regulation of fisheries; habitat restoration by tribal, state, federal and local entities; and flow regulation through the hydrosystem. All of these factors, plus the legal mandates that the LSRCP is subject to, have shaped its steelhead and Chinook hatchery programs. Consequently, any change in the LSRCP must take into account established laws, policies, and management agreements associated with harvest, conservation, habitat restoration and hydrosystem regulation. For example, at the spring Chinook symposium the state and tribal co-managers uniformly expressed that they expected the region to meet the mitigation goals established in the LSRCP, and they generally believed that additional hatchery production was unlikely to provide additional fish. Consequently action is required to improve tributary habitat capacity and productivity and mainstem and estuary survival. Improving hatchery post-release smolt survival to match current natural smolt survival would not be sufficient. To achieve these goals will require action beyond the responsibilities of the LSRCP.

Tagging and Marking: The ISRP reviews of each of the LSRCP hatchery programs contained recommendations that were made to help address future challenges. One of these was to apply visible marks to 100% of the fall Chinook produced by the LSRCP. This recommendation was made to help the cooperators quickly (a) identify the origin of fish used as broodstock, (b) refine estimates of naturally spawning hatchery fish and their spawning ground distributions, (c) improve estimates of the proportion and number of hatchery and natural origin fall Chinook returning to Lower Granite Dam, and (d) help manage the numbers of hatchery origin fish on natural spawning grounds. The ISRP understands that LSRCP cooperators have discussed at great length the need to identify project fish and the best methods to do this. They decided to use PBT instead of visible marks. PBT enables identification of individual fish origin (e.g., natural or specific hatchery, rearing and release treatments) – something that simple visible marks typically cannot accomplish. However, tissue samples must be analyzed in a laboratory and therefore origin cannot be determined from visual examination in the field, e.g., deep water spawners via underwater video or selective removal or harvest of surplus hatchery fish from spawning grounds. Consequently, an assortment of tagging and marking methods should be implemented by the LSRCP to maximize management flexibility and acquisition of information.

Hatchery Fish on the Spawning Grounds: Another challenge the LSRCP faces is regulating the proportion of hatchery Chinook and steelhead on natural spawning grounds. The HSRG recommends a long-term Proportionate Natural Influence (PNI)[14] of 0.67 (or higher) for stocks of critical conservation interest. In the case of many spring and fall Chinook supplementation populations, PNI is considerably lower than this recommended level. A number of strategies – for example, captures at weirs and consolidation of release sites – have been successfully used to regulate the abundance of hatchery steelhead and spring Chinook on spawning grounds in watersheds where a large proportion of hatchery fish are visibly marked. The selective capture and removal of fall Chinook is more problematic because they typically spawn in large rivers and sometimes in waters 10 m or more in depth. Moreover, the cooperators have made estimates of available spawning habitat for fall Chinook and believe that additional spawning areas are still available. A weir is scheduled to be installed on the South Fork of the Clearwater, and it could be used for this purpose. At this time, however, no plans are in place to regulate the proportion of hatchery fall Chinook on natural spawning grounds. Given the recent upsurge in Snake River fall Chinook abundance, it would be prudent to incorporate planning of this type into the fall Chinook Recovery Plan that is currently under development. Furthermore, harvest of surplus hatchery fish would help achieve the mitigation goals. Another challenge for the LSRCP is determining if density-dependent effects are limiting production in rivers where supplementation has occurred. As mentioned earlier, evidence for density dependence has been gathered for spring Chinook, and there is also evidence for density dependence in Snake River populations of fall Chinook and steelhead. Efforts to further test for density-dependent growth, age-at-maturation, and survival are encouraged.

[14] 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.

V. Appendix

This appendix consists of three tables, one for spring and summer Chinook, and others for steelhead, and fall Chinook. In each table, individual hatchery programs are placed in columns and performance indicators are arranged in rows under three performance categories: in-hatchery fish performance, post-release fish performance, and impacts of the hatchery program on wild stocks and other hatchery fish. These tables represent a snap-shot of the status of the individual programs based on symposium presentations and reports.

Table 1. Spring Chinook: ISRP assessment of the reporting of objectives and performance metrics in individual hatchery program reports prepared for the 2010 LSRCP Spring Chinook Program Review.

Metric	*Sawtooth*	*McCall*	*Clearwater*	*Dworshak*	*Tucannon*	*Imnaha*	*Grande Ronde*	*Catherine Creek*	*Lostine*
A. Hatchery Performance									
Broodstock Collection Goals	[1]				100 - 170				
Years Achieved				9/10					
Pre-spawning Mortality Goal	<20%	<20%	<20%		<20%	<20%	<20%	<20%	<20%
Years Achieved	9/10	8/10	10/10		10/10	8/10	7/9	8/8	
Egg to Smolt Goal	>70%	>70%	>70%	>70%	>70%	>70%	>70%	>70%	>70%
Years Achieved	10/10	10/10	9/10		8/10	9/10	8/8	7/8	
Smolt Release Goal	1.5M	1.0M	1.4M - 2.3M	1.05 - 1.4M	0.13 - 0.225M	0.36M	0.25M	0.15 - .25M	0.25M
Years Achieved	2/10	10/10	4/10	2/10	5/10	6/10	1/10	0/10	2/10
B. Post-Release Performance									
Survival to LGD Goal									
Survival to LGD[2]						>65%			
SAS Goal	4.35%	4.0%	4.35%	4.35%	4.35%	3.25%	3.25%	3.25%	
Years Achieved	0	0	0	0	0	0	0	0	
Lower Col & Ocean Harvest Goal	77,000	32,000	47,600	36,500	4,608	16,050			
Years Achieved	0	0	0	0	0	0			
SAR Goals	0.87%	0.80%	0.87%	0.87%	0.87%	0.65%	0.65%	0.65%	0.10%
Years Achieved	0/10	7/10	2/10		0/10	8/10	1/6		8/8
Return to LGD Goal	19,400	8,000	11,900	9,135	1,152	3,210	1,617	1,617/970	NR
Years Achieved	0	6	0	1	0	3	0	0	
Tribal Harvest Goals									
Years Tribal Harvest	6/10	9/10	2/10	10/10					
Sport Harvest Goals									
Years of Sport Harvest	2/10	10/10	9/10	10/10					2/10

Metric	*Sawtooth*	*McCall*	*Clearwater*	*Dworshak*	*Tucannon*	*Imnaha*	*Grande Ronde*	*Catherine Creek*	*Lostine*
Spawning Escapement Goals					750 Nat Hatch NR				250
Years Achieved					2/10 Nat				9/10
C. Interaction Performance[3]									
Age Structure	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes
Run Timing	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes
NOR Abundance	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
NOR Productivity	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
BACI Assessment	No	No	No	No	No	Yes	No	No	No
Other Supplementation Effectiveness Evaluation[4]	No	No	No	No	No	No	Yes	Yes	No
RRS Assessment[5]	No	No		No	No	No	No	Yes	No
Other Genetic Assessment	No	No		No	Yes	No	No	No	No

1. Shaded blocks indicate that no data were collected on a metric or that a metric was not applicable for a particular hatchery program
2. A number of reports provided information on smolt survival to Lower Granite Dam, but the information is in a bar graph and the ISRP cannot actually determine what the estimates are.
3. For interaction metrics Yes indicates that the data are being collected and reported, No indicates that the data are not being collected (they may not be needed everywhere), NA – Not Applicable.
4. Evaluations include effects of density-dependence, which could limit supplementation effectiveness if present
5. RRS – relative reproductive study

Table 2. Steelhead: ISRP assessment of the reporting of objectives and performance metrics in individual hatchery program reports prepared for the 2011 LSRCP Steelhead Program Review.

River Basin of Releases	***Clearwater River***	***Salmon River Hagerman NFH***	***Salmon River Magic Valley FH***	***Grande Ronde River***	***Imnaha River***	***Grande Ronde River***	***Snake River***	***Walla Walla River LFH stock***	***Tucannon River LFH stock***	***Touchet River LFH stock***	***Touchet River Endemic***	***Tucannon River Endemic***
A. Hatchery Performance												
Metric	***IDFG***	***USFWS***	***IDFG***	***ODFW***	***ODFW***	***ODFW***	***WDFW***	***WDFW***	***WDFW***	***WDFW***	***WDFW***	***WDFW***
Green Egg to Smolt Assumed Survival Goal	65%	65%	65%	70%	70%	65%	65%	65%	65%	65%	65%	65%
Years Achieved (RY2000-2009)[1]	9/10	10/10	9/10	8/10	7/10	8/10	6/10	6/10	6/10	6/10	8/ 9	6/8
Smolt Release Goal	840,000	1,700,000	1,749,000	1,350,000 to 800,000	215,000 to 330,000	160,000 to 200,000	60,000	100,000 to 175,000	100,000 to 160,000	85,000 to 125,000	50,000	50,000
Years Achieved (RY2000-2009)	3/10	0/10	8/10	5/10	5/10	6/10	8/10	6/10	7/10	9/10	4/9	6/8
B. Post Release Performance												
SAS Goal	2.61%	2.40%	2.01%	2.04%	1.83%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%
Years Achieved (BY 1995-2004)[2]	2/10	1/10	1/10	0/10	0/10	6/10	8/10	8/10	8/10	8/10	0 of 5 (2003-2007 BY based on PIT tags	0 of 5 (2003-2007 BY based on PIT tags)
Lower Col & Ocean Harvest Goal	28,000	27,200	23,200	18,368	4,000	3,002	1,260	1,800	1,750	1,500	None	None
Years Achieved (RY2000-2009)	0/10	1/10	2/10	0/10	0/10	0/10	0/10	0/10	0/10	0/10	3	

Metric	***Clearwater River***	***Salmon River Hagerman NFH***	***Salmon River Magic Valley FH***	***Grande Ronde River***	***Imnaha River***	***Grande Ronde River***	***Snake River***	***Walla Walla River LFH stock***	***Tucannon River LFH stock***	***Touchet River LFH stock***	***Touchet River Endemic***	***Tucannon River Endemic***
SAR Goals	0.87%	0.80%	0.67%	0.68%	0.61%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%
Years Achieved (BY 1995-2004)	10/10	7/10	8/10	8/10	7/10	9/10	9/10	9/10	9/10	9/10	2/6 (2003-2008 BY based on PIT tags	4/5 (2003-2007 BY based on PIT tags)
Return to Project Area Goal	14,000	13,600	11,600	9,184	2,000	1,501	630	900	875	750	250	250
Years Achieved (RY2000-2009)	6/10	7/10	8/10	8/10	7/10	10/10	10/10	10/10	10/10	10/10	2/5 (2006-2010 RY's based on PIT tags)	5/5 (2006-2010 RY's based on PIT tags)
Below Project Area Exploitation Rate[4] (BY 1995-2004)	4%	3%	5%	16%	19%	9%	12%	11%	10%	11%	None	None
Above Project Area Exploitation Rate (BY 1995-2004)	64%	72%	71%	48%	21%	57%	29%	63%	52%	48%	None	None
Total Exploitation Rate (BY 1995-2004)	49%	58%	68%	64%	40%	66%	41%	73%	62%	59%	None	None
C. Hatchery/Wild Interaction Monitoring												
Age Structure – Hatchery spawners Y/N	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Age Structure – Natural Spawners Y/N	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Run Timing - Hatchery Y/N	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Run Timing - Natural Y/N		Yes	Yes	Yes	Yes	No	No	No	No	No	Yes	Yes
NOR Productivity Y/N	No	No	No	No	Yes	No	No	No	No	No	Yes (Index)	Yes (Index)
BACI Assessment Y/N	No	No	No	No	No	No	No	No	No	No	No	No

Metric	***Clearwater River***	***Salmon River Hagerman NFH***	***Salmon River Magic Valley FH***	***Grande Ronde River***	***Imnaha River***	***Grande Ronde River***	***Snake River***	***Walla Walla River LFH stock***	***Tucannon River LFH stock***	***Touchet River LFH stock***	***Touchet River Endemic***	***Tucannon River Endemic***
Hatchery Release Stray[5] %	1.3%	6.8%	6.6%	7.8%	5.1%	9.3%	22.6%	65.1%	37.1%	52.1%	(20-40%) Based on PIT tags	(50-60%) Based on PIT tags
RRS[6] Assessment Y/N	No	No	No	No	Yes		No	No	No	No	No	No
Other Genetic Assessment Y/N	No	No	No	Yes	Yes	No	No	No	No	No	No	No

1. Run Year (RY). The number of years a goal was met in the numerator over the number of years the goal was evaluated between 2000-2009
2. Brood Year (BY). The number of years a goal was met in the numerator over the number of years the goal was evaluated between 1995-2004.
3. Shaded blocks indicate that no data were collected on a metric or the metric was not applicable to a particular hatchery
4. Exploitation Rate. Equals the percent of the total number of adults produced that was harvested. The values shown are 10-year averages for broodyears 1995-2005.
5. Stray %. The average percent of the adults that were recovered as strays from 2000-2009. A stray is defined as a fish recovered alive at traps or weirs or harvested outside of a direct line from the ocean to its release site.
6. RRS – relative reproductive study. Compares the relative reproductive success of naturally spawning hatchery and wild origin adults

Table 3. Fall Chinook: ISRP assessment of the reporting of objectives and performance metrics in individual hatchery program reports prepared for the 2013 LSRCP Fall Chinook Program Review.

A. Hatchery Performance					
Metric	***Lyons Ferry***	***FCAP[1]***	***IPC[2]***	***Irrigon LSRCP***	***Nez Perce (NPTH)***
Broodstock Collection Goals	1400 Females	[3]			526 Females
Years Achieved	2/10[4]				1/8
Pre-spawning Mortality Goal	No[5]				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			
B. 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				
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

Metric	*Lyons Ferry*	*FCAP*	*IPC*	*Irrigon LSRCP*	*Nez Perce (NPTH)*
C. 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[6]	Yes	Yes	Yes	Yes
Relative Reproductive Success Assessment	No	No	No	No	No
Other Genetic Assessment	Yes	Yes	Yes	Yes	Yes

1. 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.
2. IPC equals Idaho Power Company
3. Shaded blocks indicate that no data were collected on a metric or that the metric was not applicable for a particular hatchery program. For example, no broodstock are collected at the FCAP, IPC, or Irrigon hatcheries.
4. The number of years the goal was met is placed over the years examined.
5. "No" means that no standards have been established for this performance criterion
6. 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.