

**An Independent Scientific Review Panel Retrospective Report**

**Review of the Lower Snake River  
Compensation Plan Steelhead Program**



**ISRP 2013-3  
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## **Independent Scientific Review Panel**

for the Northwest Power & Conservation Council

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# ISRP Review of the Lower Snake River Compensation Plan Steelhead Program

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## Executive Summary

The Independent Scientific Review Panel (ISRP) conducted a review of the Lower Snake River Compensation Plan (LSRCP) steelhead program at the request of the Northwest Power and Conservation Council and U.S. Fish and Wildlife Service. For the review, the ISRP considered annual reports, summary oral presentations, and agency and tribal program reports prepared for the [Steelhead Symposium](#) that took place in Clarkston, Washington in June 2012. The format used to evaluate the LSRCP spring Chinook and steelhead program's accomplishments worked well, and we hope that the same format can be used for the Fall Chinook review. The ISRP believes the data, evaluations, and conclusions provided by the LSRCP steelhead program are applicable beyond the Columbia River Basin and Pacific Northwest. Therefore, we hope that the LSRCP summary report and presentation can serve as a foundation for a scientific paper that assesses the within hatchery and post-release performance of project steelhead.

Two hatchery performance indicators, green egg-to-smolt survival rates and number of smolts released, are universally reported for all the LSRCP steelhead hatchery programs. These two metrics indicate that the performance and practices within the hatcheries are acceptable and meet or exceed stated goals. However, these indicators do not fully summarize hatchery performance. Additional information on parental fish needs to be collected such as numbers used as broodstock and pre-spawning survival, as well as survival, growth, and disease data on their offspring from fertilization through release. Such information is important because it can be used to partition out mortality from collection to final smolt release. Without knowledge of where and when mortality takes place, it is impossible to make adaptive adjustments to hatchery practices. Some of the reports considered by the ISRP contain this information, and in some cases this information is contained in tables within the Hatchery Genetic Management Plans. The ISRP suggests that the LSRCP create a centralized database for this information that can be updated each year. Such a database can help to identify possible problem areas and indicate where improvements should be focused. Additionally, many clever and innovative methods are used to obtain hatchery performance data. These vary by agency and are perhaps affected by tradition and resource availability. Ideally these methods should be universally shared across all the LSRCP steelhead hatcheries. Perhaps one way of accomplishing this would be to attach documentation of the methods used to the suggested centralized database.

Artificial culture may affect the genetic diversity of cultured stocks and, if straying or integrated hatchery programs occur, natural populations as well. Estimates of the effective population size of hatchery stocks are provided in some of the reports the ISRP received. Tracking temporal changes in effective population sizes, effective number of breeders, mean family size, and variance of family size in hatchery and wild populations would increase understanding of the genetic risks of supplementation. Consequently the ISRP encourages the LSRCP to continue, and if possible expand, genetic analyses on hatchery and natural steelhead populations in the future.

Fish performance post-release to return is adequately reported. High straying rates of some adults, residualism or residency of released smolts, and difficulties in estimating harvest and straying rates remain as post-release problems. A multi-year experiment that compared straying and survival rates of steelhead released from acclimation ponds and directly planted without acclimation showed that fish released from acclimation ponds had lower straying rates and higher smolt-to-adult survival (SAS) rates. Once this was known, another multi-year experiment took place. This time the effects of forced and volitional releases from acclimation ponds were compared. No differences were detected in either straying or smolt-to-adult survival rates. However, the use of volitional releases did provide a method of reducing residualism. Many of the fish remaining in the acclimation ponds are maturing males. These fish were removed and used in “put and take” fisheries. These studies along with efforts that evaluate the effects of different broodstocks on straying are helping to reduce this problem. The LSRCP is to be commended for supporting and performing this work. The ISRP encourages the LSRCP to design studies on the relationships between straying and stress just prior to or during smoltification. Results from such work may provide additional approaches to further reduce straying.

Problems with estimating the straying and harvest rates of project fish were candidly presented. The straying rates presented are underestimates because not all fisheries or natural spawning areas can be sampled. Harvest rates in the lower Columbia and in the project area are also challenging to estimate, mainly because of difficulties in identifying the origin of harvested fish. The LSRCP is investigating the promising approach of using Parent Based Tagging (PBT) to resolve these issues. The application of coded wire tags, PIT tags, and other marks and tags on project fish should continue to provide a means of estimating assignment error rates to the genetically based PBT method.

Fifteen years ago during a previous review of the LSRCP steelhead program, a question was raised about “whether harvest mitigation programs and wild stock recovery can be conducted/achieved concurrently.” This question remains as relevant today as when it was first asked. Numerous risk aversion strategies have been employed by LSRCP steelhead projects to reduce potential interactions between project fish and wild steelhead and other native fishes. Among these are 1) releasing project fish below areas of natural steelhead production, 2) reducing the number of smolts released, 3) using acclimation ponds and volitional exit strategies to reduce straying and residualism, 4) creating refuge areas for natural steelhead, 5) removing hatchery adults at weirs and traps, and 6) developing endemic broodstocks. It appears that the effects of these and other implemented strategies have not been quantitatively assessed. The ISRP believes that measuring possible demographic and genetic impacts of supplementation on the wild steelhead populations in the lower Columbia River and project area represents the next big challenge for the LSRCP program. The ISRP encourages the LSRCP to investigate approaches to modify or develop new methods to assess supplementation impacts. Understanding how the existing hatchery program is influencing the genetic composition and demographic profiles of wild steelhead will help shape how the program proceeds in the future.

## **Lower Snake River Compensation Plan Steelhead Program Background<sup>1</sup>**

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 designed to replace lost adult salmon and steelhead caused by the construction and operation of four hydroelectric dams on the Lower Snake River in Washington. For steelhead, a goal was established of 55,100 adult fish returning back to the project area, after harvest downriver of the project area. It was anticipated that after the hatcheries were built and achieved full production that 37,000 adults would be caught in commercial fisheries and 73,200 in recreational fisheries downriver of the project area. The program was projected to generate 130,000 days of recreational fishing. Other than assuming that enough broodstock would return to the hatcheries to perpetuate further generations, no other beneficial uses for returning adults were specified in the plan.

Congress authorized the U.S. Army Corps of Engineers (Corps) to build five hatcheries in 1976 capable of producing 11 million smolts. The hatcheries were distributed in the Snake River Basin to reflect a desire to mitigate for the estimated losses “in kind and in place.” Construction of the first steelhead facility was completed in 1983 and the last facility was completed in 1991. Since the program was authorized, at least three major unforeseen factors have impacted the LSRCP program’s progress. First, the smolt to adult survival rate has been less than originally projected. Second, Snake River steelhead were listed as threatened under the Endangered Species Act. The need to reduce harvest rates in mainstem fisheries to protect natural-origin fish caused a higher proportion of the annual runs to escape mainstem fisheries and return to the project area than projected at the time the program was authorized. Third, states and tribes through the United States v. Oregon court-stipulated Fishery Management Plan have established specific hatchery production agreements among the states, tribes, and federal government. This agreement has substantially diversified the steelhead hatchery program by adding new off-station release sites and stocks designed to meet short term conservation objectives. Over two days in June 2012, the LSRCP agency and tribal cooperators presented the successes and challenges faced in implementing the LSRCP’s steelhead program.

### **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 Bonneville Power Administration (Bonneville) to implement the Council’s 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

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<sup>1</sup> This description is a slightly edited version of the abstract from [A Brief History of the Lower Snake River Compensation Plan Hatchery Program for Steelhead](#) provided by the U.S. Fish and Wildlife Service as background information for the 2012 Steelhead Program Review Symposium.

agency budgets that are reimbursed by Bonneville. The LSRCP is a Bonneville-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 part of a continuing, periodic review of the LSRCP. Specifically, the Council, BPA, ISRP, and the Service agreed that ISRP review of LSRCP projects be incorporated in a three-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](#)). Following this steelhead program review, the ISRP is scheduled to complete a review of the fall Chinook program in 2013 and 2014. 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 retrospective review of project accomplishments. 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 LSRCP steelhead program performance against the LSRCP goals and Fish and Wildlife Program artificial production principles. Review materials include summary oral presentations, annual reports, and agency and tribal [program summaries](#) prepared for the two-day Steelhead Symposium in June 2012. Consequently, the review is a retrospective evaluation of the collective individual program benefits to fish and wildlife and an assessment of how well the LSRCP has addressed programmatic issues raised in the ISRP's 2011 Spring Chinook Review and 2002 review of LSRCP program individual proposals.

In the 2011 Spring Chinook Review, the Service 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 this steelhead review and the upcoming fall Chinook program review.

# 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<sup>2</sup>) 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 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; 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.

The program presentation outline for each project in the LSRCP provided to the state and tribal co-managers by the Service is consistent with the ISAB recommendations for the design of hatchery monitoring programs ([ISAB 2000-4](#)). Here, the ISRP is evaluating the sufficiency of the written reports and presentations in addressing the following questions, consistent with the program outline, ISAB hatchery monitoring guidelines, and the Council's artificial production review (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?

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<sup>2</sup> HSRG 2004: Hatchery Scientific Review Group: Moberg, 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](http://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. Moberg, and S. Smith. 2009. Report to Congress on Columbia River Basin hatchery reform.

Paquet PJ, et al. (2011) Hatcheries, conservation, and sustainable fisheries—achieving multiple goals: Results of the hatchery scientific review group's Columbia River Basin review. *Fisheries* (Bethesda, Md) 36:547–561.

- 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 indicators 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'<sup>3</sup> recommendations)?
  4. How are programs being modified when problems are encountered in meeting objectives?

## **Report Organization**

This report is organized into two sections. The first section begins with a Steelhead Report Card. Then the ISRP provides evaluations of individual programs in terms of the four questions posed above and summarizes programmatic comments that apply across projects. The second section provides ISRP comments on the written summary reports for individual programs.

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<sup>3</sup> AHSWG: Ad Hoc Supplementation Work Group, Galbreath 2008.

## Steelhead Program Report Card

This report card was developed by the LSRCP Steelhead Program managers. ISRP comments on this report card are in the findings section below.

River Basin of Releases	<i>Clearwater River</i>	<i>Salmon River Hagerman NFH</i>	<i>Salmon River Magic Valley FH</i>	<i>Grande Ronde River</i>	<i>Imnaha River</i>	<i>Grande Ronde River</i>	<i>Snake River</i>	<i>Walla Walla River LFH stock</i>	<i>Tucannon River LFH stock</i>	<i>Touchet River LFH stock</i>	<i>Touchet River Endemic</i>	<i>Tucannon River Endemic</i>
Operating Agency	<i>IDFG</i>	<i>USFWS</i>	<i>IDFG</i>	<i>ODFW</i>	<i>ODFW</i>	<i>ODFW</i>	<i>WDFW</i>	<i>WDFW</i>	<i>WDFW</i>	<i>WDFW</i>	<i>WDFW</i>	<i>WDFW</i>
<b>Metric</b>												
Green Egg to Smolt Assumed Survival Goal	65%	65%	65%	70%	70%	65%	65%	65%	65%	65%	65%	65%
Years Achieved (RY2000-2009)	9 of 10	10/10	9/10	8 of 10	7 of 10	8 of 10	6 of 10	6 of 10	6 of 10	6 of 10	8 of 9	6 of 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 of 10	0 of 10	8 of 10	5 of 10	5 of 10	6 of 10	8 of 10	6 of 10	7 of 10	9 of 10	4 of 9	6 of 8
<b>Post Release Performance</b>												
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 of 10	1 of 10	1 of 10	0 of 10	0 of 10	6 of 10	8 of 10	8 of 10	8 of 10	8 of 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 of 10	1 of 10	2 of 10	0 of 10	0 of 10	0 of 10	0 of 10	0 of 10	0 of 10	0 of 10	N/A	N/A
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 of 10	7 of 10	9 of 10	9 of 10	9 of 10	9 of 10	9 of 10	2 of 6 (2003- 2008 BY based on PIT tags)	4 of 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 of 10	7 of 10	8 of 10	8 of 10	7 of 10	10 of 10	10 of 10	10 of 10	10 of 10	10 of 10	2 of 5 (2006- 2010 RY's based on PIT tags)	5 of 5 (2006- 2010 RY's based on PIT tags)
<b>Exploitation Rate</b>												
Below Project Area Exploitation Rate (BY 1995-2004)	4	3	5	16.00%	19.40%	9.00%	12.10%	10.70%	9.70%	10.90%	None	None
Above Project Area Exploitation Rate (BY 1995-2004)	64	72	71	47.80%	21.00%	57.10%	29.20%	62.80%	52.40%	48.10%	None	None
Total Exploitation Rate (BY 1995-2004)	49%	58%	68%	63.80%	40.40%	66.10%	41.30%	73.40%	62.00%	59.00%	None	None
<b>Hatchery/Wild Interaction Monitoring</b>												
Age Structure –Hatchery spawners Y/N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Age Structure – Natural Spawners Y/N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Run Timing - Hatchery Y/N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Run Timing - Natural Y/N		Y	Y	Y	Y	N	N	N	N	N	Y	Y
NOR Productivity Y/N	N	N	N	N	Y	N	N	N	N	N	Y (Index)	Y (Index)
BACI Assessment Y/N	N	N	N	N	N	N	N	N	N	N	N	N
Hatchery Release Stray Rate Y/N	1.3	6.8	6.6	Y (7.8%)	Y (5.1%)	Y (9.3%)	Y (22.6%)	Y (65.1%)	Y (37.1%)	Y (52.1%)	Y (20-40%) Based on PIT tags	Y (50-60%) Based on PIT tags
RRS Assessment Y/N	N	N	N	N	Y		N	N	N	N	N	N
Other Genetic Assessment Y/N	N	N	N	Y	Y	N	N	N	N	N	N	N

## **NOTES:**

Run Year (RY). Report number of years between 2000 and 2009 that goal was met.

Brood year (BY). Report number of years between 1995 and 2004 that goal was met.

Exploitation Rate = the percent of the total number of adults produced that was harvested. Report the 10 year average exploitation rate for Brood years 1995-2004.

Report if data are available. Y (Yes) indicates that the data are being collected and reported, N (No) indicates that the data are not being collected.

RRS – relative reproductive study

Report the average percent of the total number released recovered as strays from 2000 -2009. A stray is defined as a fish recovered alive at traps or weirs or harvested outside a direct line from release site to the ocean.

## **ISRP Findings, Conclusions, and Recommendations**

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

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

The two hatchery performance indicators that were universally reported across all the LSRCP steelhead programs were green egg-to-smolt survival rates and number of smolts released. The goal established for green egg-to-smolt survival was 65%, although for the Imnaha and Grande Ronde programs the goal equaled 70%. Annual smolt release goals depended upon the program and ranged from 50,000 to 1,750,000 smolts. These two indicators encompass hatchery performance, yet they cannot be used to partition out where mortality may be occurring while the fish are under artificial culture. Adaptive adjustments to hatchery practices, from adult handling to final smolt releases, are not possible without knowledge of when and where mortality takes place. To discover this requires that survival and other performance data be compiled from broodstock collection through offspring release.

Performance data for hatchery programs fall into two life-history stanzas: parental and offspring. Parental data would include such statistics as number of broodstock collected, pre-spawning survival, broodstock origin (including hatchery and wild fish), maturation or spawning dates, broodstock demographics such as age, life-history type, length, weight, egg size, fecundity, numbers of fish spawned, and types of crosses performed (ISAB 2000-4, ISRP 2008-7). Alternatively, number of green eggs taken, green egg-to-eyed egg survival, eyed egg-to-fry survival, monthly juvenile survival and growth, size at release, numbers released per location, rearing history such as transfers out-of-basin during potential imprinting stages, dates of release, types of release such as volitional or forced releases from acclimation ponds or direct releases, and fish health status are examples of offspring data. Most of the parental performance indicators, such as number of broodstock used and their pre-spawning survival, spawning dates, and demographic profiles of the fish used as broodstock are not directly linked to the measures that are being employed to appraise hatchery success, that is, to egg-to-smolt survival or smolt release numbers. A holistic evaluation of in-hatchery performance requires the incorporation of parental variables.

All of the hatchery programs gathered both parental and offspring data, and many were mentioned in the reports we received. Some were depicted in bar graphs or scatter plots that presented values throughout the duration of a program. In other cases, reports stated that a particular performance indicator was measured but no data were shown. The HGMPs for these programs presented much of these data in comprehensive tables. If it does not already exist, we recommend that the HGMP tables be imported into a centralized database where in-hatchery data for all of the LSRCP steelhead projects can be accessed. These summary tables should be updated annually on a hatchery-by-hatchery basis. Typically an overall mean value for each statistic like egg-to-smolt survival is provided. Whenever possible, some measure of variation, such as standard error or standard deviation should accompany a mean value.

Expected performance standards specific to each hatchery could also be inserted into the tables. This would provide a centralized location where in-hatchery standards could be readily found and where trends in performance and possible problem areas could be detected. Additionally, this information could then be easily incorporated into future LSRCP reports and presentations.

In a few instances, the effective population size or  $N_e$  of a hatchery population was estimated and presented. Recent work by Christie et al. (2011, 2012) on steelhead has suggested that artificial culture may create genetic changes in hatchery and supplemented natural populations, mainly caused by a reduction in  $N_e$  produced by inadvertent domestication. Additional work on such genetic effects of hatcheries will be valuable, and the LSRCP would benefit from tracking temporal changes in effective population sizes ( $N_e$ ), effective number of breeders ( $N_b$ ), mean family size ( $\bar{k}$ ) and variance of family size ( $V_k$ ) in its hatchery and wild populations of steelhead.

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

The in-hatchery metrics presented in the reports and hatchery HGMPs adequately measured hatchery performance. Analyses of these indicators were appropriate. Several of the reports gave comprehensive descriptions of how a number of performance indicators were calculated. Some, like determining the number of pre-smolts transferred from the Irrigon Hatchery, were innovative and validated by independent measurements. These detailed explanations were appreciated. In other cases, methods to determine in-hatchery metrics were not described. We suggest that brief descriptions of the methods employed to derive a performance indicator be attached to the summary tables mentioned above; the methods used to determine the same metric may vary by hatchery since the availability of staff, resources, and historical practices will affect method choices, but having a central repository of methods should promote sharing of techniques and may also lead to improvements in precision and accuracy and efficiencies in data acquisition. The [www.monitoringmethods.org](http://www.monitoringmethods.org) database might be a tool to meet this need.

*Are programs able to achieve the goals as planned?*

The hatchery programs usually achieve their green egg-to-smolt survival and smolt release goals (see Table 1). In Brian Leth's roll-up presentation, for example, it was reported that egg-to-smolt survival across all the programs averaged 84%. Smolt release numbers have also been met in most years. When the LSRCP began the overall goal was to release approximately 11 million smolts at 8 fish per pound (~57 g). The current goal is to release 5.3 million smolts at 4.5 (101 g) to 5 (91 g) fish per pound. Reductions in smolt numbers occurred in a number of programs at the request of managers for several reasons. First, harvest rates downstream from projects were lower than anticipated mainly due to harvest restrictions consequent to ESA listings. Therefore, fewer smolts were needed to reach above project adult abundance goals. Secondly, long-term decreases in spring water supplies at the Magic Valley and Hagerman Hatcheries have reduced the number of smolts that can be reared at these facilities. At the Clearwater hatchery, rearing space and water originally allocated for steelhead were re-

directed toward spring Chinook production. Efforts to increase the rearing capacity of steelhead juveniles at these three facilities are being planned, but no details on how that might be accomplished were provided. Smolt size was nearly doubled to increase post-release survival and to reduce residualism. In a few instances, smolt production was impacted by IHNV, but these episodes have been infrequent and lost production was backfilled by importing juveniles from other LSRCP facilities. If such episodes occur in the future, we urge the LSRCP to only use local fish to fill production voids. Outbreaks of bacterial cold water disease have also occurred, but on the whole, fish health issues have not prevented the program's hatcheries from reaching their survival and release number objectives.

*Is fish culture performance within standards expected for salmonids?*

As mentioned above, green egg-to-smolt survivals often exceed program standards, fish health issues appear to be minimal, and smolt production is typically met—all are indicative of well-run hatchery programs.

## **2. How are hatchery juveniles performing once released?**

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

Performance indicators for post-released hatchery steelhead fall into three categories: smolt performance, adult performance, and fishery benefits. Smolt performance was measured by estimating survival from release sites to the Lower Granite Dam and by assessing their arrival timing to the dam. Adult metrics included total adults produced, return timing to hatchery racks or other collection points, age and size at maturity, escapement to Lower Granite Dam (Smolt-to-Adult Recruits or SAR), smolt-to-adult survival rates (SAS), harvest rates above and below Lower Granite Dam, straying rates, and recruits per spawner (R/S). Fishery benefits were appraised by assessing angler effort; catch per unit of effort; profiling angler origin; estimating the number of wild fish caught, released, and killed; and approximating benefits to local economies. Not all of these indicators were examined by each project, but key indicators, like SAR, SAS, harvest rates above and below Lower Granite Dam, total adults reaching the project area, and straying were universally examined. Specific goals were established for some indicators such as total adults reaching the project area, SAR, SAS, and harvest rates below and above Lower Granite Dam, but in other instances standards were not established, for example straying rates and smolt survival to Lower Granite Dam. The metrics examined, however, generally allowed objective assessments of progress toward LSRCP mitigation objectives.

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

In a number of cases the performance indicators could be expanded and in some instances improved. Survival and timing of hatchery steelhead smolts to Lower Granite Dam is estimated from observation of PIT tagged fish. Yet, the effects on smolt performance of release location, type, and date remain unexamined as do the effects of river conditions such as turbidity, water

flow, and temperature. Understanding the effects of such factors on rate of travel and survival may help managers determine when fish releases should occur. Similarly, survival and travel time of project smolts to Bonneville or other lower river dams was not evaluated. Having an estimate of the number of project smolts reaching Bonneville would indicate where potential mortality problems might exist. If, for instance, estimated survival to Bonneville was high, but SAS values were low, then mortality could be linked to ocean or lower river conditions rather than to some combination of ocean and dam passage issues.

Estimates for the total number of adult fish produced from a project are problematic. These values are determined by adding rack recoveries to harvest and stray numbers. The reports we received state that stray and harvest numbers are likely underestimates because not all possible spawning and fishing areas are sampled. Ongoing efforts though may substantially improve estimates of the total number of fish produced from a project. Adult steelhead collected at Lower Granite Dam are currently being PIT tagged throughout the steelhead migration period. PIT tag arrays are being established in tributary systems throughout the project area under the auspices of the ISEMP project. Detections at these arrays are making it possible to estimate the total number of hatchery and NOR steelhead entering each sampled stream. Since stream conditions may affect detection rates in PIT tag arrays, we suggest that JSAT tags also be applied in a similar manner because their use may provide more reliable data. LSRCP sponsors are also exploring the possible use of Parent Based Tagging (PBT). To perform PBT, DNA samples from fish used as hatchery broodstock are collected at the time of spawning. Similar samples are obtained from fish that could potentially be their progeny. Pedigree analyses that employ a standardized set of Single Nucleotide Polymorphisms (SNP loci) are performed and used to identify the stock, hatchery, broodyear, and parent pair of the sampled fish. This is a promising approach that could identify the origin of strays and harvested hatchery steelhead. We urge the sponsors, however, to continue to apply marks and tags on project fish. Recoveries of these known origin fish can be used to validate origin assignments and provide error rates to PBT determinations.

LSRCP cooperators also find that harvest rates of project fish are difficult to estimate. Harvest rates of project fish in the lower river are less than those projected by the United States v. Oregon Technical Advisory Committee (TAC) team that uses a combination of index stocks to estimate harvest rates. A number of possibilities were proposed to explain this discrepancy. One was that the indicator stocks used by the TAC team were not suitable for all Snake River steelhead populations. Other suggestions were centered on possible biases associated with coded wire tag (CWT) recoveries and expansions that are used by the LSRCP to estimate harvest. The use of PBT has been proposed as one way to examine potential biases in CWT recoveries. This method would theoretically allow the origin of every harvested hatchery fish to be identified. If PBT proves to be economical and accurate it would help refine harvest rate estimates in the lower river as well as in the project area. Managers also plan to convene a run-reconstruction workgroup to further refine harvest rates. We feel both of these approaches have merit.

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

When the LSRCP for steelhead was first established in 1976 a goal of 165,300 adults was established. Two thirds of those fish or ~ 110,000 were expected to be harvested in the lower river. The remaining third or ~55,000 was established as an escapement goal for the project area. The project has never met its 165,300 adult goal. Harvest rates in the lower river declined from 40 to 50% in the mid 1980s to 5 to 10% once Snake River and middle and upper Columbia River steelhead were listed under the ESA. It is unlikely that the original harvest goal in the lower river will be realized in the foreseeable future. However, if fishing for steelhead resumes in the Columbia River below the Snake River confluence with harvest rates similar to the 1980s, harvest opportunities in the project area will be diminished if adult survival does not increase substantially. The SAS values for project fish have been quite variable ranging from 0.25% to as high as 3%. A SAS goal of 1.5% was originally established for the projects. The Grande Ronde and Lyons Ferry projects still use this goal and have met or exceeded it about 75% of the time over the past ten years. Other LSRCP programs like the Salmon, Clearwater, and Imnaha have SAS goals that are greater than 1.5% and have met their SAS goals just 8% of the time.

Although the SAR values achieved by project steelhead have also been variable, they have met or exceeded project goals, that range from 0.5% to 0.87%, eighty-five percent of the time over the past decade. Additionally, R/S values have averaged 18.6 over this same time period. Consequently, the projects have reached their adult return goals above Lower Granite Dam 87% of the time over the past ten years, in part because harvests in the lower river have been greatly curtailed. As a result, sport harvests in the project area have increased from those achieved before the LSRCP, which averaged 20 to 28 thousand fish per year. From 2000 to 2009, harvests of hatchery steelhead above Lower Granite Dam have ranged between 40 to 90 thousand fish. In some of the basins, stream areas have been closed to fishing for conservation purposes. Nonetheless, the number of angler days has increased across all the programs from the pre-project period. In general, the hatchery programs are providing ample fishing opportunities and important economic benefits to local communities which would not have occurred without the LSRCP.

### ***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 indicators for natural and hatchery fish?*

Many risk aversion strategies have been employed by the LSRCP steelhead projects in an attempt to reduce potential interactions between project and wild steelhead and other fishes. A partial list of these actions includes locating release locations below areas of natural steelhead production; scheduling release dates around expected fry emergence periods to reduce encounters between newly emerged fry and migrating hatchery smolts; reducing smolt numbers; using acclimation ponds and volitional exit strategies to reduce straying and

residualism; studying predaceous interactions; assessing disease transmission; creating refuge areas for wild steelhead; restricting fishing areas; removing hatchery adults at weirs and traps to reduce genetic impacts to wild populations; and developing alternative or endemic broodstocks to reduce straying. Yet it appears that the effects of these and other implemented strategies on natural fishes in the project area have not been quantitatively assessed. Two efforts taking place in Idaho, the Idaho Natural Production Monitoring program and the Idaho Steelhead Monitoring and Evaluation Studies, may be making such assessments. But these projects were not mentioned in the reports we received, and it is unknown whether they are coordinated with the LSRC program.

Evaluating the effects of hatchery fish on natural populations is difficult. If the LSRC has not decided on a framework for accomplishing this work, we suggest that the protocols established by Todd Pearsons and colleagues (Pearsons et al. 1998; Pearsons and Hopley 1999; Ham and Pearsons 2001; Pearsons et al. 2002) might be a good starting point. Briefly, they would use three steps in the assessment procedure developed by Pearsons. First, they would determine whether spatial overlap occurs between released hatchery fish and other fish species. Second, if overlap occurs, field methods would be used to determine if changes in abundance, spatial distribution, size, or biomass in natural populations have transpired after hatchery releases have commenced. And third, if changes have taken place, they would ask if they can be reasonably attributed to supplementation. The approach was successfully used to examine the impact of a spring Chinook supplementation program taking place in the Yakima River (Pearsons and Temple 2007) and one of its tributaries, the Teanaway River (Pearsons and Temple 2010). In the Umatilla basin, Hanson et al. (2010) also provide a good approach for quantifying density-dependent impacts associated with supplementing wild steelhead.

Probably the greatest potential impact of program fish on natural populations is through straying, especially since most of the LSRC hatcheries use a segregated rather than integrated broodstock approach. Two types of straying rates exist. One describes the proportion of fish from a hatchery that were “recovered alive at traps or weirs or harvested outside a direct line from [their] release [location].” This metric is presented in Table 1 which shows the average stray rates for each hatchery program from 2000-2009. These rates were determined by dividing the number of strays recovered by the number of juveniles released. We believe this method underestimates straying and suggest that these rates be estimated as the number of strays/total adult return. Even with this method, straying rates of project fish will likely be underestimated because it is not possible to sample all natural spawning areas and fishery locations. Stray rates varied significantly from one hatchery program to the next. The reasons behind this variation should be investigated, and hatchery practices should be modified to reduce straying to limit potentially adverse effect on natural origin steelhead populations.

The second straying rate equals the percentage of hatchery fish that are present in natural spawning populations. From an interactions perspective, it is essential to determine the proportion of strays that are present or potentially spawning in individual basins or streams. For example, the creation and maintenance of wild steelhead refugia is an important conservation strategy. Yet, the value of such locations could be undermined if large proportions of the fish

using these areas are hatchery strays. Thus, we suggest that annual genetic sampling take place in selected refuge areas to document introgression levels of hatchery fish on the wild populations. Some standard of acceptable introgression could be established by consulting with population geneticists. An example of such a rule might be that  $\leq 5\%$  of the juveniles sampled could have hatchery ancestry. If this value were exceeded over three continuous years, tools for removing hatchery adults could be instituted by reducing the size of a hatchery program, targeted fisheries, collections at weirs or other methods. High levels of stray hatchery fish on the spawning grounds also provides information suggesting that hatchery fish are not being fully utilized (harvested) to the extent that they might be.

Straying of project fish into lower Columbia River tributaries and within project basin streams has been recognized as a problem issue. Studies on the effects of different release strategies on straying and survival have been performed and were informative and nicely done. Additional studies on methods to reduce straying should be considered, particularly on how the effects of current barging procedures might be modified. A recent review of adult salmon and steelhead straying by Keefer and Caudill (2012) summarizes when and how imprinting occurs and the factors that disrupt imprinting in salmonids. They also point out where additional research could take place. We encourage LSRCP researchers to consult this document and possibly use it to help guide future straying studies. We also note that some juvenile steelhead were reared to the smolt stage in out-of-basin hatcheries (e.g., Magic Valley, Hagerman, Irrigon) then transferred back to the river of interest soon before release. The extent to which this practice contributes to straying is unknown.

Residualism of hatchery steelhead is another important factor that can influence the impact of hatchery fish on wild fish populations. Studies performed by ODFW have provided fish culture actions that can significantly reduce residualism. They found that acclimation ponds, volitional releases, and culling of non-migrating fish after the completion of a volitional release period could be used to reduce residualism. Non-migrating fish were often maturing males, and they were collected and used to support “put and take” fisheries in ponds. If this approach is not possible, we recommend that samples of smolts be taken just before release to determine the percentage of maturing males. This will provide an estimate of the number of fish likely to become residuals from a release and also improve the understanding of SAR and SAS values. Because of the positive effects of acclimation ponds and volitional release strategies, we suggest that these methods be employed by the LSRCP whenever possible.

Recreational fisheries that target hatchery origin fish may also have an impact on natural origin adults. Some estimates of hooking and post-release mortality have been made by WDFW. The ISRP encourages additional work to obtain estimates on the survival of natural origin fish that are caught and released one or more times in fisheries throughout the LSRCP area.

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

The weakest part of the LSRCP program for steelhead has been evaluating the demographic, ecological, and genetic impacts of hatchery fish on wild steelhead and other fishes. Even though a considerable number of risk adverse strategies and conservation based policies have been put into place, the program will need to develop approaches to measure the effects of these actions on wild fishes.

*Are they adequately evaluating supplementation (for example using the Ad Hoc Supplementation Work Groups' recommendations<sup>4</sup>)?*

Most of the LSRCP steelhead hatchery programs are nominally segregated. That is, most of the broodstock is from hatchery returns rather than from local wild steelhead, but a few active efforts to supplement wild steelhead with hatchery fish are occurring, for example in the East Fork of the Salmon River, the South Fork of the Clearwater, and in Little Sheep Creek in the Imnaha. All of these efforts are still taking place. If the goal of a supplementation effort is to conserve a natural population we urge the LSRCP to use methods developed by Berejikian et al. (2012). They used natural growth regimes in a hatchery setting to produce 2- and 3-yr-old steelhead smolts. Their methods reduced residualism and fitness loss due to artificial culture.

An informative Relative Reproductive Success study took place in Little Sheep Creek. However, formalized evaluation programs, such as those suggested by the Ad Hoc Supplementation Work Group, are not being carried out.

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

A previous review of the LSRCP steelhead program occurred in 1998, soon after Snake River steelhead and Chinook salmon had been listed under the Endangered Species Act. At that time reviewers felt that the existing steelhead programs would have to be substantially altered. They found that natural steelhead populations were severely depressed in basins where hatchery programs were located. Consequently they recommended instead of emphasizing recreational fishing opportunities that a shift toward recovering natural populations should take place. The genetic risks of using non-endemic hatchery fish near natural populations and of competitive interactions between hatchery and wild fish along with likely fishery effects were also recognized as potentially deleterious impacts of the existing program. A suite of adaptive management options were proposed, including reducing the number of smolts released; using acclimation ponds to reduce straying; capturing and removing project adults at weirs and traps; shifting to local broodstocks; and possibly using hatcheries to help recover natural populations (Carmichael 1998). Many of these options were tried and evaluated over the next 15 years. However, the question raised then about "whether harvest mitigation programs and wild stock

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<sup>4</sup> AHSWG: Ad Hoc Supplementation Work Group, Galbreath 2008.

recovery can be conducted/achieved concurrently” is still as germane today as it was in 1998. Particularly, it is difficult to effectively maintain the past emphasis on providing harvest while efforts are being made to develop “endemic” stocks. This difficulty needs to be addressed by the state agencies and tribes. It also needs to be clearly articulated that if selection occurs, for example on run timing, whether a hatchery should seek to more closely mimic wild fish or should segregate hatchery from wild stock to provide more separation in harvest potential. It would be useful for the managers to clarify how they see the current program meshing with their state and tribal management plans for steelhead, and how they will reconcile any discrepancies.

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## ISRP Comments on Individual Program Summaries

### 1. Idaho

#### A. Clearwater River

[Link to the summary report >](#)

##### *Background*

Steelhead originating from the Clearwater River have been impacted by dams and extractive industries like logging and mining for over a hundred years. The Lewiston Dam, which was completed in 1927 and located near the mouth of the Clearwater River, for example, interfered with steelhead migration until its removal in 1973. Similarly, the Harpster or Grangeville Dam which was built in 1910 on the South Fork Clearwater River blocked migrating adult steelhead until fish passage facilities were installed in 1935. High flows in 1949 made those facilities unusable, and steelhead were again prevented from entering a large portion of the South Fork until 1963 when the dam was removed (American Rivers 1999). Another significant steelhead blockage occurred when the Dworshak Dam was completed in 1973. It is located at the lower end of the North Fork Clearwater River, and it prevented all upstream migration of steelhead and other anadromous salmonids into approximately 25% of the entire 25,000 km<sup>2</sup> Clearwater River Basin. Finally, four dams constructed by the Corps of Engineers in the Lower Snake River from 1955 through 1972 (Ice Harbor, Lower Monumental, Little Goose and Lower Granite Dams) have also impacted Clearwater River steelhead.

A number of efforts have been undertaken to mitigate the effects of these and other factors on steelhead in the Clearwater basin. For instance, adult steelhead captured at the Lewiston Dam were released above Harpster Dam and allowed to spawn naturally in the South Fork beginning in 1961. Additionally, eyed eggs from steelhead collected at the Lewiston Dam were planted into South Fork tributaries. In 1969, the egg source for the South Fork recovery effort was changed; eggs obtained from steelhead collected from the North Fork Clearwater River at the newly completed Dworshak Hatchery were used. The Dworshak Hatchery became operational in 1969 and is located close to the mouth of the North Fork Clearwater River. It was built by the Army Corps of Engineers to compensate for the loss of anadromous salmonids caused by the Dworshak Dam. Currently, 600,000 of the 2.1 million steelhead smolts annually produced by the hatchery are released into the South Fork. Approximately 1.2 million smolts are liberated from the hatchery, and another 300,000 are planted into Lolo Creek and into a lower Middle Fork site, Clear Creek (Stiefel and Leth 2012). To offset steelhead production losses caused by the lower four dams on the Snake River the Army Corps of Engineers built the Clearwater Fish Hatchery on the North Fork of the Clearwater River approximately two miles downstream of the Dworshak Dam. It was the last hatchery to be built by the Corps under the auspices of the Lower Snake River Compensation Plan (LSRCP). Hatchery construction was completed in 1992 and in 1993 the first yearling steelhead smolts produced by the hatchery were released into the South Fork of the Clearwater River. Releases of steelhead smolts from the Clearwater Hatchery into the South Fork have occurred annually since then. These releases typically occur in mid-to-

late April and smolt sizes have averaged 90 g (range 70 to 116) and 209 mm (range 188 to 219) (Clearwater Hatchery HGMP 2011). Two satellite facilities located in the South Fork are associated with Clearwater Fish Hatchery. The Crooked River site is located at river kilometer 94 while the Red River location is at river km 101.

Originally a production goal of 1.75 million steelhead smolts was established for the Clearwater Fish Hatchery. The need to use portions of the hatchery for spring Chinook production reduced this goal to 843,000 smolts. Overall, approximately 40% of the smolts are being used to supplement wild steelhead in the South Fork Clearwater River, although the percentage varies considerably from year to year (e.g. 0.6 to 51.7% from 1994 -2003). These fish are not adipose clipped and are released at Red River (150,000), Crooked River (83,000) and Newsome Creek (100,000). The remaining 510,000 fish are being used to mitigate for lost steelhead harvest caused by the construction and operation of four lower Snake River dams. They are adipose clipped and released at Peasley Creek (250,000) and Red House Hole (260,000), two mainstem South Fork Locations (Clearwater Hatchery HGMP 2011).

Even though out-of-Clearwater-basin steelhead adults, eggs, or smolts have not been used in the South Fork program, few steelhead originating from within the South Fork have been incorporated into the broodstock. Instead, it appears fish from populations that are often more than 120 miles away from this stream have been the predominant contributors. The adults and eggs obtained from steelhead captured at the Lewiston Dam, for instance, could have originated from any upstream population. And once the Dworshak and Clearwater hatcheries became operational almost all the broodstock for the South Fork program has originated from North Fork Clearwater fish. This use of non-local fish most likely occurred because dam and hatchery sites facilitate broodstock collection. However, an effort to establish a local South Fork broodstock has recently begun. Volunteer anglers began capturing hatchery fish returning to the South Fork in 2010. These fish are then transported to the Dworshak hatchery where they are spawned and their eggs are incubated to the eyed stage before being transferred to the Clearwater Hatchery for final incubation and rearing.

### ***Stock Structure and Genetic Composition***

Clearwater River steelhead are part of the Snake River Basin Steelhead Distinct Population Segment (DPS). This DPS, which also includes all naturally spawning populations of steelhead in the Snake River Basin, was listed as threatened under the ESA in 1997. Steelhead originating from the Clearwater River have been placed into a single Major Population Group (MPG) which consists of five extant independent populations. The existing populations include: 1) Lower Clearwater mainstem, 2) Lolo Creek, 3) South Fork Clearwater, 4) Lochsa, and 5) Selway. The North Clearwater population, which is maintained entirely by artificial production at the Dworshak Hatchery, is regarded as a historic population.

The Clearwater Hatchery program under the LSRCP is designed to be an effective segregated hatchery program in a portion of the Clearwater Basin where effects on wild fish would be comparatively low.

### ***Performance of Hatchery Fish***

Two indicators of hatchery performance were reported, eyed egg-to-smolt survival rates and number of smolts released. Data on these two statistics were presented in bar graphs for broodyears 1992 – 2010. When making oral presentations, bar graphs are efficient at showing trends and general means. For reports, however, we recommend that tables also be used because means and standard error information can be easily reported and seen. The above two indicators do provide a general summary of how project fish have performed in the hatchery environment. The report, however, would have been improved if information had been included on: 1) source of broodstock, 2) numbers of females spawned, 3) number of eggs taken, 4) green egg to-eyed egg survival, 5) fry to fingerling survival, 6) fingerling to smolt survival, 7) monthly growth rates, 8) size at release, 9) dates of release, 10) numbers of fish released per location, and 11) acclimation strategies prior to release. All of these data are collected by the IDFG and are included in their HGMP for the Clearwater Hatchery (Clearwater HGMP 2011). Other parameters of interest that could be used to monitor possible inadvertent domestication effects include the size and age of the broodstock, pre-spawning survival of broodstock, maturation dates, fecundity, and mean egg weight.

When looked at collectively, the data presented in the summary report and shown in the HGMP indicate that the Clearwater Hatchery program reaches and often exceeds fish culture standards. Consequently, the hatchery program has been able to meet fish survival expectations. However, the original goal of releasing 1.75 million smolts has never been met because space and water originally programmed for steelhead has been transferred to spring Chinook production.

### ***Post-Release Performance***

Seven post-release performance indicators are reported, smolt survival to Lower Granite Dam, total adults produced, adult escapement to Lower Granite Dam, smolt to adult survival rates (SAS), straying rates, and harvest contribution rates to fisheries below and above Lower Granite Dam. Some of these measures are more challenging to determine than others, and caveats associated with how they were estimated were candidly described. Bar graphs or scatter plots are used to show broodyear or run-year values for each of these statistics. Again we recommend that these data also be put into tables for easier interpretation and possible comparative use.

Survival of released smolts to Granite Dam was estimated by using PIT tagged fish. Yearly estimates from 1993 through 2011 are presented in a figure which showed that overall survival

has averaged almost 76%. No mention, however, is made of how release location, river flow, water temperature, turbidity, or other factors may affect in-stream survival. Understanding the importance of such factors on rate of travel and survival might help managers determine when smolts should be released. Similarly, survival and travel time of project smolts to lower Columbia River dams was not mentioned. Having an estimate of the number of project fish passing the Dalles Dam, for example would help delineate where potential mortality problems might exist. If estimated survival to The Dalles was high but SAS values were low, then mortality could be linked to ocean or lower river conditions rather than some unknown combination of ocean and freshwater passage issues.

Theoretically the total number of adult steelhead produced by a project would equal the number returning to hatchery racks plus the number harvested and recovered as strays. IDFG forthrightly states that rack counts and stray numbers are problematic. Improved methods of estimating adult returns are needed for this and other steelhead stocks. Some questions about harvest rates below Granite Dam also exist. To help refine the estimate, the smolt to adult return rate (SAR) for steelhead returning to the Dworshak Hatchery was used. The estimate of total adults produced from the Clearwater project is the SAR derived from Dworshak fish multiplied by the total number of Clearwater smolts released. More information about how the Dworshak SAR was determined would have been helpful. For example, how was the age composition and origin of the fish returning to Dworshak estimated? Since SARs are calculated by broodyear, knowing the age composition of the returning fish is critical. Understanding the origin of the returning fish is equally important. Potentially, adult steelhead from the Clearwater Hatchery that were released into the South Fork could have returned to the Dworshak Hatchery; a location where they were incubated and reared for a year. Also, adult steelhead from the Dworshak Hatchery that were off-planted into Lolo and Clearwater Creek and the Salmon River may have returned to the hatchery as opposed to their release locations. Including potential strays and younger or older fish unknowingly into a SAR estimate will increase its value leading to an over-estimate of adult production. Accounting for these uncertainties would help refine the estimates for the number of adults produced by the project.

The total adult mitigation goal for the project was 42,000 fish. This goal has never been met. The primary reason for this has been that the project has not met its smolt release goal of 1.75 million. Nonetheless, the project has clearly produced adult steelhead. Since 2003, adult returns have averaged slightly more than 18,000 fish per year. If smolt survival is density independent, releases of 1.75 million fish over this same time period would have produced around 37,000 adults; a value close to the project's goal.

Recently the escapement of project adults to the Lower Granite Dam has been estimated from counts of PIT tagged fish. However, the sponsors state that variability associated with tag loss and possible differences in mortality between tagged and non-tagged fish have led them away from using this method. Instead they hope to use parent based tagging (PBT). We have two suggestions regarding these escapement estimates. First, if the sponsors wish to continue to use PIT tags as a tool for escapement estimates, they should plan on using a double marking design. CWTs, thermal otolith marks, or other tags and marks could be applied to PIT tagged

and control groups to get yearly estimates of tag loss and PIT tag effects on survival. Second, if PBT becomes the preferred tool we encourage the sponsors to continue to apply CWTs, PITs, thermal marks or other tags to portions of all the steelhead produced by LSRCP. These marks and tags can be used to help validate and assign an error rate to the assignments made by using the PBT method.

SAS values for project fish have averaged 1.8% for broodyears 1992 – 2006. This 1.8% value is comparable to ones that have been observed in Salmon River steelhead. Some explanation for how the SAS values were determined and the underlying assumptions that were used for this calculation would have been useful. Straying rates for project fish relied on recoveries of project fish in fisheries and river systems that were in areas outside a direct path to a release area. The sponsors state that their stray rate estimates are minimal ones because not all fisheries or possible natural spawning areas are sampled. Nonetheless, stray rates for project fish appear to be low, with most strays showing up in areas above the Lower Granite Dam. If PBT becomes established, more refined straying rates should be produced since every sampled fish would potentially provide information about its origin.

Harvest rates on Clearwater hatchery steelhead below Lower Granite Dam are estimated by expanding CWT recoveries. These rate estimates, however, have proven to be lower than those produced by the United States v. Oregon Technical Advisory Team (TAC) for B-run index stocks of steelhead caught below McNary Dam. Three possible reasons for this underestimation are presented. Two of them involve CWTs, in one case it is suggested that not enough fish are being tagged with CWTs to produce a reliable estimate. In some years, for example, fish from different release areas or times of release may not receive tags. When this happens it is assumed that the fish that were tagged can represent the entire population. That may not be the case as time and area of a release may influence survival rates. Consequently we urge the sponsors to apply tags across all their release groups and if possible to increase the numbers tagged. An alternative suggestion involving CWTs is that Clearwater fish are for some reason being under sampled. This would reduce the true percentage of the project fish in the catch and therefore artificially reduce the estimate of harvest rate. Another possibility, that is not mentioned, is that the total number of adult fish produced annually is being over estimated. If that were the case, then the number of expanded recoveries would represent a smaller percentage in the total Clearwater catch. As was discussed above an inflated SAR estimate made on Dworshak steelhead due to strays could lead to such an overestimation. Currently tissue samples from steelhead harvested below and above Bonneville Dam are being collected. The sponsors hope to use PBT methods to see if CWT data are in any way biased. This method appears to be a promising tool that can be used to obtain accurate and precise harvest rates.

Fishing effort (angler days), harvest rates, and total numbers of sport caught Clearwater steelhead above Lower Granite Dam are also shown. Comparisons made between sport angler effort and total catch before and after hatchery mitigation are presented. If the same methods were used to calculate these variables in each time period then the Clearwater project has enhanced effort as well as catch. There is no way to determine if that is the case, however, since the methods used to estimate effort and total catch are not described.

## ***Impacts of Hatchery Fish on Wild Fish***

The reports and presentations made on the Clearwater Hatchery program did not describe how or whether potential impacts on native fishes in the South Fork, including wild steelhead, were being assessed or minimized by hatchery practices. The HGMP for the Clearwater Hatchery makes it clear that the sponsors have considered, and in some cases evaluated, possible competitive and predaceous interactions as well as behavioral changes and disease transmission caused by hatchery fish. Moreover, a series of risk aversion measures are being employed by the Clearwater program. These measures range from attempting to reduce residualism in released steelhead to planning releases of hatchery steelhead around fall Chinook fry emergence to reduce the likelihood that migrating hatchery fish will encounter fry (Clearwater Hatchery HGMP 2011). Furthermore, the Idaho Supplementation Studies project, which is a large scale monitoring program designed to track production and productivity in treated (supplemented) and control (un-supplemented) streams, is taking place in the Clearwater basin. Additional work of this type is being conducted in the basin by the Idaho Natural Production Monitoring and Idaho Steelhead Monitoring and Study programs. A description of how these projects interface with the LSRCP steelhead program in the Clearwater would have been a welcomed addition to the report. Finally, no mention of the possible impacts of using non-local, multiple generation hatchery fish to supplement wild steelhead production in the South Fork was presented. Some discussion of any work designed to examine the effects of hatchery fish on natural origin salmonids or an explanation for why it is not being evaluated would have been helpful.

## **Program Modifications**

Three modifications are described. First, as briefly mentioned above an effort is being made to start a local broodstock collection program in the South Fork. Volunteer anglers are assisting in this effort and significant numbers of eggs have been collected. Plans are being made to build a collection weir at Meadow Creek, a tributary to the South Fork. Whether this site will be used to release hatchery fish or have acclimation ponds was not discussed. Additionally, it was not disclosed if the progeny produced by fish collected in the South Fork will be differentially marked so that survival, straying, and other comparisons between these fish and those produced by adults collected at the Clearwater hatchery are possible. We applaud this effort and hope that it can be continued into the future. Second the possible wide-scale use of PBT is another promising proposal. If this method proves to be practical, accurate, and economical, it will help resolve many of the fish origin challenges that occur in supplementation and mitigation projects. The last modification dealt with increasing the water supply to the Clearwater Hatchery. If this can be accomplished, steelhead smolt production at the facility can be increased. Specific recommendations made by the HSRG, HRT (Hatchery Review Team), and Ad Hoc Supplementation Workgroup may have also been incorporated into the program but these were not identified.

Given the limited capacity of the Clearwater hatchery, eyed egg to release survival rates are adequate and are meeting the interim goal (843,000 as opposed to 1.75 million yearlings

originally called for). The program produces upwards of 20k adults for harvest in the Clearwater, less than half its mitigation goal, primarily because water supplies are sufficient only for half the smolt production goal. Survival to lower Granite Dam has averaged 76% (range 58-86%).

Although return goals have never been met and SAS goals have been met in only three years, the fisheries have been important in the region, and there has also been substantial downriver harvest.

Work toward local broodstock development is ongoing. Development of a segregated hatchery population will require not only development of a locally adapted broodstock, that is one separate from the Dworshak broodstock, but also isolation of the stock from naturally spawning populations.

### ***Literature Cited***

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## **B. Salmon River**

[Link to the summary report >](#)

### ***Introduction and Background***

The Salmon River is one of the Snake River's largest tributaries, having a basin of approximately 14,100 square miles. It once supported robust populations of wild steelhead; however, dam construction and operations along with other human impacts caused these populations to significantly decline by the mid 1970's. Two mitigation programs, one by the Idaho Power Company (IPC) and the other by the LSRCP, have been implemented to compensate for fish losses caused by dam operations. Summer steelhead that rear in the ocean for one year (A Run)

and two years (B Run) return to the Salmon River and both types are included in the mitigation programs. Run A and B hatchery smolts are released into two sections of the Salmon River: the Little Salmon River and upstream of the North Fork or Upper Salmon River. Hatchery steelhead are not released into other areas of the basin, such as the South or Middle Forks, because these locations are managed as wild steelhead zones.

A locally adapted broodstock for A-run steelhead was successfully created. Adults produced from this line return to two upper Salmon River hatcheries, the Pahsimeroi and Sawtooth. Attempts to create a local B-run broodstock source have not been as successful. Instead, B-run smolts produced from Clearwater River steelhead returning to the Dworshak Hatchery have been used as the main source of these fish. A number of efforts are now being tried to generate a locally adapted source of B-run steelhead. Local B-run adult steelhead, for instance, are currently being collected at the Squaw Creek acclimation site located in the Upper Salmon River. Additionally, an attempt is being made to establish a source of these fish at the Pahsimeroi Hatchery. Broodstock collected in the Salmon River for the LSRCP program are spawned in the basin and incubated to the eyed egg stage at either the Sawtooth or Pahsimeroi hatcheries. B-stock adults collected at the Dworshak Hatchery are spawned and their eggs are incubated to the eyed stage at that facility. Eyed eggs from these sources are transferred to the Magic Valley and Hagerman Fish Hatcheries for final incubation and rearing to the smolt stage.

With one exception, natural origin or wild steelhead are not incorporated into any of the Salmon River broodstock collections. An integrated hatchery program has been established on the East Fork of the Salmon River. In this instance, the goal is to use 100% natural origin steelhead returning to this upper river tributary as broodstock. Hatchery smolts produced by these fish will be released into the East Fork to supplement the natural population. Hatchery origin adults will only be incorporated into the broodstock when egg take goals from natural origin fish cannot be reached. The ability to evaluate success of this effort will be delayed until a weir or other infrastructure is installed at the mouth of the East Fork.

### ***Stock Structure and Genetic Composition***

Salmon River steelhead are part of the Snake River Basin Steelhead Distinct Population Segment (DPS). This DPS, which also includes all naturally spawning populations of steelhead in the Snake River Basin, was listed as threatened under the ESA in 1997. Steelhead originating from the Salmon River have been placed into a single Major Population Group (MPG) which contains twelve extant independent populations. Four of these, the South Fork Salmon, Secesh River, Lower Middle Fork Salmon, and Upper Middle Fork Salmon are B-run populations. The Little Salmon River, Chamberlain Creek, Panther Creek, North Fork Salmon, Lemhi River, Pahsimeroi, East Fork Salmon and Upper Main Salmon River are A-run populations. A genetic analysis of Salmon River steelhead showed that fish from the Little Salmon River and Upper Salmon River have close genetic affinities to the hatchery fish that have been liberated into these areas. Steelhead in the Middle and South Forks which are wild steelhead zones have  $F_{st}$  values that make them genetically distinct from hatchery fish.

### ***Performance of Hatchery Fish***

Two indicators of hatchery performance were reported; eyed egg-to-smolt survival rates and number of smolts released. These indicators do provide a general summary of how fish have performed in the hatchery environment. The report would have been enriched if information had been included on: 1) numbers of females spawned, 2) number of eggs taken, 3) green egg to-eyed egg survival, 4) size at release, 5) dates of release, 6) numbers of fish released per location, and 7) acclimation strategies prior to release. All of these data are collected by the IDFG; see for example the HGMP for Salmon River A-run steelhead 2002. Other parameters of interest that could be used to monitor possible inadvertent domestication effects include the size and age of the broodstock, pre-spawning survival of broodstock, maturation dates, fecundity, and mean egg weight. If these data are not currently being collected, we suggest that sampling and monitoring programs that are designed to capture this information be started.

When looked at collectively, data shown in the summary report and presented elsewhere indicate that the Salmon River LSRC program reaches and often exceeds fish culture standards. Consequently, the hatchery program has been able to meet fish survival expectations. Smolt release numbers from the Magic Valley Hatchery have generally been met. Reductions in spring water at the hatchery have limited the ability of this facility to reach its smolt release target of 1.75 million from 2005 to present. A similar reduction in spring water capacity at the Hagerman National Fish Hatchery has also reduced its steelhead smolt rearing capacity from an expected 1.7 million to one that is slightly less than 1.5 million. This trend began in 1991 and has continued to the present day. Methods to increase the capacity to produce smolts at both hatcheries are being investigated. Details on how that might occur were not provided.

### ***Post-Release Performance***

Data summaries on six post-release performance indicators were provided: smolt survival to Lower Granite Dam, adult returns, smolt-to-adult survival rates (SAS), straying rates, and harvest contribution rates to fisheries below and above Lower Granite Dam. Survival of released smolts to Granite Dam was estimated by using PIT tagged fish. Yearly estimates from 1993 through 2011 were made separately for smolts produced by the Magic Valley and Hagerman hatcheries. Survival rates for smolts from both hatcheries were similar and averaged around 73%. No mention is made of how release type (direct, acclimation pond, or volitional), release location, river flow, water temperature, turbidity, or other factors may affect in-stream survival. Understanding the importance of such factors on rate of travel and survival might help managers determine when smolts should be released. Similarly, survival and travel time of project smolts to lower Columbia River dams was not mentioned. Having such estimates would help identify where potential mortality problems might exist. If for example, SAS values were

low but estimated survival to The Dalles was high, then mortality could be linked to ocean or lower river conditions.

Theoretically the total number of adult steelhead produced by a project would equal the number returning to hatchery racks plus the number harvested and recovered as strays. IDFG states that ascertaining stray numbers is problematic because of sampling difficulties. Consequently, some strays will not be detected and the total number of adult steelhead produced by the project may be underestimated. The total adult mitigation goal for the Salmon River LSRCP project equals 75,800 adults (34,980 from Magic Valley and 40,800 from Hagerman). The Magic Valley hatchery has met its adult goal three times over 27 return years while the Hagerman facility has reached it twice over the same time period. Reduced smolt releases from Magic Valley and Hagerman and less than expected. SAS values appear to be responsible. Originally SAS values of 2 to 2.4% were expected to be realized by project fish. Reported SAS values average around 1%. How these rates are estimated is not disclosed. Further, no explanation is offered for why SAS values are lower than originally expected. However, it is mentioned that until recently ventral clips were used on project fish to identify individuals with CWTs. If SAS values are estimated by using expanded recoveries of CWT fish, they are likely underestimated because ventral clips are known to affect overall survival. Perhaps existing data on companion groups of CWT fish with and without ventral clips could be examined to evaluate this possibility. Additionally, as mentioned above, partitioning mortality by life stage and area would also help clarify why SAS values may be lower than expected. Even though the project has not met its total adult production goals, steelhead produced by the LSRCP and IPC programs have supported strong annual fisheries in the Salmon River. It appears the strong Salmon River fisheries have occurred because harvest rates below Lower Granite Dam have been restricted due to conservation issues.

As discussed above, stray rates are difficult to estimate because not all possible fishing and natural spawning areas are sampled. Stray rates for steelhead smolts produced by the Magic Valley and Hagerman hatcheries are estimated to average around 4%. In some years, calculated rates have been as high as 15% to 19%. It is unclear if biases due to incomplete sampling are accounted for in these estimates, but if not, then we suggest using straying rates from similar studies to create a probability distribution for likely stray rates. The project also needs to establish a stray rate standard. It would have been useful if the relationship between stray rates and release strategies had been examined and discussed. In some circumstances steelhead smolts are held in acclimation ponds prior to release and in others they are directly released into portions of the Salmon River. It is unclear if these different types of release strategies affect homing fidelity. The ISRP also wonders how rearing of fish to the smolt stage in an entirely different region such as Hagerman and Magic Valley in the upper Snake River might contribute to straying of these fish.

Harvest rates on Salmon River hatchery steelhead below Lower Granite Dam are estimated by using CWT expansions. These estimated rates are lower than those produced by the United States v. Oregon Technical Advisory Team (TAC) for combined index stocks caught below McNary Dam. Three possible reasons for this underestimation are presented. Two of them

involve CWTs, in one case it is suggested that not enough fish are being tagged with CWTs to produce a reliable estimate. In some years, for example, fish from different release areas or times of release may not receive tags. When this happens it is assumed that the fish that were tagged can represent the entire population. That may not be the case as type of release, date, and area of a release may influence survival and residualism rates. Consequently, we urge the sponsors to apply tags across all their release groups and if possible to increase the numbers tagged. An alternative suggestion involving CWTs is that Salmon River fish are for some reason being under sampled. This would reduce the true percentage of the project fish in the catch and therefore artificially reduce the harvest rate.

In other reviews, the ISRP has cautioned that hatchery indicator stocks may not reflect what is really being harvested. Currently tissue samples collected on steelhead harvested below and above Bonneville Dam are being collected. The sponsors hope to use parent based tagging (PBT) methods to determine the origin of harvested fish. If PBT works as expected it should indicate whether CWT data are in any way biased. We encourage the sponsors to continue to apply CWTs, PITs, thermal marks, or other tags to portions of all the steelhead produced by LSRCF. These marks and tags can be used to help validate and allocate an error rate to origin assignments made by using the PBT method.

Fishing effort (angler days), harvest rates, and total numbers of sport caught Salmon River steelhead above Lower Granite Dam are also shown. Comparisons made between sport angler effort and total catch before and after hatchery mitigation are presented and it appears that the Salmon River project has enhanced effort as well as catch. In tribal and sport fisheries, some wild steelhead will be caught and released. No information is provided about the number of wild steelhead caught or what their post-release survival might be.

### ***Impacts of Hatchery Fish on Wild Fish***

Interactions between program and natural fish are minimized by where hatchery smolts are released. For example, the Upper Salmon River was chosen as a release area because its elevation level and habitat attributes minimize natural production of steelhead. This part of the Salmon River also provides excellent access for anglers. Similarly, the Little Salmon River has few if any naturally produced Chinook salmon and it too provides good access for anglers. Furthermore, genetic analyses made on Salmon River steelhead suggest that confining releases of steelhead to these two portions of the basin has protected the genetic integrity of natural steelhead populations using other parts of the river. An estimate of the number of hatchery fish spawning in areas designated for wild fish is another metric that should be assessed. Hatchery fish may reduce the productivity of wild steelhead populations and genetic surveys are not designed to detect such a possibility. Additionally the project releases large numbers of steelhead smolts into the Salmon River basin. No mention is made of how such fish may influence the residency and growth of wild steelhead that may reside in the migration corridor.

Although not mentioned in the reports we received, a suite of risk aversion strategies ranging from acclimating steelhead in rearing ponds prior to release to regulating the size and number of fish released are being implemented (Sawtooth, Magic Valley, and Hagerman HGMP 2002). Additionally, the 2002 HGMP indicates that the sponsors have considered and in some cases evaluated, possible competitive and predaceous interactions as well as behavioral changes and disease transmission caused by hatchery fish. It is also likely that work is being done in the basin under the auspices of the Idaho Supplementation Studies project and by the Idaho Natural Production Monitoring and Idaho Steelhead Monitoring and Study programs. If so, a description of how these projects interface with the LSRCF steelhead program in the Salmon River would have been a welcomed addition to the report we received.

An integrated hatchery program is being used to supplement wild steelhead in the East Fork Salmon River. This project was initiated in 2001 and was briefly described in the report we received. Adults produced from hatchery smolts released into the East Fork began returning to the river in 2004. Over the past several years, hatchery origin adults have greatly out-numbered natural returns. More information about this program is needed. What, for example is the NOR goal for the population? What is the rationale for using 100% NORs as broodstock and having no restrictions on the number of hatchery fish allowed to spawn naturally? What is the desired PNI for this population? Details also need to be presented about how this program's effects on wild steelhead in the East Fork will be evaluated.

### ***Program Modifications***

A number of ongoing or planned modifications are described. First, as mentioned above, efforts are being made to start a local B-run steelhead broodstock program. At present smolts from B-run adults that have returned to the Upper Salmon River are being released from the Pahsimeroi Hatchery. Adults produced from those releases would be the founders of this line. We support this effort as it will stop the importation of Clearwater River steelhead into the basin and should improve the survival of B-run smolts. Nevertheless, a brief summary including: 1) how long it may take to transition to a local B-run broodstock source, 2) the percentage of locally produced B-run smolts released since the program began, and 3) a discussion of any factors that might interfere with this transition, is needed.

The program also plans to follow the recommendations from the HSRG, HRT, and 2008 FCRPS Biological Opinion and install an adult weir at the mouth the East Fork Salmon River to help manage and evaluate the integrated hatchery program that is taking place in this drainage. We recommend that the weir be designed to capture juvenile salmonids and that annual estimates of juvenile abundance, smolts per spawner, age composition of smolts, as well adult abundance and origin of adults be made. The possible wide scale use of PBT is another promising modification that is being proposed. If this method proves to be practical, accurate, and economical it will help resolve many of the harvest rate and fish origin challenges that have occurred.

## ***Literature Cited***

HGMP Salmon River Basin. 2002. Salmon River basin, A-run steelhead Sawtooth Fish Hatchery, Magic Valley Fish Hatchery and Hagerman National Fish Hatchery. 65 p.  
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## **C. Yankee Fork Streamside Incubation**

[Link to the summary report >](#)

### ***Introduction and Background***

Beginning in 1995 the Shoshone-Bannock Tribes (SBT) have been using Remote Site Incubators (RSIs) placed in the Yankee Fork of the Upper Salmon River to supplement natural steelhead production. When supplied with an adequate flow of gravity-fed and debris-free water, high egg-to-fry survivals of naturally emerging fry can be produced from RSIs. The major challenges faced by those using this technology are to find reliable sources of clean water and sites where they can be protected from flooding, vandalism, or other disrupting forces. Past efforts to evaluate juvenile and adult production from RSIs have generally relied upon thermal marking or the creation of bar codes on otoliths via shifts in water temperature during incubation. The SBT, however, have used a different technique, Parent Based Tagging, to evaluate their stream side incubation program. Unlike thermal mark detection, this genetically based method does not require the sacrifice of sampled fish and it provides opportunities to evaluate survival to various life history stages as well as the discovery of juvenile habitat preferences and dispersion patterns.

### ***Review Comments***

The goal of the reported work was to determine whether any juvenile fish were produced by the Tribe's RSI or Steelhead Streamside Incubation (SSI) program. Subsequent pedigree analyses performed on juvenile steelhead collected throughout the Yankee Fork basin showed that between 11% and 16% of the sampled fish had originated from RSIs. This could, however, be an inaccurate estimate as flow and habitat conditions in Yankee Fork may prompt newly emerged fry to exit the stream to rear elsewhere. Consequently, as suggested by the Tribe, a weir equipped with fan traps or other juvenile trapping gear needs to be installed at the mouth of the stream in order to fully determine the number of fry produced from the SSI program.

During the Clarkston meeting it was mentioned that bears and other animals had on occasion knocked over project RSIs. Water shortages caused by flooding or broken pipes due to windfalls and other events can also destroy RSIs. Eggs within each RSI are a valuable research and supplementation resource. When appropriate we recommend that RSI complexes be

surrounded by portable cyclone fencing and equipped with low flow alarm systems. When RSIs are operated on Puget Sound streams, for example, water alarms and satellite phones powered by solar batteries are installed at RSI locations. If flow is interrupted the satellite phones send out a pre-recorded message to a list of responders. This ensures that timely repairs can be made with minimal amounts of mortality.

RSIs and other types of streamside incubation boxes were originally developed for chum, sockeye, and pink salmon in an effort to overcome poor spawning ground conditions. It was hypothesized that improved egg to fry survival would bring about an increase in abundance since these species generally migrate quickly into estuaries or lakes for juvenile rearing. The use of RSIs for coho, stream-type Chinook, trout, char, and steelhead may be more problematic if the factor limiting their production is not impaired spawning areas but rather degraded rearing habitat. In other words, even if fry abundance is increased a corresponding upsurge in parr, smolts, or adults will not occur unless suitable rearing conditions are present.

RSIs placed into Yankee Fork are producing juvenile steelhead. Having demonstrated that, the next step is to determine appropriately sized RSI programs for Yankee Fork, Indian Creek, and Panther Creek. The number of RSI's, their spatial distribution within a watershed, and the amount of eggs placed into each unit should be driven by attributes within each stream. Among these are the quantity of NOR juveniles present, smolts per NOR spawner, the juvenile carrying capacity of the receiving stream, planned and ongoing habitat restoration efforts, observed survival of RSI origin fry to the parr and smolt stages within a stream, and NOR adult abundance and PNI goals for each stream. Monitoring and Evaluation programs are needed to obtain this type of information. If they are not currently in place, we recommend that they be developed and implemented. Without an active M&E program the recovery and supplementation values of the SSI program cannot be established. Also, coordination with other ongoing supplementation efforts is important. For example, IDFG currently releases 440,000 A-run smolts into the Yankee Fork. Plans are also taking place to release B-run smolts at the mouth of Yankee Fork and install a weir at this location to serve as a collection point for B-run adults. Habitat restoration designed to enhance juvenile spring Chinook rearing has occurred in the basin. Furthermore the Bureau of Reclamation recently completed a tributary assessment of Yankee Fork that will be used to guide future habitat restoration actions. All of these activities, plus potential interactions between the young of the year spring Chinook and steelhead parr need to be considered when shaping how the RSI program in Yankee Fork will be implemented in the future.

It is not clear from the report if the metric entitled "% Hatch" shown in Table 1 denote eyed-egg-to fry survival or does it represent eyed-egg-to alevin survival? The metric of major interest is egg-to-fry survival as that incorporates how well the eggs placed into each RSI survived. Also Table 1 would have been more informative if the annual survival values for each RSI placed into every stream had been presented instead of a yearly average for all RSIs across all streams. Table 2 only provides data for broodyears 2006 – 08. Were these the only years where parentage analyses of collected juveniles took place? If similar analyses taken place in Panther and Indian Creeks then including results from these streams would help provide a fuller picture

of the SSI program. Have genetic analyses been performed on any of the adult steelhead returning to Yankee Fork, Indian, and Panther Creeks to determine if the SSI program is contributing adults to these streams? Habitat restoration is taking place in Yankee Fork. Are habitat restoration efforts such as those occurring in Yankee Fork also occurring in Panther and Indian Creeks? If so, will the SSI programs in these watersheds be modified as a result?

The results of the pedigree work reveal the portion of the juvenile steelhead population in Yankee Fork that originated from the SSI program and also are used to obtain juvenile dispersion data. It appears that a considerable amount of habitat assessment work also took place when juveniles were being sampled. Have any analyses been performed that could be used to link RSI juvenile presence with specific habitat attributes? As this work continues we encourage the Tribe to utilize habitat characteristics and carrying capacity considerations to help locate and size their SSI efforts. We look forward to seeing additional results from this program as they become available.

## ***2. Oregon***

### **A. Grande Ronde River**

[Link to the summary report >](#)

#### ***Introduction and Background***

The Grande Ronde River enters the Snake River above Lower Granite Dam, the most upstream of the four lower Snake River Dams. Prior to the construction of the lower four dams, the Grande Ronde supported productive and abundant runs of steelhead. After the dams were built and operating, it was estimated that 48% of the adult steelhead production was lost from the Grande Ronde system. In 1976, Congress authorized the Lower Snake River Compensation Plan (LSRCP) to mitigate for the impact of the dams on salmon and steelhead production in the Snake River. The Grande Ronde River steelhead hatchery program was started in 1976 and became part of the LSRCP program. It is a segregated program intended to augment sport and tribal harvest.

Three facilities are used in artificial production of Grande Ronde steelhead. The Wallowa Hatchery and Big Canyon Acclimation facility are located in the Grande Ronde Watershed. The Irrigon Hatchery is situated on the Oregon side of the Columbia River approximately 17 km below McNary Dam. Broodstock are collected, spawned, and their eggs incubated to the eyed stage at the Wallowa Hatchery. Eyed eggs are then transported to Irrigon where the incubation period is completed and resulting fry are reared to the smolt stage. The smolts are then transported back to the Wallowa Hatchery and Big Canyon Acclimation facility where they are held for a short time before being released.

## ***Stock Structure and Genetic Background***

Grande Ronde River steelhead are part of the Snake River Basin Steelhead Distinct Population Segment (DPS). This DPS, which also includes all naturally spawning populations of steelhead in the Snake River Basin, was listed as threatened under the ESA in 1997. Steelhead originating from the Grande Ronde River have been placed into a single Major Population Group (MPG) which contains four independent populations: 1) Lower Mainstem Grande Ronde, 2) Joseph Creek, 3) Wallowa River, and 4) Upper Grande Ronde River. Two of these, Joseph Creek and Upper Grande Ronde, are managed as wild stocks. A segregated hatchery program is used to augment steelhead harvests in the portions of the Grande Ronde that are occupied by Lower Mainstem and Wallowa populations. Wild adult steelhead collected at the lower four Snake River dams from 1976 – 1978, along with eggs from Salmon River steelhead (Pahsimeroi Hatchery) obtained in 1979, were used to start the Grande Ronde broodstock. From 1980 until the present, hatchery steelhead returning to the Wallowa Hatchery have served as broodstock.

## ***Performance of Hatchery Fish***

A suite of hatchery performance indicators are reported, including numbers of females spawned, pre-spawning mortality in broodstock, number of green eggs taken, number of eyed eggs obtained, green egg-to-eye egg survival, green egg-to-smolt survival, mean smolt size at release, number of smolts released per year, general fish health, and type of release (acclimation ponds or direct release). In one instance, validation of the method used to estimate the number of smolts being transferred to the Grande Ronde release locations is described. Additionally, accounts of the approaches used to calculate each of the hatchery performance metrics are included. These explanations of how data were obtained and validated are a welcome addition to this report.

Values of the statistics that best characterize hatchery performance, egg-to-smolt survival, and number of smolts released are presented. A Table listing the fish health issues this project has experienced is also presented. Although mentioned, data on the other hatchery performance indicators are not shown. The report would be richer if information on these metrics had been placed into appendices. Collectively, the within hatchery performance indicators show that the Grande Ronde LSRC program satisfies and often exceeds fish culture standards.

## ***Post-Release Performance***

An array of post-release performance indicators are reported including smolt survival and migration timing to Lower Granite Dam; total adults produced; smolt to adult recruit (SAR) and survival (SAS) rates; straying rates and locations where strays were found; catch and escapement distribution; adult recruits per spawner; adult return timing; age and size at age; harvest rates above and below Lower Granite Dam; angler effort; sport catch per unit of effort;

a profile of angler origin (local or out-of-state); and an assessment of the economic benefit the program provides through sport fishery opportunities.

These data clearly demonstrate how well the steelhead smolts produced from the Grand Ronde program have performed. For example, smolts released from the two acclimation sites have similar survival rates (~80%) to the Lower Granite, no different than the rates obtained by natural steelhead smolts from the Lostine River. Additionally, the migration timing of the project's smolts to the Lower Granite Dam are similar to those recorded for naturally produced steelhead smolts. These comparisons are very informative and helpful additions to the program's monitoring and evaluation work. The mitigation goal of ~ 9,200 adults above Granite Dam has been consistently met from return year 2000 to present. Additionally the SAR goal of 0.68 has also been attained from 1998 to present. The SAS standard of 2.04%, however, has only been met once or possibly twice since 1985. We recommend analyses that examine the survival of project fish through the lower Columbia mainstem dams be performed. Information derived from this work would help determine if passage circumstances in the river or ocean conditions are responsible for these lower than expected survival rates. Also, it is mentioned that some of the project fish receive a ventral clip as well as an adipose clip. A potential bias in SAS values may exist if fish with ventral clips are being used along with ad-clipped fish to estimate this parameter because ventral clips may inhibit survival. This potential source of bias could be appraised by directly comparing the survival of ad-only to ad-plus-ventral-clipped fish released during the same year.

Harvest locations, straying rates, and locations of recovered strays are well documented and informative. Many of the strays produced by the project were found in the headwaters of the Deschutes River. Recently the occurrence of strays in the Deschutes has decreased (apparently in response to reduced transportation of steelhead; see below) and straying above the Lower Granite dam by project fish appears to be minimal. Details about the return timing of project adults, their age structure, and size at age provided a means to track inadvertent domestication caused by hatchery conditions. Few if any impacts were seen. These data enrich the report. The comprehensive sport fishing analysis is also very informative. It documents the annual catch of wild and hatchery origin steelhead above Lower Granite dam and shows that the project increased harvest from the pre-project levels observed in the 1950s through 1970s. Trends in angler days and in number of hours needed to catch a single fish before and after the mitigation project took place are depicted. Additionally, a profile of participants in the fishery on this population is presented, along with an economic assessment of the yearly value of the fishery from the 1999 through 2009 return years. This analysis helps quantify the social benefits of the Grande Ronde mitigation program. All of these details point to a well-run and carefully monitored mitigation program.

### ***Impacts of Hatchery Fish on Wild Fish***

Investigating interactions between hatchery steelhead with natural origin steelhead and other native fishes in the Grande Ronde has not been a priority of this project. Nevertheless,

significant changes designed to limit such interactions have been made to the program from its beginning to its present implementation. The number of smolts released has been reduced to decrease straying into the Deschutes River. Alternative broodstocks are being developed and evaluated to further decrease straying rates. Given the project's evidence that straying is reduced in fish released from acclimation ponds, direct release of smolts into the lower and upper Grande Ronde River and Catherine Creek have been curtailed to reduce the potential number of hatchery fish on spawning grounds. All project smolts are now released from acclimation sites, a practice that, in addition to directly reducing straying, facilitates trapping and removal of hatchery origin adults. Residualism, or the incidence of freshwater residency in project smolts, has also been investigated. In an effort to reduce residualism, project smolts are now allowed to voluntarily exit acclimation ponds and juveniles that remain in the ponds are not released. Their removal is expected to reduce the occurrence of residuals and thereby limit ecological interactions between hatchery juveniles and other fish for example outbreeding with wild rainbow and predation on Chinook fry.

### ***Program Modifications***

The project was also reviewed by the HSRG and HRT. No specific recommendations for the project were suggested by the HSRG. The recommendations made by the HRT are presented and proposed actions for each are made. For instance the development of an autumn-returning broodstock has been successful enough to make a transition to that timing feasible in the near future. This development would improve fishery contributions in Oregon, reduce straying, and has been encouraged by the HRT. The project has increased its smolt size release goal from 5 ffp (91 g) to 4 ffp (113 g) to increase SAS values. The project sponsors have also developed food bank outlets for surplus hatchery returns. Continuing challenges faced by the project include the need to identify the most effective broodstock source; evaluation and testing of smolt release strategies to maximize SAS values; and continued research on reducing residualism and monitoring the ecological effects of residual hatchery steelhead. We encourage the program to continue to investigate factors influencing straying and residualism and to implement approaches to minimize both. The practices developed to reduce straying and residualism in the Grande Ronde may be applicable to other watersheds in the Columbia Basin. The report provides a history of catch of hatchery and wild steelhead in the Grande Ronde basin, but it is not clear what the mortality rate on wild steelhead has been, given that these ESA-listed fish are released from sport fisheries. Nevertheless, abundance of wild steelhead in the Grande Ronde appears to be somewhat high in recent years.

## **B. Lookingglass Wild Steelhead**

[Link to the summary report >](#)

### ***Introduction and Background***

Steelhead returning to the Upper Grande Ronde River are managed as a wild stock. Productivity of this population is high at 2.9 recruits per spawner. However, the current viability status of this population is classified as “maintained” as the geometric mean of its abundance is 1,340, less than the 1,500 minimum abundance threshold for a “viable” population (Carmichael et al. 2012). About 14% of the adult steelhead originate from Lookingglass Creek a tributary to the Upper Grande Ronde. Very little was known about Lookingglass steelhead until the mid 1960’s when ODFW began a multi-year effort to monitor adult and juvenile abundance. Spring Chinook salmon also returned to Lookingglass Creek but were extirpated after a hatchery was placed at the lower end of the stream in 1982. Beginning in 1992, spring Chinook were re-introduced into Lookingglass and a weir and downstream juvenile migrant trap were installed to evaluate the success of this effort. The weir and downstream juvenile trap provided an opportunity to collect additional information on adult and juvenile abundance and life history attributes of Lookingglass steelhead. These data have been collected since 1992, and a number of comparisons between attributes of these fish with those returning to stream from 1964 to 1974 are made. The goal of this work was to uncover basic life history information that could be used to help recover ESA-listed Snake River summer steelhead.

### ***Stock Structure and Genetic Background***

Lookingglass steelhead are part of the Snake River Basin Steelhead Distinct Population Segment (DPS) which was listed as threatened under the ESA in 1997. They also belong to the Upper Grande Ronde population which is one of four independent populations in the Grande Ronde River Major Population Group. The other independent populations in this MPG are: 1) Lower Mainstem Grande Ronde, 2) Joseph Creek, and 3) Wallowa River. No hatchery origin steelhead are allowed to enter Lookingglass Creek, and therefore this group of fish is being managed as a wild steelhead population.

### ***Review Comments***

We appreciate the effort and care that was taken to document adult and juvenile abundance and to describe the different life histories used by Lookingglass steelhead. We have a few questions about some of the assumptions, methods, and conclusions and some recommendations that we hope will prove useful. We have partitioned these questions and comments out by life history stage with juveniles first then adults.

## Juvenile Data

The methods used to evaluate juvenile abundance are well described and the use of DARR 2.0 appears to be a good approach, but more recently developed estimation methods (Bonner and Schwarz 2011) may also be applicable. If we understand correctly, the efficiency of the rotary screw trap used to capture migrating juvenile steelhead is estimated on a regular basis by liberating juveniles with PIT tags and fin clips approximately 100 m upstream of the trap. Fish over 80 mm FL are eligible to receive PIT tags while those smaller than that receive fin clips. However, the possible effect of fish size on recapture probability is not mentioned. Is it assumed that fish size has no effect on recapture rates and if so, has this assumption been tested? Furthermore, trap efficiencies often vary with flow rates. Has a flow rate by efficiency relationship been developed for this site? Additionally, no indication of the frequency of efficiency estimation is made. The report also states that the fin clip used remained constant across all the groups that were employed to evaluate trap efficiency. We suggest that alternative fin clips be employed when making such assessments. This will allow recaptured fish to be unambiguously assigned to a release period, an important consideration in a stratified mark-recapture estimate. Other easily applied marks are also available. For example, elastomer can be rapidly inserted under the clear adipose tissue located posterior to the eye. Four colors, green, red, yellow, and orange can be detected making eight possible eye locations (right or left eye) and color combinations possible.

Juvenile emigrants were placed into two groups, those that migrated in the spring and those that migrated in the fall. A graph showing the mean fork length of steelhead juveniles leaving Lookingglass Creek by month is presented. It would have been even more informative to produce a table that presented the number of smolts leaving the Creek each month each year along with their mean fork lengths. The freshwater age of the smolts is also presented in a figure. In this case, the X axis is FL and Y axis is "Count." We suggest that the count data be converted to percentages and if possible the data be presented on a year-by-year basis in a table. This should be done for both the "spring" and "fall" migrants. Such a presentation would facilitate additional comparisons between these two types of emigrants. Then it would also be possible to analyze adult production of migrants on a brood year basis with this information and lead to a better understanding of the benefits of life history variation.

The number of days it took fall and spring migrants to reach the Lower Granite Dam were found to be quite different. It took juveniles leaving in the fall an average of 200 days to reach the dam while spring migrants arrived at the dam after just 10 to 20 days of travel. The survival rates of both types of fish between leaving Lookingglass Creek and arrival at Lower Granite Dam are shown. Not unexpectedly, the fall migrants had lower absolute survival values. We suggest these survival data be converted into time-specific rates. This would provide an estimate of fish loss per day for both types of fish as they migrated to the dam. These data could be used in an analysis to examine the effects of smolt type and year on survival in this portion the Snake River basin.

It is also reported that emigrant totals during 2001 – 2011 were, on average, three times greater than those observed in the late 1960s. This conclusion is somewhat misleading. Emigrant counts during the 2001 – 2011 period were quite variable. 2002 appears to have produced almost 80,000 smolts, and two years, 2004 and 2005, probably produced 50,000 or more fish. However, production from the stream in 2009-2011 is very similar to that observed in the 1960s. The observed decrease was linked to an increase in the number of adult spring Chinook returning to the stream. Some additional discussion about this possibility and the factors that drove earlier variation of emigrant abundance would have enriched the report.

Are there any signs of density dependence in this relatively undisturbed watershed, as might be shown by plots of smolts per spawner versus spawner abundance, or shown by reduced size at age of migrants in relation to abundance of parent spawners or of smolts, or shown by increased age at smoltification in relation to smolt abundance or parent abundance? Are there more early migrants when overall abundance in the river is relatively high? What is the number of smolts per spawner reaching Lower Granite Dam for the entire parent brood, and what environmental factors influence this survival? The report summary mentions possible density-dependent interactions with spring Chinook salmon. Chinook salmon should be considered as an additional independent variable in these relationships.

## **Adults**

Adult abundance was determined by direct counts of fish intercepted at a weir or adult trap both located in the vicinity of the Lookingglass Hatchery. Adults less than 50 cm fork length were assumed to be resident trout. This appears to be reasonable, but it may be possible to use microchemical analyses of strontium in scales or otoliths to confirm this assumption (anadromous fish incorporate more strontium into their bony tissues in the ocean than in freshwater). Given the possibility that strontium may be physiologically removed from scales as an anadromous fish remains in freshwater, it would be prudent to examine scales or otoliths from known anadromous summer run steelhead to see if a recognizable strontium signal exists. If it does, then a tool like LA-ICPMS could be used to validate anadromy or non-anadromy in these fish.

External features such as snout and belly shape and vent features are being used to determine the sex of the fish. These determinations might be improved. For example, hand held ultra sound units have recently been used to sex salmonids with a high degree of accuracy. The project biologists may wish to investigate this tool. Archived DNA extracted from the scales or from tissue samples they have collected in the past could also be assayed to confirm the sex of previously sampled fish which would indicate whether an alternative method of sex determination is warranted.

The age composition of returning adults is presented on a “run year” basis. These data would be better presented on a broodyear basis. They should be put into a table in which trends in age at maturation could be detected. The fork lengths of returning males and females returning to Lookingglass Creek are shown in two figures. These data should be put into tables and split

out by year as well as by fish age. Differences in the arrival times of males and females to the weir and fish trap are presented in a table. These data could be used to test if arrival timing differs between the sexes.

The report states that variation in emigrant numbers is much higher than that observed in adult returns. The raw data shown in Figures 6 and 15 appear to show that. However, this conclusion may not be correct. We urge the project biologists to analyze the data using quantitative tools when possible to reinforce conclusions. Visual representations of data can sometimes be misleading.

Are any of the PIT-tagged wild steelhead detected as strays in other watersheds such as the Deschutes, or in hatcheries such as the Wallowa?

What is the adult return per spawner for each brood year and how does this vary with spawner abundance, i.e., a recruitment curve?

When plotting juvenile fork length relationships, please indicate the age of the fish.

Fig. 17 is mislabeled as spring migrants.

### ***Literature Cited***

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## **C. Imnaha River**

[Link to the summary report >](#)

### ***Introduction and Background***

The Imnaha River steelhead hatchery program was started in 1982 to mitigate the effects of the construction and operation of the lower four dams on the Snake River. Three facilities, the Little Sheep Creek Acclimation site located in the Imnaha watershed, the Wallowa Hatchery situated in the Grande Ronde basin, and the Irrigon Hatchery placed on the Oregon side of the Columbia River approximately 17 km below McNary Dam are used. Broodstock are collected and spawned at Little Sheep Creek. Fertilized eggs are transported to the Wallowa Hatchery where they are incubated to the eyed stage. They are then taken to the Irrigon Hatchery where the incubation period is completed. The fish are reared here for ten to twelve months before being transported back to Little Sheep Creek where they are held for a 1 to 6 week acclimation period prior to being released. Unlike many of the other LSRCP steelhead programs, adults produced by the hatchery are allowed to spawn naturally in Little Sheep Creek, a tributary stream to Big Sheep Creek. Additionally, in recent years approximately 1,000 hatchery adults plus hatchery origin smolts have been directly planted into Big Sheep Creek. This practice has been questioned by the HSRG and HRT. Whether or how it may occur in the future is currently under discussion.

### ***Stock Structure and Genetic Background***

Imnaha River steelhead are part of the Snake River Basin Steelhead Distinct Population Segment (DPS) which also includes all naturally spawning populations of steelhead in the Snake River Basin. This DPS was listed as threatened under the ESA in 1997. Steelhead originating from the Imnaha River have been placed into a single Major Population Group (MPG) which contains one independent population referred to as the Imnaha River population. Genetic samples obtained from steelhead collected in the Imnaha watershed clustered together and were distinct from Grande Ronde and other Snake River steelhead populations. Wild adult steelhead collected in Little Sheep Creek beginning in 1982 were used to start the Little Sheep Creek Hatchery broodstock and wild fish dominated the broodstock until 1987 when hatchery fish began to return to the project in fairly large numbers.

### ***Performance of Hatchery Fish***

Data are presented on an array of hatchery performance indicators, including numbers of females spawned, pre-spawning mortality rates in broodstock, the number and origin of broodstock used, PNI of the Little Sheep Creek population, number of green eggs taken, number of eyed eggs obtained, green egg-to-eyed egg survival, green egg-to-smolt survival rates, mean smolt size at release, number of smolts released per year, and general fish health. Results of a test that was used to validate the method employed to estimate numbers of pre-smolts being transferred from the Irrigon Hatchery back to the Little Sheep acclimation pond is

also included. Additionally, accounts of the approaches used to calculate each of the hatchery performance metrics are described. These explanations for how data were obtained and checked are a useful addition to this project report.

Values for the statistics that best explain hatchery performance, pre-spawning mortality of broodstock, egg-to-smolt survival, and number of smolts released, are presented. The number and origin of females used as broodstock are provided to illustrate how PNI values have changed over the course of the project and fish health issues the project has experienced are also documented. Although mentioned, data on the other hatchery performance indicators are not shown, for example the number of eggs taken and egg-to-green egg survival. The report would have been enriched if information on these metrics had been placed in appendices. A brief explanation for why three facilities are being used for the program would have been helpful. When looked at collectively, the within hatchery performance indicators, show that the Imnaha steelhead LSRCF program reaches fish culture standards.

### ***Post-Release Performance***

A group of post-release performance indicators, smolt survival to Lower Granite Dam, a multi-year comparison of the migration timing to Lower Granite Dam by hatchery and natural origin smolts, total adults produced, smolt to adult recruit (SAR) and survival (SAS) rates, straying rates and locations where strays were found, catch and escapement distribution, adult recruits per spawner, adult return timing, age, and size at age, harvest rates above and below Lower Granite Dam are reported. Data on angler effort, sport catch per unit of effort, a profile of angler origin (local or out-of-state) and an assessment of the economic benefit the program offers through sport fisheries are also included. These data clearly define how the steelhead smolts produced from the Imnaha program performed.

Some of the key findings are that the project has consistently exceeded its above Granite Dam mitigation goal for adult steelhead from 2001 to the present. Recruits per spawner (R/S) values for hatchery fish averaged 5.35 over the duration of the project and from 1999 on appear to be around 10. Recruit per spawner values for natural origin (NOR) Little Sheep Creek steelhead are often below replacement. Additionally, the SAR target of 0.61% has been surpassed from the 1998 broodyear to the last reported broodyear (2005). The anticipated SAS goal of 1.83%, however, has never been reached. We recommend that analyses of the survival of project fish through the lower Columbia mainstem dams be performed. Information derived from this work would help determine if passage circumstances in the river or if ocean conditions are responsible for lower than expected SAS rates. Also, it is mentioned that some of the project fish receive a ventral clip as well as an adipose clip. A potential bias in SAS values may exist if fish with ventral clips are being used along with ad clipped fish to estimate this parameter. Ventral clips may diminish survival more than adipose clips do. This potential source of bias could be appraised by directly comparing the survival of ad only to ad plus ventral clipped fish released during the same year.

Harvest locations, straying rates and where strays were recovered are well documented and informative. Many of the strays produced by the project are found in the headwaters of the Deschutes River. Recently the occurrence of strays in the Deschutes has decreased, apparently due to reduced transportation in barges, and straying above the Lower Granite dam by project fish appears to be minimal. Details about the return timing of project adults, their age structure, and size at age provided a means to track inadvertent domestication caused by hatchery conditions. Few if any impacts were seen. These data enriched the report. The comprehensive sport fishing analysis is also very instructive in documenting the annual catch of wild and hatchery origin steelhead above Lower Granite dam. Even though the project has reliably produced 2,000 or more adult steelhead available for harvest, the numbers caught per year by anglers has never been greater than the number harvested before the project was started. This is primarily caused by low angler effort in the Imnaha. The fishery goal of catching one fish for every ten hours of effort has been consistently met. All of these details point to a carefully monitored mitigation program.

### ***Impacts of Hatchery Fish on Wild Fish***

The Imnaha steelhead project is an integrated hatchery program. Consequently, hatchery origin fish are allowed to spawn naturally in Little Sheep Creek. This integrated approach has created some controversy. Studies performed on Hood River steelhead over the past ten years or so strongly suggest that hatchery origin steelhead spawning under natural conditions are not as successful at producing adult offspring as NORs (Araki et al. 2007). If this reduction in reproductive competency is due to genetic changes caused by inadvertent domestication then the incorporation of hatchery fish into natural populations could potentially reduce their overall fitness or productivity. The rationale for this concern is that selection pressures in natural and hatchery environments differ significantly from one another. Thus hatchery and natural origin fish are expected to possess genetic traits that are adapted to their traditional environments. Neither is expected to perform well when placed into the other's environment.

The concept of Proportionate Natural Influence (PNI) was used by the HSRG (HSRG 2009) to help manage the potential impact of naturally spawning hatchery fish on wild populations. Briefly, the idea is to regulate the relative abundance of hatchery origin adults in hatchery broodstocks and on spawning grounds to ensure that an integrated hatchery population retains its natural adaptations. PNI values can range from 0 to 1; values greater than 0.5 indicate that an integrated population is more strongly influenced by NORs than by hatchery origin fish. A generally accepted goal for most supplementation programs is a PNI value that is greater than 0.5. To reach this goal, Mobrand et al. (2005) recommend that more than 50% of the broodstock used in an integrated hatchery program should be of natural origin and that less than 50% of the naturally spawning population should be comprised of hatchery origin adults.

The need to maintain relatively high PNI values is the basis for the following two suggestions. First, as indicated in the project report, up to 66% of the hatchery adults returning to the Imnaha are released into Big Sheep Creek. Additionally, direct releases of hatchery smolts have

also been made into this stream. The ISRP concludes these releases are inconsistent with conservation of the Imnaha steelhead population which is listed under the Endangered Species Act. The LSRCP should consider ceasing these releases. Two main reasons drive this suggestion. Anywhere from 10 to 45% of the hatchery adults released into Big Sheep Creek return to the Little Sheep Creek weir. The distribution patterns of the fish that did not return are not reported, but they could migrate into other portions of the Imnaha and breed with wild fish in these locations. Additionally, the sponsors note that Big Sheep Creek appears to produce substantial numbers of NORs and supplementation is not required for this population. Consequently, releasing hatchery fish into Big Sheep Creek does not appear to be providing any benefits and may be putting other Imnaha sub-populations at risk.

Second, to increase the PNI of Little Sheep Creek steelhead, the sponsors have developed a sliding scale approach for broodstock collection. The ISRP has concluded previously that sliding scale broodstock management has not been demonstrated to provide a conservation benefit and presents substantial risks to natural population fitness. Consequently we suggest an alternative program with a minimum PNI of 0.50 be developed as soon as practical. Or a program should be developed that can experimentally demonstrate conservation benefits and estimate natural population fitness loss when PNI is under 0.50. We recognize that this suggestion may not always be possible due to a lack of NORs. However, it looks like 200 or more NORs have returned to Little Sheep Creek in 2010 and 2011. Additionally, it may be possible to reduce the number of fish needed for broodstock since adult returns over the last eight years have exceeded the above Lower Granite Dam mitigation goal. Thus, under current conditions the PNI of this population could be increased by following the Moberg et al. (2005) rule. The primary goal of the LSRCP is to mitigate for lost steelhead production. If a continued lack of NORs prevents the program from increasing the PNI in the Little Sheep Creek population, the sponsors may wish to consider switching this integrated program into a segregated one.

### ***Program Modifications***

A number of modifications to the program have occurred besides the sliding scale protocol for collecting broodstock at Little Sheep Creek. Several reductions in smolt release numbers have occurred, and volitional releases are now implemented at Little Sheep Creek to reduce residualism. Non-migrants are removed to reduce possible ecological interactions between these fish and resident fishes. The size at release standard was increased from 5 fpp (91 g) to 4.5 fpp (101 g) to maximize SAS values. Food bank outlets were developed so that surplus hatchery adults could be utilized in a responsible manner. The project was also reviewed by the HSRG and HRT. The recommendations made by the HSRG and HRT are presented and proposed actions for each are made. Continuing challenges faced by the project are also described. These include the need to increase the PNI of the Little Sheep Creek population, refine rearing and release procedures to reduce residualism and increase angler participation on project fish.

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## ***3. Washington***

### **A. Lyons Ferry**

[Link to the summary report >](#)

Overall, this clearly written report supports the conclusion that the program has performed reasonably well considering the use of an outside broodstock and the specific goals and constraints of the LSRCP. Although it was not the intent, the program did not improve depressed wild stocks and escapement. This side-benefit to wild stocks would have been welcomed. Even with the use of distant mixed broodstock, returns to the project have been met in all 25 years, perhaps aided by low downriver and ocean harvest. Total returns were met in about half of the years. Egg-to-smolt survival is not a problem as release goals have been met. Smolt size seems well-founded. Sport fisheries in the region have benefitted substantially from the program.

Some artificial selection pressures, for example age at maturity and spawning timing, have been recognized and efforts are being made to deal with them. On Page 5 it was noted that there has been a change in age composition (toward younger age at maturity) and spawn timing (earlier). WDFW is concerned that past spawning practices may have shifted spawn timing, and they recognize that a larger proportion of two-salt fish is desirable for the fishery (larger, older-aged individuals for capture). Such changes in age structure and migration timing are very common outcomes of many hatchery programs. In response, hatchery and fishery managers are planning a breeding program for more closely matching historical run/spawn timing and age-of-maturation. This plan represents an intentional selection program, a practice largely abandoned several decades ago in hatcheries where returning adults are likely to be interbreeding with natural populations of steelhead. These efforts were abandoned because of concerns about the

genetic effects of interbreeding on the resulting natural population. Undertaking this type of selection program should therefore be thoroughly thought out, and potential negative outcomes anticipated. Evidence of preliminary risk analysis, including likely heritabilities and genetic correlations, anticipated responses to selection, measurements of phenotypic and genetic response to selection, correlations between traits, correlations between phenotypic and genetic attributes of the traits of interest and fitness (full life-cycle survival) are not discussed and do not appear to have been fully considered. A risk assessment needs to be conducted that evaluates the potential fitness consequences for natural populations. A monitoring program to evaluate the selection and a monitoring program to evaluate associated natural populations need to be established. It would be useful to also consider what other artificial selections are occurring that are not easily detectable from simple metrics such as age and timing, and thus are not being addressed. In general, it might be useful to consider an array of possible selection pressures that might act on these fish over time.

For the spawning date trait, it is not completely clear to the ISRP that adequate baseline data have been collected to evaluate whether there has been a shift in the life-history trait in the population or whether there has simply been a management response to the desire to spawn fish earlier in the year. An actual shift is plausible and would not be unprecedented but is not clearly shown.

For this hatchery program there is a need to provide a succinct summary of the monitoring program and experimental design. Information is provided on fish rearing attributes, but the context for gathering information, reporting, and follow-up evaluation is missing. For example, a few disease problems occur but were indicated to not have been a large detriment to the overall production effort. Although there is mention of an IHN virus and coldwater disease incident, the report does not tell us anything about annual or periodic health inspections and how mortality is monitored; what triggers reporting up the chain of authority; and how responses to increased mortality are handled.

On Page 7, it is stated that “Adjustments are made as necessary to account for predation at the hatchery.” Some elaboration is needed on this point. How is the adjustment made? Is there a sampling design and Standard Operating Procedure to conduct the multiple-pound counts from each release group? Based on the multiple-pound counts there should be data on the variance in release size each year and changes in variance across years? Has there been any analysis?

Straying, however defined, and its effects does remain an issue that needs to be better understood and addressed. The ability to control the straying problem will have a great deal to do with how effectively the stock can continue to be utilized while protecting endemic stocks.

On Page 10, stray rate variance and precision based on tagging and recovery should be provided. Also, thresholds for stray rates need to reflect the effect in a receiving stream, for example pHOS values. That is, a small fraction straying from a total hatchery return could be a very large fraction of the number of fish spawning in a tributary stream. What are the pHOS values for streams in this region?

On Page 11, an explanation is needed for the estimation of various categories of returns for each release. In particular an estimate of the statistical error would be helpful and some idea about the proportion of fish that are not accounted for in the estimates.

Table 2 identifies “stray harvest” and also sport and tribal (presumably catch/harvest). It is not clear how sport and tribal above and below Lower Granite Dam are distinguished from stray harvest. The tables need to be improved by including the actual number of tags recovered and expansion to catch statistics based on the sampling design. As a minimum, a brief summary is needed of the sampling and estimation methods, and confirmation that the design criteria were achieved in the actual sampling.

Looked at in isolation, the hatchery program has performed well. However, the program is undergoing a transition, and a fragmentation, from the previous program dominated by the Lyons Ferry, that is primarily Wells, stock to including an endemic Tucannon program in that basin, and is poised to begin an endemic Touchet program, although the decision to move forward on the Touchet has evidently not been made. This shift was initiated because of Lyons Ferry Hatchery steelhead may be jeopardizing listed mid-Columbia river steelhead.

The authors correctly note that it is worth questioning and evaluating “whether harvest mitigation programs and wild stock recovery can be conducted/achieved concurrently.” It may be difficult to effectively maintain the past emphasis of providing harvest while efforts are being made to develop “endemic” stocks. This was a very good question to ask and would be a good question for them to answer. It also needs to be clearly articulated that if selection such as run timing occurs whether the hatchery should be seeking to more closely mimic wild fish or should distance themselves from them, for example to provide more separation in harvest potential. It would be useful for the managers to clarify exactly how they see the current program as meshing with their in-state management plans for steelhead and how they reconcile any discrepancies.

## **B. Tucannon Endemic**

[Link to the summary report >](#)

The rationale and compliance requirements for the developments of the Tucannon and Touchet endemic broodstocks in relation to Lyons Ferry Hatchery are well laid out and justified in the introduction. There is also adequate information provided in the report regarding the distinct stock characteristics of the Tucannon and Touchet stocks that confirmed their genotypic and phenotypic distinctiveness, for example incidence of repeat spawners 5% vs. 1%. In view of the considerable straying reported, for example Figures 19 and 20 of the Lyons Ferry Report, it is necessary to know how distinctive the remaining Tucannon and Touchet fish are and how strong the evidence is of distinctiveness.

## ***Touchet River***

Several questions arose concerning the Touchet River component of the Program. The authors indicate that the survival and returns of the Touchet fish are only about 1/3 of the returns to the Tucannon. This seems counterintuitive because the Touchet fish have fewer dams to pass. Is it possible that the Touchet is not as accessible as the Tucannon, thereby resulting in more straying, which might be undocumented? Or what other reasons might exist for the difference? Some information might be useful on the topic of causes of lower returns.

Also, on Page 3, it is stated that WDFW wished to pursue development of a harvest production program associated with the Touchet River using local fish rather than Lyons Ferry stock in response to a NOAA Biological Opinion recommendation. The program was intended for harvest because relatively stable abundance of adult steelhead indicated a conservation program was not needed. The report goes on to state that the Umatilla Tribe did not concur with this judgment but did agree to testing the broodstock development, with the understanding that moving from pilot to implementation would require achieving consensus. Please summarize the management option that the Umatilla Tribe prefers. It is not clear whether it is to continue using Lyons Ferry stock or to implement a conservation program. Some presentation of the rationale for the CTUIR perspective would be beneficial.

On Page 6, the anecdotal characterization of first generation performance of steelhead in culture, and subsequent adjustments to captive environments that are presented, provides support for the domestication selection risks attributed to steelhead hatchery programs.

In Table 3, what are the goals for  $N_e$ ? There should be an estimate for the composite population based on hatchery fish escapement to the spawning grounds. Are there rules for numbers and proportions of hatchery fish on the spawning grounds?

Figure 17. More information is needed on how this abundance estimate is produced and how it is interpreted. The abundance estimate appears to be based on an index area. Index estimates have been found lacking, and GRTS randomized methods have been developed. Some discussion of the appropriateness of the methods and limitations is needed. Also, how are these data interpreted with regard to natural population status, such as pHOS? How is it used to contribute to and shape management operations and decisions on the future program direction?

Is this Touchet River project monitored through the Northwest Power and Conservation Council's Fish and Wildlife Program project evaluated in the recent RME&AP categorical review?

Overall, based on evidence presented, it is not clear whether the Touchet endemic brood stock needs to be developed. The potential for the Touchet River to serve as a reference location for steelhead natural production in the Columbia River province is worth considering.

## Tucannon River

For the Tucannon, it would be helpful to outline and identify the LSRCP, FWP, and any other program projects that cooperate to perform data collection, weir construction and maintenance, data analysis and evaluation, and other activities. The ISRP is under the impression that at least a portion of the work described here is implemented using a Fish and Wildlife Program project.

An assessment of  $N_e$  in the entire population should be conducted, not just the hatchery component. Because of the larger number of adult progeny per family compared with natural spawners, there is a potential for reduced  $N_e$  in the composite population. More discussion is needed about the hatchery spawning population composition, natural population composition, and goals for the program and whether they can be achieved.

On Page 8, Figure 5: A Before After Control Impact (BACI) or other similar analysis should be conducted to evaluate the apparent increase in steelhead abundance beginning in 2008. One question is whether this is a positive population response from elimination of stocking Lyons Ferry hatchery fish. A second question is whether there is any evidence of a benefit from supplementation.

On Page 11, Figure 10 suggests that the population is currently exhibiting a decline in smolt production. A spawning stock/smolt recruitment analysis is needed, especially an analysis of smolts/spawner as a function of spawner abundance.

In Table 2, the “other” PIT tag detection numbers should be provided to show how the proportions in the table are estimated. For example, are the proportions entering the Tucannon actual detections at the Tucannon PIT tag detection array, or is it based on subtraction from detections up stream of the Tucannon River? What do these data say about PIT tag detection rates, loss of tags, and other sources of error propagated in the analysis?

For Figure 15, is there any information on spawning by out-of-basin steelhead? The assertion that these fish pose a genetic risk should be recognized as a hypothesis. It is suggested that straying is a problem, and it may be, but it is not clear if this level of straying and potential gene exchange may be normal, or close to normal, for steelhead. The idea that steelhead populations are closed may not be appropriate. In any case it should be recognized as an uncertainty. What are the threshold values of straying that would initiate management discussions and influence operational decisions?

### **C. Grande Ronde (Wallowa Stock)**

[Link to summary report >](#)

Returns to the project area have been met or exceeded every year, and returns to the river met about half of the time. SARs and survivals have also met goals, although the quantified goal, that is the planning assumption, is rather low.

The straying study involving these fish and ODFW Wallowa fish, which stray more, should continue. It would be useful to identify factors affecting stray rates.

There is reference in this report that design of the release program and hatchery facilities were based on 0.5% SAR to the project area, and an SAS of 1.5% to the Columbia River, and that these were not goals. Rather they were planning assumptions. While perhaps this is technically correct, for evaluation purposes the difference is irrelevant. One question to address in review is whether the planning assumptions are reasonable, for the purpose of reflecting on planning assumptions that are still ongoing for other programs. Another question is the extent to which hatchery production can actually fulfill mitigation goals. From the perspective that the planning assumption is used to establish facility and program size from a mitigation goal, these questions can be addressed.

It would be of interest to have the program discuss why the ODFW and WDFW Wallowa stocks differ seasonally in the catch statistics. Is this due to location of the fishery? It would improve the report if more detail was included about the ODFW program. For example the ODFW program is mentioned as having larger stray rates into the Deschutes, and an experiment is under development, but the release sites for the experiment – Cottonwood AP, Wallowa AP, Big Canyon AP are located on maps in the report. Is the Big Canyon AP the Nez Perce Clearwater site? While reading the report it would be helpful to have a better picture of how many smolts are being released within the Grande Ronde by ODFW.

In Table 3, the various headings and associated numbers are confusing. The data appear to be from both creel surveys and report cards, but the actual methods of collection and expansion are not provided. For example, the first data column is wild SH released, and the fifth is estimated wild SH caught, and this number is smaller than the first. How can this be? Should both of these numbers be summed to obtain the number of wild SH caught? Also, the annual steelhead run estimate is reported to be based on a 15% Lower Granite Dam counts with a USACE citation to 1975. Is it reasonable to assume that stock fractions estimated in 1975 are still valid? Finally, to argue that a creel survey is adequate based on no discernible impact needs to be corroborated based on sampling theory and redundant measures of the same parameter or citations provided to other investigations where precision estimates are obtained as part of the monitoring design.

This project appears to be meeting its goals. The discussion should expand to address the average 33% return to the Cottonwood trap. The report that excess fish are provided to food

banks is reasonable. Is there any possibility of reducing smolt numbers and “over” escapement yet maintaining fishing yield?

Production goals are being met, and fishery benefits are present. However, the continued depression of the wild stocks suggests that this program is not benefitting them and may in fact be hindering their recovery.

## ***4. Topical Research***

### **A. Performance of New Steelhead Line Grande Ronde**

[Link to summary report >](#)

#### ***Introduction and Background***

The desire to reduce straying and to enhance opportunities to harvest hatchery steelhead from September through December led ODFW researchers to develop and evaluate a new source of steelhead for the Grande Ronde River steelhead program. Biologists from ODFW, the Nez Perce Tribe, and the Confederated Tribes of the Umatilla Indian Reservation along with general public volunteers collected broodstock by angling in the Grande Ronde River near Troy, Oregon. Fish were collected in October in 2003 - 2006. They were spawned at the Wallowa Hatchery and were used to create a new brood source for the Grande Ronde program, called the Autumn Line. Eggs collected at the Wallowa hatchery were incubated at Wallowa hatchery until the eyed stage. They were then transported to the Irrigon Hatchery where the incubation period was completed. Resulting fry were reared for 10 to 12 months and then returned to the Wallowa Hatchery as pre-smolts where they were held in an acclimation pond for at least 27 days prior to being released. Adults produced from these fish were captured at the Wallowa Hatchery and spawned to create a second generation. Currently, third generation Autumn line fish are being cultured.

The original broodstock for the Grande Ronde program was created from fish captured at lower Snake River dams and from the Pahsimeroi Hatchery. As the program matured, broodstock were collected from the Wallowa Hatchery, the Big Canyon Acclimation site (located in the Grande Ronde basin), and from fish collected at Cottonwood Creek, a Washington State tributary to the Grande Ronde. This line is referred to as the Standard Stock line and is very productive and has met the above-Lower-Granite-Dam mitigation goal of >9,000 plus fish every year since 2001. Adults from the Standard line, however, typically enter the Snake River in the early spring, and this is when most of them are harvested. Significant numbers may stray into the Deschutes River, possibly using it as a cool water refugium.

Project biologists hypothesized that straying would be reduced if migration timing was advanced earlier so that the fish could avoid high water temperatures in the Columbia. The

Autumn line was created in an effort to: 1) modify adult run timing, 2) reduce straying, and 3) enhance fall fishing opportunities in the Grande Ronde. Studies were undertaken to evaluate and compare adult run timing, straying rates, fall fishery contribution rates and SAS and SAR values of fish from the Autumn and Standard lines. CWT returns and PIT tag detections were used to make these comparisons and fish from the first and second generation Autumn lines were included in the analyses.

### ***Comments on the Study***

We support the effort to develop a local Grande Ronde broodstock and commend the careful and detailed monitoring and evaluation program that was undertaken to evaluate and compare the Autumn line's performance with that of the Standard line. The experimental design of the comparisons made between the post-release performance of the Autumn line and Standard line is appropriate. Fish from each line were kept separate from one another and were differentially marked and tagged making it possible to estimate SAS and SAR values, survival, straying rates, migratory behavior, and contributions to fisheries.

This investigation is instructive concerning the challenges of incorporating a selection scheme into hatchery management programs in a large open environment. In artificial animal breeding, parents are chosen that exhibit a value of interest for a specific trait and bred with each other in hopes of changing the mean value of the trait in the population. To evaluate the proposition that such a breeding plan can alter a population's mean phenotype, specific procedures are followed: the mean phenotype of the entire population is established, the mean phenotype of the select group of parents is chosen, and then the phenotypes of the progeny are evaluated. The difference in phenotype between the general population and the selected population is the Selection Differential; these attributes are then measured in the progeny populations and the difference in value is the Selection Response. In most cases the selection response is less than the selection differential, and when evaluated over generations indicates the gain achieved by the selection.

In this case, a selection response is measured in first generation progeny as migration timing across particular dams in the Columbia River, but there is no evaluation of selection differential for the parents collected for breeding. In the second generation, produced from progeny from selection in the first generation, the response to selection is less than observed in the first generation. Multiple interpretations are provided for this observation, and some discussion is provided about attempting to refresh the line periodically by collecting parents by angling in the fall, the practice which was used to establish the original Autumn line.

The program for advancement of the Autumn line, as it's currently structured, will continue to be ambiguous as to the interpretation of genetic and environmental causes for observations. The study design would benefit from consultation with quantitative geneticists. Selection will probably need to be continuously applied, as it is in most animal breeding programs—selection for a single generation will not bring a permanent change in the population mean. One

challenge presented by the open environment is confirming that the selected parents are not simply chosen randomly from the population with respect to timing. Parental Based Tagging may provide a method of choosing both breeding and evaluation methods. It would also allow monitoring of population effective size. The variety of life history patterns, that is emigration timing as well as adult immigration patterns, exhibited by this new artificially propagated population should also be closely monitored with a concern over any deterioration. And the effect of strays, particularly into the upper Deschutes, should be closely monitored.

Some important details that would have strengthened the report were lacking. For example, were paired releases of Autumn and Standard line smolts made from the Wallowa Hatchery, ensuring that smolts from both groups would encounter similar in-river conditions? The following eleven comparisons and conclusions were made between the two lines:

- 1) size and condition of smolts at release (no difference)
- 2) travel time and survival of smolts to Lower Granite Dam (no difference)
- 3) adult arrival date of adults to Bonneville Dam and passage over Lower Granite Dam (F1, first-generation, Autumn line adults arrived 26 days earlier than Standard line adults)
- 4) smolt to adult survival to Bonneville Dam (F1 Autumn line had higher SAS values)
- 5) smolt to adult returns to the Wallowa Hatchery (F1 Autumn line had greater SAR values)
- 6) age composition of adults produced from each line (F1 Autumn line had more 1-ocean fish)
- 7) stray rates of fish from each line (no difference detected)
- 8) Date of straying into the upper Deschutes watershed (F1 Autumn line penetrated the upper Deschutes sooner than Standard line adults)
- 9) percentage of fish from each line that leave the Deschutes and continue to migrate upstream (no difference)
- 10) proportion of adults from each line that were harvested in September and October (a greater proportion of F1 Autumn line fish were harvested at this time than Standard line fish)
- 11) harvest per 1000 smolts released that occurred in September and October (F1 Autumn line fish had greater harvest rates at this time of year).

These comparisons were informative; however, in only two instances (numbers 4 and 5) were statistical probability-values provided, and in only one case (number 4) was the statistical procedure identified. Identification of the tests used or even just the reporting of probabilities would have strengthened the report.

The statement that Wallowa stock steelhead stray farther up the Deschutes than other stocks (page 1) is not established by the associated reference to figure 1. The figure does indicate a larger proportion of Wallowa stock than others but does not indicate how far up river the monitoring involves. Along with the proportion, it would be useful to have the absolute value of stray numbers to know whether the Wallowa includes both a larger proportion of the stock and a larger absolute number of fish. If there are substantial differences in the stock abundances, a large fraction of a stock may stray, but it will not be a greater number of fish than other stocks with larger numbers of individuals.

Nevertheless, the report indicates some promising results. Perhaps somewhat surprisingly, F2 adults have not exhibited the early migration behavior of their parents. The project biologists state that the parents of these fish were selected throughout the entire run. They also state that they found a positive relationship between passage over Lower Granite Dam and arrival at the Wallowa weir. We encourage them to continue to analyze this relationship as it may provide them with a way to select for parents with early migration traits. Another question they may wish to investigate is the possible impact of transferring smolts from Irrigon to their acclimation sites in the Grande Ronde. Hauling fish can induce stress which is known to interfere with imprinting and subsequent homing. Experiments designed to evaluate the effects of transferring juvenile steelhead after differing rearing periods at Irrigon might help identify a strategy that would reduce adult straying rates. We commend the manner in which the program is being expanded and look forward to hearing about more results in the future.

## **B. Release Strategies to Improve Post-release Performance of Hatchery Steelhead in Northeast Oregon**

[Link to summary report >](#)

The LSRCP contributes significant resources toward the artificial production of steelhead to meet its mitigation objectives of providing harvest opportunities. Successful hatchery programs have to accomplish a number of objectives. Two important ones are to 1) maximize the post-release survival of the fish they release, and 2) minimize ecological interactions between the fish they release and other fishes. The release method for hatchery fish can clearly impact both post-release survival as well as the likelihood of interactions with resident fishes. ODFW researchers performed three studies designed to see how different types of release strategies affected immediate survival, freshwater migration rates, smolt to adult survival (SAS), and straying rates. All three studies used paired releases of fish from two alternative treatments. Three journal publications were produced; the investigators should be complemented for this effort to undergo greater peer-review and to share their work with a broader audience.

The first study compared steelhead smolts that were placed into acclimation ponds prior to release vs. those that were transported from a hatchery and released directly into a stream. Fourteen paired releases were made over a ten-year period. Releases took place in three different locations. Two were in the Grande Ronde basin, the Wallowa Hatchery and at Deer Creek (Big Canyon Acclimation site) and the last site was at Little Sheep Creek in the Imnaha basin. Fish in each release group were marked and tagged making it possible to identify their origin and each release group contained approximately fifty thousand fish. The investigators found that smolts exposed to an acclimation period (AC) took longer to migrate to Lower Granite Dam.

However, no evidence of a difference in the survival rates of AC fish and direct release fish (DR) to Lower Granite Dam was found. There was evidence that AC fish did achieve higher SAS rates and lower straying rates.

These results indicated that holding fish in acclimation ponds prior to release had beneficial effects. The overall design and statistical approaches taken appear to be appropriate. One potential confounding factor in the study was how fish were selected for each treatment. It was hypothesized that fish held in acclimation ponds would grow slower than those retained at the hatchery due to differences in water temperature. In an attempt to make smolts approximately the same size at release, study fish were graded into three groups based on weight. The largest fish were assigned to the AC group while those in the middle third were placed into the DR group. Whether this method of assigning fish into the treatment groups biased the results of the study is not known. This possibility is discussed by the investigators, and several reasons are given for why it may be relatively unimportant.

The second study was designed to compare the performance of steelhead held in acclimation ponds that were either forced to leave their pond all at once or given a two-week period to volitionally exit from a release site. Six paired releases were made over a four-year period. Two release locations, Spring Creek in the Imnaha basin and Deer Creek in the Grande Ronde, were used. No difference was detected in how long it took forced released (FR) and volitionally released (VR) smolts to reach Lower Granite Dam. VR groups achieved higher survival rates to Lower Granite Dam, but no differences were detected in SAS and straying rates. The investigators state that volitional releases do provide managers with opportunities to remove non-migrating fish from rearing ponds. They found that many of the fish remaining in acclimation ponds after a two-week release period had been completed were maturing males. These fish were transported to ponds and exposed to trout fisheries. This approach was taken to reduce residualism of hatchery fish.

Spring Chinook were used in the third experiment which evaluated performance differences in fish that had been held in acclimation ponds for either two or four months prior to release. This study took place in the Umatilla River. As with the other studies, the general approach was to use paired releases to decipher differences between treatments. Approximately 45,000 fish were assigned to each release group and CWTs and PIT tags were applied to the fish for later identification. Metrics compared were travel time and post-release survival to the John Day Dam, SAS, and straying rates. Results of this work showed that fish held for four months (NT) took longer to reach the John Day Dam than those that were held for two months (JT). No differences in survival to the John Day were detected; however, NT fish had higher SAS rates than the JT smolts. Straying rates in both groups was rare, and no comparisons were made on this metric.

These are nicely done experiments. An important point about the design of these studies is that MULTIPLE years of experiments are needed to deal with year-to-year variability in the results. The author suggests at least 4 years needed – but 6+ years would appear to be a more realistic number based on variability seen in the graphs. The analyses reported seem appropriate except

for the use of the chi-square tests performed on pooled (over years) data – this would appear to be an example of sacrificial pseudo-replication (see Hurlbert 1984). A more appropriate analysis would take into account the multiple-years of releases before comparing sex and age proportions among release groups.

The investigations provide useful information that should be used to reduce straying and increase survival of steelhead. A key finding was that acclimation increased survival to adult and decreased straying raising the question, was increased survival due in part to reduced straying? The authors state that all releases are now acclimated, but it is not clear if this occurs throughout the Snake River Basin, or just in this subbasin. The authors also noted that volitional releases did not increase survival or reduce straying but the approach did allow the opportunity to remove residual steelhead. Direct releases were found to stray farther up the Deschutes River where this stock contributes relatively high numbers of stray steelhead. To what extent can the lessons learned here be used to reduce straying into the upper Deschutes River by Wallowa steelhead? It was noted that similar travel times to LGD suggested that the fish had similar opportunity to be barged, and therefore stray as an adult. To what extent might have barge transportation confounded the analysis? Can barged and in-river fish be analyzed separately?

Volitional releases from acclimation sites can also be used to cull non-migrating steelhead juveniles from release groups possibly reducing the subsequent occurrence of residuals. Current acclimation sites are large concrete raceways. The investigators suggest that earthen ponds might be a viable alternative as that would give the fish opportunities to learn how to feed in a more natural environment. We hope that the results obtained from this work can be transferred to other LSRCP projects as appropriate.

### ***Literature Cited***

Hurlbert, S.H. 1984. Pseudoreplication and the design of ecological experiments. Ecological Monographs 54: 187 – 211.

### **C. Imnaha Juvenile Steelhead**

[Link to summary report >](#)

This project monitors the life stage performance of hatchery and natural origin steelhead smolts by evaluating performance measures including emigrant abundance, emigration timing, size and condition factor, juvenile arrival timing at Lower Granite Dam (LGD), juvenile survival at LGD, hatchery and natural origin adult arrival timing at Bonneville Dam (BON) and LGD, adult conversion rate from BON to LGD, and smolt to adult return rate (SAR).

Two strategies are used to release hatchery smolts. Some are placed into an acclimation pond, reared for a period, and then volitionally released. Others are directly planted into Big Sheep Creek. Natural origin steelhead smolts are produced in Big and Little Sheep Creeks as well as the rest of the basin's tributaries and mainstem Imnaha.

Smolt abundance estimates were made by using a single rotary screw trap (RST) that was placed in the lower Imnaha River above all its major tributaries except for Cow Creek since 1994. Details about when and how the trap is operated and fish handling methods are clearly described.

From 1994 to 1999, the trap only operated in the spring; from 2000 to 2009 the trap was operated in the spring and fall; since 2010 the trap has been operated year round. Presumably, all hatchery fish (IRH) have been fin-clipped for identification while natural fish (IRN) do not have a fin-clip. Only fish > 80mm captured in the RST were then subsequently PIT-tagged to provide information on adult returns. From 1994->2007 both IRH and IRN were PIT-tagged at the RST; since 2008, IRH are PIT-tagged at the hatchery. Daily RST-efficiency was determined by transporting about 50 IRN fish upstream about 1 km.

The RST could not be operated in some periods because of water conditions – the current estimation methods likely then underestimate the actual smolt emigration abundance. Analyses to extrapolate to fish passage during times when the screw trap was not operational have not been completed but should be in order to have a better estimate of IRN steelhead smolt production. For example, Bonner and Schwarz (2011) have recently developed methods that can interpolate missing data. The authors seem to be aware of this work and will presumably be updating the document.

The standard errors reported in Table 2 are likely underestimates of the actual uncertainty because of heterogeneity in trap-efficiency over time and missing data when the trap is pulled. Again, consult Bonner and Schwarz (2011) for details on how to adjust the standard errors for heterogeneity in trap efficiency and other problems.

One common source of heterogeneity is stream flow. The USGS operates a gauging station on the Imnaha that collects both flow (cfs) and total discharge data. We suggest these data be regressed with the project's trap efficiency information to determine if predictive relationships exist. If they do, this information can be incorporated into newer estimation methods.

In some cases, the outgoing run is so large that it overwhelms the RST. The sponsors describe methods they use to estimate catch composition and abundance when large catches make it impossible for them to process all the fish they have captured. We recommend that battery powered fish counters be used as opposed to counting dip net scoops of fish. Some of these counters process up to 5 fish per second, can operate for 5 to 7 days on a single battery charge, and have a reported accuracy rating of 95%. Their use should allow the project to obtain more precise and accurate counts. The composition or origin of the fish captured can be difficult to estimate when catches are high and there is concern about damaging or hurting fish held in live

boxes. Using the composition of several scoopfuls of fish to estimate catch composition is an expedient approach. However, different species of salmonids tend to occupy different portions of a water column. Hatchery fish may also be more surface-oriented than wild conspecifics. Therefore, unless a sample of juvenile salmonids is completely mixed it is possible that biased composition estimates may occur. If fish counters are used, sub samples of fish could be set aside as the counting process proceeds and used to generate catch composition data.

We appreciated the inclusion of the number of fish marked and recovered in the trapping efficiency trials. It would have been helpful if more information was presented about the 2006 year. The reported trap efficiency for that year was expressed as 9% but only 17 recoveries out of a potential 1,482 fish were made. How was this roughly 1% efficiency expanded to 9%?

It is also mentioned that only natural origin fish are used to make trap efficiency assessments. Size and migratory behavior may affect capture probabilities. Consequently, the sponsors may wish to collect some PIT tagged hatchery smolts from the Little Sheep Creek Acclimation facility and release them simultaneously with natural origin smolts to see if trap efficiency values are the same for both types of fish.

While no RST-trap efficiency trials were conducted prior to 2004, some rough information is available by looking at the total number of hatchery fish released and then subsequently seen in the RST. This will provide a very rough estimate of the trap efficiency, but is better than nothing. A Bayesian hierarchical model may be useful here to model the variation in trap efficiency over the years, say as a function of flow, to further get something for the earlier 10-year period. Table 2 shows that the average trap efficiency in most years is about 10%. It would be a shame to ignore the previous 10 years of data.

Figure 2 is pretty convincing that direct releases tend to arrive earlier than the volitional or natural releases at the RST. The use of Kolmogorov-Smirnov tests to examine migrating timing of juveniles (and of returning adults) seems to be a good way of comparing this metric because it looks at the entire migration period as opposed to a median or average value.

The ISRP concurs that the effect of arrival timing at the screw trap on juvenile survival and adult returns is needed to evaluate the release strategies for hatchery steelhead smolts. The results indicating that the cumulative arrival timing distribution of IRH was earlier than that of IRN raises questions concerning possible reasons and consequences of this difference. The influence of arrival timing could be confounded with smolt size and condition so careful interpretation is needed, as well as possible experimental evaluation of these factors.

The observation that IRN and IRH juveniles had similar arrival timing at LGR may well indicate a localized pattern of emigration persisting in the hatchery release groups but could also be an indication of a non-optimal strategy for IRH juveniles.

The report briefly mentions that juvenile survival from the RST to LGD and MCN were determined using PIT-tag interrogation at the juvenile bypass facilities. Presumably, this was

computed after adjusting for the detection efficiency at LGD and MCN, but the actual methods are not presented in the report. A brief summary of how this was done would be helpful. It is also not clear, why the survival rate was not partitioned between RST -> LGD and then LGD -> MCN rather than reporting only the cumulative survival to MCN in Figure 4. The ratio can be extracted from the figure. The highly variable, and somewhat low, survival of both IRN and IRH juveniles to MCN for 1995-2011 suggests that further analysis and interpretation could be fruitful including, as suggested, an evaluation of environmental conditions. The survival of natural and hatchery origin smolts to the Lower Granite Dam and to McNary dam were compared by using t-tests, but it was unclear if pairing by year was taken into account. A similar comment may also be made about the comparisons of the SAR data that were collected.

The report indicates the conversion rate was roughly the same between IRN and IRH despite a mark-selective fishery. Is information available, for example from creel surveys, on how many steelhead were captured in the mid-Columbia to see if the fishery is actually very small?

It is somewhat surprising that the larger IRH fish did not perform better for example higher SAR or higher survival than the IRN fish. This may again be an indication of a non-optimal strategy for IRH juveniles.

### ***Editorial***

Reference to Steinhorst et al. 2004 is misspelled.

The label on the vertical axis of Figure 4 should include mention of MCN in addition to LGD. Try jittering the year slightly to prevent the error bars from overlapping.

### ***Literature Cited***

Bonner, S.J. and Schwarz, C.J. (2011). Smoothing population size estimates for time-stratified mark-recapture experiments using Bayesian p-splines. *Biometrics* 67: 1498 – 1507.

## **D. Imnaha Adult Steelhead**

[Link to summary report >](#)

Three natural spawning populations were studied to see the extent of hatchery intrusion on the populations. In conjunction with the Imnaha River Adult Steelhead Monitoring Project (ISAM) and the Integrated Status and Effectiveness Monitoring Project (ISEMP) the plan is to have a comprehensive assessment of the status and viability of the entire Imnaha River subbasin.

Each population was studied for about 3 to 7 years using a weir on the stream. Fish were marked (operculum punch) as they moved upstream and recaptured moving downstream. A simple Petersen estimator was used to assess abundance. The Petersen estimator appeared to work well early in the season when stream flows were relatively low. However, in some years high flows allowed adults moving downstream to pass over weirs which impacted the estimation method, likely resulting in a negative bias in the estimates. It was mentioned that flood events often occurred later in the season when fewer adults were in the monitored streams. Consequently, perhaps one way to partially get around this problem would be to stratify these estimates by time period. As well, estimated standard errors for abundance are likely underestimates of the actual uncertainty because of heterogeneity in catchability over the season. A stratified estimate, for example by month, may again be useful to see how big of an issue is caused by heterogeneity in catchability.

Standard biological information was collected on handled fish. Hatchery fish were identified through fin-clips or CWT scans. The rotating panel design does allow a greater number of streams to be evaluated given limited resources. However, the rotation of sampling among streams increases the risks of making conclusions based on incomplete information for specific streams.

A resistivity counter was also used on some the systems in later years to compare its count to MR abundance estimates based on PIT-tags. The PIT-tags also provide downstream tracking of kelt migration. Information on kelt migration could be quite useful in evaluating the contribution kelts make to steelhead VSP parameters.

Other performance measures included are the Hatchery fraction, Age-at-return, Size-at-return, Adult spawner sex ratio, and Return spawn timing. Results indicate that steelhead returns were highly variable. The average hatchery-fraction varied greatly by location but were generally low. Total adult abundance in Cow, Horse, and Lightning creeks was small enough that hatchery strays could comprise anywhere from 2 to 30% of the spawning adults. Hatchery returns appeared too low to make meaningful interpretation of hatchery influence on population productivity. Studies that are examining the relative reproductive success of Imnaha hatchery fish in Little Sheep Creek are taking place. Results from this work may help quantify the risk straying hatchery fish pose to natural populations of Imnaha steelhead.

No evidence of a difference in mean length between natural and hatchery origin fish was found, but the power of the test to detect meaningful difference was not presented. Some evidence of a difference in the age distributions were found, but no discussion of implications for management were presented.

Lessons learned are clearly presented, particularly in locating the resistivity counters well downstream from weirs and spawning habitat. One possible downside to relying on this technology for fish counts is the inability to assign fish targets to hatchery or wild origin or to males or females.

Significant results are clearly presented, but interpretation of the results raises questions that need to be addressed, such as the potential risk/benefit of observed hatchery fractions to the natural populations. For example, when the Snake River steelhead distinct population segment was listed, the initial natural origin abundance estimate for Imnaha River steelhead was 1,000. A 2011 estimate for the basin indicated that 3,410 natural origins returned. If this quantity of steelhead continues to return to the basin its status as “maintained” will likely be changed to viable.

## **E. Variation in Straying Patterns and Rates in the Deschutes River**

[Link to summary report >](#)

The Oregon Department of Fish and Wildlife (ODFW) has documented an exceptionally large number and fraction of out-of-basin hatchery steelhead strays in the Deschutes watershed. For example, 35% of spawners in the Eastside stock are strays, and in the nearby John Day watershed, up to 40% strays were identified in EMAP surveys where no hatchery or supplementation program has occurred (Carmichael and Hoffnagle 2012, Ruzycki and Carmichael 2010). The Interior Columbia Technical Recovery Team (ICTRT) concluded that out-of-basin (DPS) straying poses a major risk to many of Oregon’s mid-Columbia River steelhead populations, which are listed as threatened under the ESA. For example, steelhead redd densities in the John Day watershed has declined steadily since 1959 potentially in response to numerous strays and an associated decline in fitness of natural origin steelhead (Ruzycki and Carmichael 2010). This investigation examined factors contributing to the high stray rates of Snake River steelhead to the Deschutes and John Day watersheds.

For the ISRP review, Carmichael and Hoffnagle provided their 2012 PowerPoint presentation (Carmichael and Hoffnagle 2012), and earlier reports (Ruzycki and Carmichael 2010, Carmichael and Hoffnagle 2006) that provide background and context for the 2012 PowerPoint.

Key conclusions were:

- Barged juvenile steelhead strayed more than in-river steelhead (2 years of data comparing stray fish with initial detections at Bonneville Dam):

Barged hatchery:	10.3% of detections strayed
Barged wild:	8.4%
In-river hatchery:	1.6%
In-river wild:	0.0%
- Stray rates between hatcheries were correlated suggesting that some environmental factor(s) contributed to straying.
- Wallowa Hatchery produced the highest stray rates.
- Release location influenced straying, e.g., release of same stock from Wallowa versus Big Canyon.
- Maintaining a reduced number of barged Snake River steelhead smolts would contribute significantly to recovery of mid-Columbia steelhead in Oregon and improve steelhead returns to the LSRC area.

Most hatchery strays entering the Deschutes River are recovered in lower river sport fisheries during August to October depending on stock. “Stray steelhead” appear to enter the lower Deschutes River in order to reduce exposure to high water temperatures in the mainstem Columbia and/or to overwinter there. If not captured and retained, many of these recovered fish could have potentially emigrated from the Deschutes River and returned to their natal stream. Nevertheless, the large number of out-of-basin hatchery fish and the relatively small populations of natural origin steelhead led to a high proportion of naturally spawning steelhead represented by hatchery fish in both the Deschutes and John Day rivers. It was not clear in the report why the proportion of spawners represented by hatchery strays was higher in EMAP survey areas versus Index areas in the John Day River.

The information contained in these reports is important for evaluating 1) the effectiveness of transporting steelhead in barges around the dams, 2) evaluating the performance of hatchery steelhead, and 3) evaluating the effects of hatchery fish on threatened wild steelhead populations in the mid-Columbia River. Many of the data presented here are several years old suggesting that data collection or analysis has not continued in recent years. CSS (2011, p. 127) reported that 78% of all hatchery steelhead strays and 50% of all wild steelhead strays were recovered in the Deschutes and John Day rivers, indicating their importance for cold-water holding or overwintering refugia.

## ***Recommendations***

- Hatchery managers should continue to collect and report information on straying, especially the proportion of hatchery steelhead on the spawning grounds (pHOS), and evaluate ways to minimize straying of Snake River hatchery steelhead. For example, why were so many Willowa steelhead on the spawning grounds compared with other hatchery stocks? Does rearing history in out-of-basin hatcheries, such as Magic Valley, Hagerman, or Irrigon, influence straying rates? Were some steelhead released without acclimation to the local stream water? Data on numbers of stray steelhead overwintering in the lower Deschutes should be collected.
- The correlation between stray rates from various hatcheries suggests a strong environmental factor influencing stray rates. Transportation of steelhead smolts was a key factor influencing stray rates, and this effect should be statistically controlled so that the effects of other environmental factors can be examined. More effort is needed to identify hatchery-specific practices and environmental factors such as temperature, flows, and migration timing that might influence stray rates. These effects may be investigated by hatchery managers or the CSS, which has also evaluated the effects of transportation on straying. A reduction in straying could improve viability of ESA-listed steelhead while also contributing toward the goal of more steelhead reaching the Snake River basin.

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## F. Management Information from PIT Tags

[Link to summary report >](#)

PIT-tags are an extremely useful tool in the Columbia Basin for evaluating a variety of management issues, as noted in this three-page brief. Given the ubiquity of PIT tagging in the basin, controlled experiments to assess biases associated with the PIT tagging process and subsequent fish survival are not as common as they should be, and more work along the lines of this brief would be welcome. Previous studies have shown tag loss and tag-related mortality can influence findings based on PIT-tags, such as Prentice et al. 1994 *in* Knudsen et al. 2009, and in the more recent Knudsen et al. 2009, CSS 2011. These investigators are working on this highly important issue involving both steelhead and Chinook salmon.

This brief is too short to allow the ISRP to make detailed technical comments about the study approach and design. However, the authors note some conflicting results from current studies, which they suggest may be influenced by small sample sizes. For example, the preliminary results showing the need for highly variable expansions is not yet adequate because factors affecting this high variability are not known. It will take some designed experiments to identify out the factors associated with PIT tag biases.

Therefore, a key recommendation is to use existing data to determine appropriate sample sizes needed to detect impacts on estimates that are relevant to management purposes and to continue to evaluate tag-loss and tag-related mortality and its impact on expansion factors. The ISRP also encourages the investigators to evaluate factors that might influence variability in tag loss rates and tag-related mortality rates, such as stock, size at tagging, and tagging personnel.

### ***Technical Issues with the document***

Figure 2. Some additional columns should be added to this figure. They should indicate the years the data were collected and the number of adult PIT tagged fish used to calculate the percentages shown. This additional information would help provide a sense for how precise the estimates shown in the figure are.

Figure 3. Is this a composite over many studies or one specific study?

Figure 5. There is some concern about the last column of Figure 5. How is this obtained from the data presented? For example, how can the corrected expansion factor in the last row be larger than the original expansion factor when fewer fish than predicted returned? Similarly for the second last row, how can the corrected expansion factor be smaller when more fish returned? These may be more fully explained in the detailed documents, but some explanation is warranted in the brief.

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## **G. Relative Reproductive Studies/Hatchery Reform Research**

[Link to summary report >](#)

### ***Introduction and Background***

The Lower Snake River Compensation Plan has three broad goals, to mitigate the loss of salmon due to hydropower development, to restore lost harvest opportunities, and to supplement or enhance local populations. Salmonid hatcheries are being used to address all three of these aims. Traditionally hatcheries have been used to augment harvest or to mitigate for lost habitat. More recently they are also being used for conservation or supplementation purposes. Whenever possible, local natural origin adults (NORs) are used as broodstock in supplementation programs. Offspring produced from these fish are artificially raised for varying periods of time before being released into the natural environment. Because hatchery conditions significantly improve early survival, an increase in adult abundance is expected to occur.

Yet, simply providing a population with additional adult fish through artificial culture may not provide an enduring increase in abundance. Hatchery fish used to supplement a population must also be able to spawn and produce adult offspring under natural conditions. In addition, for supplementation to be effective the factors that have limited population size in the past need to be identified and corrected. If these improvements take place in areas where the fish spawn and rear then a sustainable increase in the population may occur. In time, such supplemented populations will reach a new domain of abundance which will be constrained by another set of limiting factors. Consequently, supplementation for conservation purposes is expected to end after the population has reached its new and presumably upper carrying capacity. Sometimes the term supplementation is used to describe hatchery programs designed to augment harvest. In this circumstance, wild or NOR adults are incorporated into hatchery broodstock on a continuing basis and hatchery origin adults are commonly allowed to spawn naturally. Unlike conservation supplementation, these programs may run for indefinite periods of time.

Supplementation, in either form, is a controversial strategy because differences in behavior, morphology, and physiology have been detected between hatchery and wild salmonids. Genetic changes due to artificial culture have also been observed. A decrease in allelic richness and increases in linkage disequilibrium and relatedness, for example, were found in hatchery steelhead returning to the Hood River (Christie et al. 2012). Conversely, Chittenden et al. (2010) found that rearing environments, rather than genetic changes, strongly affected a suite of juvenile traits in hatchery- and wild-born coho salmon. Two perspectives about the value of supplementation exist (Fraser 2008). The predominant understanding is that hatchery conditions will negatively impact the long-term fitness of salmonids due to inadvertent domestication. The alternative view is that the genetic risks associated with hatcheries have been overstated and that evidence supporting fitness loss is often confounded by factors such as broodstock origin and management decisions.

During the last decade a number of studies have been performed that compare the ability of naturally spawning hatchery- and natural-origin salmonids to produce juvenile and adult offspring. In these investigations DNA from potential parents and offspring are used in pedigree assessments to estimate the number of offspring each type of fish produces. Work performed on Hood River steelhead indicated that hatchery origin adults were not as reproductively successful as natural origin fish when spawning under natural conditions (Araki et al 2007). Conversely, recent work by Hess et al. (2012) that compared the reproductive success of naturally spawning NOR and hatchery-origin spring Chinook found no differences. Araki and colleagues also discovered that the offspring of hatchery steelhead spawning under natural conditions produced fewer adult progeny than naturally spawning wild fish. They suggest this carryover effect is caused by genetic changes due to hatchery exposure (Araki et al. 2009). Additional work by Christie et al. (2012) on Hood River steelhead indicated that the effective number of breeders producing hatchery fish was quite small and genetic variation in the hatchery population was further reduced by significant differences in reproductive success among the individuals used as broodstock. Further studies on reproductive success need to be carried out on other populations of steelhead and additional species of salmonids to determine how universal the results of the Hood River studies may be.

### ***Review Comments***

Two studies by Ewann Berntson and colleagues that compared the relative reproductive success of hatchery and natural origin salmonids were presented at the LSRC meeting held at Clarkston WA in June of 2012. One was completed on steelhead returning to Little Sheep Creek in the Imnaha River, and the other was performed on Grande Ronde spring Chinook salmon in Catherine Creek. As mentioned above, previous work with spring Chinook has suggested that this species may not be as impacted by hatchery conditions as steelhead. Consequently, the investigation taking place in Catherine Creek provided another opportunity to look at hatchery effects on natural reproduction in this species.

The study that took place in Little Sheep Creek not only examined the importance of fish origin on reproductive success (RS) but also evaluated the consequences of relative fish size, return date, number of same sex competitors, total density, and number of opposite sex individuals on RS. Two assessments, the capacity to produce juveniles (breeding success) and ability to produce adult offspring (reproductive success) were made. The pedigree analyses of progeny sampled at both the juvenile and adult stage disclosed that the relative reproductive success of hatchery fish was 30 to 60% of that of natural origin cohorts. General Linear Models indicated that fish origin, length, return date, and the number of same sex competitors had the greatest effects on relative reproductive success. Of these factors, fish origin had the strongest effect. Interestingly, natural origin spawners were less impacted by spawner density than hatchery fish and the influence of same-sex competitors was more strongly felt by females than males. This suggested that spawning habitat might be limited under certain densities. They also discovered that relative reproductive success (RRS) values estimated by juvenile and adult production were quite similar to one another. They further stated that adult-to-juvenile studies were simpler to perform and often had greater statistical power because of the larger sample sizes such studies typically have. Consequently, in situations where it is logistically difficult to conduct adult-to-adult reproductive success studies, adult-to-juvenile assessments are expected to provide equally informative data.

Berntson et al. (2011) also maintain that it is unlikely that domestication or genetic changes to hatchery fish caused by exposure to hatchery conditions can fully explain the differences they observed in RS. Instead they suggest that obvious environmental differences in hatchery and wild fish play significant roles. In the past, large numbers of hatchery fish were allowed to spawn in Little Sheep Creek, and as a consequence it is likely that many of the NOR fish returning to the stream have some hatchery ancestry. This notion is supported by a genetic examination performed by Berntson et al. of 102 NORs used as hatchery broodstock. Two thirds of these fish had at least one hatchery parent. Thus, the fact that significant differences were found in the RS of hatchery and natural origin adults spawning in Little Sheep Creek suggests that environmental factors may be largely responsible for the differences seen. If genetic changes had occurred, the expectation would be that NORs with hatchery ancestry would be impacted and therefore have similar or possibly slightly greater RS values to those achieved by hatchery fish. That was not the case. NORs that had been removed from the hatchery environment for one or more generations had almost double the RS values of hatchery adults. To fully investigate this issue, the breeding success of adults produced by naturally spawning hatchery fish, needs to be compared to the breeding success of natural origin adults. In this instance, both types of adults would have experienced similar early environments. Any differences in RS could then be attributed to genetic differences rather than to a possible combination of environmental and genetic effects. Berntson and her colleagues plan to make such comparisons in the future.

The study that took place on Catherine Creek also produced some valuable results. In this case, naturally spawning hatchery origin spring Chinook adults had RS values that were very similar to those obtained by NORs. This result falls in line with other studies that have examined RS in hatchery and NOR spring Chinook. Distinct differences in how hatchery exposure affects

steelhead and Chinook appear to exist. An intriguing question is why is this occurring? Perhaps it is simply a difference in the number of fish used as broodstock.

### ***Suggestions for Future Work***

Studies in the Columbia Basin have played a leading role in investigating the biological and genetic consequences of using hatcheries for supplementation. Future investigations by the LSRCP steelhead, spring Chinook, and fall Chinook programs could be undertaken to resolve some of the outstanding questions that still remain. One of these is to make empirical and modeling evaluations of the effects of sliding scale broodstock plans. That is, what are the genetic and overall fitness effects on natural populations when sliding scale programs are implemented? Secondly, additional research efforts need to be performed to assess the occurrence and strength of the carryover effect. One possible way of approaching this problem would be to compare the reproductive success of NOR salmonids spawning in streams with varying levels of hatchery influence. If genetic changes have produced a carryover effect, an inverse relationship between hatchery prevalence in a population and R/S in NORs should exist. Another expected outcome would be a narrowing of differences in RRS between naturally spawning NORs and hatchery fish as the historical frequency of hatchery spawners increases. This expectation is based on the premise that NORs produced by one or more hatchery parents would have reduced R/S values due to genetic changes caused by domestication selection. The Imnaha might be an appropriate river basin for such evaluations as it appears to contain tributaries with varying proportions of spawning hatchery steelhead. Other basins in the LSRCP may have similar conditions. As suggested by Berntson et al. (2011) such studies could also compare the breeding success of NORs and hatchery origin fish. In this case, the ability to produce juvenile offspring as opposed to adult progeny would be assessed.

Thirdly, in order for supplementation to enhance population abundance two conditions must be met. First, fish brought into a hatchery whose offspring are allowed to spawn under natural conditions must produce more grand progeny than they would have if they had reproduced entirely under natural conditions. And second, hatchery grand progeny should enhance population abundance and not simply replace NOR progeny. BACI designs could be used to evaluate this issue ([ISAB 2003-3](#), [ISRP/ISAB 2005-15](#)).

And finally, further work on the possible genetic effects of supplementation needs to be performed. Tracking temporal changes in effective population sizes ( $N_e$ ), effective number of breeders ( $N_b$ ), mean family size ( $\bar{k}$ ), and variance of family size ( $V_k$ ) in hatchery and wild populations would increase our understanding of the genetic risks of supplementation. Empirical evaluations of the effects of differing PNI levels on natural populations would also be a fruitful research topic. As more studies are completed, the region and the LSRCP will need to determine how this information should be applied to extant and planned hatchery and conservation efforts.

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