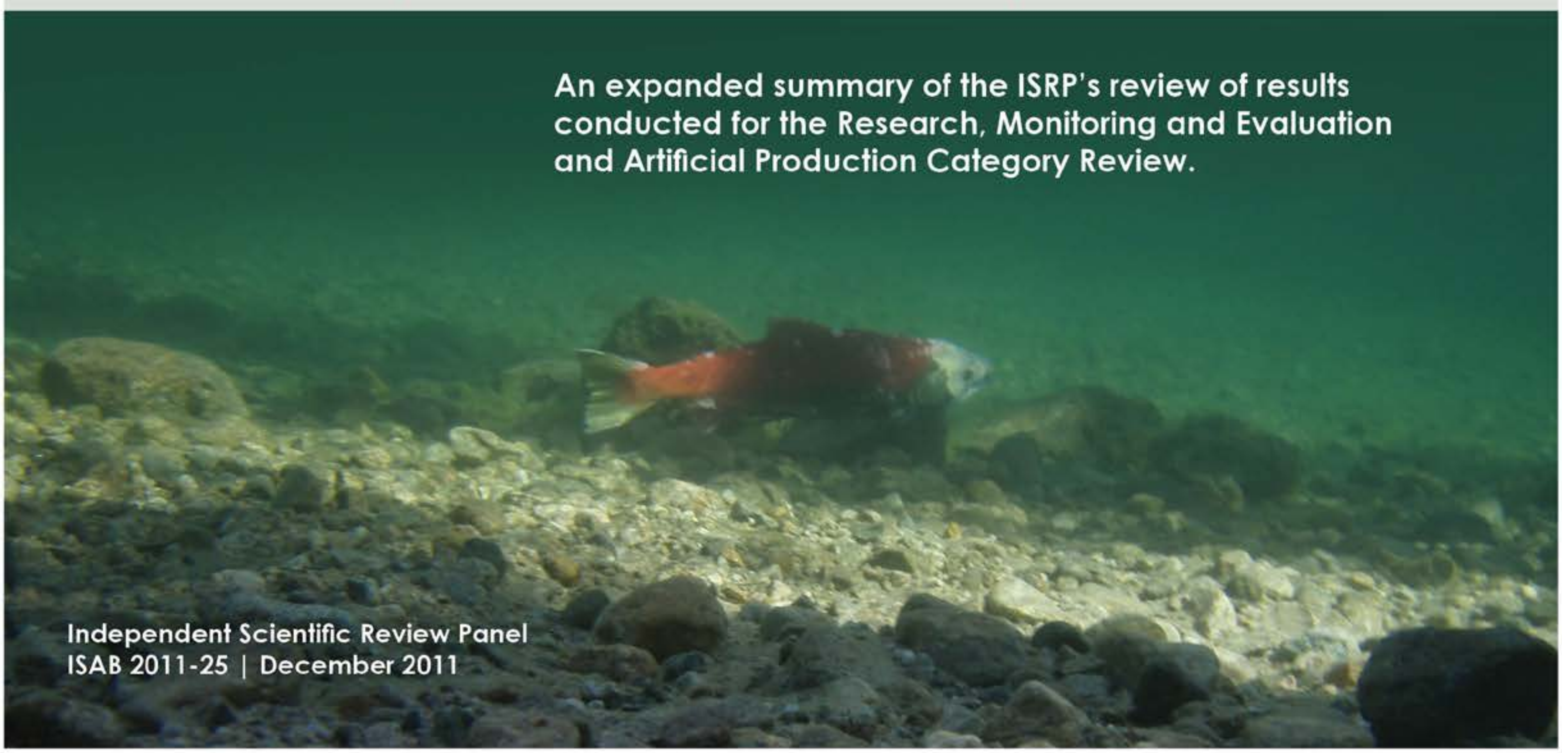
Independent Scientific Review Panel

Retrospective Report 2011



An expanded summary of the ISRP's review of results conducted for the Research, Monitoring and Evaluation and Artificial Production Category Review.

Independent Scientific Review Panel
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Executive Summary

This 2011 Retrospective Report expands upon the review of results that the ISRP conducted as part of its programmatic and individual review of projects in the Research, Monitoring, Evaluation, and Artificial Production Category Review (RMEAP Category Review Report; ISRP 2010-44). As requested by the Northwest Power and Conservation Council, this report summarizes accomplishments of approximately 150 Fish and Wildlife Program projects and the status of major basinwide programmatic issues in three key areas: 1) artificial production, 2) passage through mainstem dams, the river, and reservoirs, and 3) habitat restoration monitoring. The ISRP undertook this effort in response to the Council's desire to increase the visibility of project and program results. The ISRP did not summarize accomplishments of projects or topics for which synthesis reports are anticipated in 2012, such as ocean and estuary projects, the Integrated Status and Effectiveness Monitoring Project (ISEMP), and sturgeon projects.

The ISRP found that monitoring and evaluation has improved in all three major areas covered by this report. Nonetheless, lack of a comprehensive analysis of biological objective achievements for hatchery and habitat efforts impedes the understanding of program effectiveness. The Basin would benefit from an evaluation of management strategies and a structured decision approach for these categories, an approach that combines habitat, hatchery, passage, and full life-stage recruitment information. Although hatchery production has contributed to more adult fish, and in recent years harvest opportunities have increased, with some exceptions, supplementation experiments generally have not demonstrated improvement in the abundance of natural-origin salmon and steelhead. In addition, major biological improvements have not been measured as a result of habitat restoration. Although passage issues may seem largely addressed, several topic areas remain of concern, including contaminants, altered life histories (e.g., mini-jacks), and competition and predation from non-native species.

For the three main areas of focus, the ISRP provides the following summary of conclusions and recommendations.

Artificial Production

An analysis of abundance and productivity is urgently required for projects in the supplemented locations, especially for those tributaries where there is a conservation objective in the management plan. Based on findings listed below, the ISRP concludes that there is an absence of empirical evidence from the ongoing projects to assign a conservation benefit to supplementation other than preventing extinction. The supplementation projects with high proportions of hatchery fish in the hatchery broodstock and on the natural spawning grounds are likely compromising the long-term viability of the wild populations. Evaluation of most supplementation projects would benefit from a more thorough comparison with life-stage specific productivity and recruitment of salmon from un-supplemented reference streams. All programs should evaluate the potential influence of density-dependent effects. In programs where density-dependence has been detected at lower adult population levels than previously estimated, there is a need for further research into the causes of this situation. In other words, there is a need to better understand the limitations on capacity of spawning and rearing habitat and whether such limitations are restricting the production of smolts when additional adults reach the spawning grounds, even though total spawner abundance is currently low relative to historical conditions.

Although managers using hatchery supplementation seem to be aware of ongoing habitat restoration efforts, there is a need to better integrate supplementation with habitat restoration because rebuilding natural populations will ultimately depend on improving habitat quality and quantity. Recruits per spawner ratios must exceed 1 on a consistent basis in naturally-spawning stocks to achieve the ultimate goal of self-sustaining wild populations. Until this happens, supplementation is only a life support system. In supplemented streams where density dependence constrains natural abundance, supplementation may enhance genetic risks for loss of natural spawning fitness without any attendant benefit.

A Before-After Control-Impact (BACI) design was used to evaluate spring Chinook supplementation in the Imnaha River, Oregon (summarized in the Lower Snake River Compensation Plan Review; ISRP 2011-14), and steelhead supplementation in the Umatilla River, Oregon, but not in other programs. The ISRP recommends that this method, or alternatives of similar statistical validity, be used at all locations that have programs where the intention is that returning hatchery fish will spawn in the streams.

The BACI analysis of Imnaha spring Chinook (reported in ISRP 2011-14) indicated that abundance of Imnaha River fish decreased post supplementation relative to five reference sites and increased relative to four reference sites. The analysis found that spring Chinook productivity in the Imnaha River had decreased relative to all nine unsupplemented sites. In Umatilla River steelhead, BACI analysis using John Day River steelhead populations as a reference location demonstrated an increase in natural-origin adult steelhead abundance without a decrease in productivity. However, in a separate analysis, larger numbers of Umatilla steelhead spawners were associated with reduced numbers of smolts per spawner, reduced length at age, and increasing smolt age, suggesting that habitat conditions in the watershed constrained population growth. Quantification of supplementation effects on abundance and productivity needs to be evaluated at the other locations to establish the range of benefits and losses.

For steelhead, spring Chinook, and fall Chinook, the numbers of smolts per spawner often declined in response to larger numbers of parent spawners. Density-dependent survival in these watersheds appeared to be restricting the increase in smolt production that was expected from increased spawner abundance in the streams. Length-at-age decreased and average age of steelhead smolts increased with greater spawning abundance in the Umatilla watershed, suggesting that density dependence in this watershed was related in part to the food web.

Most, but not all, of the hatchery programs were self-sustaining. At least one adult female returned to the hatchery or tributary weir from the spawning of one adult female in the hatchery. On this basis, the program might maintain an important genetic lineage that otherwise would be lost. Over the long term, however, hatchery-dominated programs implemented to reduce extinction risk will result in genetic changes due to domestication selection. These adverse effects have the potential to offset demographic benefits to natural origin fish.

Fish and Wildlife Program projects using parentage analysis often demonstrated that the relative reproductive success of hatchery-origin adults was less than natural-origin adult salmon and steelhead. The range and variation in relative reproductive success among species and systems was substantial and warrants case-by-case consideration in management decisions. Steelhead from hatchery programs using non-local stocks typically exhibited very small relative reproductive success when contrasted with local natural-origin steelhead. Local stocks of steelhead used in supplementation programs exhibit a range of relative reproductive success; there is evidence for a substantial genetic contribution to the reduced relative reproductive success and also evidence this carries over to naturally produced progeny of hatchery-origin parents. The implication of this observation is that deleterious genetic effects from the hatchery may depress the productivity of the natural population. In spring Chinook salmon, local stocks used in supplementation exhibited relative reproductive success ranging from greater than 90% of natural fish to approximately 50% of natural fish. However, in regard to the case of the 50% success rate, when spawning location was included as a covariate, there was no difference in female reproductive success.

The ISRP recommends a review and summary of post-release performance differences be conducted among the hatcheries or within years in a hatchery for a number of the fish culture practices such as acclimation versus direct release, on-site versus satellite facility release, rearing densities, and size and timing at release. This summary could contribute to explaining differences in the performance of smolts after release and inform modifications in hatchery operations.

Kelt reconditioning as a recovery tool is in an early stage of development. Successful reconditioning to increase survival and subsequent reproduction may not provide benefits for recovery; evaluations of the demographic effects of kelt reconditioning on viability assessments at the population and evolutionary significant unit (ESU) are necessary. The scale of implementation required for contributing to recovery and delisting must be estimated before assessment about the potential for success of kelt reconditioning as a recovery tool can be made.

The sockeye captive brood project has successfully prevented extirpation of the Red Fish Lake sockeye population. However, substantial improvements in survival are still needed before a natural population could be viable. The program needs to continue and expand monitoring of survival during each life stage of natural sockeye and identify areas of focus that are likely to enhance viability of the sockeye population. A comprehensive synthesis and assessment of the sockeye rebuilding effort would be worthwhile as a means to identify specific metrics and activities needed to achieve a viable natural population.

Mainstem Hydrosystem Passage and Related Life History Monitoring and Research

The ISRP considered four categories of projects related to passage: 1) development and installation of new monitoring systems plus data storage and management, 2) hydrosystem core RME projects, 3) training and data analysis support projects, and 4) life history, fish population status, and hydrosystem/hatchery uncertainties.

In the review, the ISRP found that the projects answered most of the Council's questions regarding major program management issues and associated high level indicators (HLI's). In addition, the ISRP did not find excessive overlap of objectives, data gaps, or duplication of data collection among this group of projects.

The ISRP concluded that projects providing important monitoring tools, data storage, and support services for listed salmonids and other stocks and species in the Columbia River Basin are essential, and there is a continuing need for further development, testing, and evaluation of Passive Integrated Transponder (PIT) tag technologies and data storage and retrieval systems. The ISRP concluded that the successful development of spillway PIT tag detection systems for mainstem dams is a high priority and recommended additional effort to evaluate the biological aspects of PIT tagging such as tag loss and tag-related mortality.

Projects that include coordinating and mobilizing data sets for management applications are of great benefit. The projects providing real time series of juvenile passage data to support a decision framework for hydrosystem operations to benefit fish passage, providing information on how survival of migrating juvenile salmonids is affected by operation of the Federal Columbia River Power System (FCRPS), and providing long-term data series of the smolt-to-adult portion of the life cycle to address management questions are all beneficial. One project that is designed to empirically test the hypothesis that smolts that pass through Snake River dams experience delayed or extra mortality has potential to provide answers to some of key questions and should be continued.

Of particular value in this group of projects categorized as mainstem projects were the Snake River wild fall Chinook research and early life history studies. The analyses of abundance and growth data with stock recruitment relationships to address density dependence in supplementation programs were revealing. Post supplementation, there has been a significant decrease in smolt size. Hatchery supplementation has been associated with large increases in redd counts, followed by a leveling off/slight decline of natural fish. There are some indications that density dependent factors might have an effect as stock size rebuilds. Whether or not density-dependence or other hatchery-wild interactions are occurring may be a contentious issue, but regardless of the outcome, addressing these questions with their long-term data sets is a highly important use of the data, and an appropriate approach for evaluating and shaping other supplementation projects in the Basin.

The development of the hydrosystem has altered predator prey interactions. A considerable amount of useful work on individual predator species has taken place. Perhaps it should now be asked what specific salmonid stocks are most vulnerable to various predators in an attempt to sort out potential population effects. Some large-scale life-cycle modeling seems in order that includes mortality from all predators as a group. The importance of predators on smolt-to-adult ratios (SARs) is a continuing issue that needs attention.

Habitat Restoration Monitoring

Progress has been made in the standardization of effectiveness evaluation in habitat restoration. While the ISRP applauds overall attempts to bring greater consistency to habitat restoration effectiveness monitoring, we caution against attempting to apply a "one-size-fits-all" habitat monitoring and evaluation approach to every situation. Advances in physical and chemical measurement and analytical technology will render some approaches to monitoring obsolete over time, and any monitoring protocols must be open to new, more efficient techniques. Unusual circumstances such as natural disturbances (fires, floods, etc.) and some types of anthropogenic impacts, such as chemical use, may provide opportunities to apply non-standard monitoring tools and altered sampling schemes to maximize learning opportunities. Finally, there is a risk that strict adherence to standardized habitat monitoring and evaluation protocols may stifle creativity on the part of monitoring practitioners if "doing something extra" is discouraged, the risk being that a potentially important environmental factor could be overlooked. For all these reasons, the ISRP recommends that Council should always view habitat action effectiveness monitoring and evaluation as a continuing work in progress, and while there is a need for an appropriate level of consistency to enable broad regional syntheses of status and trends, we doubt that a single standardized habitat monitoring approach is achievable, or even desirable.

On the other hand, the ISRP does feel that improved standardization of measuring fish response to habitat restoration is needed. At the very least, we believe that more tributaries where restoration actions are taking place should be monitored for "adults in" and "smolts out" so that the ratio of smolt production to adult escapement can be established as a tracking metric for monitoring action effectiveness.

The ISRP believes that it is important to consider how long it will take to measure the effects of habitat actions on focal species. The statement in the Council's final decision document for the RMEAP category review (NPCC 2011) that "*The Council will not conclude this review without being comfortable that the monitoring and evaluation protocols and analytical methods are in place to give us a reasonable chance of knowing -- in 5, 10, 20 years -- whether the region's huge investment in an evolving suite of habitat actions is contributing significantly to the recovery and rebuilding of fish species important to the region*" implies that action effectiveness ought to be known in 5, 10, or 20 years if we conduct monitoring in a thoughtful, appropriate, and efficient manner. The question of the time needed to detect the effects of a habitat restoration action, or collection of actions, on target populations seems to be at the heart of uncertainty currently being articulated, including in BiOp rulings, over whether or not the huge investment in habitat restoration will achieve intended outcomes.

There is no standard time frame for expecting measurable results from habitat restoration. In some habitat improvement actions, improvement will be more-or-less immediate and detecting results should be relatively swift and straightforward. The removal of Hemlock Dam on an important steelhead spawning tributary of the Wind River in August 2009 is an example of an action that has had immediate and measurable benefits for Trout Creek. It is also likely that the recent decommissioning of Condit Dam on the White Salmon River will also have immediate benefits. However, other actions may require multiple years for their full benefits to be expressed. These include some types of in-stream structure modifications or floodplain reconnection projects that rely on annual hydrologic fluctuations to complete the task of habitat formation or restoration of ecological function. Still other types of projects, including many riparian forest protection and restoration efforts, require decades for their full benefits to be expressed. In fact, most habitat actions aimed at restoring natural watershed processes fall into the category of projects requiring many years to achieve objectives. Each type of habitat project can be worthwhile, but the amount of time needed to document benefits will vary greatly among them. We thus recommend long-term monitoring for a suite of projects falling into such different categories.

A more problematic issue is the even greater amount of time needed to measure the effects of habitat improvement on fish populations. The ISRP and ISAB have addressed this question several times (e.g., ISAB 2003-2, ISAB/ISRP 2007-5, ISRP 2008-4) and cautioned that the high level of variation in abundance caused by a mix of natural and anthropogenic factors requires that considerable time, sometimes on the order of decades, is needed *both before and after implementing restoration projects* to measure the effects of actions on target populations with a reasonable level of certainty. Many projects simply do not have the time or resources to accomplish a statistically sound evaluation of restoration success. Furthermore, very few projects are able to compare results with an appropriate unimproved reference site, a comparison that is required to accurately identify responses to the application of habitat actions. For this reason, the ISRP has been generally supportive of Intensively Monitored Watersheds (IMWs), which are using a planned experimental approach to evaluating restoration effectiveness at watershed scales. The main point here, however, is that the expectation of definitive answers to the question "Is it working?" may, in many instances, not be achievable in a 5-20 year window. The ISRP therefore suggests that additional dialogue is needed among habitat managers, scientists, and policy-makers so that realistic timeframes can be established, and appropriate schedules agreed upon, to monitor and evaluate different types of restoration actions, and to establish a suite of control and treatment streams, appropriately monitored over reasonable time frames to evaluate success.

Programmatic Issues

The need for inclusion of full life-stage based recruitment information into the effectiveness evaluation of hatchery, habitat, and hydrosystem passage projects has been noted. In addition, there were three programmatic issues identified during this review, including: (1) a need for Structured Decision Management in the Columbia River Basin, (2) implications of precocious maturation of male Chinook salmon (mini-jacks), and (3) potential biases in metrics based on PIT tags. These issues are discussed in the body of this report and several recommendations are provided on each issue.

Structured decision management (SDM): In a previous retrospective report, the ISRP introduced and described the SDM process. Since then, there have been few, if any, direct applications of the SDM approach within the Columbia Basin. There are many example areas where SDM may benefit resource management in the Columbia Basin. For example, the Lower Snake River Compensation Program has recently completed a review and faces decisions on harvest and hatchery policy. Results and models from the recent review could be useful toward this decision process, and much could be gained by including all stakeholders and agencies by applying SDM. Similarly, several habitat projects entail complex decision-making, such as the evaluation of habitat restoration effectiveness, flow augmentation projects (e.g., Walla Walla, Umatilla, Wenatchee), and barge versus in-river modes of hydrosystem passage. Other examples might include predator control (e.g., pikeminnow, sea lions), hatchery production goals versus harvest and wild fish impacts (several areas), recreational versus commercial harvest including selective harvest, largemouth and smallmouth bass or pike recreational fisheries versus salmon and steelhead trout or resident fish recovery, and many other examples. The ISRP encourages application of SDM to these and related management options.

Mini-jacks: Anadromous Chinook salmon and steelhead are known to produce precocious male salmon, that is, young male fish that are sexually mature without going to sea, also called mini-jacks. Progress has been made on evaluating the presence and contribution of precocious salmon among hatchery populations. However, additional research and monitoring is needed to evaluate factors contributing to the frequency of precocious salmon and their abundance in each hatchery. These data are needed to improve estimates of SARs and other metrics associated with hatcheries. For example, SARs based on fish captured and PIT-tagged in the mainstem where a small proportion]of mini-jacks present could produce different results compared with fish PIT-tagged at the hatchery prior to release where all mini-jacks are present. Finally, potential bias in salmon metrics caused by the presence of mini-jacks among hatchery salmon should be recognized and considered by all managers and researchers that rely upon these data.

PIT tags: In the Columbia River Basin, PIT tags are a key tool used to estimate stock-specific survival and migration time of salmonids, including survival of juvenile salmonids emigrating through the system via transportation barge or inriver migration. Decisions to spill more water or to transport more fish around the dams rely upon accurate and unbiased metrics produced by PIT-tagged salmonids. However, recent studies suggest fish may shed PIT tags and/or may experience higher mortality compared with untagged fish, thereby leading to high estimates of mortality. The extent to which tag loss and tag-related mortality may vary from year-to-year and from watershed to watershed are unknown. Given the high value of reliable PIT tag data, additional studies are needed to evaluate the influence on tag loss and tag-related mortality of fish species, fish size, sex, tagging operations, and post-release environmental conditions. These data could be used to develop and apply correction factors, thereby improving the accuracy and precision of metrics that rely upon PIT tags.

Introduction

A. Background

This 2011 Retrospective Report expands upon and further summarizes the review of results that the ISRP conducted as part of its programmatic and individual review of projects in the Research, Monitoring, Evaluation, and Artificial Production Category Review (RMEAP Category Review Report; ISRP 2010-44). The ISRP undertook this effort in response to discussions with the Council and their stated desire to improve results reporting in general and increase the visibility of our reviews of project and program results.

The ISRP recognizes that retrospective reports need to be conducted in the context of other concurrent efforts that track results of the Fish and Wildlife Program. The ISRP designed this review to be consistent with the Council's draft Monitoring, Evaluation, Research and Reporting (MERR) plan and to inform the proposed "High-Level Indicators" report and the Council's annual report to the Northwest Governors on Fish and Wildlife Program expenditures (see www.nwcouncil.org/library/2010/2010-06.htm). In addition, the Columbia Basin Fish and Wildlife Authority (CBFWA) issues an annual report of the status of the resource, and the Bonneville Power Administration has made progress on project tracking through Pisces and Taurus. These efforts and the ISRP's retrospective review share a target of not only reviewing the results that are currently reported but establishing a systematic and meaningful reporting of project results as a central feature of the Fish and Wildlife Program.

Below, we describe the ISRP's retrospective review charge and the ISRP's past efforts to comply with the charge, followed by an outline of this report's substantive content.

B. The Retrospective Review Charge

In addition to reviews of proposed projects, the 1996 amendment to the Power Act, Section 4(h)(10)(D)(iv), directs the ISRP, with assistance from the Scientific Peer Review Groups, to review annually the results of prior-year expenditures based on the ISRP's project review criteria and submit its findings to the Council. As stated in the Council's 2009 Fish and Wildlife Program, "the retrospective review should focus on the measurable benefits to fish and wildlife made through projects funded by Bonneville and previously reviewed. The ISRP's findings should provide biological information for the Council's ongoing accounting and evaluation of Bonneville's expenditures and the level of success in meeting the objectives of the 2009 Program, as described in the monitoring and evaluation section. Also as part of the ISRP's annual retrospective report, the ISRP should summarize major basinwide programmatic issues identified during project reviews."

C. Past ISRP Retrospective Reviews

The ISRP has complied with this retrospective charge in three basic ways.

1. Proposal Reviews

A major element of the ISRP's reviews of ongoing projects, such as for the recently completed RMEAP Category Review, is an examination of each project's reporting of past results consistent with the retrospective review charge. The proposal form specifically asks for a concise summary of biological results, a discussion of the adaptive management implications of those results, and notice that the ISRP will use the information submitted for its retrospective review. In addition to review comments on each project, the general sufficiency of results reporting and incorporation of project accomplishments into future planning is summarized by the ISRP in the programmatic section of category and geographic reviews.

2. ISRP Retrospective Reports

The ISRP has released three distinct "retrospective" reports. In 2005, the ISRP completed its first retrospective report, *Independent Scientific Review Panel's Retrospective Report 1997-2005* (ISRP 2005-14, August 2005). The report focused on programmatic issues and observations identified in ISRP reviews dating back to the ISRP's first report in 1997. In 2006, the ISRP's review of Fiscal Year 2007-09 proposals included an examination of the results reported by ongoing projects. The ISRP reported the results of that analysis in its *ISRP 2006 Retrospective Report* (ISRP 2007-1, March 2007). The ISRP's *Retrospective Report 2007: Adaptive Management in the Columbia River Basin* (ISRP 2008-4, April 2008) focused on how projects are changing their objectives, strategies, and methods based on learning from the results of their actions. The ISRP accomplished this by looking at themes that emerged in previous ISRP retrospectives, examining a subset of projects that were reviewed in Fiscal Year 2007, and investigating how proponents applied the results of their past projects to proposed future actions and monitoring.

3. ISRP Review of "Retrospective" or "Synthesis" Reports drafted by Project Proponents

The ISRP has reviewed a number of "retrospective" reports that were produced by proponents of long-term, ongoing projects. Some of these reports were requested by the ISRP in a specific project review; see the *ISAB and ISRP Review of the CSS Ten-Year Retrospective Summary Report* (ISRP 2007-6, November 2007). Other examples include the Lower Snake River Compensation Plan Spring Chinook Program review (ISRP 2011-14) and ISRP follow-up reviews of the Select Area Fisheries Enhancement Program, the ODFW John Day fencing program, and the Grande Ronde model watershed habitat restoration effectiveness report.

D. Recommendations Regarding the Review Approach

The ISRP found that it was inefficient to generate extensive summaries of project results from annual reports for a retrospective evaluation of the projects. A recent example where the ISRP found that an independent retrospective evaluation worked well was for the evaluation of the Lower Snake River Compensation Plan (LSRCP) for spring Chinook, as indicated above. In that format, the program co-managers summarized the outcomes from their individual program components and compared them to goals established in the LSRCP. Co-managers' summaries were presented to the ISRP during a three-day symposium, followed by written reports. The ISRP evaluated the summary documents provided by the co-managers.

Recommendation: The ISRP recommends that the Council use the approach of the 2011 LSRCP review for future retrospective evaluation of Fish and Wildlife Program category and geographic projects by the ISRP. Having the project proponents and co-managers develop a summary report that is evaluated by the ISRP would be more efficient and productive than attempting to extract summary information from proposal materials and annual reports via Taurus.

E. Topics of the 2011 Retrospective Report

This review is in essence a combination of the three types of reviews above. It employs results reported by projects reviewed in the RMEAP Category Review, and it provides these in a focused retrospective report. Because the Council has made funding recommendations on those sets of projects that generally last for the next three to five years, the ISRP's review is intended to inform the next program amendments, the next project reviews, and refinement of the Council's Research and MERR plans.

The review focuses on the following sets of projects:

1. Artificial production including monitoring and research

2. Mainstem hydrosystem passage monitoring and research

3. Habitat restoration monitoring and research

In this retrospective report the ISRP presents the summarized results reported for the above. The ISRP's depth of emphasis of the three major topic areas varies in this report. The reporting of results for artificial production is the most detailed and in-depth. Artificial production was emphasized because recent progress has been made in compiling and reporting comprehensive data and results. In addition, the ISRP understands artificial production, especially the supplementation strategy, is a topic of heightened concern for the Council and Fish and Wildlife Program. The coverage of artificial production includes 1) a summary section in the main body of the text that contains findings and recommendations on the results reported, and 2) an appendix that contains more extensive summaries of the projects, along with data and analyses of research efforts drawn from project proposals and project annual reports. Readers should be aware that there is repetition between the main body text and the appendix and should refer to the report section that best meets their need to understand the details of specific artificial production issues and projects.

The ISRP provided a less detailed assessment of mainstem passage results because the ISRP understands that the Council is regularly briefed by NOAA Fisheries, the Action Agencies, and the fish and wildlife managers on passage survival results and status. Moreover, the Independent Scientific Advisory Board (ISAB) regularly reviews the results of Fish Passage Center and Comparative Survival Study efforts, including annual reports and other technical analyses. The ISRP's coverage of habitat monitoring acknowledges that critical pieces of a habitat monitoring approach for the Program are in early stages and results of habitat projects will be reported in Geographic Reviews. In addition, the ISRP did not focus on results of projects or topics for which synthesis reports are anticipated in the next year such as ocean projects, the Integrated Status and Effectiveness Monitoring Project (ISEMP), and sturgeon projects.

ISRP Conclusions, Recommendations, and Programmatic Issues

A. Identification of Programmatic Issues

1. Structured Decision Management

In a previous retrospective report, the ISRP introduced and described the structured decision management (SDM) process (ISRP 2008-4). Since then, there have been few, if any, direct applications of the SDM approach within the Columbia Basin. Nonetheless, numerous successful examples of SDM have emerged in the formal fisheries literature, e.g., for recreational fisheries (Irwin et al. 2011), water resources (Liua et al. 2007), hydroelectric developments and water use (Failing et al. 2007), coastal marine ecosystems (Espinosa-Romero et al. 2011), and lamprey control in the Great Lakes (Haeseker et al. 2007). In addition, several recent management plans within the Columbia Basin have benefitted from a similar, although indirect SDM approach (e.g., Chief Joe Hatchery Master Plan and the All-H Analyzer (AHA) model application to hatchery reviews). Also within the Columbia Basin, Peterman (2004) included a decision analysis example from the Snake River in his review of recent work on fisheries challenges, illustrating that decision analysis is a useful framework for focusing efforts of members of a diverse multi-stakeholder team, and taking into account their sometimes strongly differing views about hypotheses and uncertainties, even for issues around Chinook salmon and dams in the Columbia River. We briefly re-introduce and update SDM here, to further encourage its application to resource management in the Columbia Basin.

An excellent presentation on the application of structured decision making to recreational fisheries management was provided recently by Irwin et al. (2011). They reflected on the realizable benefits accrued to fisheries management by involving stakeholders, explicitly defining objectives and options, and modeling to incorporate options, outcomes and uncertainties, all based on their experiences and applications to recreational fisheries. The lessons learned are directly applicable to the Columbia Basin Fish and Wildlife Program.

In today's world of rapidly evolving computer technology, communication, and the development of tools for decision management, complex processes for consensus building, risk analysis, trade-offs, results prediction, and formal decision-making are aided by simulation modeling. Real-time, hands-on involvement of the stakeholders in deliberative decision-making frameworks using computers in work group setting successfully involves the following steps and criteria (from Irwin et al 2011):

- Clear statement of the purpose of SDM, the consensus approach and process, the scope, and expectations.

- Setting of the analytical context with explanations.
- Involvement of experts, respected stakeholder members, and modellers and a facilitation team (10 to 20 participants). Facilitators may be modellers and must be independent.
- Appropriate time and money. Work group formation, background analyses, model forecasting, participate involvement, and iterative feedback and development, and other aspects of the SDM process may require more than one year. Timelines to completion, planned reviews, and identification of potential crises are important to successful completion.

There are many example areas where SDM may benefit resource management in the Columbia Basin. For example, the Lower Snake River Compensation Program and Supplementation has recently completed a review, and faces decisions on harvest and hatchery policy. Results and models from the recent review could be useful towards this decision process, and much could be gained by including all stakeholders and agencies by applying SDM. Similarly, several habitat projects entail complex decision-making, such as the evaluation of habitat restoration effectiveness, flow augmentation projects (e.g., Walla Walla, Umatilla, Wenatchee), and hydrosystem passage (barge versus in-river). Other examples might include predator control (e.g., pikeminnow, sea lions), hatchery production goals versus harvest and wild fish impacts (several areas), recreational versus commercial harvest (including selective harvest), largemouth and smallmouth bass or pike recreational fisheries versus salmon and steelhead trout or resident fish recovery, and many other examples. We encourage its application to these and related management options.

2. Implications of Precocious Male Maturation (Mini-jacks)

Anadromous Chinook salmon (all races) and steelhead are known to produce precocious male salmon, i.e., young male fish that are sexually mature without going to sea. In the Columbia Basin, most male Chinook salmon mature after two or three winters at sea. Smaller numbers of jack salmon mature after one winter at sea, whereas precocious male Chinook salmon mature after their first summer in freshwater (precocious parr) or after spending one winter in freshwater (mini-jacks). Recent studies indicate up to approximately 50% of male Chinook salmon smolts released from Columbia Basin hatcheries are mini-jacks (Larsen et al. 2010a; see Table 1 below). Very few precocious parr are produced in hatcheries; perhaps some contribute to mortality in the hatchery. In contrast, although few studies have quantified mini-jacks in the wild, mini-jack rates among wild Chinook salmon are believed to be less than 5% (Larsen et al. 2010a, b). Most mini-jacks remain in the natal river, but a small proportion of the mini-jack population emigrates through the mainstem Columbia River and may be detected, if PIT-tagged, while migrating upriver through adult salmon ladders on mainstem dams (Beckman and Larsen 2005). Counts of the mini-jacks observed in the adult salmon ladders typically represents less than 1% of the total release of PIT-tagged salmon from hatcheries, but some emigrating mini-jacks likely die before detection.

Rapid salmon growth in the hatchery, especially during summer, has been shown to increase the mini-jack rate (Larsen et al. 2010a). However, growth experiments in which hatchery smolts were equal in size to wild spring Chinook salmon still revealed a four-fold increase in mini-jack rates among the hatchery fish, indicating that some factor(s) other than growth contribute to mini-jack rates. Some emerging evidence suggests that integrated hatchery stocks, which incorporate natural fish into the broodstock, have higher mini-jack rates than domesticated stocks. Research on this topic by NOAA Fisheries is continuing. The research outcome has implications for supplementation programs that are trying to rebuild natural populations through use of integrated hatchery stocks, as recommended by the Hatchery Scientific Review Group.

The large proportion of mini-jacks in some hatcheries and the high variability in mini-jack rates from year to year raises significant ecological, genetic, and management issues. Precocious hatchery salmon that remain in the watershed may consume or compete with native fishes. Precocious hatchery salmon may also mate with much larger anadromous female salmon through sneak behavior, but some evidence suggests relatively few precocious hatchery salmon survive to spawn (Larsen et al. 2010b). In the Yakima Basin, few precocious male Chinook salmon were observed on the spawning grounds. However, in the Tucannon River, WDFW reported up to 11 precocious parr per Chinook salmon redd (Gallinat, WDFW; www.fws.gov/lsnakecomplan/Meetings/2010SpringChinookHatcheryReviewSymposium.html). The precocious parr in the Tucannon were believed to be produced by natural spawners.

Mini-jacks produced by hatcheries are typically not enumerated at hatchery racks or elsewhere on the river. Mini-jacks contribute to the higher mortality that is observed among hatchery versus wild Chinook salmon, but the amount of mortality associated with mini-jacks is not documented. Nevertheless, the effect of precocious maturation on SARs might be large in some years. For example, approximately 50% of male smolts released from Lookingglass Hatchery were reportedly mini-jacks in 2006 and 2007 (Table 1). Assuming 50% of the smolt release was male, approximately 25% of the entire smolt release was lost because the fish matured too early. Hatchery managers do not believe mini-jack rates at hatcheries such as Lookingglass are this high (~50%; R. Carmichael, ODFW, comment at the LSRCP workshop in 2010). However, comprehensive and accurate of sampling of salmon gender ratios returning from hatchery releases is not routine or may be inaccurate if sampling occurs several months prior to spawning, i.e., before external sexual traits become developed. Furthermore, greater age-at-maturation of female Chinook salmon and associated mortality should lead to somewhat fewer female than male salmon in the adult return, if precocious males were insignificant. The presence of equal or more numerous female Chinook salmon is an indication of the presence of mini-jacks.

In summary, progress has been made on the presence and contribution of precocious salmon among hatchery populations. However, additional research and monitoring is needed to evaluate factors contributing to the frequency of precocious salmon and their abundance in each hatchery. These data are needed to improve estimates of SARs and other metrics associated with hatcheries. For example, SARs based on fish captured and PIT-tagged in the mainstem (small proportion of mini-jacks present) could produce different results compared with fish PIT-tagged at the hatchery prior to release (all mini-jacks present). Finally, potential bias in salmon metrics caused by the presence of mini-jacks among hatchery salmon should be recognized and considered by all managers and researchers that rely upon these data.

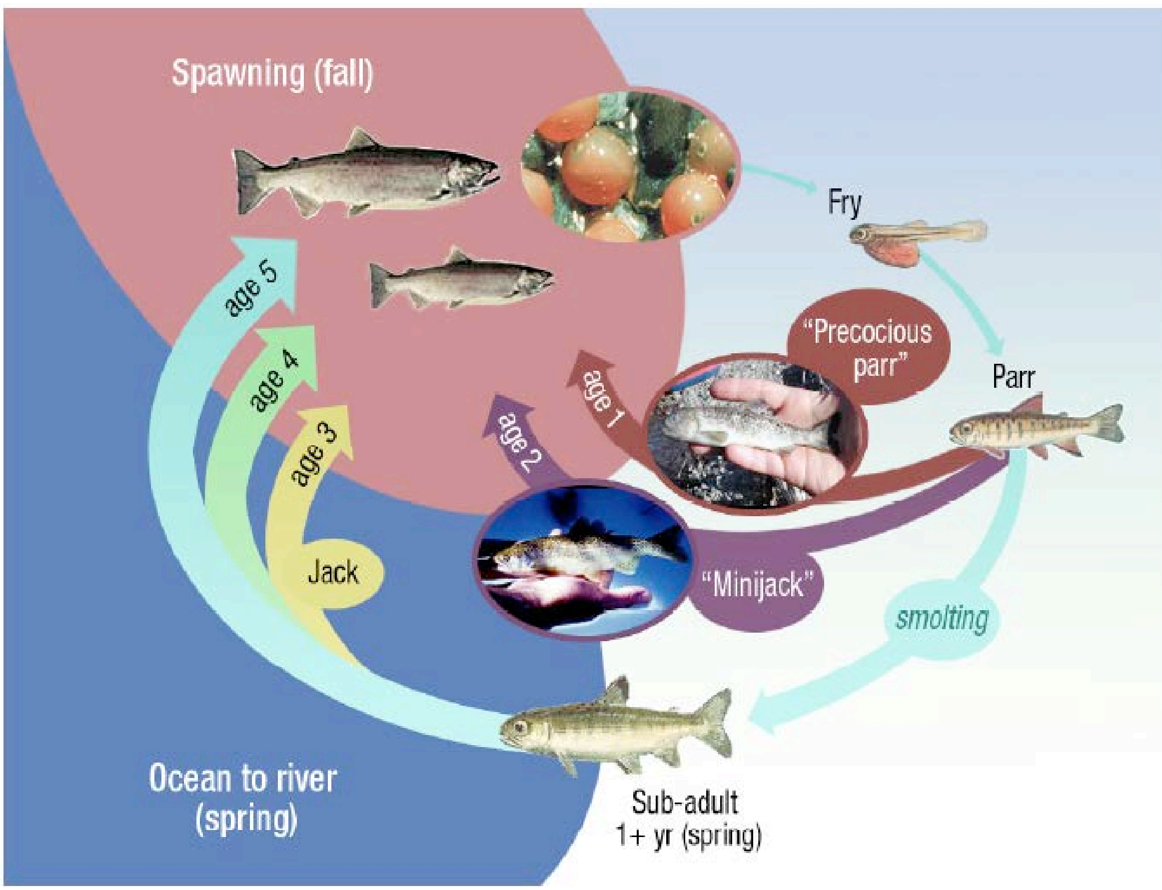

Figure 1. Life cycle of spring Chinook salmon including precocious parr and mini-jack life forms. Source: Larsen et al. 2010a.

Table 1. Estimates of minijack production in various Columbia River hatchery spring and summer Chinook stocks. Source: Larsen et al. 2010a.

Hatchery, River	Stock	Brood Year	Minijacks (% males)	Average % Minijacks
Cle Elum, Yakima R., WA	Spring Chinook	1997	44.0	**41**
		1998	72.0	
		1999	48.8	
		2000	35.5	
		2001	54.3	
		2002	36.2	
		2003	19.9	
		2004	22.0	
		2005	28.8	
		2006	51.0	
		2007	34.2	
Leavenworth, Wenatchee R., WA	Spring Chinook	2003	9.4	**20**
		2004	14.2	
		2005	33.1	
		2006	28.8	
		2007	16.3	
Entiat, Entiat R. WA	Spring Chinook	2003	13.2	**11**
		2004	7.9	
		2005	10.7	
Winthrop, Methow R. WA	Spring Chinook	2003	16.6	**27**
		2004	28.1	
		2005	35.3	
		2006	38.5	
		2007	14.2	
Lookingglass, Lostine R, OR	Spring Chinook	2006	47.3	**52**
		2007	56.2	
Lookingglass, Imnaha R., OR	Spring Chinook	2006	51.7	
Dryden Pond, Wenatchee R., WA	Summer Chinook	2006	16.8	**10**
		2007	4.1	
Carlton Pond, Methow R., WA	Summer Chinook	2006	36.6	**28**
		2007	19.5	
Similkameen Pond, Similkameen R., WA	Summer Chinook	2006	11.0	**10**
		2007	8.6	

3. Potential Bias in Metrics Based on PIT tags

Passive Integrated Transponder (PIT) tags are a key tool used to estimate stock-specific survival and migration time of salmonids in the Columbia River Basin, including survival of juvenile salmonids emigrating through the system via transportation barge or inriver migration. Decisions to spill more water or to transport more fish around the dams rely upon accurate and unbiased metrics produced by PIT-tagged salmonids. However, recent studies suggest fish may shed PIT tags and/or may experience higher mortality compared with untagged fish, thereby leading to high estimates of mortality. The extent to which tag loss and tag-related mortality may vary from year to year and from watershed to watershed are unknown (CSS 2011, p 161). Given the high value of reliable PIT data, additional studies are needed to evaluate the influence on tag loss and tag-related mortality of fish species, fish size, gender, tagging operations, and post-release environmental conditions. These data could be used to develop and apply correction factors, thereby improving the accuracy and precision of metrics that rely upon PIT tags. Findings of a few recent studies are briefly summarized below to show the significance of this issue.

Knudsen et al. (2009) released a total of 193,648 spring Chinook salmon into the Yakima River that were tagged with both PIT and coded-wire (CWT) tags during a five year period. Another 2.7 million fish were released with CWT only. All fish in the study received adipose fin clips. The investigators reported that PIT tag loss averaged 2% at release and 18.4% among fish returning 6 months to 4 years after release. Estimated smolt-to-adult recruit survival (SARs) of PIT-tagged fish was 25% lower, on average, than that of non-PIT-tagged fish because of a combination of tag loss and reduced survival. After correcting for tag loss, the estimated PIT-tag-induced mortality was 10.4%, on average, but reached 33% for one brood year. Mean length-at-age and weight of PIT-tagged fish were significantly smaller than control fish. The investigators noted that tag-induced mortality seemed to be greater during years of high overall mortality while migrating through the Columbia mainstem.

During the review of the Lower Snake River Compensation Program, Casinelli (IDFG; www.fws.gov/lsnakecomplan/Meetings/2010SpringChinookHatcheryReviewSymposium.html) reported that 12.5% of jack Chinook salmon (n = 8 fish total) and 30.6% of Chinook salmon spending two years at sea had shed their PIT tag (n = 36 fish). Greater tag loss over time is especially problematic if this is a common occurrence among PIT-tagged fish. However, Knudsen et al. (2009) did not detect an increase in tag loss associated with age at maturation of spring Chinook.

Shedding of PIT tags may also depend on gender, possibly in relation to gamete development at full maturation. During one of the first evaluations of PIT tag effects on salmon, Prentice et al. (1994 *in* Knudsen et al. 2009) found that tag loss of mature coho salmon (double tagged as juveniles) was highly dependent on gender, averaging 59% among females and only 13% in males.

A number of investigators have shown that SARs of untagged salmon are considerably higher than that of PIT-tagged salmon, an issue that was also addressed by the ISAB (2006). For example, CSS (2011) reported the finding of two long-term studies in which SARs of untagged salmon were 19% or 38% higher (geometric means) than those developed from PIT-tagged salmon. The CSS noted that SARs of untagged and PIT-tagged salmon were highly correlated, and concluded that a definitive control group has been lacking to quantify the potential post-marking mortality or tag shedding bias in PIT tag SARs. Nevertheless, a variety of investigations provide evidence that PIT tags have an effect on salmonids and additional investigation is needed to quantify this effect.

B. Artificial Production

The artificial production project proposals and contextual projects considered in the RMEAP Category Review included (a) projects that involve the planning, development, operation and maintenance of artificial production programs implemented through the Council's Program; (b) projects that specifically collect and analyze monitoring data used to evaluate the Program's artificial production initiatives; and (c) research, monitoring, evaluation and coordination projects investigating critical hatchery uncertainties and the effectiveness and effects of hatchery production (NPCC 2011, Council decision document, page 20). In general these projects received favorable ISRP review with regard to their ability to collect and summarize data required to report on the results achieved by these programs relative to their intended objectives established in subbasin plans, hatchery master plans, and artificial production principles in the Fish and Wildlife Program.

In this retrospective report, the ISRP presents findings, conclusions, and recommendations regarding the results reported by research projects investigating critical hatchery uncertainties and the results of Fish and Wildlife Program artificial production initiatives. The Appendix includes more extensive summaries of the projects, along with data and analyses of research efforts drawn from project proposals and project annual reports. These Appendix summaries form the basis of the ISRP findings, conclusions, and recommendations.

There are three primary topics or questions regarding the efficacy and effects of artificial production programs in the Columbia River basin:

1. To what extent can artificial production initiatives achieve the adult production and harvest goals established in hatchery master plans and legal mitigation agreements (e.g. Revised Hood River Hatchery Master Plan, Lower Snake River Compensation Program, John Day Dam Mitigation Program, U.S. v. Oregon);

2. To what extent can hatchery-origin adult salmon and steelhead contribute to recovery of natural populations by spawning in nature (e.g., supplementation projects);

3. To what extent do hatchery programs have adverse effects on natural populations – effects on fitness of the natural population following interbreeding and effects on abundance and productivity through ecological effects of predation, competition, and disease transmission?

Hatchery production has been, and continues to be, the primary strategy for directly providing fish for harvest and conservation. Scientific frameworks for implementing hatchery production have received substantive independent scientific review (NPPC 1999-4) and Council has established artificial production principles and performance standards (NPPC 1999-15). The ISRP and ISAB have provided guidance on specific monitoring and evaluation metrics and analyses consistent with this scientific framework (ISAB 2000-4, ISRP/ISAB 2005-15, ISRP 2008-7).

Assessing hatchery production initiatives (i.e., implementing a master plan) 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 fish outside the hatchery (ISAB 2000-4). Information and assessment in these three areas is required to establish benchmarks and evaluate targets for survival in the hatchery environment, to understand how practices in the hatchery influence post-release survival and performance, to establish post-release survival for harvest management, and to establish quantitative estimates for benefits and risks to natural populations.

For select production programs reviewed in the RMEAP Category Review, the ISRP used information in Taurus and in recent annual reports to assemble information on the essential metrics for hatchery performance, post-release performance, and interactions with natural populations. Time availability and ongoing ISRP assignment obligations precluded summarizing every production program. For the findings, conclusions, and recommendations section presented here text was taken verbatim from the recent ISRP review of the Lower Snake River Compensation Plan spring Chinook program review (ISRP 2011-14), and updated as appropriate with information obtained in the RMEAP Category Review.

Raising salmon and steelhead in captivity and releasing them into the natural environment entails challenges during both captive culture and following reintroduction, including nutrition, disease, endocrinology, and genetics. The presence of hatchery and wild salmon in populations being harvested and in spawning runs creates difficulties in managing harvest and assessing the status of natural populations. To address these challenges, there are a number of Fish and Wildlife Program projects aimed at improving the performance of hatchery fish post release and at better understanding the interactions of hatchery and natural salmon in the wild. For these projects we present the management reasons for implementing the project and summarize results and accomplishments during the most recent funding cycle (2007-09).

1. Hatchery Uncertainties Research and Development – Basinwide

a. Relative Reproductive Success and Genetics of Hatchery Salmon and Steelhead

Adult hatchery salmon and steelhead mix with natural-origin fish in many spawning populations. Intermixing of hatchery-origin and natural-origin salmon and steelhead complicates estimating the viability of natural populations that are protected under the Endangered Species Act. For both status assessment of natural populations and evaluation of intentional supplementation, it is necessary to know the relative reproductive success of natural-origin adults compared to hatchery-origin adults that spawn in the wild.

Study Results

Findings:
Recent results from Fish and Wildlife Program projects using parentage analysis often demonstrate that the relative reproductive success of hatchery-origin adults is less than natural-origin adult salmon and steelhead. The range and variation in relative reproductive success among species and systems is substantial and warrants case-by-case consideration in management decisions.

<u>Steelhead</u>

Steelhead from hatchery programs using non-local stocks typically exhibited very small relative reproductive success when contrasted with local natural-origin steelhead.

Local stocks of steelhead used in supplementation programs exhibit a range of relative reproductive success. In the Hood River, in the first generation when wild fish were used as parents in the hatchery, the subsequent hatchery-origin parents had 86% (males) and 98% (females) of the success of natural-origin counterparts and were not statistically different. In later generations, when the hatchery population was composed of both returning hatchery- and natural-origin parents, the relative reproductive success of hatchery fish in the wild was only 50% (males) and 77% (females). Similarly, in the Kalama River first generation hatchery-origin steelhead had reproductive success indistinguishable from the wild population from which they were derived. In the Imnaha River, a steelhead supplementation program using local fish was initiated in 1982, and the hatchery propagation includes using returning hatchery adults in the broodstock. For this program, the relative reproductive success of hatchery-origin adults estimated for the brood-years 2000 through 2005 (approximately six generations) ranged from 29% to 59% of the natural-origin fish.

In Hood River steelhead there is evidence for a substantial genetic contribution to the reduced relative reproductive success and also evidence this carries over to naturally produced progeny of hatchery-origin parents. Natural-origin steelhead that had one hatchery-origin parent had 92% (males) and 84% (females) of the reproductive success of natural-origin steelhead with two natural-origin parents; natural-origin steelhead with two hatchery-origin parents had 31% (males) and 42% (females) of the reproductive success of natural-origin steelhead with two natural-origin parents. The implication of this observation is that deleterious genetic effects from the hatchery may depress the productivity of the natural population.

Spring Chinook

Two relative reproductive studies of hatchery spring Chinook are examining supplementation programs using broodstocks established with local fish.

In Catherine Creek in the Grande Ronde subbasin data has been collected from returning adults since brood-year 2002. Combined by age and sex, the relative reproductive success of hatchery-origin adults is 103% for parr production, 100% for migrant production, and 77% for adult production.

In the Wenatchee River subbasin spring Chinook supplementation was implemented in the Chiwawa River in 1989. Male and female hatchery-origin spring Chinook in the Wenatchee/Chiwawa supplementation program have about half of the smolt and adult reproductive success relative to natural-origin salmon of the same sex and age. When the analysis includes spawning location as a covariate, the difference in reproductive success between hatchery- and natural-origin females is non-significant. Hatchery-origin females spawn lower in the tributaries in habitat that is less productive for both natural- and hatchery-origin fish. For males, when weight and spawning location covariates are included in the analysis hatchery-origin remains a significant factor for smolt production for the 2006 brood year and for adult production by the 2005 brood year.

Replication, Gaps, Study Longevity

Findings:
The 2000 BiOp called for two studies of relative reproductive success (RRS) per ESA listed evolutionarily significant unit (ESU, aka distinct population segment (DPS)). The follow-up 2008 BiOp called for continuing RRS investigations for spring-Chinook in the Wenatchee River and Grande Ronde River subbasins and steelhead in the Hood River subbasin. Additionally, a steelhead RRS study was identified for the Methow River and a fall Chinook RRS study in the Snake River.

RRS studies initiated in 2003 to fulfill the 2000 BiOp RPA do not cover the entire range of ESA ESUs. There is no explanation for why the scope of RRS investigations was reduced in 2008 from the level in the 2000 BiOP. The current Fish and Wildlife Program investigations provide coverage of all but the Snake River fall Chinook RRS study that were identified in 2008 BiOp RPA 64.

In addition to the investigations to fulfill the RPA 64 obligation, RRS studies were initiated through CRITFC Accord Proposal 200900900.[1] This project will provide genotyping and analysis for the Nez Perce Tribe's Johnson Creek spring Chinook supplementation project (JCAPE, 199604300) and begin RRS studies in spring Chinook and coho salmon reintroduction projects. Spring Chinook relative reproductive studies of various scopes are conducted within the Idaho Supplementation Studies (199809800), and Yakima River Monitoring and Evaluation (199506325). Steelhead relative reproductive studies are ongoing in the Kalama and Wenatchee rivers using Mitchell Act and PUD funding respectively. RRS studies of coho and chum salmon are also ongoing outside of the Columbia River Basin.

Conclusions:
There appears to be reasonable replication of steelhead and spring Chinook salmon (yearling/stream life history type) studies. There is need for a Snake River fall Chinook (underyearling/ocean life history) study and a discussion among scientists and managers about whether Columbia River coho and chum salmon studies are warranted.

The ISRP is not aware of any statistical algorithm or test that will establish the number of stream or system replicates needed, or the number of generations required, to fully capture the range and variation in relative reproductive success between hatchery- and natural-origin salmon and steelhead. Based on the empirical evidence that is accumulating, at least two, and probably not more than three salmon generations in multiple systems for different life-history types should provide reasonable estimates of the important parameters.

Coordination and Integration of Projects

Findings:
New investigative endeavors, like these relative reproductive success studies, will be untidy. There will be surprises and challenges in the effort to collect fish in the field, in efforts to genotype fish, to assign fish to parents, and to analyze and interpret the data. These challenges have been evident in relative reproductive studies to date. In some cases weirs have failed and adults have accessed spawning grounds without being sampled, juveniles have migrated without being sampled, fish have spawned below weirs complicating experimental design, and many fish cannot be matched with known parents. In a few select locations such as the Wenatchee River with Tumwater Dam and

[1] This is a nine-digit BPA project identification number. The first four numbers generally indicate the year the project was started. In this report, in some instances this number is broken up with dashes (e.g., 2000-000-00), and in other instances no dashes are used. These numbers are useful to track projects in Taurus.

the Hood River with Powerdale Dam (now removed), it appears that robust fish capture, data generation, and analysis were in place. Migration delay of adult sockeye has been identified at the Tumwater Dam Chinook trap and will be reportedly fixed in 2011. Whether delay of Chinook is a problem with the RRS analysis is not discussed in project reports.

Conclusions and Recommendations:
In order to efficiently integrate the information from different species and river systems the ISRP believes that coordination to produce data and analysis that are consistent among projects is warranted. Further, the Columbia River co-managers need to refine and clarify the purpose of collecting these data and describe how they will be incorporated into viability analysis for ESA biological reviews and artificial production program risk assessments. For example how will these data inform AHA modeling, the Columbia River Hatchery Effects Evaluation Team (CRHEET) framework, and NOAA biological opinions for hatchery programs?

Environmental and Biological Correlates and Mechanisms Research

Findings:
For some of the ESU life-history types and river systems, the initial question of what is the relative reproductive success of hatchery-origin fish has been answered. Investigations are beginning on explaining observations and researching biological mechanisms producing the results such as genetic effects versus ecological effects. Some adverse ecological effects on lower RRS may be caused by hatchery adults homing back to areas near rearing acclimation ponds where spawning habitat is less favorable.

Conclusions and Recommendations:
These research efforts are likely to provide information important to decisions on the use of artificial production for both harvest mitigation and recovery. The ISRP believes that developing a structured decision framework that articulates how the relative reproductive success evidence will be interpreted and how the evidence will guide adaptive decision-making regarding the basin’s hatchery system is needed.

b. Hatchery Culture Practices

Fish culture techniques that reduce differences and interactions between hatchery and local salmonids.

Findings:
In annual reports and proposal summaries from hatchery programs on the Yakima and Clearwater Rivers, NATURES rearing protocols that were intended to improve SARs of hatchery fish have not demonstrated a clear benefit. These rearing protocols provide overhead cover, subsurface feeding, and some predator exposure in an attempt to

produce salmon juveniles with improved post-release survival. Projects are also underway to determine whether modification of growth can be used in a hatchery to produce two-year old hatchery steelhead smolts that are more like natural smolts, or to influence precocious male development in Chinook salmon. Individual programs (see summaries in part II for specific details) have explored using acclimation ponds, as well as release location, size, and age to improve SAR and reduce straying. The outcome from these efforts is occasionally successful but appears to be largely case specific.

Conclusions and Recommendations:
Efforts to improve hatchery salmon SARs and conduct cause-and-effect experiments are important and likely to provide insights into the biology/life-history of propagated salmon that will add to our understanding of natural populations as well. The ISRP continues to caution that individual project experiments are not a holistic examination of hatchery reform, and that incremental benefits in the hatchery phase of the salmon life-cycle may not yield desired gains in hatchery SARs, owing to mortality in the mainstem and ocean and density dependent mortality in the release watershed. Further, if attempts to make hatchery salmon more like natural salmon are successful, ecological interactions may increase. The consequence might be a failure to improve total recruitment to fisheries and escapement for natural and hatchery spawning.

c. Salmon and Steelhead Gamete Collection and Preservation

Findings:
Male gametes (sperm cells) from Snake River spring Chinook (N = 2773; 15 independent populations, 4 Major Population Groups (MPGs) and summer steelhead (N = 1403, 13 independent populations, 5 MPGs) have been cryopreserved (frozen) to provide a gene bank of ex situ conservation for these ESA listed fish species. The project’s scientific rational is based on the empirical demonstration that fish sperm cells can be frozen, stored, and subsequently thawed and used to successfully fertilize eggs. The management justification for the project is the small number of adult fish that were returning to the Snake River basin in the early to mid-1990s.

The intention of the project was to collect gametes from at least 500 individuals from a minimum of 2 independent populations of each spring Chinook and summer steelhead MPG in the Snake River basin. The goal of collecting gametes from 500 individuals in each population was only achieved in the Imnaha River (Grande Ronde/Imnaha MPG) spring Chinook population. While not achieving the original goal, collections of spring Chinook were from multiple populations and MPGs, and the number collected reasonably large. In contrast obtaining samples from steelhead proved more difficult and while sampling took place in many MPGs, most were from hatchery populations.

Recommendation:
In the 2010 RMEAP Category Review, the ISRP recommended a schedule of testing the stored sperm cells, and a plan for when to use the gametes, and a protocol for amplifying the genetic material using captive culture strategies. A draft document (Young et al. *in prep,* www.nezperce.org/~dfrm/Research/gametes.html) cited in Young 2010 may begin to serve this task. The ISRP still believes development of a decision framework would be most useful before the populations decline to the abundance levels observed in the mid-1990s.

d. Kelt Reconditioning – Research and Development Pilot Investigations

Steelhead occasionally repeat-spawn; post-spawned individuals (kelts) migrate downstream and a portion survive the in-river and oceanic migration to return and spawn again, unlike other Pacific salmon (Chinook, coho, chum, and sockeye). Managers and scientists in the Columbia River Basin are interested in attempting to improve the ESU status of steelhead by increasing kelt survival. There is also a hypothesis that mortality of kelts at mainstem Snake and Columbia River dams has reduced the incidence of kelt spawning in the upper Columbia and Snake River portions of the Basin.

There are investigations to increase kelt survival using 1) operational modifications at dams, and 2) active collection, transport, and/or short- and long-term reconditioning of kelts. The assumption is that kelts in an improved condition would likely have higher rates of repeat spawning, and that intervention (reconditioning) could improve their condition. Projects reviewed in 2010 primarily address kelt reconditioning.

Findings:
Summaries of study results for various kelt reconditioning treatments in mid-Columbia (Yakima River and Deschutes River (Shitike Creek) and the upper-Columbia (Okanogan River (Omak Creek) subbasins using data from proposals and recent annual reports indicate there can be considerable variation in the success rates of these strategies between locations and also between years at the same location. In general, little advantage has been observed between in-river migrants and individuals transported below Bonneville Dam and then released, or individuals that have short-term reconditioning (feed for short period and then transport and release below Bonneville Dam). Individuals that have experienced long-term reconditioning (held and feed for several months), exhibit survival ranging from 5% in the Deschutes River subbasin to 38% for fish from the Yakima River subbasin.

Kelt gamete and progeny viability evaluated at Parkdale Fish facility on the Hood River demonstrated that egg quantity/quality were similar when comparing maiden spawning Skamania summer steelhead with their subsequent performance as reconditioned kelts. Successful natural reproduction has been confirmed for 3 of 4 reconditioned kelts in Omak Creek, Washington. However, parentage assignment of 791 juveniles from Shitike

Creek, Deschutes River subbasin, Oregon failed to detect progeny from kelts that were reconditioned and released.

Conclusions and Recommendations:
Kelt reconditioning (either transportation, short-term, or long-term) as a recovery tool as envisioned by the agencies is in an early stage of development. It remains to be seen whether reconditioning can contribute meaningfully as a recovery strategy. Efforts from transportation and short-term reconditioning have not yielded substantial gains compared with in-river migration. Long-term reconditioning has demonstrated some promise. An adequate comparison of reproductive performance between natural and reconditioned kelts has not yet been accomplished. It remains uncertain whether nutrition and gametogenesis in reconditioned kelts is sufficient. In any case, it should be recognized that successful reconditioning – survival and subsequent reproduction – is a necessary, but not sufficient condition, for kelt reconditioning to provide benefits for recovery.

Evaluation of the demographic effects of kelt reconditioning on viability assessments at the population and ESU are necessary. Even if successful, in many cases habitat may already have been filled to its smolt capacity so steelhead populations may not effectively respond since the limiting life stage remains in survival from smolt to adult. The scale of implementation to affect steelhead population viability and to contribute to recovery and delisting is needed before the strategy can be judged as providing benefits to fish. Fish managers need to recognize that there appears no end point to implementation if it is judged effective, since the reconditioned kelt strategy is incapable of redressing the actual cause of depressed abundance and productivity.

e. Sockeye Salmon

Snake River Sockeye Captive Propagation

Findings:
The captive broodstock project has successfully maintained an *ex-situ* population of Snake River sockeye salmon that releases eyed-eggs, pre-smolts, smolts, and adult salmon into Stanley basin lakes and the upper Salmon River since 1993. Fish production goals have been met in most recent years except less than 100,000 presmolts have been released in recent years. Evidence suggests that the current population contains over 90% of the genetic variation of its founders (IDFG 2010). The captive broodstock program has demonstrated high survival during each life stage while held in captivity. Egg–to-smolt survival in the hatchery was approximately 58%, which is much higher than survival of sockeye salmon in the wild. This high survival rate is key to viable hatchery production because hatchery fish released into the lakes typically have higher mortality than wild counterparts.

Sockeye salmon are monitored in the lakes, during smolt emigration, and during adult return. Overwinter survival of pre-smolts varies considerably year-to-year and from lake to lake. The smolt-to-adult return rate averaged 0.5% (range: 0.23-1.1%, IDFG 2010). The average recruit per hatchery female spawner was 7.0 during brood years 2004-2006. In contrast, the average SAR of natural smolts was 1.4% (range 0.84-1.92%) with an average recruit per female spawner of 2.5, or R/S = ~1.25. Available survival data indicate that a natural population of sockeye salmon may not be self-sustaining even during the favorable conditions that produced relatively high survival rates in recent years. Approximately 70-88% of returning adults in 2008 and 2009 originated from hatchery rather than natural spawning areas (including eyed-egg plants).

Conclusions and Recommendations:
The project has successfully developed a captive broodstock program and prevented extirpation of the sockeye population which is dependent on artificial production for its continuation. Success with the captive program and recent favorable environmental conditions in the mainstem river and ocean environment has led to increased adult returns to the watershed. While it is worthwhile to build upon relatively high survival of sockeye salmon in recent years and transition to a conventional hatchery program, it is important to recognize that substantial improvements in survival are still needed before a natural population could be viable. In response to the increasing numbers of sockeye salmon in the system, the program needs to continue and expand monitoring of survival during each life stage of natural salmon and identify key bottlenecks where additional focus might enhance viability of sockeye salmon. Limnological assessment of the capacity of the lakes to support increasing numbers of sockeye salmon is an important task. A comprehensive synthesis and assessment of the sockeye rebuilding effort would be worthwhile as a means to identify specific metrics and activities needed to achieve a viable natural population that might support a small harvest in some years.

2. Fish and Wildlife Program Hatchery Production Programs: Yakima, Umatilla, and Clearwater

The questions below follow the format established for the ISRP review of the Lower Snake River Compensation Plan (LSRCP) spring Chinook program review (ISRP 2011-14). This approach uses the categories of hatchery monitoring established in the Council artificial production review (NPCC 1999-15) and recommended by the ISAB and ISRP (ISAB 2000-2, ISAB 2000-4, ISRP/ISAB 2005-15, ISRP 2008-7). The text was initially taken verbatim from the LSRCP review and subsequently edited to reflect information obtained in the RMEAP category review.

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

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

Finding 1.1:
There were four primary unambiguous performance metrics for in-hatchery performance: broodstock collection, pre-spawning broodstock mortality, egg-to-smolt survival, and smolt release numbers.

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

Finding 1.2:
Performance goals and empirical results were variably presented and reported. Often substantial searching of annual reports and proposal background and major accomplishment sections is required to gather all the data on broodstock collection, pre-spawning mortality, egg-to-smolt survival, and smolt release numbers. Frequently, many projects' stated goals and objectives have changed over time; different sections of proposals contain conflicting information; or information in proposals conflicts with information in annual reports or HGMPs.

Are individual programs able to achieve the goals of the projects as planned?

Finding 1.3:
Goals for pre-spawning mortality and egg-to-smolt survival were generally met within the program guidelines. The occasional years when pre-spawning mortality was high in specific facilities was usually associated with warm water temperatures. Most programs have been able to achieve egg-to-smolt survival objectives. The success in collecting broodstock was variable. Many of the established mitigation programs met collection goals, whereas newer supplementation programs did not. For those programs that regularly are unable to meet smolt release objectives, the most frequent causes are

difficulty obtaining broodstock and reduction in production program effort because of inadequate water supplies at some hatchery facilities.

Is fish culture performance within standards expected for salmonids?

Finding 1.4:
Yes, overall the in-hatchery performance was acceptable.

Conclusions and Recommendations:
Artificial production programs should conform to the performance indicators established in the Council's Artificial Production Review and subsequent ISAB and ISRP reports on production metrics. For each production metric the programs should have a clearly identified standard and report on whether the objective is achieved. Appendices in annual reports should keep a running report for each year of production (see the ISRP summary for the Nez Perce Tribal Hatchery spring Chinook production). The Umatilla program updates a running summary which makes following the program's progress straightforward.

There was no summary of differences among the hatcheries (or within years in a hatchery) for fish culture practices such as acclimation versus direct release, on-site versus satellite facility release, and rearing densities, size, and timing at release that might contribute to explaining differences in the performance of smolts after release.

2. How well are project fish performing once released?

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

Finding 2.1:
The primary indicators of fish performance following release were smolt survival from release to a major dam equipped with PIT-tag detection, and adult production by release/brood year measured back to the mouth of the Columbia River and/or to the hatchery or tributary. No goal has typically been established for juvenile survival. Adult abundance expressed both as numbers of fish and as rate of return was used as the adult life-stage performance metrics. For a number of programs adult recruits-per-spawner was estimated for both hatchery and natural spawning adults and compared. This provided a measure of the full life-cycle benefit of hatchery rearing to total adult abundance. Information on harvest and straying was inconsistently presented. The hatchery reports also provided hatchery smolt migration timing compared to natural smolts, adult migration time, age class, and in some reports spawning distribution compared to natural fish. A "natural" salmon is a fish produced by hatchery-origin or natural-origin parents that spawned in nature. The ISRP discusses these migration timing, age class, and other life-history metrics below under the topic of demographic, ecological, and genetic impacts of the programs on wild fish.

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

Finding 2.2:
Adult SAR and actual abundance at specified points (i.e. the Columbia River mouth or Wells or Lower Granite Dam) were inconsistently measured, reported, and analyzed. Hatchery smolt survival and comparison to natural smolt survival was difficult to interpret. Since there were no standards, the interpretation of the survival rate is ambiguous. There typically was no analysis of the factors that might affect smolt survival. The allocation of the adults that return to the Columbia River from the ocean and then contribute to tribal harvest, sport harvest, broodstock, and natural spawning escapement was insufficiently presented for most projects.

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

Finding 2.3:
No, most hatchery programs have not achieved adult production goals to the Columbia River mouth or to the project area. A comparison of recruits-per-spawner for hatchery and natural spawning adults did reveal a substantial full life-cycle benefit from using artificial production. There are many more adult fish as a consequence of the hatchery production, and in recent years harvest opportunities have increased.

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

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

Finding 3.1:
There were no easily obtained, unambiguous, scientifically justifiable indicators for evaluating the ecological (predation and competition) or genetic (fitness effects of interbreeding between hatchery and natural-origin fish) impacts of hatchery programs on wild salmon populations. There was no apparent explicit evaluation of the impact of hatchery smolts on the parr and smolt populations that are resident at the time of releases, including potential residualism of hatchery smolts. Genetic effects were indirectly investigated by comparing age of return of hatchery and natural fish, and tracking the trend in this life-history characteristic in natural fish. Adult females from hatchery-reared spring Chinook cohorts produced more three-year-old fish and fewer five-year-old fish than their natural counterparts. It is not known the extent to which this alteration in life history may involve selection for specific genotypes. By monitoring the trend through time, the rationale is that if the trend in hatchery fish increased over time it might have a considerable genetic component. If the trend in the natural population started to indicate that younger age fish were increasing, it would support

the idea that interbreeding between the hatchery and natural salmon was leading to changes in the genetics of natural populations. The collection of this information is important, but the interpretation is fraught with complications.

The trends over time in both the hatchery and natural populations need to be contrasted to an unsupplemented reference population that is carefully monitored. Without that contrast, trends in the natural population and hatchery population may reflect natural selection to a changing environment. Analysis of the current data does not permit identifying the genetic component of any change or any environmental causes.

Stray rates were estimated for some programs, but this metric was not uniformly presented in the reports. In some streams, the distribution of natural and hatchery spawners (breeding locations) was monitored. Investigation of natural- and hatchery-origin salmon spawning distribution is worth continuing and may provide insight into differences in natural and hatchery fitness in the wild.

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

Finding 3.2:
The information on age structure, migration timing, and spawning distribution was reasonably collected, presented, and analyzed.

Is supplementation being adequately evaluated (for example using Ad Hoc Supplementation Work Group recommendations)?

Finding 3.3:
A Before-After-Control-Impact (BACI) model was used to evaluate spring Chinook supplementation in the Imnaha River (summarized in the Lower Snake River Compensation Plan Review [ISRP 2011-14]) and steelhead supplementation in the Umatilla River (summarized in Part 2) but not in other programs. This is a method that the ISRP believes is scientifically valid. We recommend that this method (or alternatives of similar validity) be used at all locations that have programs that plan to use returning hatchery fish to spawn in the streams.

Finding 3.4:
The BACI analysis of Imnaha spring Chinook (reported in ISRP 2011-14) indicated that when contrasted to nine unsupplemented reference locations, the Imnaha River showed decreased abundance post-supplementation relative to five sites and increased abundance post-supplementation relative to four sites. The BACI analysis found that productivity in the Imnaha River had decreased relative to all nine unsupplemented sites. In Umatilla River steelhead, BACI analysis using John Day River steelhead populations as reference locations demonstrated an increase in natural-origin adult

steelhead without a decrease in productivity. In separate analysis, in the Umatilla River there was reduced smolts per spawner with increasing adult abundance, reduced length at age, and increasing smolt age, suggesting reduced production. Quantification of supplementation effects on abundance and productivity needs to be evaluated at the other locations to establish the range of benefits and losses.

Finding 3.5:
Smolts-per-spawner in several river systems for both steelhead and spring- and fall Chinook strongly suggests density dependence in smolt production. Density-dependent survival in these watersheds was a factor that appeared to be restricting the increase in smolt production that was expected from increased spawner abundance in the streams. Length-at-age decreased and average age of steelhead smolts increased with greater spawning abundance in the Umatilla watershed, suggesting density dependence in this watershed was related in part to the food web.

Finding 3.6:
Most (but not all) of the hatchery programs were self-sustaining. At least one adult female returned to the hatchery or tributary weir from the spawning of an adult female in the hatchery. On this basis, the program might maintain an important genetic lineage that otherwise would become extirpated. Over the long-term, however, hatchery-dominated programs that are implemented to reduce extinction risk will result in genetic changes, due to domestication selection and drift that are likely to offset any demographic benefit.

Recommendations and Conclusions:
Analysis of abundance and productivity in the supplemented locations, especially those tributaries where there is a conservation objective in the management plan, is urgently required. The ISRP concludes that there is an absence of empirical evidence from the ongoing projects to assign a conservation objective other than preventing extinction. The supplementation projects, as they are currently conducted with high proportions of hatchery fish in the hatchery broodstock and on the natural spawning grounds, are likely compromising the long-term viability of the populations. Evaluation of most supplementation projects would benefit from a more thorough comparison with life-stage specific productivity of salmon from unsupplemented reference streams. All programs should evaluate the potential influence of density-dependent effects. Programs where density-dependence has occurred at low population levels should investigate to determine why. In other words, is the capacity of spawning and/or rearing habitat restricting production of smolts when additional adults reach the spawning grounds?

C. Mainstem

The Mainstem section of this report consists of three subsections: 1) Hydrosystem Passage RME and Related Life History Projects, 2) Lamprey, and 3) Predation and Effects of Non-Natives/Invasives.

1. Hydrosystem Passage RME and Related Life History Projects

Table 2. A list of hydrosystem passage RME and related life history projects including project characteristics and brief summary results

Project Number	Title	Proponent	Purpose and Emphasis	Primary Monitoring	Summarized Recent Results	Meets Scientific Criteria? (RMEAP Review)
1983-319-00	New Marking and Monitoring Technologies	NOAA	Hydrosystem RM and E	Evaluate Fish Performance FCRPS	From 2007-2009 results: (1)Evaluated the B2 corner-collector PIT tag system with juvenile salmonids. (2)Electronically quiet power system was designed for instream applications. (3)Developed a timer-relay system that saves batteries. (4)Started the development and testing of a PIT tag system for spillbays at Bonneville Dam.	Yes (Qualified)
2001-003-00	Adult PIT Detector Installation	NOAA, Pacific States Marine Fisheries Commission (PSMFC)	Hydrosystem RM and E	Fish population status	In 2009 a full flow juvenile PIT tag detection system was successfully installed and tested at Little Goose Dam.	Yes (Qualified)
2008-506-00	Smolt Monitoring Video Feasibility Project	Columbia River Inter-Tribal Fish Commission	Programmatic RM and E	Migration characteristics and river condition	The 2010 annual report indicated that the project had no success in attaining useful video images.	No

Project Number	Title	Proponent	Purpose and Emphasis	Primary Monitoring	Summarized Recent Results	Meets Scientific Criteria? (RMEAP Review)
1990-080-00	Columbia Basin Pit-Tag Information	PSMFC	Programmatic RM and E	Fish population status	PTAGIS system has been adequately operated and maintained.	Yes
1994-033-00	Fish Passage Center	PSMFC	Programmatic RM and E	Fish population status; Fish performance in the FCRPS; Migration characteristics and river conditions	FPC project is performing its basic functions and producing annual reports and specific products as proposed.	Yes (Qualified)
1987-127-00	Smolt Monitoring by Non-Federal Entities	PSMFC	Programmatic RM and E	Fish population status; Fish performance in the FCRPS; Migration characteristics and river condition	The project provides an important and useful real time, consistent and continuous data time series of juvenile fish passage characteristics.	Yes (Qualified)
1996-020-00	Comparative Survival Study (CSS)	Columbia Basin Fish and Wildlife Authority (CBFWA), PSMFC, US Fish and Wildlife Service (USFWS)	Programmatic RM and E	Fish population status; Fish performance in the FCRPS; Effects of Configuration and Operations Actions Tributary Habitat Conditions and Limiting Factors	This project is performing its basic functions and producing reports and products. The CSS data set is used to address a wide range of management questions.	Yes (Qualified)

Project Number	Title	Proponent	Purpose and Emphasis	Primary Monitoring	Summarized Recent Results	Meets Scientific Criteria? (RMEAP Review)
2005-002-00	Lower Granite Dam Adult Trap Operations	NOAA	AP RM and E	Fish population status; Fish performance in the FCRPS; Investigate Hydro Critical Uncertainties	The importance of the facility continues to increase with the increase in upper basin PIT tag studies.	Yes
1993-029-00	Survival Estimate for Passage through Snake and Columbia River Dams and Reservoirs	NOAA	Hydrosystem RM and E	Fish population status; Fish performance in the FCRPS; Effects of configuration and operation actions	The information from this study has focused research and mitigation efforts and were used in preparation of the NMFS 2000, 2004, and 2008 BIOPs.	Yes
2003-041-00	Evaluate Delayed (Extra) Mortality Associated with Passage of Yearling Chinook Salmon through Snake River Dams	NOAA	Hydrosystem RM and E	Performance in the FCRPS; Migration characteristics and river condition; Effects of configuration and operation actions	Returns of age-3-ocean adults in 2009 produced a SAR ratio indicating a small, but insignificant, effect from passing through additional dams. Comparison of SARs between the Lower Granite and a reference group indicated no significant trucking effect.	Yes
1996-021-00	Gas Bubble Disease Monitoring	US Geological Survey (USGS)	Hydrosystem RM and E	Migration characteristics and river condition	Support project, training provided as required.	Yes

Project Number	Title	Proponent	Purpose and Emphasis	Primary Monitoring	Summarized Recent Results	Meets Scientific Criteria? (RMEAP Review)
1991-028-00	Pit Tagging Wild Chinook	NOAA	Hydrosystem RM and E	Fish population status; Performance in the FCRPS; Migration characteristics and river condition; Effects of configuration and operation actions	In 2008-2009, estimated parr-to-smolt survival to Lower Granite Dam for wild smolts from Idaho and Oregon streams combined averaged 17.7% (range 10.8-30.0% depending on stream of origin).	Yes (Qualified)
1989-107-00	Statistical Support For Salmon	University of Washington	Programmatic RM and E	Fish population status	Support Project	Yes
1991-051-00	Modeling and Evaluation Statistical Support for Life-Cycle Studies	University of Washington	Programmatic RM and E	Performance in the FCRPS; Migration characteristics and river conditions	Support Project	Yes
1991-028-00	Pit Tagging Wild Chinook	NOAA	Hydrosystem RM and E	Fish population status; Performance in the FCRPS; Migration characteristics and river condition; Effects of configuration and operation actions	In 2008-2009, estimated parr-to-smolt survival to Lower Granite Dam for wild smolts from Idaho and Oregon streams combined averaged 17.7% (range 10.8-30.0% depending on stream of origin).	Yes (Qualified)

Project Number	Title	Proponent	Purpose and Emphasis	Primary Monitoring	Summarized Recent Results	Meets Scientific Criteria? (RMEAP Review)
1999-003-01	Evaluate Spawning of Fall Chinook and Chum Salmon Just Below the Four Lowermost Mainstem Dams	ODFW, PNNL, PFMSC	Habitat RM and E	None assigned for BiOp Strategy or Action	Chum salmon redd locations and hourly temperature data are provided to the FPAC and TMT for in-season management of water for the protection of spawning fish at Ives Island.	Yes (Qualified)
1991-029-00	Research, monitoring, and evaluation of emerging issues and measures to recover the Snake River fall Chinook salmon ESU	University of Idaho, USFWS, US Geological Survey (USGS)	Programmatic RM and E	Migration characteristics and river condition; Hydro critical uncertainties; Hatchery uncertainties	Recognition of a reservoir overwintering life history attribute in some Snake River fall Chinook, and extension of operation of the juvenile bypass systems at the lower Snake dams. Post supplementation, there has been a significant decrease in smolt size of natural fish. There are some indications that density dependent factors might be acting as stock size rebuilds.	Yes
2002-032-00	Snake River Fall Chinook Salmon Life History Investigations	PNNL, University of Washington, USFWS, USGS	Hydrosystem RM and E	Fish population status; Hydrosystem critical Uncertainties; Tributary habitat conditions and limiting factors	Subyearling fall Chinook migrating from spawning areas in the Clearwater River migrate rapidly in the free-flowing portion, but then slow and delay in the area above the confluence with the Snake River (transition zone). Survival through the confluence area is low, but the survivors grow to relatively large sizes and apparently survive well during migration and marine life.	Yes

In the review of the above 20 Hydrosystem RME projects (Table 2) in the RMEAP Category Review (ISRP 2010-44), the ISRP found that as a group, they answered most of the Council's questions regarding major program management questions and associated high level indicators (HLIs). The projects also were responsive to 2008 BiOp RPAs. In addition, the ISRP did not find excessive overlap of objectives, data gaps, or duplication of data collection among this group of projects.

The ISRP found no priority Fish and Wildlife Program data gaps (such as route specific passage survival) in this set of projects. This is in part because the U.S. Army Corps of Engineers Anadromous Fish Evaluation Program (AFEP) projects provide detailed study data such as route specific passage survival at individual dams and other significant survival and fish performance data regarding juvenile and adult salmonid hydrosystem passage. The AFEP program complements the Fish and Wildlife Program studies, such as the CSS Study (1996-020-00) and NOAA Fisheries survival (1993-029-00) and delayed (extra) mortality (2003-041-00) studies, which are broader whole dam and reach survival studies.

The life history related projects in this group also provide important information on Lower Snake River salmonids including: (1) wild spring-summer Chinook - population status, migration characteristics, and tributary habitat conditions (1991-028-00), and (2) wild and hatchery fall Chinook - population status, migration characteristics, hydrosystem critical uncertainties, and hatchery critical uncertainties (1991-029-00 and 2002-032-00).

The Hydrosystem projects, based on their objectives, can be broken into four subcategories: (a) Development and Installation of New Monitoring Systems plus Data Storage and Management (4 projects), (b) Hydrosystem Core RME Projects (6 projects), (c) Training and Data Analysis Support Projects (3 projects), and (d) Life History, Fish Population Status, and Hydrosystem/Hatchery Uncertainties (4 projects). The following review of results, and ISRP conclusions and recommendations are presented for each of the subcategories.

a. Development and Installation of New Monitoring Systems Plus Data Storage and Management

The first four projects in Table 2 that comprise this group (198331900, 200100300, 200850600, and 19900800) have objectives to develop, install, and test PIT tag and video monitoring systems, plus store and manage data from the PIT tag systems. They do not produce fish monitoring or population status data, per se. They provide tools and data management systems used by others to collect and store PIT tag and video data.

Findings:
A list of significant accomplishments and results for these projects includes successful development of a full flow PIT tag system at McNary Dam, development and successful testing of a flat plate detector at the B2 corner collector, successful installation and testing of a full flow juvenile PIT tag detection system at Little Goose Dam, development of detection systems for many Columbia River Basin tributaries, and adequate operation and maintenance of the regional PIT Tag Information System (PTAGIS). Development of a spillway PIT tag detection system is underway at Lower Granite Dam and/or Ice Harbor Dam.

Conclusions and Recommendations:
The ISRP believes that these projects have assisted in providing important monitoring tools, data storage, and support services for listed salmonids and other stocks and species in the Columbia River Basin, and there is a continuing need for further development, testing, and evaluation of these PIT tag technologies and data storage and retrieval systems. The ISRP recommends that these projects continue on track with proposed objectives and concludes that the successful development of spillway PIT tag detection systems for mainstem dams is a high priority. The ISRP also recommends additional effort to evaluate the biological aspects of PIT tagging such as tag loss and tag-related mortality.

b. Hydrosystem Core RME Projects

The next six projects described in Table 2 (199403300, 198712700, 199602000, 200500200, 199302900, 200304100) are comprised of some of the most extensive hydrosystem monitoring projects in the Fish and Wildlife Program. The first four of these projects focus on providing service and products to collect, manage, and store data related to fish passage so past and present data are accessible to management agencies and others. The last two of the projects analyze data to better understand the role of the hydrosystem on juvenile passage mortality and on delayed mortality. These two projects provide metrics for tracking recovery and status and trends. These six projects provide valuable information for evaluating the effects of hydrosystem management and guiding future operations. The ISAB relies on the results of these projects on a consistent basis to conduct reviews of in-river v. transportation effectiveness, flow augmentation, and latent mortality issues pertaining to fish passage through the hydrosystem. In addition, the ISAB has a role conducting a regular review of Fish Passage Center and Comparative Survival work products, including draft annual reports.

Although at first glance there may appear to be substantial overlap in activities among these six projects, each project fills a distinct role in the Fish and Wildlife Program and the amount of overlap is small, and appropriate.

Fish Passage Center (FPC)

Findings:
The primary and most important activity of project #199403300, the Fish Passage Center, is the provision of technical support to the state, federal, and tribal fishery management agencies in matters related to juvenile and adult fish passage through the mainstem Columbia and Snake River hydrosystem. The FPC web site is heavily used by agencies, tribes and the public as the primary vehicle for distribution of fish passage data and analysis. In addition the web site is used by managers on a real-time basis in their consideration of hydrosystem management actions for fish passage on a daily and weekly basis. Daily juvenile passage indices, daily river conditions, flow, spill, and water temperature are updated on the web site for use by regional parties. The Project deliverable annual reports provide an important basis for establishing hydrosystem fish passage mitigation measures and operations. The state, federal, and tribal fishery management agencies are dependent upon the technical service and products provided by the project to facilitate their management roles relative to fish passage management mitigation.

Conclusions and Recommendations:
This project is performing its basic functions of providing juvenile and adult passage data in a timely manner and producing annual reports and specific technical work products which are reviewed by the ISAB. The overall benefit of the project to the activities of coordinating and mobilizing the data sets for management applications is high.

Smolt Monitoring Project (SMP)

Findings:
Project #198712700, the SMP, successfully provides a real-time, consistent and continuous data time series of juvenile fish passage characteristics. The project objectives are to provide juvenile salmon and steelhead travel time, passage duration, survival passage distribution for state, federal, and tribal fishery management agencies' deliberations on fish passage mitigation. The real-time data generated by the SMP has been posted promptly to the FPC web site and provided to the region, thereby facilitating the discussions and decision framework for hydrosystem operations to benefit fish passage. The historical data generated by the SMP and managed, stored and distributed through the FPC web site provides a foundation for analyses of past and future hydrosystem fish passage mitigation measures.

Conclusions and Recommendations:
This is a high priority project that is called for in the Fish and Wildlife Program. The importance of this work is clear. However, information in the proposal is lacking on the historical background of the project, including project evolution over time, lessons learned from the past, improvements in the new proposed activity, key relationships

and details concerning how the project actually functions. The proponents are encouraged to develop a protocol for evaluating the effectiveness of project deliverables. A project perspective that includes an overall vision would be useful to add value to the effort.

Comparative Survival Study (CSS)

Findings:
The primary objective of project #19960200, the CSS, is to provide long term life cycle monitoring data for collaborative analysis by state, tribal, and federal fishery management agencies. The project has developed a consistent time series of smolt-to-adult return ratios (SARs) for steelhead and Chinook for over a decade. CSS data are distributed region wide through the Fish Passage Center web site at www.fpc.org.

Conclusions and Recommendations:
This project performs its basic functions and produces annual reports and specific products. The CSS estimates survival rates over the smolt-to-adult portion of the life cycle of spring and summer Chinook salmon and steelhead. The resulting valuable data set is used to address a wide range of management questions.

Lower Granite Dam Adult Trap Operations

Findings:
Project #200500200 funds operation of the adult salmonid trap at Lower Granite Dam by NOAA Fisheries. The Lower Granite Dam adult trap is operated most of the year to sample steelhead, spring/summer Chinook, sockeye, and fall Chinook for broodstock collection, run-reconstruction, transport, and life history studies. The Integrated Status and Effectiveness Monitoring Project (ISEMP), Idaho Fish and Game, Nez Perce Tribe, and NOAA are cooperating to provide a consistent tagging program at Lower Granite to monitor steelhead and Chinook populations in the Snake River above Lower Granite.

Conclusions and Recommendations:
This project has proven its value in the past, and its continuation is certainly justified. The importance of the facility continues to increase, especially with the escalation of the number and scope of upper Snake basin PIT tag studies.

Survival Estimates for the Passage of Juvenile Salmonids through Snake and Columbia River Dams and Reservoirs

Findings:
This project (#199302900) estimates reach survival and travel time for juvenile salmonids through Snake and Columbia River dams and reservoirs using PIT-tagged fish. Factors that affect survival/travel time and smolt-to-adult return rates are analyzed.

Data from PIT tag trawling in the estuary enables completion of reach survival estimates to downstream of Bonneville Dam and comparison of those migrants to those released from barges.

The reach and project survival information gained from this study have been instrumental in focusing research and mitigation efforts throughout the hydropower system and were used extensively in preparation of the NMFS 2000, 2004, and 2008 BiOps. The results from this study have also helped in our understanding of the role hydropower system mortality plays within the entire salmon life cycle.

Conclusions and Recommendations:
This project is one of the high priority projects in the Fish and Wildlife Program. It continues to provide critical survival estimates/metrics for tracking recovery and status and trends of listed salmonids. The information provided by this project is central to understanding how survival of migrating juvenile salmonids is affected by operation of the FCRPS. Information from this study has been used by managers in the Basin to help guide structural and operational changes at Snake and Columbia River dams in order to improve smolt travel time and survival. The travel time and smolt survival data have also been used for development of NOAA's COMPASS model and continue to be used each year to evaluate COMPASS model performance and to improve the model. The proposal also addresses past concerns about possible overlap with CSS and other studies by stating that some duplication of the critical data and analyses of this and the CSS project is not necessarily bad, but can provide an error check mechanism and instill more confidence if results are consistent.

Evaluate Delayed (Extra) Mortality Associated with Passage of Yearling Chinook Salmon through Snake River Dams

Findings:
This project (#200304100) empirically tests the hypothesis that smolts passing through Snake River dams causes delayed or extra mortality that is not expressed until smolts have passed through the hydropower system and return as adults. Spring/summer Chinook smolts are collected and PIT-tagged at Lower Granite Dam then trucked below Ice Harbor Dam for release (bypassing 3 of 4 Snake River Dams) or released directly into Lower Granite tailrace, with smolt-to-adult returns compared between groups.
Returns of age-3-ocean adults in 2009 completed returns from fish marked as juveniles in 2006. Based on the estimated numbers of juveniles surviving to McNary Dam tailrace in 2006, SARs were 0.71 (95% CI 0.61-0.80) for the Ice Harbor group, 0.70 (0.61-0.78) for the Lower Granite group, and 0.65 (0.59-0.72) for the reference group. This produced a weighted geomean SAR ratio of 0.94 (0.65-1.36) for Lower Granite to Ice Harbor Dam groups indicating a small, but insignificant effect from passing through the additional dams. Comparison of SARs between the Lower Granite and reference group to

determine if a trucking effect exists produced a weighted geomean SARs ratio of 1.06 (0.92-1.22), indicating no trucking effect.

Conclusions and Recommendations:
Although the results of this project are limited in space and time, the results could justify further studies, which together with this project, could provide a more complete understanding of potential delayed mortality. The results could inform future decisions on dam configuration and operations.

c. Data Analysis and Training Support Projects

The following three related projects provide support functions for other hydrosystem RME projects as well as projects throughout the Fish and Wildlife Program:

Gas Bubble Disease Monitoring

Findings and Conclusions:
The primary objective of this project (#199602100) is for the USGS Columbia River Research Lab to provide training for fish monitors looking for signs of gas bubble disease in juvenile salmonids. Examination of migrating salmonid smolts for signs of gas bubble disease continues to be a necessary component of the Smolt Monitoring Program at FCRPS dams and is required by the states of Oregon and Washington water quality agencies. Standardized methods for scoring the severity of gas bubble disease were developed in the early years of this project and described in reports and refereed publications. The present activity consists of training Smolt Monitoring Program personnel in the use of these methods. This training has been provided each year since 1999.

Modeling and Statistical Analysis Support for Salmonid Survival and Life Cycle Studies

Findings and Conclusions:
There are two projects (#198910700 and 199105100) that meet these needs for the Fish and Wildlife Program. The statistical services and products provided by project #198910700 makes a major contribution to fish-tagging studies by state, federal, tribal, and academic entities throughout the region. Project #199105100 has provided real-time smolt migration data (through DART), and statistical analysis and modeling tools for measuring hydrosystem survival, smolt performance, and SARs estimates. The proposal effectively relates the project to the 2008 BiOp via many RPAs, the Accords, the Fish and Wildlife Program, and the MERR plan.

d. Life History, Fish Population Status, and Hydrosystem/Hatchery Uncertainties

Three life history related projects in this group provide important status and trends information on Lower Snake River salmonids including: (1) wild spring-summer Chinook - population status, migration characteristics, and tributary habitat conditions (199102800), (2) wild and hatchery fall Chinook - population status, hydrosystem critical uncertainties, and hatchery critical uncertainties (199102900), and (3) wild and hatchery fall Chinook migration and hydro-passage patterns (200203200). One additional project (199900301) is studying spawning habitat conditions and success for fall Chinook and chum salmon below Bonneville Dam.

PIT Tagging Wild Chinook

Objectives of this project are to assess the migrational characteristics and estimate parr-to-smolt survival rates for wild spring/summer Chinook salmon smolts at Lower Granite Dam; characterize the survival and movement of parr and smolts as they leave natal rearing areas of selected streams and examine the relationships between fish movement, environmental conditions within the streams, and weather and climate data; monitor parr-to-smolt growth rates on previously PIT-tagged wild parr at Little Goose Dam each spring.

Findings:
Summary results indicate that annual parr-to-smolt survival estimates for the combined Idaho and Oregon populations over the last 18 years have ranged from 8.2 to 24.4%, with an average annual survival rate of 16.4% (Achord et al. 2010). The lowest parr-to-smolt survival rates were estimated in 2004 and 2005 (8.2 and 8.4%, respectively). These low estimates may have resulted from stream conditions with much higher parr density, thereby implying density-dependent survival. Returns of wild adults to the Snake River basin from 2001 to 2003 were more than an order of magnitude greater than returns from 1994 to 1996, when they measured the highest rates of parr-to-smolt survival (20.6 to 24.4%).

Conclusions and Recommendations:
This long-term project has provided important information regarding the early life history characteristics and survival data for wild Snake River spring Chinook. Key significant findings include parr-to-smolt survival rates, growth rates, migration timing, and intra- and inter- annual variation in movements between habitats. The information gained continues to be of value to managers and other decision makers regarding this listed stock. While gathering these long-term data may be worthwhile in itself, the ISRP suggests that to fully utilize these data, the next logical steps are 1) start to develop a modeling and analysis outline for the data and 2) start framing and testing critical hypotheses. The ISRP noted that the proponents have started to do this type of analysis

for a five-year set of data by examining the variation in survival based on size (Zabel and Achord 2004).

Research, Monitoring, and Evaluation of Emerging Issues and Measures to Recover Snake River Fall Chinook salmon ESU

Findings:
The latest annual progress report from project #199102900 to BPA (Conner and Tiffan 2011) summarizes results of selected research activities conducted during 1992–2009 to make an incremental contribution to the management and recovery of fall Chinook salmon in the Snake River basin.

Objective 1: Describe the biological variables that influence subyearling growth, migration rate, and mortality in rearing areas and to Lower Granite Dam.

Results: They found evidence that the increase in fish densities following hatchery supplementation in the Snake River has elicited responses in each of these factors in different ways, including a significant decrease in smolt size of natural subyearlings.

Objective 2: Describe the morphological differences found between hatchery and natural subyearlings that can be used to distinguish between the two groups at time of PIT tagging in the field.

Results: They determined that natural subyearlings could be distinguished from hatchery subyearlings with over 99% accuracy. This is critical to ensuring future inferences from PIT tag data can be made to the natural population of Snake River fall Chinook salmon.

Objective 3: Evaluate the post-release performance of acclimated hatchery, directly-released hatchery, and natural subyearlings in the Snake River.

Results: They found that acclimated subyearlings (1) usually passed downstream faster on average than directly released subyearlings, (2) always passed downstream earlier than directly released subyearlings, and (3) always survived during early seaward migration at higher rates than directly released subyearlings. Based on comparisons of growth rate, passage rate, and survival made between the two groups of hatchery subyearlings and natural subyearlings, they found less potential for interaction between acclimated and natural subyearlings than between directly released and natural subyearlings.

Objective 4: Develop a new method for estimating bypass probabilities over short time intervals and over a range in operations at Lower Granite Dam for PIT-tagged subyearlings using a multistate mark-recapture model based on radio-telemetry data.

They expressed bypass probability as linear combinations of total outflow and its allocation to the turbines and juvenile fish bypass and collection system.

Results: Together turbine allocation and total outflow provided the best expression of bypass probability, explaining ~71% of the null deviance. Comparison of their findings between operational scenarios using other methods and estimates of bypass probability based on PIT tag information indicated the mark-recapture model obtained from radio-tagged fish was more robust against violation of a key assumption and errors associated with spill and dam operations.

Objective 5: Examine the growth and physiology of PIT-tagged hatchery subyearlings exposed to various rearing temperatures from 12 to 28°C.

Results: PIT-tagged and control fish had similar growth, survival, and physiology up to 20°C. At 24°C, growth decreased and some physiological changes were observed. All fish died in the 28°C treatment. These laboratory results support field growth data of Snake River fall Chinook salmon.

Objective 6: Examine if increases in fish densities following hatchery supplementation has affected subyearling growth opportunity.

Results: Although growth in riverine rearing areas has not changed, growth has significantly declined in reservoir habitats following supplementation. They believe that this is due in part to increased competition as a result of increased fish abundance that is influenced by hatchery supplementation.

Objective 7: Describe the post-release performance of hatchery subyearlings that are used as surrogates for natural fish. The purpose for this objective is to provide the fisheries community with the empirical information needed to evaluate the efficacy of the surrogate release strategy to better interpret patterns in future SARs from PIT-tagged surrogate and production subyearlings with different passage experiences.

Results: Based on the results, the proponents conclude that (1) juvenile life history varies markedly between the natural and hatchery populations and (2) post-release performance was much more similar between natural and surrogate subyearlings than between natural and hatchery subyearlings.

Conclusions and Recommendations:
This ongoing project has collected field data on Snake River fall Chinook salmon spawning activity, juvenile recruitment, survival, and growth for almost two decades, and proposes to continue these studies. The project also manages a very ambitious PIT-tagging program, with almost 400,000 hatchery fall Chinook PIT-tagged annually. This project has provided a large portion of the available data on the Snake River fall Chinook Salmon ESU. The data have been used for development of the recovery plan, for

planning of the Lyons Ferry hatchery program, and for design of the summer flow augmentation program. The study documented overwintering of juvenile fall Chinook salmon in the hydropower system reservoirs, and contributed to the decision to extend the operation of the juvenile bypass system at Lower Granite Dam later into the fall. This project is a collaborative effort between the USFWS and the USGS, and will provide information essential to NOAA life-cycle modeling efforts. A number of additional Federal and State agencies are involved in data collecting and reporting. The activities funded by this proposal would not duplicate other efforts.

One of the highlights of the project's discoveries has been the recognition of a reservoir overwintering life history attribute in some Snake River fall Chinook, and extension of operation of the juvenile bypass systems at the lower Snake dams reflects this new understanding of year-round movement patterns. The research questions have been refined and focused over the years, and are addressing some of the most critical data gaps concerning this ESU.

Of particular value in this proposed work are their analyses of abundance and growth data with stock recruitment relationships to address density dependence in supplementation programs. Post supplementation, there has been a significant decrease in smolt size. Hatchery supplementation has been associated with large increases in redd counts, followed by a leveling off/slight decline of natural fish. There are some indications that density-dependent factors might be acting as stock size rebuilds. Whether or not density dependence or other hatchery-wild interactions are occurring may be a contentious issue, but regardless of the outcome, addressing these questions with their long-term data sets is a highly important use of the data, and an appropriate approach for evaluating and shaping other supplementation projects in the basin as well. Results of the analysis should provide a biological basis for recovery goals. The proponents also have a riverine bass predation element to their project that will provide information related to survival. This project is exemplary in that it is making the attempt to truly assess a supplementation program not just through intermediate steps such as more smolts or more redds, but in terms of its ultimate impact on recovery, the wild stock, density effects, and other higher level population dynamics.

Snake River Fall Chinook Salmon Life History Investigations

The objectives of project #200203200 are to understand how temperature, predation, and total dissolved gas affect Snake River juvenile fall Chinook salmon behavior, survival, and life history and its consequences to management activities such as transportation and flow augmentation. It also seeks to quantify mortality risks that ultimately affect population productivity.

Detailed Findings:
From the latest annual report (September 2010): In 2009, they used radio and acoustic telemetry to evaluate the migratory behavior, survival, mortality, and delay of subyearling fall Chinook salmon in the Clearwater River and Lower Granite Reservoir. They released a total of 1,000 tagged hatchery subyearlings at Cherry Lane on the Clearwater River in mid-August and monitored them as they passed downstream through various river and reservoir reaches. Survival through the free-flowing river was high (>0.85) for both radio- and acoustic-tagged fish but dropped substantially as fish delayed in the transition zone and confluence areas. By the end of October, no live tagged juvenile salmon were detected in either the transition zone or the confluence.

They also radio tagged 84 smallmouth bass and six channel catfish in the confluence reach and later detected 48 bass and 1 catfish during mobile tracking. Predators were primarily located along shorelines in the confluence, but a couple of smallmouth bass swam into the Clearwater River. Most radio-tagged subyearlings that they determined to be dead were also located in shoreline areas suggesting that predation could account for some of the mortality observed.

Total dissolved gas (TDG) monitoring in the lower Clearwater River showed a cyclic pattern of low (~102%) TDG in the morning and higher (~110%) TDG in the late afternoon. Using a compensation depth of 1 m, they found that 15.4% (3.9 ha) of the lower 13 km of the Clearwater River would not provide fish with an opportunity for depth compensation in a low flow year.

From October 2008 to February 2009 and from July 2009 to March 2010 they used monthly mobile hydroacoustic surveys to estimate the number of juvenile fall Chinook salmon in Little Goose and Lower Granite reservoirs, the first two reservoirs encountered on the lower Snake River by downstream migrants. Concurrent lampara seining was used to verify acoustic targets, calculate condition factors, and to examine spatial and temporal density patterns. Resulting data indicated that holdovers are larger in warmer water temperature years and smaller in colder water temperature years. Lampara catch data indicated that holdovers were seasonally the most abundant and in the best condition in November and December, whereas the hydroacoustic data showed population peaks in October in Lower Granite Reservoir and in January in Little Goose Reservoir. Maximum population estimates in Lower Granite Reservoir were 6,929 in October 2008 and 7,218 in October 2009. In Little Goose Reservoir, maximum population estimates were 9,645 in January 2009 and 10,419 in January 2010. By February, abundances and relative condition factors decreased as most holdovers had probably moved past Lower Granite and Little Goose dams. Spatial differences were primarily longitudinal with greater holdover abundances in the lower reaches of both reservoirs.

Summary Findings:
Progress on this project to date has provided important new information on the early life history and life history diversity of Snake River fall Chinook salmon. Subyearlings migrating from spawning areas in the Clearwater River migrate rapidly in the free-flowing portion, but then slow and delay in the area above the confluence with the Snake River (transition zone). Survival through the confluence area is low, but the survivors grow to relatively large sizes and apparently survive well during subsequent migration and marine life. Over-wintering of juvenile Fall Chinook salmon in the hydrosystem reservoirs has thus been shown to be a viable life history strategy.

Conclusions and Recommendations:
The net benefit for survival through the entire life cycle has yet to be determined. Much remains to be learned about the implications of the over-wintering life history strategy for management operations, including bypass, transportation, spill, and summer flow augmentation. The questions being asked (role of predation in limiting survival of overwintering reservoir-type Chinook parr, importance of gas bubble disease, and the influence of water temperature) are difficult to answer in such a large aquatic ecosystem, but the project has shown that it can successfully carry out the large-scale studies and reach scientifically supported conclusions. The proponents have a strong record of peer-reviewed publication of past results.

The proponents also hypothesize that predation is higher now than 15 years ago, especially in summer. This project would produce needed information on current losses of juvenile fall Chinook to predators, updating and expanding on studies done over 20 years ago. Understanding how predation, gas-bubble disease, and temperature interact to affect survival of reservoir-type fall Chinook salmon would be useful for management of the ESU.

Evaluate Spawning of Fall Chinook and Chum Salmon just below the Four Lowermost Mainstem Dams

Findings and Conclusions:
Project #199900301 monitors spawning and abundance of fall Chinook salmon below Bonneville Dam and collects and builds on previously collected data. Riverbed temperature is continuously monitored in order to estimate chum salmon emergence timing. Redd locations and hourly temperature data are provided to the Fish Passage Advisory Committee and Technical Management Team for in-season management of water for the protection of spawning fish at Ives Island.

Results from a recent annual report (2011) indicate that during chum salmon spawning (mid-November 2009 through December 2009), mean riverbed temperature in the Ives Island area was 14.1°C, approximately 6°C higher than in the river, where mean temperature was 8.1°C. During the incubation period (January through mid-May 2010), riverbed temperature was more than 2°C higher than in the overlying river (10.6°C and 8.0°C, respectively). Chum salmon preferentially select spawning locations with hyporheic flow where riverbed temperatures are elevated; consequently, the incubation time of alevin can be shortened before they emerge, relative to incubation times based on river temperatures. Emergence timing estimates made using temperature monitoring data ranged from the end of January (for earliest emergence) to early April (for 90% emergence). Peak emergence estimates ranged from late February to late March.

2. Lamprey

Opening quote
"Our results also demonstrated that even if presumptive causes of extirpation (of lamprey) were known and removed before reintroduction, success is not guaranteed. Reintroduction not only assists in redistributing animals to parts of their historical range, but in conjunction with monitoring, it may be essential to identify additional limiting factors that were unknown at reintroduction" Close et al. (2009) page 234.

Findings:
The ISRP reviewed two lamprey restoration projects in the review: 199402600 in the Umatilla River (proponents National Oceanic and Atmospheric Administration [NOAA], Umatilla Confederated Tribes [CTUIR]) and 200201600 in the Deschutes River (proponents Confederated Tribes of Warm Springs). There are also projects underway in the Fifteenmile Creek and Hood River subbasins, the Willamette River, and the Klickitat and Yakima Rivers. In addition CRITFC is working on a Master Plan for all tribal lamprey research in the Basin, and there are major USACE projects dealing with lamprey passage issues under the AFEP program being conducted in the mainstem Columbia River.

The ISRP recognizes the significant progress being made by these studies on the little-known Pacific lamprey, a key anadromous species from a tribal cultural point of view and also possibly an important species for bringing marine derived nutrients to tributary ecosystems (ISAB 2009-3).

It is encouraging to note that the proponents of both lamprey projects, in association with others working on this species in the Columbia River Basin, have agreed to lead, assist in, or contribute to a synthesis report on the lamprey efforts under the program addressing the issues and questions raised by the ISRP. Critical questions to analyze include the value of tributary habitat projects in helping to improve lamprey returns, whether mainstem dam passage is the key limiting factor, and the relative role of other factors such as ocean conditions and toxic contaminants. Table 3 is a summary table of progress toward selected major factors which may be important for lamprey evaluation and restoration. An ISRP concern is that the effects of poor ocean conditions combined with mainstem passage problems may be so pervasive as to counteract any positive impacts of tributary restoration actions.

Conclusions and Recommendations:
The Columbia Basin Pacific Lamprey Technical Workgroup (a subgroup of the CBFWA Anadromous Fish Committee) ranked passage as the highest priority for recovery of Pacific lamprey in the Columbia River Basin. The Umatilla project is making progress on passage over low head dams and irrigation screen problems. However, most of the passage studies over mainstem dams are being conducted by researchers working with the U.S. Army Corps of Engineers.

The need to "Obtain the information necessary to begin restoring the characteristics of healthy lamprey populations" is cited as an objective for performance of losses in the 2000 Fish and Wildlife Program (NPPC 2000). The two projects reviewed are making reasonable progress on certain aspects (see Table 3), but as noted in the ISRP's report, it is difficult to determine how substantial the effort is without a synthesis of results.

As mentioned above, the proponents have agreed to contribute to a summary report, which will include all the lamprey restoration projects in the Columbia River Basin. Biologists working on lamprey in the Umatilla have already summarized results in a paper (Close et al. 2009). Although time constraints are apparently limiting publication of results in the Deschutes Basin, publication of results should be encouraged.

Table 3. Progress toward knowledge of selected key aspects of lamprey ecology that are necessary for planning restoration in the Umatilla and Deschutes subbasins

Topic	*Progress and comments*
Sampling efficiency of traps	Poor in Umatilla and Deschutes; a cross cutting problem but little effort evident to resolve.
Resolution of low head dam passage problems	Recently started in Umatilla but engineering progress on other systems.
Resolution of irrigation diversion screens problems	Recently started in Umatilla.
Habitat modelling to estimate potential for recolonization	Considerable effort in Deschutes but only moderately successful and no verification evident. Includes thermal barrier work which would tie in with low head dam passage and irrigation screen issues.
Recolonization/Translocation	Extensive effort in Umatilla. F1 generation is being produced but subsequent generations are not.
Spawner enumeration	Redds are being investigated in Deschutes but only preliminary results are available.
Contaminants	Considered beyond the scope of both projects or unclear in the case of Umatilla.

Topic	*Progress and comments*
Ammocoete and larvae enumeration in the benthic habitat–but problems found by ISRP in the Umatilla	Standard electrofishing methods are being used.
Tagging technology for adults and juveniles	Half duplex tags are being used for adults in Deschutes; juvenile tag under development in other rivers.
Aging technique	Statoliths are being used in both systems but age verification is a problem.
Out of basin factors	Improvement of passage over main stem dams is being pursued by USCAE; no focused work under way on ocean/estuary issues although acknowledged as an issue.

3. Predation and Non-Native/Invasive Species

Table 4. A list of predation and invasive species projects including project characterizations and brief summary results

Project Number	Title	Proponent	Purpose and Emphasis	Primary Monitoring	Summarized Results	Meets ISRP Criteria? (RMEAP Review)
1997-024-00	Avian Predation on Juvenile Salmonids	Oregon State University	Predation RM and E	Evaluate effects of configuration and operations; Monitor Caspian tern population, double crested cormorants population, and inland avian predation	The two avian species now take 15-20 million smolts annually, i.e., ~15% of all smolts. Stocks affected include every ESA-listed stock from throughout the Basin.	Yes
1990-077-00	Development of Systemwide Predator Control	Pacific States Marine Fisheries Commission (PSMFC)	Predation Predator removal	Evaluate effects of configuration and operations; Monitor piscivorous fish predation	After 20 years the program has achieved 10-20% exploitation rates on large northern pikeminnow, and a model estimates a 40% reduction in predation on out-migrating smolts.	Yes (Qualified)
2007-275-00	Impact of American Shad in the Columbia River	U.S. Geological Survey (USGS)	Programmatic RM and E	Estuary/ocean critical uncertainties	Migratory patterns among Columbia River juvenile and adult American shad are more complicated than previously known with some juvenile shad rearing in reservoirs 1-2 years.	Yes (Qualified)
2008-004-00	Sea Lion Non-Lethal Hazing	Columbia River Inter-Tribal Fish Commission	Predation RM and E	Marine mammal control measures; Monitoring marine mammal predation on fish	Hazed sea lions returned to previous feeding habitats, but predation patterns were somewhat altered.	Yes (In Part, Qualified)

The four projects listed above in Table 4 are focused on the potential impacts of avian (199702400, Caspian tern and double-crested cormorants), fish (199007700 northern pikeminnow and 200727500 American shad) and marine mammals (200800400 sea lions) on juvenile and adult salmonids of the Columbia River Basin. Creation of islands using dredged materials has created nesting habitat for Caspian terns. Development of the hydrosystem has altered predator prey interactions in the Columbia River to allow northern pikeminnow easy access to juvenile salmonids just above and below dams, and sea lions easy access to adult salmonids when entering fish ladders. Fish ladders have also provided American shad access to reservoirs up river for spawning and rearing habitat. These human activities have potential consequences that we are now trying to understand in terms of predation losses and competition effects and ultimately salmon population effects. Understanding population effects at the salmonid ESU level is critical, but we are not there yet.

Summary Conclusions and Recommendations:
In the 2010 RMEAP report (ISRP 2010-44) the ISRP recommended that the proponents of this group of projects increase their coordination to more fully understand the role of predation/competition as a potential impediment to recovery of listed salmonid stocks in the context of reservoir food webs. Perhaps it should be asked what stocks are taken and to what extent by the various predators, and then evaluate the findings on a stock-by-stock basis in an attempt to sort out population effects. Perhaps the confounding effect of ocean conditions could be eliminated or minimized with this type of stock-by-stock approach). On an individual project basis, some nice work has been accomplished. Some large-scale life cycle population modeling is in order, especially with respect to the role of predators as a group. The importance of various predators, or predators as a group, will continue to be of interest. A unique point for this group of projects is that most of the predators of greatest concern are native species, which is an indication that the system has been greatly modified and increased the vulnerability of salmon to these predators, that is, the system is out of balance. A key question is, can we hope to understand the effects of various predation rates on juvenile salmon survival (e.g., 15% by predator #1, 20% by predator #2, etc.) when less than 1 or 2% of juveniles return as adults? Some serious thought is needed on this issue. In addition, further work on anticipated effects of climate change and the interaction with invasive species seems warranted.

a. Avian Predation on Juvenile Salmonids

The primary objectives for project #199702400 are to evaluate the efficacy of management initiatives implemented to reduce predation on juvenile salmonids by Caspian terns nesting on East Sand Island; collect and compile data needed to complete the NEPA analysis required to manage double-crested cormorants nesting on East Sand Island, and once cormorant management is initiated, evaluate the efficacy of implemented management actions; assist resource managers in the development of plans for long-term management of avian predation as warranted.

Findings:
This project, jointly funded by BPA and the U.S. Army Corps of Engineers, was initiated in 1997 and rapidly evolved over time. From an initial concern in the estuary about Rice Island Caspian terns eating juvenile salmonids, the project now primarily concerns Caspian terns and double-crested cormorants nesting on East Sand Island (an alternate nesting site closer to the ocean developed by the Corps, to reduce the importance of salmonids in the tern diet, which it did [from 94% to 47%]). But now, other nesting fish-eating birds including Brandt's cormorants, California brown pelicans (nesting behavior, no egg laying yet), Glaucous-winged/Western gulls, ring-billed gulls, American white pelicans, and pelagic cormorants from throughout the Columbia River Basin are part of this more holistic investigation. The combined consumption of juvenile salmonids by Caspian terns and double-crested cormorants nesting on East Sand Island in recent years has been estimated at 15-20 million smolts annually. This represents about 15% of all salmonid smolts that survive to the estuary in an average year and represents all ESU-listed stocks. Estimated smolt losses to fish-eating colonial waterbirds that nest in the estuary are more than an order of magnitude greater than those observed elsewhere in the Basin. Therefore, management of terns and cormorants on East Sand Island has the greatest potential to benefit ESA-listed salmonid populations throughout the Basin.

This is a well-developed, well-designed, and important program for the Fish and Wildlife Program that supports a clear need to better understand avian predation on salmonids in the Columbia River Basin. The investigators have demonstrated that avian predation concentrated in certain specific areas has a large effect on salmonid outmigrant survival. They developed and presented the necessary data to show the potential need, and to support the management plans, to move nesting birds and reduce the predation. Within this dynamic system, the relative importance of the various species of birds, as salmonid predators, has changed over time. However, the project has adjusted to these avian changes and modified locations and species for their data collection schemes accordingly. The basic data collected has become fairly standardized, including procedures developed specifically on this project.

Considerable efforts are now taking place outside the Columbia River Basin to provide suitable alternative nesting sites (islands built by the Corps) to attract Caspian terns (in compliance with the Environmental Impact Statement, Record of Decision). These types of construction activities on a regional scale take considerable planning and associated biological investigations, if there is to be any success. There has been some success in attracting nesting terns to the constructed islands, but drought has limited the use of several island sites (no water) to date. A planned reduction in size of the East Sand Island nesting site (sandy area) for Caspian terns from 6 to ~1.5 acres is the approach used to force the terns to leave, with the overall goal to still maintain a viable tern population in western North America. This sandy habitat reduction on the East Sand Island is associated with a 2:1 ratio of habitat enhancement for nesting elsewhere (islands in California and Oregon). This enhancement phase of the tern project is nearing completion. Interestingly**,** the 2011 nesting year for Caspian terns on East Sand Island was a complete failure, which followed an extremely low production year in 2010. In general, nesting success at the East Sand Island tern colony peaked in 2001 and has trended downward since then. Bald eagles routinely swooped down to catch adult terns on the nest in 2011 and flushed the colony off their nests. Then, gulls feasted on the unprotected eggs. It would seem that only one or two eagles could start this whole new feeding approach, and then others would soon join in. It is ironic that this sounds very much like what probably happened with a few sea lions at Bonneville Dam some years ago, and then "all of their friends showed up at the dam." Time will tell. A similar situation occurred with ospreys nesting on power poles in the Pacific Northwest. A few short years after the first osprey nest on a power pole was found in 1976 along the Willamette River, nearly 90% of the osprey nests were on power poles or other manmade structures. Prior to then, all nests were in trees. Information about new feeding approaches or nesting approaches seem to pass quickly through avian populations.

The recent dramatic increase in nesting double-crested cormorants at East Sand Island is a new issue that is just beginning to be investigated in this dynamic system. East Sand Island is now the home of the largest double-crested cormorant colony in Western North America (13,596 breeding pairs in 2010), which is a 10% increase over 2009. The double-crested cormorant diet included 9.2% salmonids in 2009 and 16.4% in 2010 (consumed an estimated 11.1 and 19.2 million salmonids respectively), which is more than the terns now take. It is noteworthy that the double-crested cormorant population in North America (including the Pacific Northwest) was greatly reduced for decades due to the influence of DDT, and so was the bald eagle population. Another predator of island nesting birds in the lower Columbia River, the mink, was nearly extirpated by another contaminant (PCBs). Perhaps the return of some avian predators into the system is now having some influence on rebalancing the ecosystem. Elliott et al. (2011) summarized declines in waterbird abundance or reproductive success in the Pacific Northwest attributed to recent increases in bald eagle abundance. Species adversely affected included great blue heron (*Ardea Herodias*), double-crested cormorant, common murre (*Urea aalge*) (3 locations), black-legged kittiwake (*Rissa tridactyla*), pelagic cormorant (*Phalacrocorax pelagicus*), thick-billed murre (*Uria lomvia*), glaucous-winged gull (*Larus glaucescens*), and Canada goose (*Branta canadensis*).

Basic data collected annually includes nesting chronology; colony size; productivity; diet composition and salmonid consumption; predation rates based upon PIT tag recoveries at the colonies; and color banding with band re-sighting. Gratefully, much of this information has been summarized in a draft annual report to BPA (2011). This report also lists the 21 project publications in scientific journals, plus another manuscript submitted for publication. This type of reporting is exceptional and provides the information to all for use in adaptive management. The project shows a history of providing useful information to address management problems with fish-eating birds and seems to be planning far ahead to obtain the information needed to assess responses from current and planned management activities.

This study is also important to understanding the predation rate of fish-eating birds on various salmon stocks, and uses the PIT tags found at the colonies (first discovered at colonies in 1996) to estimate these values. This predation rate is being evaluated in considerable detail in the estuary, although unfortunately, the lower Columbia River salmonid (below Bonneville Dam) predation rates cannot be estimated due to the lack of detection gear below Bonneville Dam and near the river mouth. This deficiency should be addressed, because some information from several hatchery stocks from the lower Columbia River show extremely high avian predation rates. In an earlier evaluation, the ISRP noted that although the predation rate is being evaluated in considerable detail (including adjustments for not finding PIT tags), the predator influence on the overall survival rate of the various stocks is unknown - is it mostly compensated for or is it additive? A draft report “Benefits to Columbia River anadromous salmonids from potential reductions in avian predation on the Columbia Plateau” by Lyons et al. (2011) uses PIT tag data from Columbia River Interior bird colonies and the framework of a simple deterministic, age structured, matrix population growth model to translate potential changes in smolt survival due to reductions in avian predation into increases in average annual population growth rate for the various ESUs. Estimates were produced for a range of reduction in avian predation and with various assumptions for levels of compensatory mortality. The assumptions made were documented. Then, locations for the greatest potential for predation rate reductions were discussed to prioritize management actions. This seems like a large step forward and indicates that data collected is being used effectively to address many issues, but at the same time still recognizing its limitations.

Finally, what influence does juvenile salmonid loss (bird and fish predators) have on the adult return rate of various juvenile salmon stocks? Perhaps, it should be asked what stocks are taken and to what extent by the various predators, and then evaluate the findings on a stock-by-stock basis in an attempt to sort out population effects (perhaps the role of ocean conditions and other factors could be eliminated/minimized with this type of approach). This approach may be particularly useful if avian predation rates vary considerably from stock to stock and year to year. However, can these fish populations be modeled in a realistic way if the smolt-to-adult return rate is only 1 or 2 percent (maybe lower)? The importance of the various predators is going to be asked time after time. This study is collecting meaningful basic data and is the best chance for answering the salmon population effect question. Perhaps, the answer is that no amount of predation rate information alone can answer the population effect question. If the answer is no, can pooling information about other factors fit into a meaningful model to provide insight into the population dynamics, including predation rates, of the various ESUs? Other factors could also include contaminant effects, because the various ESUs are exposed to different concentrations and types of contaminants (see ISAB Food Web Report 2011-1).

The Corps has evaluated avian predation at the John Day Dam for about a decade using a quite detailed approach (Zorich et al. 2011), and shown that California Gull consumption of juvenile salmonids can be greatly reduced by hazing and some lethal take. For example, the estimated smolt consumption was 18,000 in 2010 when a large new avian deterrent line array and intensive boat hazing occurred. This was a reduction of 76% from the 80,000 smolts consumed in 2009. Disoriented fish taken below dams by gulls brings up another issue. The question that has not been answered to date concerns: Does this mortality consist of fish that would die anyway (compensatory mortality) or would they survive (additive mortality) and swim downstream? Ruggerone (1986) recognized this issue in interpreting consumption in his early work on avian predation at dams. This is an added complication to the general use of the terms “compensatory” and “additive” mortality used for the tern and cormorant segments of this review, where the mortality refers to having an effect or no effect on the adult fish rate of return.

Weitkamp (2008) reports that high lipid levels may impede the ability of hatchery fish to regulate buoyancy and may increase their vulnerability to surface avian predators. Furthermore she reports that lipid levels that vary with both environmental water density and fish origin (hatchery vs. wild) clearly complicate the interpretation of this variable during the transition to salt water. Perhaps there is a benefit to wild fish if avian predators select for hatchery smolts.

Conclusions and Recommendations:
This important program has provided critical information to demonstrate the influence of avian predation on various salmonid stocks in the Columbia River Basin and to support management plans and actions to move nesting birds and reduce predation. The work proposed will continue these efforts, support efforts to move cormorants to appropriate nesting locations, and continue to determine the importance of predation by other nesting waterbirds (including the relatively recent arrival of pelicans in the estuary). Although the predation rates of fish-eating birds on various salmon stocks are being evaluated in considerable detail, the predator influence on the overall survival rate of the various stocks is unknown. For a true cost-benefit analysis, this question needs to be answered. Perhaps avian biologists working with salmon biologists can address this critical issue by working together on salmon life stage models for various stocks, especially since predation rates seem to vary among species and stocks. What is the effect on return rates of various adult salmonid stocks? To what extent are birds consuming less healthy salmon that would have otherwise died from other factors?

b. Development of Systemwide Predator Control

The primary objective for project #199007700 is to remove 10-20% of the predatory sized fish each year, which modeling estimated would reduce pikeminnow predation on salmonid smolts up to 50%.

Findings:
Major summary results from the project include:
(1) Fisheries for northern pikeminnow, have resulted in the removal of over 3.3 million northern pikeminnow >250-mm fork length throughout the lower Columbia and Snake rivers, with annual exploitation from 1991-2009 averaging approximately 13%.

(2) Exploitation of northern pikeminnow >250-mm fork length has remained above 10% since 1998, and has increased in recent years. Exploitation rates in 2004 (18.5%), 2005 (19.0%), and 2008 (19.5%) were the highest observed rates in the history of the program.

(3) Predation index values have generally decreased since the early years of the program (1990-1993), especially above Bonneville Dam. Below Bonneville Dam, predation indices have fluctuated recently (1999, 2004, and 2005), but remain below mean 1990-1996 values.

This proposal describes a successful ongoing program to encourage anglers to exploit a native nuisance predator, the northern pikeminnow, and to evaluate the effectiveness of this exploitation for reducing predation on outmigrating salmonids. After 20 years of modifications and fine-tuning, the program has achieved 10-20% exploitation rates on large northern pikeminnow, which are the most predaceous, and an estimated 40% reduction in predation on out-migrating smolts.

Conclusions:
The overall significance of these northern pikeminnow removals on SARs remains unknown, relative to marine survival in particular, as the proponents note:

"Although it is inherently difficult to relate predator removals to smolt survival benefits, it should in theory be relatively easy to estimate the correlation between SARs and [Northern Pikeminnow Management Program] NPMP exploitation rates. The NPMP staff plans to complete this evaluation in the next project cycle." This issue is the same as mentioned with the avian predation work and perhaps requires a combined effort using both the avian and fish predation rate data collected.

c. Impact of American Shad in the Columbia River

There are five objectives for Project #200727500 as follows: Objective 1. Estimate abundance of juvenile American shad in reservoirs, Objective 2. Corroborate existing shad bioenergetics model, Objective 3. Characterize zooplankton in mainstem reservoirs, Objective 4. Characterize fitness of subyearling Chinook salmon when shad are abundant, and Objective 5. Characterize food habitats of subyearling Chinook in lower Columbia River reservoirs when shad are abundant.

Findings:
The results summarized are from an annual progress report by Parsley et al. (2011) from the U.S. Geological Survey (USGS) to the Bonneville Power Administration (BPA). This final report summarizes work conducted between May 1, 2007 and December 31, 2010.

Chapter 1 provides information on the diet of juvenile and adult American shad that were captured during 2007 and 2008. They examined the stomach contents of 436 American shad captured in 2007 and 1,272 captured in 2008. The diet of age-0 American shad varied spatially and temporally but was comprised primarily of crustaceans and insects. Prey diversity of age-0 American shad, as assessed by the Shannon Diversity Index, increased with decreasing distance to the estuary. Pre- and partial-spawn adult American shad primarily consumed *Corophium* species throughout the Columbia River; however, post-spawn adults primarily consumed gastropods upstream of McNary Dam.

Chapter 2 describes growth characteristics of age-0 American shad based on otolith analysis. The objective was to determine time of hatch and size at age of age-0 fish. This information will enable better quantification of prey consumption with a bioenergetics model. Fish used in the development of a growth model ranged in age from 6 to 66 days and a polynomial regression model with natural logarithm transformed total length and age values provided the best fit for growth.

Chapter 3 describes parameterization of a Wisconsin bioenergetics model for age-0 American shad using published physiological data on American shad and closely related alosine species. The model can be used as a tool to explore various hypotheses about how age-0 American shad directly and indirectly affect Columbia River salmon through ecological interactions in lower Columbia River food webs. They demonstrate the utility of bioenergetics models to address management questions by using the American shad bioenergetics model to explore prey consumption by age-0 American shad. In addition, they will use a fall Chinook salmon bioenergetics model to explore the growth potential of juvenile fall Chinook salmon predating on age-0 American shad in the lower Columbia River.

Chapter 4 presents findings from two ancillary investigations completed during the contract period; assessment of the levels of thiaminase activity in juvenile and adult American shad and characterization of some life history traits, including the age and interoparity of adult fish. Thiaminase activity of Columbia River American shad was typically higher than that reported for alewives from 10 stocks in the Great Lakes, suggesting that additional studies should be conducted to determine if predators of American shad exhibit thiamine deficiency. They found differences in age, size, and spawning frequency between male and female American shad. Most spawning males were age 4 (range 3-6) and most females were age 5 (range 4-7). Overall, males had a higher rate of iteroparity than females, and females were larger than males of the same age.

Chapter 5 verifies the existence of a “freshwater” type life history variant of juvenile American shad in the Columbia River by examination of length frequencies and otolith analysis. Their results show that some juvenile American shad remain in freshwater for one to two years. Even if this life history variant is relatively rare within the American shad population, the sheer abundance of American shad produced in the Columbia River Basin could result in appreciable numbers, potentially with significant ecological impact. They also show that migratory patterns among Columbia River juvenile and adult American shad are variable and more complicated than previously thought.

Conclusions and Recommendations:

The proponents have provided documentation of their accomplishments and results. Information gained should allow managers to consider options for near-term management of shad in the system, including prospects for control of this non-native fish. A key finding is the likely influence of disease on shad survival. If the population crash of the species continues, will shad continue their high population levels? Disease and thiamine deficiencies might be key limiting factors, but the scope and nature of the problem is still evolving.

The investigators appear to be starting to publish the data they have collected since 2007 in the peer-reviewed literature, which is a good sign of progress, and a key to ensuring a strong basis on which future research and management can be built.

d. Sea Lion Non-Lethal Hazing

There are three objectives for project #200800400 as follows: Objective 1. Conduct boat-based non-lethal sea lion hazing annually, Objective 2. Develop a video system to enumerate sea lions and estimate predation, and Objective 3. Track movements of individual sea lions at various spatial scales in the Columbia River using acoustic telemetry.

Findings:
Based on an annual report from CRITFC to BPA (2011):

(1) Boat based hazing resulted in 202 and 377 “takes” or hazing events of California and Steller sea lions. For the first time hazing events involved Steller sea lions more than California sea lions. In general, the response to hazing in 2010 was similar to that seen in previous years. There was no apparent reduction in overall sea lion activity or predation in response to hazing. There does appear to be an immediate effect on the animals while hazing is occurring. Stansell et al. (2010) reports some reduction in sea lion presence during hazing hours.

(2) After months of testing a variety of camera and DVR settings they eventually were able to record images that were far more useful in identifying sea lions and their prey. Final images recorded from late in the 2010 season demonstrate that there is promise in creating a video system that is capable of achieving the objective.

(3) Acoustic pingers (ultrasonic transmitters) were attached to 11 sea lions captured at Bonneville Dam in order to track movements and infer foraging behavior around Bonneville Dam and in the lower Columbia River. Five California sea lions were tagged with depth sensing tags as a part of this study.

Additionally, the states tagged six Steller sea lions at Bonneville Dam with standard pingers. They included tracks of these Steller sea lions for discussion and comparison with the California sea lions. For comparison they included movement data from Steller sea lions tagged at Bonneville Dam. In general, Steller sea lions tend to range farther below Bonneville Dam on a daily basis with regular trips to Phoca Rock near river mile 133. Steller sea lions tend to range approximately 12 miles whereas California sea lions tend to stay within the BRZ portion of the Bonneville Dam tailrace. Only 1 SSL left Bonneville Dam was detected in the estuary and then returned to Bonneville Dam. All other tagged Steller sea lions stayed exclusively near Bonneville and when they traveled downstream below Phoca Rock they left the Columbia River system. By comparison the only California sea lions that did not make trips from Bonneville Dam to the estuary and back were tagged late in the season when animals tend to leave the system.

Conclusions and Recommendations:
Pinniped species, including California sea lions, Steller (or northern) sea lions, and Pacific harbor seals are natural predators of salmon and other fish species in rivers and estuaries. A high abundance of hatchery fish and physical structures such as dams will invariably attract pinnipeds and other salmon predators. Results to date do not indicate that harassment or hazing have been effective, but the preliminary results of video surveillance and acoustic tagging and monitoring offer some promise.

The ISRP recommends that an ecosystem-based trophic model is required here to direct the research plan and to assess the potential benefits of predator harassment and/or removal. Currently, there is no indication that intensive hazing or lethal removal, as are currently being implemented, will result in reduced predation overall, nor have a significant benefit to salmonid survival.

D. Habitat Restoration

1. Background

This section of the 2011 ISRP Retrospective Report examines effectiveness monitoring and evaluation of habitat restoration projects. We review a set of ongoing projects dealing with habitat improvement, asking the questions framed in the Council's RMEAP Final Decision Document (NPCC 2011) that were relevant to tributary habitat restoration:

- Is the project scale and resource commitment appropriate for the project's objectives?
- For research projects, is a critical uncertainty being addressed? What is the hypothesis being tested, and is it prioritized in the Research Plan?
- Is the monitoring or research conducted by a project proportional to the biological risk or project success risk?
- Does the project contribute valuable data to inform one of the nine program-management questions from the working list proposed by the Council and the associated High Level Indicators?
- What are the major accomplishments of these projects, and are the data derived from the projects useful and relevant?
- Is the project part of a comprehensive monitoring program?
- Does the project fill a priority Program data gap, or is the project required by a biological opinion or a recovery plan for species listed under the Endangered Species Act?
- Does the project's RME data have a reasonable certainty or a reasonable confidence level?
- Are data produced by the project fully described, including metadata and methodologies used, easily available for public review, and capable of being used to aggregate data to an appropriate higher scale, such as a broader geographic scale or population scale?

The RMEAP review document further makes it clear that the Council considers habitat action effectiveness monitoring and evaluation to be a cornerstone of gauging the success of the Fish and Wildlife Program. The Council states:

> *"…the* critical programmatic issue in the RM&E/AP review is whether the collective suite of proposed projects is adequate to monitor and evaluate the effectiveness of our habitat actions in ultimately improving the population characteristics of our key fish species, and to be able to use what we learn to adapt the implementation and management of the program."[2]

However, it is also clear that Council considers existing habitat RME efforts somewhat lacking:

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[2] p. 11 - http://www.nwcouncil.org/fw/budget/2010/rmeap/2011_06decision.pdf

> "Yet most of the elements of the habitat effectiveness monitoring and evaluation effort are in flux or under development. This includes the precise contours of the status and trend monitoring of habitat characteristics and the relationship of this monitoring to the fish population status and trend monitoring, the distinct but related role of the cause-and-effect 'intensively monitored watershed' research effort, and especially the analytical methods and procedures that will be used to evaluate all of this information and report on what is being learned… the Council still needs clarity and further definition on the monitoring, evaluation and reporting elements of the habitat effectiveness monitoring and evaluation. The Council will not conclude this review without being comfortable that the monitoring and evaluation protocols and analytical methods are in place to give us a reasonable chance of knowing -- in 5, 10, 20 years -- whether the region's huge investment in an evolving suite of habitat actions is contributing significantly to the recovery and rebuilding of fish species important to the region." (ibid.)

2. Efforts to Standardize Habitat Monitoring

Is it feasible to standardize habitat monitoring and if so, is standardization warranted?

Conclusions:
There are significant impediments to progress in addressing habitat action effectiveness monitoring and evaluation. One is that monitoring efforts are often not prioritized, designed, or funded at a level necessary to establish project effectiveness. However, equally daunting is a broad divergence in habitat monitoring and analytical protocols that exist among the organizations sponsoring monitoring programs. Many of these organizations (in particular, large federal and state agencies) have been engaged in habitat monitoring for decades and their methods tend to be firmly entrenched in institutional traditions.

Recent efforts attempt to address difficulties that may arise when attempting to establish fish habitat status and trends in major subbasins, or even regional scales, where multiple organizations conduct surveys in different ways. The Council and BPA have taken important steps to bring greater consistency to the habitat monitoring and evaluation process in the Columbia River Basin. The Skamania workshop in 2009 led to the development of the Anadromous Salmonid Monitoring Strategy (ASMS), and the Council's recent draft Monitoring, Evaluation, Research and Reporting Plan (MERR) has provided a framework for monitoring and evaluation of restoration projects supported by BPA. Both of these efforts are helping to bring monitoring practitioners together to further the data-sharing process and to work toward producing large-scale indicators of overall population and habitat trends. However, both the ASMS and MERR need time to mature as overarching monitoring strategies and to produce the coordinated data needed to address the Council's difficult habitat-related questions.

The Columbia Habitat Monitoring Program (CHaMP) deserves special mention because it occupied a substantial portion of the ISRP's time in 2011. CHaMP is best described as a companion project to the Integrated Status and Effectiveness Monitoring Program (ISEMP), with which it shares many cooperators. Perhaps more than any other existing monitoring effort in the Columbia Basin, CHaMP's explicit objective is documentation of status and trends needed to address habitat RPAs in the FCRPS Biological Opinion, and further development of a set of protocols for measuring habitat, analyzing data, and displaying results. Other regional monitoring programs in place long before CHaMP have produced copious amounts of habitat data, but are often less clear about how the data will be analyzed and reported. In 2011 the ISRP recommended that CHaMP proceed in a phased manner with the initial year or two devoted to pilot-scale testing and further protocol refinement in a limited number of tributaries before being applied broadly throughout the basin (ISRP 2011-10). The ISRP anticipates reviewing ISEMP and CHaMP in FY 2012 and has asked for a more detailed explanation of the coordination of CHaMP with ISEMP and the intensively monitored watersheds (IMWs).

While the ISRP applauds overall attempts to bring greater consistency to habitat action effectiveness monitoring, we caution against attempting to apply a "one-size-fits-all" habitat monitoring and evaluation approach to every situation. Advances in physical and chemical measurement and analytical technology will render some approaches to monitoring obsolete over time, and any monitoring protocols must be open to new, more efficient techniques. Unusual circumstances such as natural disturbances (fires, floods, etc.) and some types of anthropogenic impacts such as chemical use may require application of non-standard monitoring tools and altered sampling schemes to maximize learning opportunities. Finally, there is a risk that strict adherence to standardized habitat monitoring and evaluation protocols may stifle creativity on the part of monitoring practitioners if "doing something extra" is discouraged, the risk being that a potentially important environmental factor could be overlooked.

Recommendations:
For all these reasons, the ISRP recommends that the Council should view habitat action effectiveness monitoring and evaluation as a continuing work in progress, and while there is an urgent need for increased consistency and broad regional syntheses of status and trends, the ISRP doubts that a single standardized habitat monitoring approach is achievable, or even desirable. On the other hand, the ISRP recommends improved standardization of measuring fish response to habitat restoration. At the very least, more tributaries where restoration actions are taking place should be monitored for "adults in" and "smolts out" so that the ratio of smolt production to adult escapement can be established as a tracking metric for monitoring action effectiveness.

3. Establishing Realistic Time Frames for Results

How long will it take to measure the effects of habitat actions on focal species?

The ISRP believes that it is important for all parties to consider how long it will take to measure the effects of habitat actions on focal species. The statement, quoted above, that "The Council will not conclude this review without being comfortable that the monitoring and evaluation protocols and analytical methods are in place to give us a reasonable chance of knowing -- in 5, 10, 20 years -- whether the region's huge investment in an evolving suite of habitat actions is contributing significantly to the recovery and rebuilding of fish species important to the region" implies that action effectiveness ought to be known in 5, 10, or 20 years if we conduct monitoring in a thoughtful, appropriate, and efficient manner. The question of the time needed to detect the effects of a habitat restoration action, or collection of actions, on target populations seems to be at the heart of uncertainty currently being articulated (including in BiOp rulings) over whether or not the investment in habitat restoration will achieve intended outcomes.

There are some habitat improvement actions where change will be more-or-less immediate and detecting results should be relatively swift and straightforward. The removal of Hemlock Dam on an important steelhead spawning tributary of the Wind River in August 2009 (reviewed below) is an example of an action that has had immediate and measurable benefits for Trout Creek. It is also likely that the recent decommissioning of Condit Dam on the White Salmon River will also have immediate benefits. Other actions may require multiple years for their full benefits to be expressed. These include some types of in-stream structure modifications or floodplain reconnection projects that rely on annual hydrologic fluctuations to complete the task of habitat formation. Still other types of projects, including many riparian forest protection and restoration efforts, require decades for their full benefits to be expressed. In fact, most habitat actions aimed at restoring natural watershed processes fall into the category of projects requiring many years to achieve objectives. Each type of habitat project can be worthwhile, but the amount of time needed to document benefits will vary greatly among them.

A more problematic issue is the time needed to measure the effects of habitat improvement on fish populations. The ISRP and ISAB have addressed this question several times (e.g., ISAB 2003-2, ISAB/ISRP 2007-5, ISRP 2008-4) and cautioned that the high level of variation in abundance caused by a mix of natural and anthropogenic factors requires that considerable time, sometimes on the order of decades, is needed both before and after implementing restoration projects to measure the effects of actions on target populations with a reasonable level of certainty. Many projects simply do not have the time or resources to accomplish a statistically sound evaluation of restoration success. Furthermore, very few projects are able to compare results with an appropriate unimproved control site. For this reason the ISRP has been generally supportive of IMWs, which are using a planned experimental approach to evaluating restoration effectiveness. The main point here, however, is that the expectation of definitive answers to the question "Is it working?" may, in many instances, not be achievable in a 5-20 year window.

Recommendations:

The ISRP therefore suggests that additional dialogue is needed between habitat managers, scientists, and policy-makers so that realistic timeframes can be established, and appropriate schedules agreed upon, to monitor and evaluate different types of restoration actions.

4. Retrospective Comments on Selected Habitat Projects

a. Wind River Watershed Restoration - 199801901

This project has been in place for slightly more than a decade and has focused on wild steelhead, the only anadromous salmonid capable of ascending Shipherd Falls near the river's mouth. The project's objective is to increase understanding of how a naturally spawning steelhead population without hatchery augmentation will respond to habitat restoration in the Columbia Gorge province. Of particular significance is the examination of steelhead response to the removal of a small dam[3] that previously hindered (nearly blocked) access to one of the most potentially productive steelhead spawning tributaries in the Wind River – Trout Creek. The Wind River steelhead population represents one of the few populations in the Columbia Gorge province that is supported almost entirely by natural production and has been declared a "steelhead sanctuary" from in-river harvest in most years. Nevertheless, the relatively small steelhead runs in Trout and nearby Panther Creeks, which have been important monitoring sites, exhibit high annual variability that makes it hard to detect response to habitat restoration.

Although much of the long-term monitoring in the Wind River has focused on Trout Creek and the Hemlock Dam removal effort, there have been a large number of habitat improvement projects in the watershed that have been implemented by the principal land manager, the U.S. Forest Service. The majority of projects have involved decommissioning problem roads (those prone to failure and frequent erosion) as well as placing logs and other large structures in streams to increase pools, provide cover, and promote channel complexity. The Wind River project proponents have acknowledged these actions, but in general have not provided very much detail about them, and in particular, how the actions have influenced steelhead survival. The scarcity of effectiveness monitoring at the watershed scale is not unique to the Wind River project, however. Many other watershed-based restoration projects lack a strong effectiveness monitoring component and because adult escapement tends to be highly variable, the amount of time needed to detect actual restoration effects is likely to be great. The Wind River project has recently entered into the CHaMP partnership, and 25 baseline CHaMP habitat monitoring sites have been established throughout the watershed in locations accessible to anadromous salmonids. The ISRP hopes that fish population monitoring will soon be included at each site (if this has not been done already) so that restoration effectiveness can be better understood.

There are two other aspects of the Wind River watershed project that are notable and illustrate why increasing the emphasis on fish population monitoring would be worthwhile. The first is that many steelhead in the Wind River exhibit a "mainstem life history" in which a substantial portion of freshwater rearing takes place in the mainstem instead of the spawning tributaries.

[3] Hemlock Dam was scheduled for removal in 2008 but was not actually dismantled until 2009. A separate monitoring project (Hemlock Dam Removal 200707700) has been funded by BPA and is closely linked with the Wind R. watershed restoration effort.

Whether the amount of tributary rearing will gradually increase over time as tributary habitat continues to improve would be valuable information. Additionally, many streams in the Wind River, including upper Trout Creek, have naturally spawning populations of brook trout. How this non-native species will respond to habitat restoration, and how they will interact with steelhead and possibly Chinook salmon, is also worth knowing.

In summary, the Wind River habitat restoration and monitoring programs appear to be well coordinated. A solid working relationship has been established between the USGS Western Research Center at Cook, the Underwood Conservation District, Washington Department of Fish and Wildlife (WDFW), and the Forest Service. Each of these organizations plays a major role in this project. Due in part to the somewhat simplified land ownership pattern in the Wind River subbasin, coordination among various management entities has been better than average. Limiting factors have been examined multiple times in the past and have been modeled using EDT, and it is to the partnership's credit that they are willing to periodically reassess their limiting factor assumptions. The addition of CHaMP habitat monitoring protocols is a potential benefit, but the most important need at present is expansion of the biological monitoring effort. Trout Creek and Panther Creek are reasonably well-studied, but strengthening fish monitoring, with particular emphasis on adult spawning and smolt production, in other parts of the watershed where restoration is taking place would make the project even more valuable.

b. Water Entity – Water Transaction Program - 200203101

With a large annual budget, this project is one of the most expensive efforts funded by the Fish and Wildlife Program. It is a good example of a well-intentioned program that in theory will provide significant habitat benefits to resident and anadromous fish populations. However, aside from documenting the quantity of water reserved to in-stream uses through water rights acquisitions, there have been relatively few definitive demonstrations of biological benefits. To demonstrate that the investments in water acquisitions are worth it, the project should produce more details about its record of success. In particular, examples are needed showing that increases in fish habitat or various population metrics can be attributable to increased flows resulting from Columbia Basin Water Transaction Program (CBWTP) acquisitions and not from other restoration actions taking place in the same watersheds.

The project has six objectives: 1) improve flow rates through identified stream reaches, 2) improve water volumes, 3) improve available habitat, 4) improve egg-to-smolt survival, 5) increase off-channel habitat, and 6) monitor species diversity and abundance. Each water acquisition is mediated by a "qualified local entity" (QLE), which coordinates the transaction and arranges for implementation and monitoring. Each QLE uses its own approach to predict and monitor the effects of water acquisitions, and details about why certain methods were selected over others are often not provided in project reports. An example is the frequent use of Instream Flow Incremental Methodology (IFIM) techniques to assess habitat improvements after flow increases. Although IFIM protocols have been in widespread use throughout the west for the last three decades, other methods (newer habitat models, as well as a variety of channel classification techniques) could be employed to estimate habitat change. Project cooperators have generally failed to provide evidence that alternative decision support tools have been considered.

The program would benefit from providing details of how subbasin analyses and knowledge of limiting factors are incorporated into water acquisition priorities. Water transactions should be framed within the larger context of Columbia River Basin priority needs. This would be particularly helpful in locations such as the Upper Columbia province, where large-scale integrated habitat restoration efforts are occurring (e.g., Upper Columbia Implementation and Action Effectiveness Monitoring – 201007500). The project provides an extensive accounting of programs and plans within the region where in-stream flow is identified as a critical factor, but does this in a general manner rather than tying the CBWTP specifically to these programs. This list establishes the importance of stream flow more than it establishes the significance of the CBWTP to regional programs concerned with improving flows. Implementation results are presented in terms of acre feet of water conserved through the program (either permanently or temporarily) through water rights agreements. It is difficult to place these water gains in a larger context.

In addition to estimating acre feet of water reserved for in-stream use through the CBWTP, it would be helpful to estimate what percentages of the river flow during the irrigation season these figures represent. Likely the contribution of the CBWTP varies from subbasin to subbasin, but without knowing how it has impacted rivers during the low flow period it is difficult to judge the program's success. Again, the main difficulty arises when insufficient information is presented to permit an assessment of the impact of the water acquisitions on fish habitat quantity and quality (e.g., x% increase in base flow, approximate increases in the area of key habitats, effect of the water acquisitions on in-stream temperatures, etc.). We suspect that delays in implementing effectiveness monitoring - both habitat and biological response - have restricted the amount of available data, but the project needs to report a more thorough summary of results to date.

The QLEs have adopted the ISRP's recommendations for prioritizing water transactions (ISRP 2003-1) - a good example of adaptive management. It would also be useful to know if adoption of the prioritization criteria has resulted in any shifts in QLE approaches to working with landowners. As well, we recommend the CBWTP cooperators carefully examine other basin-wide aquatic habitat monitoring programs (e.g., CHaMP/ISEMP, AREMP, EMAP) to determine what elements of those programs can contribute to the water acquisition decisions and monitoring efforts undertaken by the QLEs.

Programmatic changes include the expansion of the application of market-based mechanisms for water conservation to acquisition decisions. CBWTP state that they have "advanced water transactions as a cost-effective tool for restoring flow to imperiled rivers and streams," but to our knowledge the cost effectiveness of the CBWTP approach has not been fully assessed.

Recent reports and proposals provide an adequate description of the changes in the program over time to adapt to changing circumstances; mergers of QLEs, QLE prioritization of acquisitions, experimentation with new acquisition tools, implementing related programs, and the development of monitoring protocols in response to recommendations of a 2007 external program review and ISRP reviews that the biological impacts of the acquired water be evaluated. In spite of some of the concerns expressed here, the program does appear to have a reasonably good history of learning from past experience and adapting approaches on the basis of what has been learned and in response to changing conditions.

Since 2002, the program has completed over 240 water right transactions and has restored over 819 cfs of flow to tributary streams using various water acquisition methods.[4] It is impossible from the data available to know how much of flow improvement has occurred at critical flow times of the year (perhaps flow improvement should be summarized differently). In terms of priority localities for water acquisitions, it is noted that stream flow has been mentioned in subbasin plans or other key documents. However, CBWTP also relies on willing landowners and the presence of other activities in the area to play an important part in the decision making process. There seems to be an approval process that would tend to eliminate less important transactions. The program was independently evaluated in 2007, with a report indicating that in addition to monitoring compliance and flow benefits, that standards be established for habitat monitoring.

Biological effectiveness monitoring methods are the responsibility of the QLEs, but there should be a statement of the types of methods that BPA would consider reasonable. The ISRP notes that even after the nine years that the project has been in place, many water transactions still do not have an agreed-upon effectiveness monitoring plan. Additionally, the QLEs may have to rely on cooperation from other effectiveness monitoring efforts in the area (e.g., the CHaMP/ISEMP project), and how the Water Transactions Program would contribute to the implementation and funding of effectiveness monitoring should be better defined. Despite having developed protocols for biological monitoring and compliance monitoring in the past year, details of these protocols or how they will be applied to monitoring or data collection have not yet been published.

Flow monitoring will be a key component of assessing the habitat effects of water acquisition, and the project has provided reasonable details concerning where flow monitoring would be carried out. It would be helpful, however, for the QLEs to describe how quality assurance and quality control will be accomplished on the flow determinations. This is important because some of the water acquisitions will comprise a relatively small percentage of the river's discharge and accurate flow measurements will be needed to verify that flow objectives are actually being achieved. It would also be helpful for the project to describe in more detail where data related to water acquisitions and post-acquisition monitoring are archived and made publicly available.

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[4] The Taurus web site shows 100 transactions and 500 cfs, but the larger accomplishment figures were presented in the most recent project proposal and are used here.

Appendix. Detailed Summaries of Artificial Production Project Results

The artificial production project proposals and contextual projects considered in the RMEAP Category Review included (a) projects that involve planning, development, operation and maintenance of artificial production programs implemented through the Council's Program; (b) projects that specifically collect and analyze monitoring data used to evaluate the Program's artificial production initiatives; and (c) research, monitoring, evaluation and coordination projects investigating critical hatchery uncertainties, the effectiveness of hatcheries and effects of hatchery production on natural salmon (NPCC 2011, Council decision document, page 20). In general these projects received favorable ISRP review with regard to their ability to collect and summarize data required for reporting results achieved by these programs relative to their intended objectives established in subbasin plans, hatchery master plans, and artificial production principles in the Fish and Wildlife Program.

In this retrospective report the ISRP presents the results reported by research projects investigating critical hatchery uncertainties and the results of Fish and Wildlife Program production initiatives. The main body of this report provides a brief summary of findings along with ISRP conclusions and recommendations. In this Appendix, more extensive summaries are provided of the data and analyses of research efforts and production initiatives, drawn from both project proposals and from recent project annual reports. These summaries form the basis of the ISRP findings, conclusions, and recommendations.

There are three primary topics regarding the efficacy and effects of artificial production programs in the Columbia River Basin:

- To what extent can artificial production initiatives achieve the adult production and harvest goals established in hatchery master plans and legal mitigation agreements (e.g., Revised Hood River Hatchery Master Plan, Lower Snake River Compensation Program, John Day Dam Mitigation Program, U.S. v. Oregon);

- To what extent can hatchery-origin adult salmon and steelhead contribute to recovery of natural populations by spawning in nature (aka supplementation projects);

- To what extent do hatchery programs have adverse effects on natural populations – effects on fitness of the natural population following interbreeding and effects on abundance and productivity through ecological effects of predation, competition, and disease transmission.

Hatchery production has been, and continues to be, the primary strategy for directly providing fish for harvest and conservation. Scientific frameworks for implementing hatchery production have received substantive independent scientific review (NPPC 1999-4), and Council has established artificial production principles and performance standards (NPPC 1999-15). The ISRP and ISAB have provided guidance on specific monitoring and evaluation metrics and analyses consistent with this scientific framework (ISAB 2000-4, ISRP/ISAB 2005-15, ISRP 2008-7).

Assessing hatchery production initiatives (i.e., implementing a master plan) 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 fish outside the hatchery (ISAB 2000-4). Information and assessment in these three areas is required to establish benchmarks for survival in the hatchery environment, to understand how practices in the hatchery influence post-release survival and performance, to establish post-release survival for harvest management, and to establish quantitative estimates for benefits and risks to natural populations.

For select production programs reviewed in the RMEAP Category Review, the ISRP used information in Taurus and in recent annual reports to assemble information on the essential metrics for hatchery performance, post-release performance, and interactions with natural populations. Time availability and ongoing ISRP assignment obligations precluded summarizing every production program.

Raising salmon and steelhead in captivity and releasing them into the natural environment entails challenges during both captive culture and following reintroduction, including nutrition, disease, endocrinology, and genetics. The presence of hatchery and wild salmon in populations being harvested and in spawning runs creates difficulties in managing harvest and assessing the status of natural populations. To address these challenges there are a number of Fish and Wildlife Program projects aimed at improving the performance of hatchery fish post release and aimed at better understanding the interactions of hatchery and natural salmon in the wild. For these projects we present the management reasons for implementing the project and summarize results and accomplishments during the most recent funding cycle (2007 – 09).

A. Hatchery Uncertainties Research and Development – Basinwide

1. Relative Reproductive Success and Genetics of Hatchery Salmon and Steelhead

Projects reviewed in the RMEAP category review.

Project Number	**Proponent**	**Subbasin**	**Species**
198909600	NOAA	Imnaha	Steelhead
198909600	NOAA	Grande Ronde	Spring Chinook
200303900	NOAA/WDFW	Wenatchee	Spring Chinook
200305000	U of Wash	Forks Creek	Steelhead
200305400	OSU	Hood River	Steelhead
200306300	USFWS	Abernathy Ck	Steelhead
200720900	ODFW	Deschutes	Steelhead
200900900	*CRITFC*	*Multiple*	*Multiple*
201003300	*WDFW*	*Methow*	*Steelhead*

1. Italics projects were reviewed in the Accords or Fast Track Review and used for context in the RMEAP category review

Background

Adult salmon and steelhead are produced as juveniles in hatcheries in the Columbia River Basin for harvest mitigation and to contribute to recovery mix with natural-origin fish in many spawning populations. Intermixing of hatchery-origin and natural-origin salmon and steelhead complicates estimating the viability of natural population required for evaluating species status under the Endangered Species Act. For both status assessment of natural populations and evaluation of intentional supplementation, it is necessary to know the relative reproductive success of the hatchery-origin adults spawning in the wild compared to natural-origin adult salmon and steelhead.

To estimate the relative reproductive success, it is necessary to have a large number of genetic markers to identify and track individual parents, an ability to capture a large fraction of the potential breeding population to sample the pool of parents, and an ability to capture juveniles or adults produced by the parent pool. Advances in genotyping technology had progressed sufficiently so that the 2000 FCRPS Biological Opinion included Reasonable and Prudent Action 182:

> *The Action Agencies and NMFS shall work within regional priorities and congressional appropriations processes to establish and provide the appropriate level of FCRPS funding for studies to determine the reproductive success of hatchery fish relative to wild fish. At a minimum, two to four studies shall be conducted in each ESU. The Action Agencies*

shall work with the Technical Recovery Teams to identify the most appropriate populations or stocks for these studies no later than 2002. Studies will begin no later than 2003.

On March 14, 2003 BPA initiated a Request for Studies: Research, Monitoring, and Evaluation that solicited proposals for projects to fulfill the mandate of FCRPS 2000 BiOp RPA 182. Proposals were received, reviewed by the ISRP, and recommended for funding by Council and implemented by BPA. Ongoing projects 200303900, 200305000, and 200305400 reviewed in the RMEAP category review were begun from this request for studies.

The 2008 FCRPS Biological Opinion RPA 64 called for continuing relative reproductive studies for listed salmon:

Subaction 64.1
Estimate relative reproductive success (RRS) of hatchery
Continue to estimate the relative reproductive success (RRS) of hatchery-origin salmon and steelhead compared to reproductive success of their natural-origin counterparts for ESA-listed spring/summer Chinook population in the Upper Grande Ronde, Lostine River, and Catherine Creek; listed spring Chinook in the Wenatchee River, and listed steelhead in the Hood River. Continue to fund the ongoing RRS feasibility study for Snake River fall Chinook to completion in 2009.

Subaction 64.2
Determine if artificial production contributes to recovery
Determine if properly designed intervention programs using artificial production make a net positive contribution to recovery of listed populations.

Subaction 64.3
Fund new RRS study for ESA-listed steelhead in Methow River
In collaboration with the other entities responsible for steelhead mitigation in the Methow River, BPA will fund a new RRS study for ESA-listed steelhead in the Methow River and will also fund a new RRS study for listed fall Chinook in the Snake River. NOAA Fisheries will provide technical assistance to the Action Agencies in development of conceptual study designs suitable for use by the Action Agencies in obtaining a contractor to implement the new studies.

Project 200900900 was evaluated in the Columbia River Fish Accord Proposal review initiated in November 2008, project 201003300 was evaluated during the RME Fast Track review April 15, 2010. Project 200720900 was submitted in the 2003 Request for Studies, received a meets scientific review criteria recommendation by the ISRP, was not funded, was submitted again in the 2007-09 open solicitation and not funded, but was approved for funding in 2010. Field results are not available for these last three projects. They are presented here to provide context for the breadth of species, geographic areas, and hatchery programs (supplementation and reintroduction) included in this uncertainties research.

Project 198909600 began as an investigation of genetic changes in natural spring Chinook populations in the Snake River from interaction with hatchery salmon using allozymes and tracking allele frequency changes. Advances in genotyping technology permit parentage and mixed stock fishery analysis superseding the original experimental design. Relative reproductive study designs using microsatellite DNA markers have been added to this project.

Reported Results from Fish and Wildlife Program Relative Reproductive Study Projects

Table 5. Relative reproductive success reported by Fish and Wildlife Program projects reviewed in the RMEAP Categorical Review.

Project	Species	Subbasin	Hatchery Program	Life-stage	Effect Estimated	Sex	RRS
Steelhead							
198909600	Summer Steelhead	Imnaha	Local Broodstock	Adult to Smolt	Confounded	Combined	0.49
	Summer Steelhead	Imnaha	Local Broodstock	Adult to Adult	Confounded	Combined	0.41
200305400	Winter Steelhead	Hood River	Non-Local	Adult to Adult	Confounded	M	0.06
						F	0.11
	Summer Steelhead	Hood River	Non-Local	Adult to Adult	Confounded	M	0.30
						F	0.30
	Winter Steelhead	Hood River	Local Broodstock	Adult to Adult	Confounded 1st Generation	M	0.86
						F	0.98
	Winter Steelhead	Hood River	Local Broodstock	Adult to Adult	Confounded W v H(ww)	M	0.50
						F	0.77
	Winter Steelhead	Hood River	Local Broodstock	Adult to Adult	Confounded W v H(cw)	M	0.32
						F	0.30
	Winter Steelhead	Hood River	Local Broodstock	Adult to Adult	Genetic H(ww) v H(cw)	M	0.54
						F	0.55
	Winter Steelhead	Hood River	Local Broodstock	Adult to Adult	Genetic W(ww) v W(cw)	M	0.92
						F	0.84

Project	Species	Subbasin	Hatchery Program	Life-stage	Effect Estimated	Sex	RRS
	Winter Steelhead	Hood River	Local Broodstock	Adult to Adult	Genetic W (ww) v W(cc)	M	0.31
						F	0.42
200306300	Winter Steelhead	Abernathy Creek	Local Broodstock	Adult to Smolt	Confounded	Combined	0.33
200305000	Winter Steelhead	Forks Creek Non-Columbia R	Non-local	Adult to Smolt	Confounded	Female	0.06
	Winter Steelhead	Forks Creek Non-Columbia R	Non-local	Adult to Adult	Confounded	Female	0.07
Spring-Chinook Salmon							
198909600	Spring Chinook	Grande Ronde Catherine Creek	Local Broodstock	Adult to Smolt	Confounded	M	0.97
						F	1.14
	Spring Chinook	Grande Ronde Catherine Creek	Local Broodstock	Adult to Adult	Confounded	M	0.66
						F	0.91
200303900	Spring Chinook	Wenatchee	Local Broodstock	Adult to Smolt	Confounded	M	0.62
						F	0.51
	Spring Chinook	Wenatchee	Local Broodstock	Adult to Adult	Confounded	M	0.49
						F	0.63
2. Genetic v Env: Genetic – RRS estimates a genetic effect; Confounded – RRS estimates genetic and environmental effects together.							

Table 5 above provides simple arithmetic means for natural-spawning relative reproductive success between different types of fish, both hatchery-origin versus natural-origin and between hatchery-origin fish with different parent types and between natural-origin fish with different parent types, reported by Fish and Wildlife Program projects in the RMEAP Taurus proposal, annual reports, and peer-reviewed publications. The projects involve steelhead in four watersheds and spring Chinook in two watersheds.

These results, using microsatellite DNA markers and parentage analysis, are largely consistent with published reports from the 1970s, 80s, and 90s that employed allozyme markers and mixed stock fishery analytical methods or behavioral observations (Reisenbichler and McIntyre 1977, Chilcote et al. 1986, Leider et al. 1990, Fleming and Gross 1993, Fleming et al. 1997) summarized by Berijikian and Ford (2004) and Araki et al. (2008). The relative reproductive success of hatchery-origin adults is typically less than natural-origin adult salmon and steelhead. The range and variation in relative reproductive success among species and systems is substantial and warrants discussion.

Steelhead

Contemporary hatchery programs in the Pacific Northwest include a mix of harvest mitigation programs that use non-local stocks (the released fish were originally derived from stocks in a different geographic area) and supplementation programs that use locally derived broodstocks to produce fish that are hoped to be better adapted to local watershed environments with the intention of contributing to both harvest and recovery.

Non-local hatchery stocks of steelhead have exhibited very small relative reproductive success when contrasted with local natural-origin steelhead (see 200305400 Hood River winter and summer steelhead non-local RRS and 200305000 Forks Creek winter steelhead, RRS table 5).

Local stocks of steelhead used in supplementation programs exhibit a range of relative reproductive success. In the Hood River (200305400), in the first generation when wild fish were used as parents in the hatchery, the subsequent hatchery-origin parents had 86% (males) and 98% (females) of the success of natural-origin counterparts and were not statistically different. In later generations, when the hatchery population was composed of both returning hatchery- and natural-origin parents, the relative reproductive success of hatchery fish in the wild was only 50% (males) and 77% (females). Similarly, in the Kalama River first generation hatchery-origin steelhead had reproductive success indistinguishable from the wild population from which they were derived (Sharpe et al. 2010). Information from subsequent generations of steelhead propagation in the Kalama is yet to be reported. In the Imnaha River (19890960), a steelhead supplementation program using local fish was initiated in 1982, and the hatchery propagation includes using returning hatchery adults in the broodstock. For this program, the relative reproductive success of hatchery-origin adults estimated for the brood-years 2000 through 2005 (approximately six generations) ranged from 29% to 59% of the natural-origin fish.

The studies of relative reproductive success that involve comparing hatchery-origin and natural-origin salmon or steelhead are unable to unambiguously determine the extent to which the difference in performance is due to genetic effects and that due to the hatchery rearing experience (including low reproductive success owing to spawning in poor habitats because they are imprinted on acclimation and release sites). The Hood River steelhead investigation has accomplished analysis that permit a more direct estimate of the genetic effects. Comparisons have been made of the natural-spawning relative reproductive success of hatchery steelhead that had either two natural or one natural and one hatchery parent when produced in the hatchery [H(WW) v H(HW) comparison]. Hatchery-origin steelhead that had a hatchery-origin parent had only 55% of the production of hatchery-origin steelhead that had two natural-origin parents. There is evidence for a substantial genetic contribution to the reduced relative reproductive success observed in steelhead.

It is also necessary to determine whether the natural progeny of naturally spawning hatchery fish exhibit depressed reproductive performance when they return as adults. The Hood River studies have been able to address this question by comparing the relative reproductive success of natural-origin fish that had two natural, one natural and one hatchery, or two hatchery parents [W(WW) v W(HW) and W(WW) v W(HH) comparisons]. Natural-origin steelhead that had one hatchery-origin parent had 92% (males) and 84% (females) of the reproductive success of natural-origin steelhead with two natural-origin parents; natural-origin steelhead with two hatchery-origin parents had 31% (males) and 42% (females) of the reproductive success of natural-origin steelhead with two natural-origin parents. These investigations involved hatchery stocks of local-origin. The implication of this observation is that deleterious genetic effects from the hatchery may depress the productivity of the natural population.

Spring Chinook

The two relative reproductive studies of hatchery spring Chinook that have reported results are both examining supplementation programs using broodstocks established with local fish.

In Catherine Creek in the Grande Ronde subbasin data has been collected from returning adults since brood-year (BY) 2002. Evaluation of relative reproductive success in parr and migrating juvenile production has been completed for BY 2002 through BY 2007 and in adult production for BY 2002 – BY 2004. Combined by age and sex, the relative reproductive success of hatchery-origin adults is 103% for parr production, 100% for migrant production, and 77% for adult production. Jacks are returning in small numbers and their production of progeny is less than expected based on their relative abundance. However, some jacks are very successful in producing smolts, whereas most fail. Precocious parr have been caught in smolt traps in 2005 (N=90) and 2007 (N=40), and both their parents and offspring have been identified.

In the Wenatchee River subbasin spring Chinook supplementation was implemented in the Chiwawa River tributary in 1989 as part of the Rock Island Mitigation Agreement and operated under the Rock Island Habitat Conservation Plan. Relative reproductive studies of the program (project 200303900) began in 2004. To date, relative smolt production is completed for BY 2004 – 2007, and relative adult production is evaluated for BY 2004 and 2005 for adult returns through 2009.

Male and female hatchery-origin spring Chinook in the Wenatchee/Chiwawa supplementation program have about half of the smolt and adult reproductive success relative to natural-origin salmon of the same sex and age. When the analysis includes spawning location as a covariate, the difference in reproductive success between hatchery- and natural-origin females is non-significant for both smolt and adult production in all years. Hatchery-origin females spawn lower in the tributaries in habitat that is less productive for both natural- and hatchery-origin fish. Whether hatchery-origin spawning location is owing to homing to juvenile release sites or migratory behavior is unknown. For males, when weight and spawning location covariates are included in the analysis, hatchery-origin remains a significant factor for smolt production for the 2006 BY and for adult production by the 2005 BY.

ISRP Comments on the Aggregate Relative Reproductive Studies

Replication, Gaps, Study Longevity

The original 2000 BiOp called for two studies of relative reproductive success per ESA listed evolutionarily significant unit (ESU, aka distinct population segment [DPS]). The follow-up 2008 BiOp called for continuing RRS investigations for spring-Chinook in the Wenatchee River and Grande Ronde River subbasins, and steelhead in the Hood River subbasin. Additionally, a steelhead RRS study was identified for the Methow River and a fall Chinook RRS study in the Snake River.

Former and ongoing RRS studies do not cover the entire range of ESA ESUs. There is no explanation for why the scope of RRS investigations was reduced in 2008 from the level in the 2000 BiOp. The current Fish and Wildlife Program investigations provide coverage of all but the Snake River fall Chinook RRS study that were identified in 2008 BiOp RPA 64.

In addition to the investigations to fulfill the RPA 64 obligation, RRS studies were initiated through CRITFC Accord Proposal 200900900. This project will provide genotyping and analysis for the Nez Perce Tribe’s Johnson Creek spring Chinook supplementation project (JCAPE, 199604300) and begin RRS studies in spring Chinook and coho salmon reintroduction projects. Spring Chinook relative reproductive studies of various scopes are conducted within the Idaho Supplementation Studies (199809800), and Yakima River Monitoring and Evaluation (199506325). Steelhead relative reproductive studies are ongoing in the Kalama and Wenatchee rivers using Mitchell Act and PUD funding respectively. Outside of the Columbia River Basin studies of coho and chum salmon are ongoing.

There appears to be reasonable replication of steelhead and spring Chinook salmon (yearling/stream life history type) studies, and a need for Snake River fall Chinook (underyearling/ocean life history), coho, and chum salmon studies.

The ISRP is not aware of any statistical algorithm or test that will establish the number of stream or system replicates needed, or the number of generations required, to fully capture the range and variation in relative reproductive success between hatchery- and natural-origin salmon and steelhead. Based on the empirical evidence that is accumulating, at least two, and probably not more than three salmon generations in multiple systems for different life-history types should provide baseline estimates of the important parameters.

Coordination and Integration of Projects

After the initiation of new investigative endeavors, like these relative reproductive success studies, there will be surprises and challenges in the effort to collect fish in the field, in efforts to genotype fish, to assign fish to parents, and to analyze and interpret the data. These challenges have been evident in the relative reproductive studies. In some cases weirs have failed and adults have accessed spawning grounds without being sampled, juveniles have migrated without being sampled, fish have spawned below weirs complicating experimental design, and many fish cannot be matched with known parents. In a few select locations like the Wenatchee River with Tumwater Dam and the Hood River with Powerdale Dam (now removed), it appears that robust fish capture, data generation, and analysis were in place. In order to efficiently integrate the information from different species and river systems, the ISRP believes that coordination to produce data and analysis that is consistent among projects is warranted. Further, the Columbia River co-managers need to refine and clarify the purpose of collecting this data and describe how it will be incorporated into viability analysis for ESA biological reviews and artificial production program risk assessments. For example how will these data inform AHA modeling, the Columbia River Hatchery Effects Evaluation Team (CRHEET) framework, and NOAA biological opinions for hatchery programs?

Environmental and Biological Correlates and Mechanisms Research

For at least some of the ESU life-history types and river systems the initial question of what is the relative reproductive success of hatchery-origin fish has been answered and investigations are beginning on explanation of the observations and research on biological mechanisms producing the results. These research efforts are likely to provide information important to decisions on the use of artificial production for both harvest mitigation and recovery. The ISRP believes that developing a structured decision framework that articulates how the relative reproductive success evidence is going to be interpreted and how the evidence will guide adaptive decision making regarding the Basin’s hatchery system is needed.

2. Hatchery culture practices

Project Number	Title	Proponent
1993-056-00	Research to Advance Hatchery Reform	NOAA: NWFSC

Research to Advance Hatchery Reform (NOAA: 1993-056-00)

Background

The project goal is to advance hatchery reform throughout the Columbia River Basin by developing fish culture techniques that reduce differences and interactions between hatchery and local salmonids.

Initially this project focused research and development efforts on safety-net programs (captive broodstocks). Project scientists developed methods and provided guidance on best management practices for the ESA-listed populations reared in captivity. Studies on the reproductive performance of captively-reared Chinook salmon focused on the proximate mechanisms responsible for variation in reproductive fitness to support Columbia Basin captive broodstock programs implementing adult release strategies. Methods were developed to reduce early (age-2) male maturation and improve gamete quality. Initially, studies were conducted on the use of gonadotropin-releasing hormone (GnRHa) implants to advance spawning time in sockeye salmon (Swanson 1995; Swanson et al. 1997). Protocols were established for the type of implant, doses, and timing of hormone implants to ensure high fertility of gametes. These have been used in both sockeye and Chinook salmon captive broodstock programs to synchronize spawning of males and females and improve gamete quality (c.f. Swanson et al. 2004). The project has developed diets and growth regimes to reduce early male maturation in Chinook salmon (Silverstein et al. 1998; Shearer and Swanson 2000; Shearer et al. 2006). Results from studies conducted in both coho (Campbell et al. 2006) and Chinook salmon (Campbell et al., submitted; Swanson et al. 2005) demonstrated that oocyte growth prior to yolk incorporation is strongly influenced by body growth. This information and novel research on photoperiod and emergence timing manipulation is now being used to design growth regimes to minimize early male maturation with the goal of matching wild life history phenotypes (proportion of fish maturing at various ages and sizes) more closely.

Research on imprinting in sockeye salmon has formed the basis of recommendations to the Stanley Basin Sockeye Technical Oversight Committee that early releases of captively-reared sockeye may facilitate imprinting and that if captively-reared smolts are released they should experience their natal lake for an extended period to facilitate proper odor learning and imprinting. Behavioral assays of imprinting have demonstrated experimentally for the first time that sockeye salmon learn imprinting odors at multiple developmental stages (the alevin and smolt stage) and the duration of odor exposures was critical for successful imprinting. Ongoing experiments are directly examining the imprinting efficacy of current release strategies employed in Stanley Basin by exposing fish to imprinting odorants during developmental periods and durations that parallel the on-ground assessments of survival being conducted by the IDFG.

Objectives

During the FY 2007-09 funding cycle project 1993-056-00 pursued three objectives: 1) maintain adaptive life history characteristics in Chinook salmon, 2) improve imprinting in juvenile sockeye salmon, and 3) match wild phenotypes in Chinook and sockeye salmon reared in hatcheries. A summary of the results are as follows:

Objective 1. Adult male Chinook salmon access to females, participation in spawning events and adult-to-fry reproductive success increased with their decreasing frequency in a breeding group, providing the first experimental evidence of negative frequency-dependent selection during mating in the family Salmonidae. Jack males exhibited the same pattern (increasing jack success with decreasing jack frequency) although the relationships were not as strong as for adults. Overall, jack and adult males mated with a similar number of females but jacks sired only 20% of all offspring. Offspring of jack males grew faster from egg to smolt than offspring of adult males, demonstrating a genetic basis for growth rates of the two life history types under simulated natural conditions. The implications for broodstock management and the results will be integrated into a planned regional workshop in 2011 on age-at-maturity and broodstock management of Chinook salmon.

Objective 2. To determine the critical period(s) for imprinting for sockeye salmon, juvenile salmon were exposed to known odorants at key developmental stages. Previous molecular assessments of imprinting-induced changes in odorant receptor gene expression indicated that odorant receptor expression is influenced by developmental status and odor exposure history. Specifically, these molecular and behavioral studies demonstrated experimentally that there are multiple critical periods for imprinting for juvenile sockeye salmon and, in particular, the alevin and smolt stages are both important developmental periods for successful olfactory imprinting. Taken together, the results suggest that sockeye salmon are capable of imprinting to homing cues during the developmental periods that correspond to several of current release strategies employed as part of the Captive Broodstock program (specifically, planting eyed eggs, fall and smolt releases into the lake) appear to be appropriate for successful homing of sockeye in Redfish Lake. The results of these experiments have helped captive broodstock biologists develop and prioritize future rearing and release plans to minimize straying.

Objective 3. The results of this study indicate that alterations in the seasonal timing of fry emergence and growth after ponding of Yakima River spring Chinook salmon can have profound effects on later life history events; including age of male maturity, and age and seasonal timing of smoltification. Another study using Sacramento River winter run Chinook salmon showed similar effects of emergence timing and growth on the life history phenotypes, suggesting this may be a more general pattern in Chinook salmon. Many hatcheries manipulate emergence timing and growth to more efficiently utilize facilities that often accommodate different species and to achieve a critical size for tagging prior to release. However, the results of this study indicate that the practice of altering emergence timing can dramatically affect later life history events. Results from this study also show that photoperiod at emergence and feeding regimes can alter the range of phenotypes within a population. Fish reared under conditions to delay emergence and slow growth had the least variation in phenotypes with most fish smolting as yearlings in the spring and no age-1 male maturation. In contrast, early emerging fish raised on high growth conditions had the greatest variation in seasonal timing of smolting and highest rates of early male maturation with most males maturing at age 1.

The FY10 project has three objectives: 1) improve survival and reduce fitness loss in Columbia River steelhead by minimizing unnatural selection on body size and other smolt characteristics, 2) identify behavioral and physiological traits under selection through laboratory-scale research (e.g., body size, smolt development, age-at-maturity, rate of residualism), and 3) validate endocrine and genomic markers of precocious maturation in male steelhead at the time of smolt release.

Objective 1. Hatchery steelhead typically achieve high growth rates and are released as age-1 smolts, whereas natural steelhead typically smolt at age 2 or age 3. Initial findings show that age 2 smolts released from the hatchery were larger, travelled faster (potentially reducing ecological interactions with other salmonids), and had less variable travel time though the hydrosystem (Rocky Reach to Bonneville) compared with the typical age 1 smolts. Survival of age 2 smolts was significantly greater than survival of age 1 smolts from release to Rocky Reach Dam, but survival through downstream dams was similar. Analyses are ongoing.

Objective 2 is ongoing. During year 1, the re-circulating fish culture system was constructed at the Manchester Lab, and water quality and fish growth were examined for adequacy to conduct the experiment beginning June 2011. Tests indicated that the system delivers sufficient flow and water quality to achieve growth rates needed to produce yearling and age-2 steelhead smolts needed for the study.

Objective 3. Previous studies demonstrated that steelhead residuals are a mixture of fish that failed to migrate because they either did not smolt or were maturing males. The investigators demonstrated that yearling steelhead (winter run) that had initiated puberty by May (28% of total v. 36% in September) also tended to have elevated levels of specific hormones. Identification of precocious male steelhead was not clear-cut in May, but conservative estimates could be made that might be sufficient for comparing treatment effects on the proportion of steelhead maturing in hatcheries at the time of smolt release. The investigators believe that that precocious maturation of summer steelhead will be more advanced in May, leading to identification of a higher percentage of precociously maturing steelhead. This research is important because the findings will be used to identify hatchery culture techniques that may reduce precocious maturation, which reduces adults available for harvest and increases interactions with native fishes in streams.

ISRP Comment

This ongoing research effort addresses a critical uncertainty related to hatchery production and its effects on native fishes. The project investigates hatchery steelhead culture approaches that attempt to minimize differences between hatchery and natural salmonids as a means to reduced adverse interactions. The project responds to information gaps identified in the FCRPS Biological Opinion Reasonable and Prudent Alternatives 39, 63.2, 64.2. The project is consistent with Council goals. Detailed annual progress reports and journal publications on associated efforts have been produced.

3. Salmon and Steelhead Gamete Collection and Preservation

Project Number	Title	Proponent
1997-038-00	Listed Stock Chinook Salmon Gamete Preservation	Nez Perce Tribe

Background

This project cryopreserves male gametes (stores frozen sperm cells) from Snake River spring Chinook and summer steelhead to provide a gene bank as a form of *ex-situ* conservation for these ESA listed fish species. The project's scientific rational is based on the empirical demonstration that fish sperm cells can be frozen, stored, and subsequently thawed and used to successfully fertilize eggs. The management justification for the project is the small number of adult fish that were returning to the Snake River basin in the early to mid-1990s.

Results

Gamete collections began in 1992 with support from the Lower Snake River Compensation Program; most of the collections were made from 1997 through 2008 with support from the Fish and Wildlife Program. Currently the project is not collecting additional samples, and resources are being used to maintain semen samples in frozen storage at the University of Idaho, Washington State University, and a subset are being transferred to the United States Department of Agriculture, National Animal Germplasm Program in Fort Collins, Colorado for long-term storage.

The intention of the project was to collect gametes from at least 500 individuals from a minimum of 2 independent populations of each spring Chinook and summer steelhead Major Population Group in the Snake River basin. The numbers of individuals that contributed gametes to the repository from different populations and MPGs are given in tables 6 and 7 below.

Table 6. Spring/summer Snake River Chinook populations included in the *ex-situ* germplasm repository.

Chinook Salmon Major Population Group/Population	Gamete Samples
Grande Ronde / Imnaha Major Population Group	
Minam River	6
Lostine River	177
Catherine Creek	78
Upper Grande Ronde River	59
Imnaha River	521
South Fork Salmon River Major Population Group	
Lake Creek	204
Johnson Creek	417
South Fork Salmon River	375
Middle Fork Salmon River Major Population Group	
Big Creek	189
Marsh Creek	142
Capehorn Creek	42
Elk Creek	1
Upper Salmon River Major Population Group	
Pahsimeroi River	206
Upper Salmon River	356
Other	
Rapid River	217

Table 7. Snake River summer steelhead populations included in the *ex-situ* germplasm repository.

Steelhead Major Population Group/Population	Gamete Samples
Lower Snake River MPG	
Tucannon River	51
Clearwater River MPG	
North Fork Clearwater River	295
Fish Creek	15
Selway River	5
Grande Ronde/Imnaha River MPG	
Upper Grande Ronde River	2
Imnaha River	2
Little Sheep Creek	463
Lightning Creek	3
Cow Creek	4
South Fork Salmon River MPG	
South Fork Salmon River	46
Johnson Creek	4
Upper Salmon River MPG	
Pahsimeroi River	207
Other	
Snake River (Oxbow Hatchery)	306

The goal of collecting gametes from 500 individuals in each population was only achieved in the Imnaha River (Grande Ronde/Imnaha MPG) spring Chinook population. While not achieving the original goal, collections of spring Chinook were from multiple populations and MPGs, and the number collected reasonably large. In contrast obtaining samples from steelhead proved more difficult and while sampling took place in many MPGs, most were from hatchery populations. Age structure comparisons of Chinook salmon that provided gametes to the germplasm collection were similar to the hatchery and natural populations from which they were drawn. Age structure analysis of steelhead samples was not conducted because of the limited sample size. Genetic structure and variation was also used to assess the sufficiency of the collections. Analysis demonstrated that the sampled individuals represented a relative large level of genetic diversity relative to the population from which they were drawn. The individuals that were sampled clustered in the appropriate MPG.

ISRP Comment

In the 2010 RMEAP review, the ISRP recommended a schedule of testing the stored sperm cells, a plan for when to use the gametes, and a protocol for amplifying the genetic material using captive culture strategies. A draft document (Young et al. *in prep*) cited in Young 2010 may begin to serve this task. The ISRP still believes that a decision framework would be most appropriately developed before the populations decline to the abundance levels observed in the mid-1990s.

4. Kelt Reconditioning – Research and Development Pilot Investigations

Project Number	Title	Proponent
2007-401-00	Kelt reconditioning and reproductive success	CRITFC
2008-458-00	Steelhead kelt reconditioning	Yakama Tribe

Background

Steelhead occasionally repeat-spawn (iteroparity). Post-spawned individuals (kelts) migrate downstream and a portion survive the in-river and oceanic migration to return and spawn again, unlike their Pacific salmon cousins (Chinook, coho, chum, and sockeye). Rates of repeat spawning are highly variable, averaging ~10% in coastal populations, whereas summer-run steelhead in up-river populations tend to have much lower rates (~2%). Snake River and upper Columbia River steelhead Evolutionarily Significant Units (ESUs) are listed under the Endangered Species Act, and improvements are needed in adult abundance and productivity to restore these species to viable status. Managers and scientists in the Columbia River Basin have determined that the ESU status of steelhead may be improved by increasing kelt survival. There is also a hypothesis that mortality of kelts at mainstem Snake and Columbia River dams has reduced the incidence of kelt spawning in the upper Columbia and Snake River portions of the basin.

Consequently, Reasonable and Prudent Alternative (RPA) actions have been included in the Federal Columbia River Power System Biological Opinion (FCRPS BiOp) to investigate opportunities to increase kelt survival using 1) operational modifications at dams and 2) active collection, transport, and/or short- and long-term reconditioning of kelts. The assumption is that kelts in an improved condition would likely have higher rates of repeat spawning, and that intervention (reconditioning) could improve their condition.

Kelt reconditioning is used to attempt to increase post-spawning survival and repeat spawning by collecting kelts and holding them for various length of time before releasing them to continue their life-cycle. To assess effectiveness, reconditioning variations are compared to either a group of in-river migrants or a group of kelts that was transported around the hydrosystem.

The in-river migration involves collecting, PIT-tagging, and immediately releasing steelhead kelts at the point of collection, and serves as an experimental control when comparing other operational or reconditioning strategies.

The transport alternative involves collecting and immediately transporting kelts around the hydroelectric projects for release into the Columbia River estuary downstream of Bonneville Dam. This alternative provides for a comparison that helps to isolate and identify the effects of downstream passage through the hydrosystem on kelt survival.

Short-term reconditioning involves collecting and holding kelts until they initiate post-spawn feeding, followed by transportation of kelts around mainstem hydro projects for release into the Columbia River downstream of Bonneville Dam and maturation in the Pacific Ocean. PIT and radio tags have been used to assess survival, movement, distribution, travel time, as well as residence time of kelts in the Columbia River estuary.

Long-term reconditioning involves collecting and then holding kelts for 6-10 months, actively feeding kelts to resume growth and gonadal development. Long-term reconditioned kelts are released in the fall coincident with migration of adult steelhead, typically near their collection location so they may over-winter and return to spawning locations on their own volition.

Fish and Wildlife Program Kelt Reconditioning Study Results

Summaries of study results for various kelt reconditioning treatments in mid-Columbia (Yakima River and Deschutes River [Shitike Creek]) and the upper-Columbia (Okanogan River [Omak Creek]) subbasins using data from the 2009 Kelt Management Plan and 2010 annual report for project 2007-401-00 are presented below. There can be considerable variation in the success rates of these strategies between locations and also between years at the same location.

In-River and Transport

Yakima Subbasin

In-river release (control) of kelts has averaged a return-rate of 4% since implementation in 2005, with its best year (6%) in 2007 and worst (2%) in 2006. The return of transport-only treatment group had a detection rate at Bonneville Dam as high as 7% for the 2004 emigration and as low as 0% in 2007 emigration (Branstetter et al. 2008). Survival from release below Bonneville Dam to ocean entry averages 47% for transport-only treatments in 2004-2008 (Branstetter et al. 2008).

Short-Term Reconditioning

Yakima Subbasin

Data from short-term reconditioned kelts collected during 2005-2008 were compared to transport treatment group and reference kelts that migrated in-river. The 2005-2008 mean percent of kelts returning to Bonneville Dam from these groups was 2.5% from the short-term reconditioned group, 1.75% from the transport only group, and 3.75% for the in-river migrants , whereas the mean of the total multi-year estimates for each treatment (not equal) are 4% (0-9%, 2002-2008) for short-term reconditioning, 3% (0-7%, 2003-2008) for transport only, and 3.75% (2-6%, 2005-2008) for in-river migrants. Survival from release below Bonneville Dam to ocean entry averages 49% for short-term treatments in 2004-2008 (Branstetter et al. 2008)

Long-Term Reconditioning

Yakima Subbasin (Prosser Hatchery- Yakima River)
Over the period of 2000 through 2008, a total of 4,186 kelts were long-term reconditioned (ranging from 512 to 662 fish per season). Survival to maturation and release ranged from 19% to 56% with an average survival of 38% (Branstetter et al. 2008).

Deschutes Subbasin (Warm Springs NFH- Shitike Creek)
Over the period of 2005 through 2008, a total of 38 kelts were long-term reconditioned (from 4 to 14 fish per season). Survival to maturation and release ranged from 0% to 11% with an average survival of 5% (Branstetter et al. 2008).

Okanogan Subbasin (Cassimer Bar Hatchery- Omak Creek)
Over the period of 2005 through 2008, a total of 153 kelts were long-term reconditioned (ranging from 27 to 51 fish per season). Survival to maturation and release ranged from 6% to 28% with an average survival of 14% (Branstetter et al. 2008).

Physiology, Gamete Quality, and Natural Reproduction

Kelt gamete and progeny viability evaluated at Parkdale Fish facility on the Hood River by comparing maiden spawning Skamania summer steelhead with their subsequent performance as reconditioned kelt steelhead demonstrates that egg quantity/quality are similar. Successful natural reproduction has been confirmed for 3 of 4 reconditioned kelts in Omak Creek, Washington. However, parentage assignment of 791 juveniles from Shitike Creek, Deschutes River subbasin, Oregon failed to detect progeny from kelts that were reconditioned and released

Additional Kelt Studies

Recently, at the American Fisheries Society's Annual General Meeting in Seattle (2011[5]), 14 presentations on kelts were included and are highlighted here:

- Seamons and Quinn presented results that provide insights into evolutionary trade-offs associated with iteroparity and the effect of reproductive life history on fitness traits and demography of steelhead populations.
- In the Snake River, the proportion of repeat spawning is often less than 2% (Buelow et al.). Differences in nutritional, electrolyte, tissue damage, or hormone among individuals

[5] http://afs2011.org/wp-content/uploads/downloads/2011/09/AFS_Abstract_Book_9-20-11.pdf

and wild and hatchery fish among years suggested a broad variation, some perhaps pre-disposed.

- Jones et al. found similar differences among fish as Buelow et al., noting that fish size and location in the watershed were also factors in migration timing, condition and survival.
- Penny et al. have developed and utilized bioenergetics models and plan to provide and present further analysis and insight into bioenergetic potential of these important steelhead stocks with other relevant variables and scenarios to improve the evaluation of energy expenditure of migration and spawning in Snake River steelhead trout.
- Metabolic factors and reproductive condition (Caldwell et al.) and life history theory (Mangel) that combines proximate (physiological) and ultimate (evolutionary) mechanisms, and which has been applied to both Atlantic salmon and steelhead, shall allow the empirical comparisons in a conceptual framework. Mangel and Satterthwaite (2008) have presented models of such life history events and a decision framework for smolts, and they suggested similarities in iteroparity.
- Boyce et al. have begun studies on relative reproductive success and migration behavior. They conclude thus far that that only maturing fish migrated upriver and those with higher lipid levels were more likely to show migratory behavior consistent with spawning. Rates of upriver and migration and maturation were <50%, and there may have been "skipspawners".
- Null et al. summarized rates and stated that rates of iteroparity in steelhead vary among populations with greater frequency occurring in southern steelhead populations compared to northern populations and a lower frequency occurring in populations as distance from the ocean increases. They are examining rates in California populations.
- Hatch et al. suggested that long-term reconditioning of kelts shows great promise as a tool for restoration based on data from locations in the Columbia River. Kelts collected in the river, transported, and released below the Bonneville dam returned at rates, averaged over several years, of 13% (John Day), 5.8% (Prosser Dam, fed), 3% (Prosser dam, unfed), and 2% (Lower Granite Dam). Results were highly variable. Fish reconditioned at Prosser Hatchery had 10-times the survival over fish left untreated in the river.
- Branstetter et al. also suggested that kelt reconditioning may be used to bolster or increase this naturally occurring life history trait toward the betterment of depressed steelhead populations throughout the Basin. This was based on gamete and progeny viability of reconditioned kelt steelhead from the Hood River in a hatchery setting. The kelts, when compared against their maiden spawning year, increased in egg production, egg fertilization, and progeny survival. They also compared the long-term reconditioning of kelts against the incoming maiden brood. The kelts on average performed as well or better than the best maiden spawners in egg and progeny performance categories.
- Matala indicated that population-specific rates of iteroparity are variable and have a genetic base. Matala has developed genetics tools to assist in identification and examination of this life history tactic that appears to differ among A-run and B-run populations of the upper Columbia River.

- Davids presented on results to provide baseline data for evaluating kelt mortality and life history characteristics associated with iteroparity among inland steelhead populations, based on PIT tags, to provide in-river survival and migration timing.

ISRP Comments

The focus and magnitude of the research and development work on steelhead repeat spawning is encouraging and much shall be learned. Hopefully information will be obtained that contributes to management decisions regarding recovery strategies. Kelt reconditioning (either transportation, short-term, or long-term) as a recovery tool as envisioned by the agencies is in an early stage of development. It remains to be evaluated whether it can contribute meaningfully as a recovery strategy. Efforts from transportation and short-term reconditioning have not yielded substantial gains compared with in-river migration. Long-term reconditioning has demonstrated some promise. It is possible to recondition kelts. An adequate comparison of reproductive performance between natural and reconditioned kelts has not yet been accomplished. It remains uncertain whether nutrition and gametogenesis in reconditioned kelts is sufficient. In any case, it needs to be recognized that successful reconditioning – survival and subsequent reproduction – is a necessary but not sufficient condition for kelt reconditioning to provide benefits for recovery.

Evaluation of the demographic effects of kelt reconditioning on viability assessments at the population and ESU are necessary, and this remains a challenge. Even if successful (i.e., reconditioned kelts spawn and contribute to filling the habitat to capacity with fry and smolts), in many cases habitat may already have been filled to its smolt capacity, and steelhead populations may not effectively recover since the limiting life stage remains in survival from smolt to adult. Further, it is possible that the recruitment from re-conditioned kelts to the smolt-to-adult return stage in the wild may be less than from non-reconditioned or wild kelts that survive at high rates at sea.

The scale of implementation required to affect steelhead population viability and contribute to recovery and delisting is needed before the strategy can be judged as providing benefits to fish. Fish managers need to recognize that there appears no end point to implementation if it is judged effective. Even if the artificial process of kelt reconditioning performed as hoped, agencies would be committed to a continuing program, since reconditioned kelts are incapable of redress the cause of depressed abundance and productivity. Beyond the logistics of kelt re-conditioning, much more work is required via population modelling and computer simulations to explore the demographic consequences of this action. Several habitat-based life history and demographic models are available as a template for this work, including AHA and SHIRAZ, but also the life history models of Mangel and Satterthwaite (2008). Such work requires a clear definition of the overall objectives, i.e., not just the logistics of the re-conditioning tactic per se; objectives and appropriate response variables remain obscure in most of the kelt re-conditioning studies to date.

Passage of kelts remains an issue. Arguably, effort and expense at kelt reconditioning might be better placed at efforts to improve passage of kelts though Columbia River dams, both upstream and downstream, if necessary. Alternatively, a recent paper suggests that kelt passage at the Bonneville Dam at least, has been addressed and 80% of kelts are routed away from turbines (Wertheimer 2007). A comparison of in-river migration and survival rates within an un-obstructed system, similar to the Welch et al. (2008) study on smolts would be also be of comparative interest, as would further studies of migration of kelts at sea, and in comparison to smolts (Welch et al. 2011). Research on passage issues continues, as described in the Plan, mainly at the Dalles Dam.

It appears that a previous ISRP recommendation on kelt re-conditioning still applies: “The ISRP finds … the overall assumed benefits to steelhead NOR abundance (or other VSP criteria) has not been established…and the evaluation methods are not sufficiently detailed to determine the ability to measure any benefit that might occur. The ISRP believes that if further consideration is given to kelt reconditioning as a recovery strategy the appropriate beginning point is a review of iteroparity in UCR steelhead leading to simulation and recruitment analysis that includes historical and current rates of iteroparity, potential benefits of using reconditioned kelts, and the effect of altering the rates of iteroparity on steelhead life-history. This would serve the important function of identifying the potential benefit to steelhead VSP metrics that would need to be produced using kelt reconditioning as a recovery strategy and quantified during implementation. This background effort has not yet been completed.” (ISRP 2009-33).

The recent 2009 Kelt Plan has begun the review process, but the more difficult simulation and recruitment analyses remains. There is at the least a need for a program and ISRP review of the eventual Plan prior to development of basinwide implementation as a recovery tool. In addition to a revised Plan review, further research by agencies and graduate students should continue, including the life model studies mentioned above, to be presented within a Master Plan. Even afterwards, it shall remain debatable if intervention and kelt reconditioning should be implemented on a grand scale.

5. Sockeye Salmon

Project Number	Title	Proponent
2007-402-00	Snake River Sockeye Captive Propagation	NOAA, IDFG, SBT
2008-503-00	Factors Limiting the Abundance of Okanagan and Wenatchee Sockeye Salmon	CRITFC
2008-307-00	Development of a sockeye salmon population in Deschutes Basin	CTWSR

Snake River Sockeye Captive Propagation – Project #2007-402-00

Background

This project is a consolidation of five previous projects related to the Snake River sockeye salmon captive broodstock program. The primary goal is to use the existing Snake River sockeye salmon (*Oncorhynchus nerka*) captive broodstock to rebuild the natural population that was listed in 1992 as Endangered under the United States Endangered Species Act. Captive broodstock culture provides a safety net that attempts to maintain the genetic uniqueness of this ESU that probably would have gone extinct without the intervention in the early 1990s. The captive broodstock will remain the primary source of gametes for reseeding natural habitats for the next few years. These reseeding efforts, which have included the release of pre-spawning adults, smolts, pre-smolts, fry and eyed-eggs, have recently enabled hundreds of anadromous adults to return to the Sawtooth Valley for natural spawning. The progeny of these natural spawners are exposed to natural selection that hones their adaptive traits to unique habitat that is located at a higher elevation and greater upstream migration distance than any other anadromous sockeye salmon population in the contiguous Unites States. The smolt release program will be expanded via the proposed Springfield Hatchery to increase overall population abundance. Over time, as All-H factors affecting the ESU are potentially resolved, the Program proponents expect these releases will lead to a self-sustaining population of sockeye salmon. All hatchery operations and monitoring activities are funded by BPA.

The ISRP (2011-2) recently reviewed the Master Plan (Step One) for the Springfield Sockeye Hatchery, which represents Phase 2 (re-colonization) of the three-step rebuilding plan. The ISRP concluded that the Plan generally meets scientific review criteria, but it requested a response to a number of issues. In particular, there is a need to estimate improvements needed in terms of smolts produced per spawner and smolt-to-adult returns necessary for rebuilding of the natural population. This information should be used to guide restoration efforts while also accounting for variable ocean conditions.

Fish Production Goals

NOAA Fisheries interim recovery goals for sockeye salmon abundance are 1,000 naturally-produced adults returning to Redfish Lake and 500 naturally-produced adults returning to two additional lakes. The current (Phase 1) release goals for the program are (IDFG 2010):

- 50,000 eyed-eggs planted in egg boxes in Pettit Lake
- 100,000 pre-smolts planted in Redfish, Alturas and Pettit lakes (combined release)
- 150,000 smolts planted at the outlet of Redfish Lake and in the Upper Salmon River upstream of the Sawtooth Hatchery, and
- 400 full-term hatchery adults planted primarily in Redfish Lake

The Program plans to transition to a conventional hatchery program following the construction of the Springfield Sockeye Hatchery, which is currently under review. The production goal for the Springfield Hatchery is 400,000 to 1 million marked smolts per year. The targeted smolt release size is 23-45 g, which is considerably larger than most naturally-produced sockeye smolts. The captive broodstock program would be terminated when the 5-year running average of hatchery- and natural-origin adult sockeye returns to the hatchery and Redfish Lake exceeds 2,150 adults (IDFG 2010; see additional trigger values).

Recent Artificial Production

The captive broodstock has successfully maintained an *ex-situ* population of Snake River sockeye salmon, as shown by the number of eyed-eggs, pre-smolts, smolts, and adult salmon released into the lakes since 1993 (Table 8). Fish production goals listed above have been met in most recent years except less than 100,000 presmolts have been released in recent years. Evidence suggests that the current population contains over 90% of the genetic variation of its founders (IDFG 2010). The captive broodstock program has demonstrated high survival during each life stage while held in captivity (Table 9; IDFG 2010). Egg to smolt survival in the hatchery was approximately 58%, which is much higher than survival of sockeye salmon in the wild. This high survival rate is key to viable hatchery production because hatchery fish released into the lakes typically have higher mortality than wild counterparts.

Post Release Survival, Adult Returns

Sockeye salmon are monitored in the lakes, during smolt emigration, and during adult return. Overwinter survival of pre-smolts varies considerably year-to-year and from lake to lake (Table 10). The smolt-to-adult return rate averaged 0.5% (range: 0.23-1.1%, P. 7 of IDFG 2010). The average recruit per hatchery female spawner was 7.0 during brood years 2004-2006. In contrast, the average SAR of natural smolts was 1.41% (range 0.84-1.92%) with an average recruit per female spawner of 2.5, or R/S = ~1.25. Available survival data indicate that a natural population of sockeye salmon may not be self-sustaining even during the favorable conditions that produced relatively high survival rates in recent years. Approximately 70-88% of returning adults in 2008 and 2009 originated from hatchery rather than natural spawning areas (including eyed egg plants) (Table 11).

ISRP Comments

The project has successfully developed a captive broodstock program and prevented extirpation of the sockeye population. Success with the captive program and recent favorable environmental conditions in the mainstem river and ocean environment has led to increased adult returns to the watershed. The program is transitioning to a hatchery program with a goal of releasing approximately 500,000 to 1 million smolts per year. While it is worthwhile to build upon relatively high survival of sockeye salmon in recent years and transition to a conventional hatchery program, it is important to recognize that substantial improvements in survival are still needed before a natural population could be viable. In response to the increasing numbers of sockeye salmon in the system, the program needs to continue and expand monitoring of survival during each life stage of natural salmon and identify key bottlenecks where additional focus might enhance viability of sockeye salmon. Limnological assessments of the capacity of the lakes to support increasing numbers of sockeye salmon are an important task. A comprehensive synthesis and assessment of the sockeye rebuilding effort would be worthwhile as a means to identify specific metrics and activities needed to achieve a viable natural population that might support a small harvest in some years.

Table 8. Snake River sockeye salmon captive broodstock program egg and fish reintroduction history, 1993-2010 (Peterson et al. 2011). Hatchery-reared and anadromous adults were released into Redfish Lake for volitional spawning.

Year of Reintroduction	Eyed Eggs	Presmolts	Smolts	Hatchery-Reared Adults	Anadromous Adults
1993	0	0	0	20	0
1994	0	14,119	0	65	0
1995	0	91,572	3,794	0	0
1996	105,000	1,932	11,545	120	0
1997	105,767	255,711	0	120	0
1998	0	141,871	81,615	0	0
1999	20,311	40,271	9,718	18	3
2000	65,200	72,114	148	71	200
2001	0	106,166	13,915	65	14
2002	30,924	140,410	38,672	178	12
2003	199,666	76,788	0	315	0
2004	49,134	130,716	96	241	0
2005	51,239	72,108	78,330	173	0
2006	184,596	107,292	86,052	464	0
2007	51,008	82,105	101,676	494	0
2008	67,984	84,005	150,395	398	571
2009	75,079	59,538	173,055	682	667
2010	59,683	65,851	179,278	372	1,210
Total	**1,065,591**	**1,542,569**	**928,289**	**3,796**	**2,677**

Table 9. Survival of hatchery sockeye eggs for Snake River production, 1998-2007 (IDFG 2010).

Year	Egg Take	Green-Eyed Survival (%)	Eyed-Ponding Survival (%)	Egg Survival Performance Standard	Fry – Fingerling Survival (%)	Rearing Survival Performance Standard	Fingerling – Smolt Survival (%)
1998	32,375	48.10%	84.09%	NA	99.60%	NA	96.80%
1999	162,056	39.00%	88.71%	NA	89.52%	NA	94.96%
2000	433,304	58.40%	95.27%	NA	92.81%	NA	98.09%
2001	287,720	42.20%	85.52%	NA	89.97%	NA	96.34%
2002	119,555	55.10%	93.33%	NA	86.48%	NA	99.71%
2003	341,921	88.90%	98.80%	NA	97.09%	NA	99.50%
2004	193,349	72.83%	98.42%	NA	95.99%	NA	99.58%
2005	208,712	69.57%	99.63%	NA	91.93%	NA	99.19%
2006	332,675	77.66%	97.50%	NA	86.28%	NA	100.00%
2007	236,393	74.37%	99.00%	NA	56.76%	NA	99.78%

Table 10. Estimated overwinter survival until out-migration for Sawtooth Fish Hatchery-reared pre-smolts released in the fall to Redfish, Alturas, and Pettit lakes (Peterson et al. 2011).

Out-migration Year	Redfish Lake	Alturas Lake	Pettit Lake
2000	29%	34%	46%
2001	20%	75%	29%
2002	40%	30%	29%
2003	15%	NA	59%
2004	27%	54%	35%
2005	35%	82%	56%
2006	43%	38%	64%
2007	23%	26%	25%
2008	27%	53%	59%
2009	25%	31%	54%
2010	17%	9%	24%

Table 11. Hatchery and natural sockeye salmon returns to Redfish Lake, 1998-2009 (IDFG 2010).

Return Year	Total Return	Natural Return	Hatchery Return	Observed (Not Trapped)	Naturals Kept for Broodstock	Hatchery Kept for Broodstock
1998	1	1	0	0	1	0
1999	7	0	7	0	0	7
2000	257	10	233	14	4	39
2001	26	4	19	3	0	9
2002	22	6	9	7	0	0
2003	3	0	2	1	0	2
2004	27	4	20	3	4	20
2005	6	2	4	0	2	4
2006	3	1	2	0	1	2
2007	4	3	1	0	3	1
2008	650	142	457	51	25	48
2009	833	85	732	16	63	84

Source: Project annual reports to Bonneville Power Administration and project annual reports to NOAA Fisheries for ESA Section 10 activities.

Studies into Factors Limiting the Abundance of Okanagan and Wenatchee Sockeye Salmon – Project #2008-503-00

Proponents: Columbia River Inter-Tribal Fish Commission

Background

This study, which in 2010 was in its second year of funding under the Columbia Basin accords, seeks to expand knowledge on the factors limiting production of Okanogan and Wenatchee sockeye salmon stocks. The study expands upon previous work, funded by the Pacific Salmon Commission from 2006 to 2008, to examine upstream survival and timing by inserting Passive Integrated Transponder (PIT) tags in adult sockeye sampled at Bonneville Dam as part of the annual Pacific Salmon Commission (PSC) funded sockeye stock identification project. These PIT-tagged fish were then detected at upstream dam fish ladders with detection capability (McNary, Priest Rapids, Rock Island, Rocky Reach, and Wells Dams on the Columbia River, Ice Harbor and Lower Granite Dams on the Snake River, and Tumwater Dam on the Wenatchee River) as well as at in-stream detection arrays. In 2010, this study had the following tasks:

1) Install PIT tag detection at Zosel Dam.
2) Maintain the VDS3 PIT tag antenna array.
3) Analyze upriver migration of sockeye salmon PIT-tagged at Bonneville Dam.
4) Install an acoustic network in the Okanagan Basin between its mouth and Okanagan Falls and acoustic tagging sockeye at Wells Dam to track sockeye moving through this network.
5) Conduct an acoustic trawl survey in Lake Wenatchee to estimate smolt abundance and compare to similar surveys done in Osoyoos Lake.
6) Outreach including a presentation at a professional meeting and planning of a sockeye symposium for the 2011 National AFS meeting in Seattle.

Results

A total of 913 adult sockeye salmon were PIT-tagged at Bonneville Dam between May 27 and July 14, 2010 (Fryer 2011). Of these fish, 870 were subsequently detected. An estimated 62.6% of the sockeye run passed Wells Dam, 13.3% passed Tumwater Dam, and 0.7% passed Lower Granite Dam (Snake River). In 2009, the Okanagan Basin produced an estimated 82.6% of the adult sockeye passing Bonneville Dam whereas the Snake River produced 1.8% (Figure 2; Figure 6 in Fryer 2011). Approximately 54% of the fish tagged at Bonneville were detected in the Okanagan River, leading to an estimated escapement of 178,700 sockeye salmon. The median time for migration from Bonneville to Tumwater Dam was 27.8 days, and 16.0 days to Wells Dam. The project uncovered fish passage problems at Tumwater Dam where the median passage time was almost 6 days compared to less than 10 minutes at other mainstem dams upstream of Bonneville Dam. Furthermore, the data suggest that 30% of sockeye salmon reaching Tumwater Dam, or roughly 15,000 fish, did not pass over Tumwater Dam. These delays likely result from a spring Chinook trapping program at Tumwater Dam that likely will be modified in 2011 to reduce impacts to sockeye salmon.

An acoustic network of 24 receivers was installed and 64 fish were tagged at Wells Dam. Relatively few sockeye tagged during the latter migration period migrated upstream of Zosel Dam; high water temperature appears to adversely affect the salmon. An acoustic trawl survey was conducted in Lake Wenatchee in late September 2010 (Fryer 2011). The juvenile sockeye population was estimated at 1.6 million fish or 1600 fish per hectare. Mean length of captured sockeye was 58 mm, which is somewhat small compared with other sockeye systems.

Presentations were given at several meetings, and a sockeye salmon symposium was organized at the 2011 AFS meeting in Seattle.

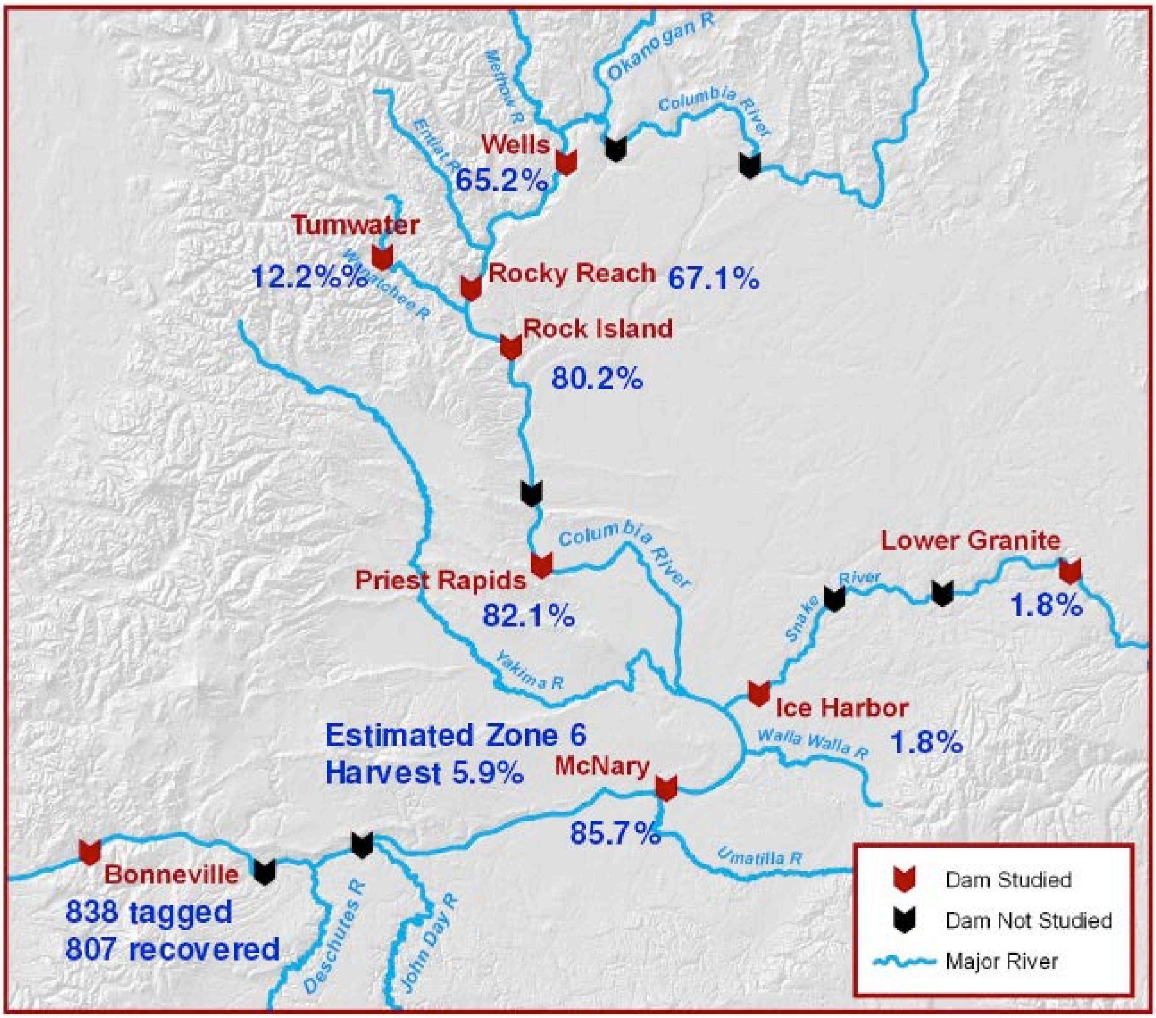

Figure 2. Map of Columbia River Basin from Bonneville to Wells and Lower Granite dams showing the number of fish PIT-tagged at Bonneville Dam and the percentage of the run estimated to pass other Upper Columbia and Lower Snake dams in 2008.

ISRP Comments

The project appeared to successfully complete the proposed tasks, and it provided important information. The project detected a serious problem with a Chinook salmon trap that affected movement of 15,000 sockeye salmon in the Wenatchee River. A new detailed report is reportedly forthcoming that will complement the detailed report produced in 2009. The release of hatchery sockeye salmon (mostly fry) into the upper Okanagan watershed by Canada has significantly increased in recent years to approximately 1.7 million per year. Effort is needed to assess the proportion of hatchery fish in the adult return so that status of the natural stock can be assessed.

Development of a sockeye salmon population in Deschutes Basin – Project #2008-307-00

Proponents: Confederated Tribes of Warm Springs Reservation of Oregon

Historically, the Deschutes River Basin supported one of two sockeye salmon runs in Oregon. Spawning and rearing was mainly in Suttle Lake and Link Creek in the Upper Metolius Watershed. The sockeye run was significantly depressed in the 1930s due to passage issues, and extirpated in 1964 following construction of Round Butte Dam without fish passage facilities. A self-sustaining population of kokanee remains in Suttle Lake and Lake Billy Chinook (LBC), and these fish are believed to produce anadromous sockeye based on periodic observations of adult sockeye below the dam. An anadromous sockeye run is to be established as part of the relicensing of Pelton and Round Butte dams. The project is supported by the Accord. The proposed objectives of this long term project, in partnership with ODFW and PGE, are to 1) determine the age distribution of *O. nerka* in LBC, 2) refine *O. nerka* spawner escapement into the Metolius watersheds, 3) determine if Suttle Lake *O. nerka* age 1+ production performs differently than LCB out-migrants, and 4) develop a more robust life history model to efficiently predict age 1+ populations to better manage sockeye out-migrant needs.

The project was funded in 2010. However, the eight project objectives listed in the funding letter from the Council to BPA (August 19, 2010) are different from the four objectives listed in the proponent proposal located on the Council website. The ISRP was not able to find a technical progress report for the Deschutes sockeye project in Taurus or on the Council web page.

6. Selective Gear Deployment

Project Number	**Title**	**Proponent**
2008-105-00	Selective gear deployment	Colville Tribes

The Selective Gear Deployment project (#2008-105-00) (Colville Tribes) was created in the Fish Accord Review of May 2008, however, funding was not allocated (no work was conducted) in FY2008-FY2010. The project is a continuation of two BPA-funded projects, the Broodstock Collection Study, which explored methods to collect broodstock for area, and the Evaluation of Selective/Live Capture Gear Project (#2007-249-00), which evaluated the effectiveness of live-capture fishing gears and associated costs. The Selective Gear Deployment project is critical to the success of the Chief Joseph hatchery Program (CJHP) (Kutchins et al. 2008). A purse seine fishery in mainstem Columbia River near the mouth of the Okanogan River and a semi-permanent weir in the Okanogan River are proposed to provide hatchery salmon (marked by an adipose fin clip) for CJHP broodstock and to remove a high proportion of CJHP hatchery salmon for ceremonial and subsistence uses by the Colville Tribes. These activities would reduce the proportion of hatchery-origin (HOR) spawners (pHOS) on natural spawning grounds, while live natural-origin (NOR; unmarked) salmon are released to spawn naturally. In addition, data collected at the weir will be used to estimate escapements of salmon and steelhead in the Okanogan River. Because this is a new project, there is no history of results reporting, however, the online proposal history reports the results of selective harvest operations for 2008-2010 conducted as part of project (#2007-249-00). Data reported included fishing effort and harvest and release numbers by gear type, species, and origin (HOR and NOR), condition of released fish, distribution of harvested fish (number of tribal members receiving fish and distribution to other tribal services), and number and condition (mortality or live release) of incidental harvests of adipose fin-clipped juvenile and adult steelhead. The results presented indicate that the seine fishery may be very successful at accomplishing project goals.

B. Fish and Wildlife Program Production Initiatives

1. Lower Columbia/ Estuary Subregion

Project Number	Title	Proponent
1993-060-00	Select area fisheries enhancement project	ODFW, WDFW, Clatsop County

The primary goal of the *Select Area Fisheries Enhancement Project (SAFE,* #199306000) is to produce hatchery and pen-reared coho and Chinook salmon for harvest by non-treaty commercial and recreational fisheries at four terminal areas, off-channel sites in the lower Columbia River—an approach designed to minimize harvest impacts on non-local and ESA-listed species and stocks. Funds provided by BPA are not used by SAFE for on-the-ground collection of data for results reporting, except for nearly 100% sampling of the Deep River commercial fishery catch. For most results reporting, SAFE compiles, analyzes, and synthesizes relevant data collected by other regional programs, e.g., fisheries and escapement monitoring programs within ODFW and WDFW that collect coded-wire tag, catch, and escapement data. To improve this process, SAFE has conducted a gap analysis of existing programs and data to identify data need, sources, availability, and quality, and plans to increase communication and coordination with other projects to fill gaps and refine data analyses for results reporting.

Results of program performance are presented in project proposals, annual reports, and project completion reports to BPA (e.g., North et al. 2006; Whisler et al. 2006, 2009). Results reporting of performance of the fish in the hatchery include information on production goals and time-series data on actual release numbers, numbers of coded-wire tagged fish released, tag codes, and release size of smolts by species, brood year, study group, release site, and date. Results reporting on performance of the fish post release includes time-series estimates of harvest and stock and age composition of commercial and recreational catches by season, commercial harvest ex-vessel value, number and percentage of total salmonid catch sampled for marks during SAFE fisheries, pre-season forecast precision for SAFE fisheries by species, contribution of SAFE fish to total non-treaty commercial harvest by species, run-reconstructions, smolt-to-adult survival (SAR), distribution of adult SAFE fish in other commercial and recreational fisheries, ocean by-catch by non-target fisheries, and escapement to hatcheries and streams by brood year and species. These estimates are frequently compared to post-release performance results of other in-basin hatchery releases. Summaries of the effects of released fish on natural populations, including a time series of estimated impact rates of ESA-listed upriver spring Chinook, are reported in annual and technical reports, joint staff reports, and fact sheets. In addition, Technical Advisory Committee develops an annual summary reports to assess compliance with limits established under the U.S. Endangered Species Act (e.g., TAC 2008). Overall, this project appears to be meeting or exceeding its performance and production goals. Reporting of results by this project is excellent, and will likely continue to improve as identified gaps in information continue to be filled.

2. Middle Columbia River Basin Subregion

Klickitat River Subbasin

Project Number	**Title**	**Proponent**
1988-120-35	Klickitat River Management, Data and Habitat-Yakima/Klickitat Fisheries Project (YKFP)	Yakama Confederated Tribes
1995-063-35	Klickitat River Monitoring and Evaluation-Yakima/Klickitat Fisheries Project (YKFP)	Yakama Confederated Tribes
1988-115-35	Klickitat River Design and Construction-Yakima/Klickitat Fisheries Project (YKFP)	Yakama Confederated Tribes
1997-013-35	Klickitat River Operations and Maintenance (O&M) for Hatcheries and Acclimation Sites-YKFP	Yakama Confederated Tribes

Background

The fisheries enhancement projects listed above for the Klickitat subbasin were not reviewed as part of the RMEAP review; however, artificial production related projects in the Klickitat subbasin have been reviewed several times by the ISRP. The projects were reviewed extensively in 2000 as part of the Provincial Review and again in the 2006 Annual Review. In both instances, the ISRP recommended further review of the suite of artificial production projects as part of a single comprehensive Master Plan through the Council's Three-Step Review process.

The Step-1 Review process for the Yakama Nation's Klickitat Anadromous Fisheries Master Plan (#198811535) began in 2004. In 2008, the ISRP found the Master Plan to be a well-balanced, relatively thorough plan that met ISRP scientific review criteria and Three-Step Review criteria with a qualification that elements of the steelhead and spring Chinook natural and artificial production plans needed additional detailed explanation. These details, which are needed for both the spring Chinook and steelhead components, are to be developed in the Step-Two submittal.

The 2008 Klickitat Anadromous Fisheries Master Plan reflected some important advances (compared to the previous drafts reviewed by the ISRP) in thinking from traditional enhancement projects. Goals and targets were presented, but require further elaboration and justification in the Step 2 submittal. Decision management tools would aid that process, along with Consequence Tables to guide management actions and deal with variability and uncertainties in measured and monitored results and actions, including regime shifts and climate change.

Results

<u>Recent Hatchery Performance</u>

Hatchery spring Chinook smolt-to-adult survival rates have averaged approximately 0.35% and ranged from 0.01% to 1.31% for brood years 1990 through 2000. This rate of survival has resulted in a measured recruit per spawner ratio (R/S) of 2.67. In contrast, the natural spring Chinook population over this same time period had an average R/S value of 3.48. The high R/S value for natural spring Chinook is quite high and unexplained.

Total hatchery spring Chinook production for return years 1990 through 2006 ranged from 746 to 4,838 and averaged 2,186. This estimate does not include those fish harvested in marine and mainstem Columbia River fisheries. The inclusion of these fish would increase total production by between 3% and 13% depending on the return year.

Culture practices at the Klickitat Hatchery have resulted in an egg-to-smolt survival rate of 73%. Bacterial Kidney Disease (BKD) has been a problem in the past, but has been reduced through the implementation of better culture methods at the Klickitat River Hatchery.

Klickitat River YKFP RME (Project #1995-063-35)

Selected recent results (2009-2010) are included from the most recent annual progress report (Zendt et al. 2010).

Spawning ground surveys (redd counts)

Objective
Monitor spatial and temporal redd distribution of spring and fall Chinook, coho, and steelhead, and collect biological data from carcasses. Spawning ground surveys provide a means of monitoring annual adult spawner escapement as well as spawner distribution.

Results
Spring Chinook
Spring Chinook redd counts provide a more accurate indicator of annual spawner escapement than other species due to the fairly limited geographic area of spawning and relatively good survey conditions in most years (low flows and good visibility). Spring Chinook surveys were conducted from August 18 to October 3, 2009, covering over 60 river miles. In 2009 above Castile Falls, four redds were observed and 9 live spring Chinook adults were observed. While this was an increase over what was observed in 2008 (0 redds and only 1 live fish), it was a substantial decrease from 2007 (in which 36 redds were observed above Castile Falls) when there had appeared to be an increasing trend in redd counts above Castile following the recently-completed passage improvements.

Fall Chinook
Fall Chinook are mainstem spawners and generally utilize the lower portion of the river, downstream of the Klickitat Hatchery. Surveys were conducted from October 28 to December 3, 2009. The total 2009 redd count was 754, which is higher than redd counts of the previous few years and is similar to an average redd count over the period of record for fall Chinook surveys. The 2009 counts were also probably biased somewhat low due to river ice, then snow, rain, and high turbidity in early and mid-December, which precluded surveys for much of the month. This would indicate that the 2009 Klickitat fall Chinook return was at least average to slightly above average.

Coho
Coho spawning generally occurs in the lower reaches of most lower river tributaries and the mainstem below Parrott's Crossing (RM 49.4). Coho spawner surveys began on November 17, 2009 and continued until February 25, 2010. River ice followed by snow, rain, and high turbidity in early and mid-December, precluded surveys for much of the month. High flows and turbidity in mid-January also limited surveys for about 1 week. These factors likely biased the redd counts somewhat low for 2009-2010. The total redd count was 214. More redds were observed

in the reach below the Klickitat Hatchery (73) than in any other reach. A large number of redds (65) were also observed in Canyon Creek below Lyle Falls.

Steelhead
Steelhead spawner surveys typically span two annual reporting periods due to the spawn timing (February through May). In this report we present final steelhead spawning data from spring 2009 and a progress report for spring 2010. Surveys in 2009 began in early February and ended in mid-June. The total redd count was 62, and included 10 in the mainstem Klickitat and 52 in tributaries. No redds were observed above Castile Falls (see the spring Chinook spawner survey results section for a description of passage at Castile Falls); however, only limited late-season surveys were conducted in the upper Klickitat.

Adult salmonid monitoring at Lyle Falls fishway

Objective
Monitor adult salmonid passage, run size, and run timing, and collect biological data at the Lyle Falls fishway on the lower Klickitat River.

Methods
Adult salmonids were trapped, enumerated, and then released in the upstream end of the Lyle Falls fish ladder at RM 2.4 on the Klickitat River. Biological data were collected from individual fish including fork length, sex, scales, genetic samples, body and gill color, existing marks, and presence of coded wire, and PIT tags.

Results
A total of 3813 adult steelhead, spring Chinook, fall Chinook, and coho salmon were trapped and released at Lyle Falls during this reporting period in 2010.

Results of spring Chinook mark-recapture population estimation are 5846 for hatchery and 675 for wild. The run size estimates for wild spring Chinook in for the last 3 years have not been very high (averaging about 500 fish) and do not seem consistent with historical reports of a "large run of spring Chinook" (Bryant 1949). Although Klickitat spring Chinook, as part of the Middle Columbia River evolutionarily significant unit, are not listed under the ESA, they are rated as "depressed" by WDFW's Salmonid Stock Inventory (SaSI) due to chronically low returns (WDFW 2002). These estimates along with recent results from Klickitat spring Chinook redd counts (see Spawning Ground Survey section) warrant some level of concern regarding the status and trend of this native population.

Steelhead population estimates for run size are 3700 for hatchery and 1506 for summer-winter wild (1235 for summer wild and 271 winter). The 2009-2010 estimate represents the first estimate after a two-year gap resulting from difficulties setting up angler recapture data collection. Also in 2009, a large run of hatchery steelhead destined for the upper Columbia and Snake rivers was observed in the lower mainstem Columbia River (FPC 2009). From Floy tag return reports and preliminary radio tracking (see Radio telemetry monitoring section), it is believed that a substantial number of steelhead migrating up the Columbia River dip into the Klickitat River during the summer and fall months before continuing migration up the Columbia, and it is possible that presence of these fish in the Lyle adult trap may have biased the 2009 hatchery steelhead estimate high.

PIT tagging

Hatchery spring Chinook and steelhead PIT tagging
Objective: Use Passive Integrated Transponder (PIT) tagging as a means of monitoring spring Chinook salmon and steelhead travel and/or holdover time between the Klickitat River and Bonneville Dam detection sites, estimating smolt survival rates to Bonneville Dam, and estimating smolt-to-adult return rates.

Methods: Spring Chinook salmon juveniles from the Klickitat Hatchery were injected with PIT tags in June 2009 and released from the hatchery into the Klickitat River in March 2010. More than 35,000 fish were tagged; an estimated 34,688 fish were released. The most reliable estimate of number of fish released came from monitoring the hatchery pond for tagged-fish mortalities and subtracting these fish from the total number of fish tagged. Tag data was entered into the regional PIT Tag Information System (PTAGIS) database for monitoring at mainstem Columbia River detection sites. Returning adult fish are detected at Bonneville Dam adult fish ladders to provide smolt-to-adult return rate (SAR) information. Approximately 10,000 hatchery steelhead juveniles were PIT-tagged at Skamania Hatchery in early October 2009; these fish were transported via truck and released as smolts into the Klickitat River in April 2010. Future adult returns of these fish will provide SAR information and will be presented in future reports.

Results: To date, returning adult information is available up through return year 2010 (which includes returns up to age-4 fish for brood year 2006 and age-5 fish for brood year 2005). A preliminary average SAR estimate (using projected returns of 5- and 6-year-old fish based on average age compositions) for brood years 2005 and 2006 fish is fairly low, at approximately 0.5%. Additional returns in subsequent years will yield more complete SAR estimates for Klickitat Hatchery spring Chinook.

Wild salmonid PIT tagging
Objective: In order to monitor smolt-to-adult return rates and travel times through the Columbia River system of wild Klickitat anadromous stocks, outmigrating juvenile salmonids were trapped in the lower the Klickitat River, sampled for biological data, and implanted with a 12mm passive integrated transponder (PIT) tag. Detections will occur at the Bonneville Dam juvenile and adult passage facilities.

Results: Activities during this reporting period consisted of setup and training of staff for PIT tagging at smolt traps using a small sample of hatchery smolts. Eleven fall Chinook salmon were PIT-tagged during the winter of 2009-2010. Tagged fish varied in length between 107mm and

83mm. All recovered from anesthesia and were released. No juvenile fish PIT-tagged during this period has yet to be detected in the Columbia River (Bonneville Dam PIT tag detectors).

Umatilla River Subbasin

Project Number	Title	Proponent
1983-435-00	Umatilla Hatchery Satellite Facilities O&M	CTUIR
1989-035-00	Umatilla Hatchery O&M	ODFW
1989-024-01	Evaluate Umatilla Juvenile Outmigration	ODFW
1990-005-00	Umatilla Hatchery Monitoring and Evaluation	ODFW
1990-005-01	Umatilla Basin Natural Production M&E	CTUIR

Background

The Umatilla River subbasin encompasses approximately 2,290 square miles in north central Oregon. The river's headwaters originate in the Blue Mountains of northeastern Oregon at an elevation of 5,800 feet and the river flows northwest entering the Columbia River at river-mile 289 just below McNary Dam, at an elevation of 260 feet. The mainstem of the Umatilla River is 89 miles long. In the early 1900s irrigation dams/diversions were constructed in the lower 35 miles of the Umatilla River and irrigation storage reservoirs developed in the Cold Springs and McKay creeks watersheds. Until recently, water diversion for irrigation dewatered portions of the river channel annually during summer months, and at other times during drought. Prior to development of irrigated agriculture the fish fauna was known to include spring- and fall-Chinook, coho salmon, summer steelhead, and lamprey. By the late 1970s spring and fall Chinook and coho salmon were extirpated and summer steelhead and lamprey were in decline.

Restoration of fishery resources in the Umatilla River involves a water transfer program to re-wet the mainstem for fish migration; adult passage improvements at irrigation diversions; fish screening at diversions for smolt protections; transport of adults and smolts through river segments that are excessively warm during migration periods; tributary habitat improvements; and reintroduction of spring and fall Chinook and coho salmon and supplementation of steelhead using hatchery technology.

The Confederated Tribes of the Umatilla Indian Reservation (CTUIR) and Oregon Department of Fish and Wildlife (ODFW) co-manage the fishery resources.

In 1982, CTUIR released 3.8 million hatchery Tule stock fall Chinook in the lower Umatilla River. Subsequent annual releases of hatchery fall Chinook came from Upriver Bright stock released in the lower and upper Umatilla River. Hatchery-produced coho salmon from Toutle stock were released by CTUIR in 1987 in lower and mid-river segments (DeBano et al. 2004). In 1988, hatchery-produced Carson stock spring Chinook were introduced in the upper Umatilla River (DeBano et al. 2004). The first attempt to supplement the natural population of summer steelhead in the Umatilla River and tributaries was in 1967 when hatchery-produced, non-endemic steelhead from Skamania and Idaho (Oxbow) stocks were released in the Umatilla River (DeBano et al. 2004). From 1968 through 1970 only non-endemic Skamania stock was released into the Umatilla River. No hatchery-produced steelhead were released in the Umatilla River from 1971 through 1974. The first release of endemic Umatilla stock occurred in 1975. There were no releases of hatchery produced steelhead from 1976 through 1980. Annual releases of Umatilla stock summer steelhead ensued from 1981 to the present.

The Umatilla Hatchery Master Plan (CTUIR and ODFW 1989) developed artificial production and habitat and flow requirements needed to achieve salmon restoration goals. The Umatilla Subbasin Plan (NPCC 2004) replaced the Master Plan with revised qualitative and quantitative program goals. Three monitoring and evaluation projects were designed to provide data to answer critical uncertainties identified in the Umatilla Fish Hatchery Master Plan: Umatilla Hatchery Monitoring and Evaluation #199000500 (ODFW), Umatilla Basin Natural Production Monitoring and Evaluation #199000501 (CTUIR) and Umatilla River Juvenile Outmigration and Survival Monitoring and Evaluation #198902401 (ODFW).

Fish Production Goals

Table 12. Fish Production Goals for the Umatilla River

Objective	**Summer Steelhead**		**Spring Chinook**		**Fall Chinook**	
	Wild	**Hatchery**	**Wild**	**Hatchery**	**Wild**	**Hatchery**
Annual Adult	4000	1500	2000	6000	6000	6000
Broodstock	100	20	92/5 jacks	416/21 jacks	768	
Natural Spawning	4000		3000		6000	
Harvest	1384		4000		5000	
Smolt Production	150,000		810,000		1,080,000	
Egg to Smolt	75%		80%		77%	
Smolt to Adult	2.7 %		0.75%			
Egg Production	201,000		1,020,000		1,400,000	

Summary of Results

<u>Summer Steelhead</u>

Hatchery Production

Summer steelhead broodstock are collected at Three Mile Falls Dam adult trapping facility, transferred to Minthorn Springs for holding and spawning, and green eggs are transferred to Umatilla Hatchery for incubation and rearing. Juveniles are transferred to Minthorn Springs and Pendleton acclimations facilities for acclimation and release. The annual broodstock collection goal is 50 pairs of natural-origin adults (100 steelhead) and 10 pair of hatchery-origin adults (20 steelhead). The release plan is 150,000 yearling smolts: Minthorn Springs 50,000, Pendleton

50,000, and Bonnifer Springs 50,000 (direct release). Anticipated survival from egg take (spawning) to transfer to acclimation ponds is 75%.

The summer steelhead program has generally met the broodstock collection, egg take, and smolt release goals. For run years 1990/91 through 2002/03 the collection of natural-origin adults ranged from 86 to 225, with a geometric mean of 107, and collection of marked (hatchery) adults ranged from 3 to 103, with a geometric mean of 21 (Contor and Reznicek 2010). The number of parents used in spawning ranged from 61 to 172, with a geometric mean of 89; egg take ranged from 181,000 to 477,000 with a geometric mean of 241,000; survival from egg to fry ranged from 63% to 85% (geometric mean, 78%) and survival from egg to smolt ranged from 54% to 83% (geometric mean, 72%) (Umatilla Subbasin Plan, Steelhead HGMP 2004). Smolt releases from brood year 1991 through 2009 ranged from 130,500 to 199,300 (geometric mean, 147,300) (Appendix Table 12 in Clarke et al. 2011).

Post Release Survival, Adult Returns to the Umatilla River, Straying and Harvest

Juvenile Migration and Survival. Juvenile migration and mortality was monitored by PIT tag detection of released smolts at Three Mile Falls Dam, John Day Dam, and PIT tag surveys of avian rookeries. Survival probabilities to John Day Dam are typically under 50% (figure 17 in Clarke et al. 2011) without a consistent trend as to which release site produced the largest survival. However, in four of the last seven years Bonnifer Springs (Meacham Creek RM 2) direct releases had the smallest survival. In 2010, 196 Umatilla Hatchery steelhead PIT tags were detected on avian rookeries for an estimated 3.2% to 5.2% mortality across different release groups. (It is unknown whether this mortality has been adjusted for ~50% mortality down to John Day Dam.)

Hatchery Steelhead Adult Returns, Straying, and Harvest. Adult hatchery-origin steelhead produced by the program in brood years 1991 through 2006 ranged from 178 to 1660 with a mean of 726. Smolt-to-adult survival (SAS, return to the Umatilla River plus harvest and straying) ranged from 0.109% to 1.08% (geometric mean, 0.43%), well below the SAS goal of 1%, which has been met in only one broodyear (1999). Across years, 82% of adult steelhead returned to the Umatilla River and 18% were believed to have strayed to other locations. Umatilla Hatchery steelhead have been observed in U.S. ocean commercial harvest, Columbia River tribal commercial harvest, Columbia River and Umatilla River non-tribal recreational fisheries, Umatilla River Tribal recreational fisheries, and Mid-Columbia and Snake River mainstem non-tribal recreational fisheries. For run-years 1992 through 2008 the total number of steelhead estimated in the harvested in all fisheries ranged from 10 to 1025 (geometric mean, 140). Averaged over run years, 55% of the harvest was in the Umatilla River and 45% out-of-subbasin, with most out-of-subbasin fish captured in Columbia River mainstem fisheries.

Natural and Hatchery Adult Returns to the Umatilla River. For Umatilla hatchery steelhead the number of adults arriving at Three Mile Falls Dam in return-year 1992 through 2009 ranged from 345 to 1,895 (arithmetic mean, 908). Natural steelhead adults arriving at Three Mile Falls Dam in those same return years ranged from 862 to 3,895 (arithmetic mean, 1,911) and is presented in Figure 3 below along with the lines indicating the 1,500 fish abundance goal for hatchery steelhead and the 4,000 fish abundance goal for natural steelhead. Hatchery steelhead achieved their abundance goal only twice, in 1996 and 2001.

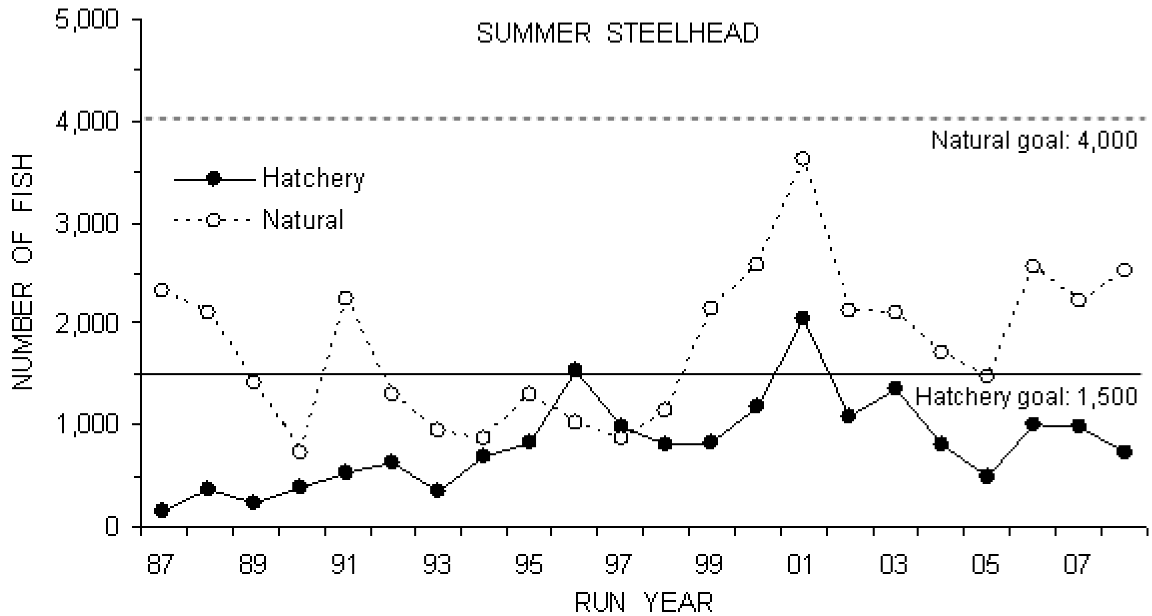

Figure 3. Summer steelhead returns to Three Mile Fall Dam (river mile 3.7) on the lower Umatilla River (1966-2009) (from proposal 1990-005-00).

Supplementation Effectiveness

One of the goals of the Umatilla steelhead hatchery program is to increase the abundance of natural-origin adult steelhead, a strategy known as supplementation. The approach is to remove spawning adult steelhead and use them in hatchery production, and then to permit the subsequent off-spring to spawn in the wild with natural-origin steelhead. Hopefully this spawning population will be of larger number than in the absence of hatchery production and the reproduction and subsequent survival of juvenile fish will yield an increase in adult abundance in future years. For the strategy to provide a benefit in abundance, the hatchery population must have more adult returns per spawner than the wild population, the hatchery fish must spawn successfully and habitat quantity and quality must be sufficient to support an increased juvenile population.

In Umatilla River steelhead, progeny-to-parent ratios ranged from 1.3 to 15.3 (arithmetic mean=7.3) for hatchery steelhead and 0.4 to 2.7 (arithmetic mean=1.1) for natural spawning steelhead. There is an approximately 7-fold adult production yield in hatchery steelhead. Since 1992 from 44 to 116 natural females have been removed from the spawning population to serve as hatchery broodstock, and from 161 to 842 hatchery-origin adult females have been permitted to spawn naturally. Each year there has been an increase in the natural spawning population by the addition of hatchery fish ranging from 45 to 792 females. There has been an approximate 20% increase in the number of female spawners, annually, from the addition of hatchery-origin females.

Because of density dependence and other limits to production, the population response to this supplementation is best evaluated by comparison to reference (control) systems that are not being supplemented. For Umatilla steelhead this analysis has been conducted by comparing trends in abundance and productivity between the Umatilla population and locations in the John Day River. Total abundance, natural-origin abundance, and natural productivity (density corrected recruits/spawner, a measure of fitness decline risk) have been estimated. The analysis indicates that total abundance and natural-origin steelhead abundance have increased, and that productivity has not declined. For this river system, it appears that supplementation has benefited abundance without a decline in productivity. The ISRP caveats this conclusion with the observation that it is not clear that the extent of habitat improvements in the Umatilla River, and unintended supplementation of the John Day River by stray hatchery steelhead have been factored into the analysis (stray hatchery fish could have been counted as local fish thereby boosting the abundance and productivity estimates in the John Day River). Analysis of productivity should evaluate the residual from a Ricker curve so density effects are removed.

Summer steelhead Natural Production

Spawning escapement, natural smolt abundance, smolts-per-female. Female spawning escapement, including both natural- and hatchery-origin adults ranged from 807 (1994) to 3006 (2002), averaging 1508 from spawning year 1992 through 2009, and exhibits a modest trend of increasing abundance (Figure 4, data from Contor and Reznecik 2010). Smolt abundance, evaluated at Three Mile Falls Dam, from natural spawning by these females ranged from 7,899 (1997) to 82,005 (2002) for the 1995 through 2009 outmigration years, averaging 42,781 individuals (coefficient of variation among years = 42%). There is a slight decreasing trend in smolt abundance (Figure 5, data and figure from Hanson et al. 2010). This upward trend in spawning escapement coupled with the declining trend in smolt abundance demonstrates a strong negative relationship between escapement and smolts-per-female (Figure 6, from Hanson et al. 2010), with which is interpreted to indicate density dependence and a population at or above carrying capacity. This interpretation is reinforced by a decreasing trend in egg-to-smolt survival (1993 to 2000 mean = 0.9%) (Figure 7, from Hanson et al. 2010). In contrast, smolt-to-adult (SAR) exhibits an increasing trend, averaging 2.9% over the 1995 – 2007 (Figure 8, from Hanson et al. 2010). Length-at-age of steelhead declined and age-at-smoltification increased with increasing egg deposition (parent spawners), suggesting that reduced growth was a mechanism influencing the density-dependent response.

Hanson et al. (2010) establish that long-term trends in abundance and survival indicate that in the last two decades marine survival has increased and freshwater survival decreased, and conclude that production and productivity were most influenced by available freshwater habitat. Achieving the co-managers objectives for the Umatilla River subbasin are likely to require further improvements in water quality, adult and juvenile passage, and tributary habitat. The interpretation of the data that declining productivity in freshwater, possibly due to density dependence, has been offset by increasing survival at sea. If this is the case, it indicates the importance of considering freshwater carrying capacity in supplementation planning and evaluation.

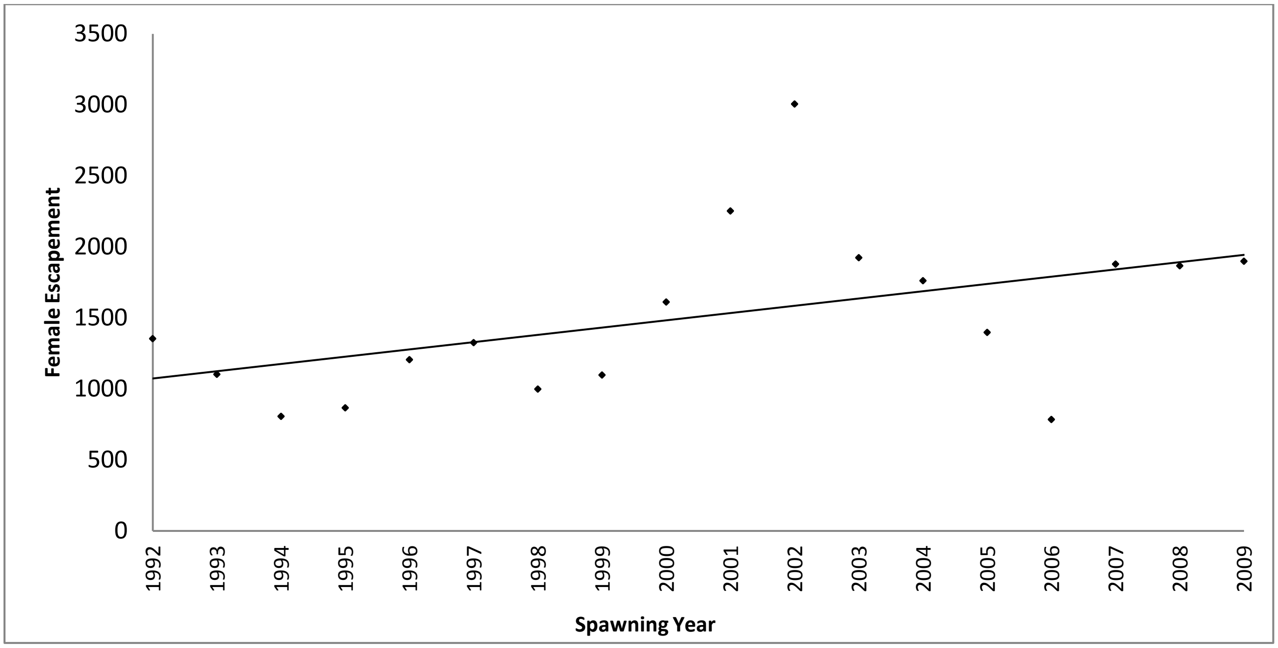

Figure 4. Umatilla summer steelhead spawning escapement, spawning years 1992 – 2009 (data from Contor and Reznecik 2010).

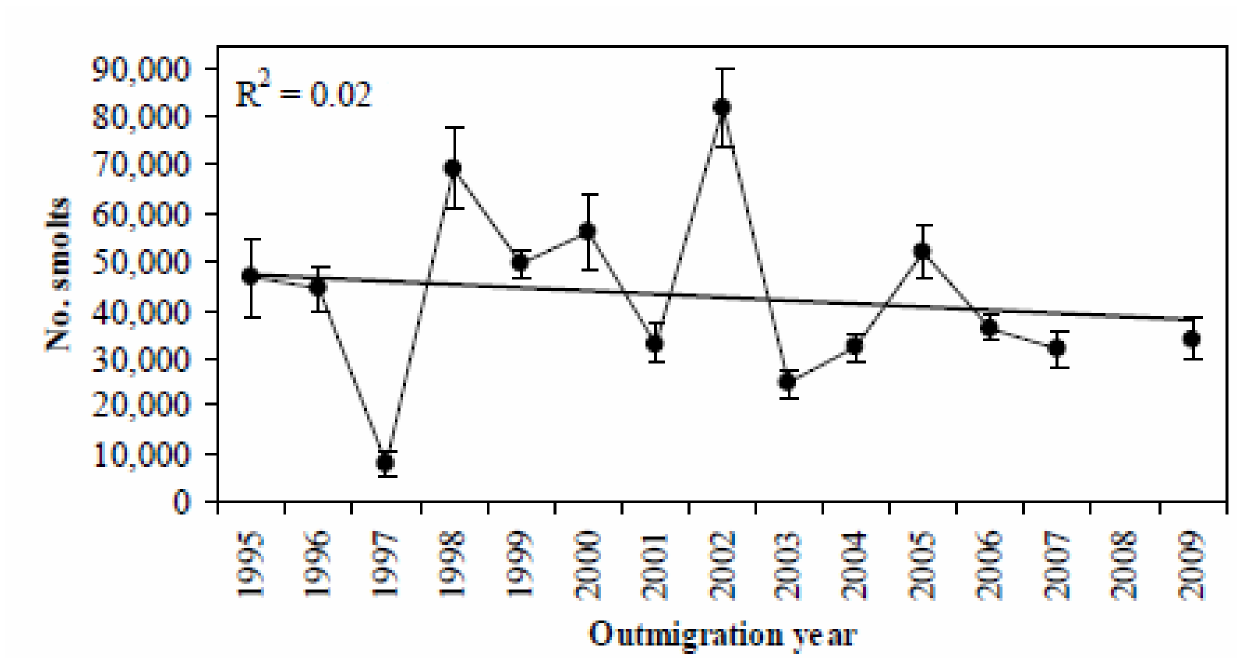

Figure 5. Abundance estimates for natural summer steelhead smolts at Three Mile Falls Dam, Umatilla River, 1995 – 2009 (from Hanson et al. 2010).

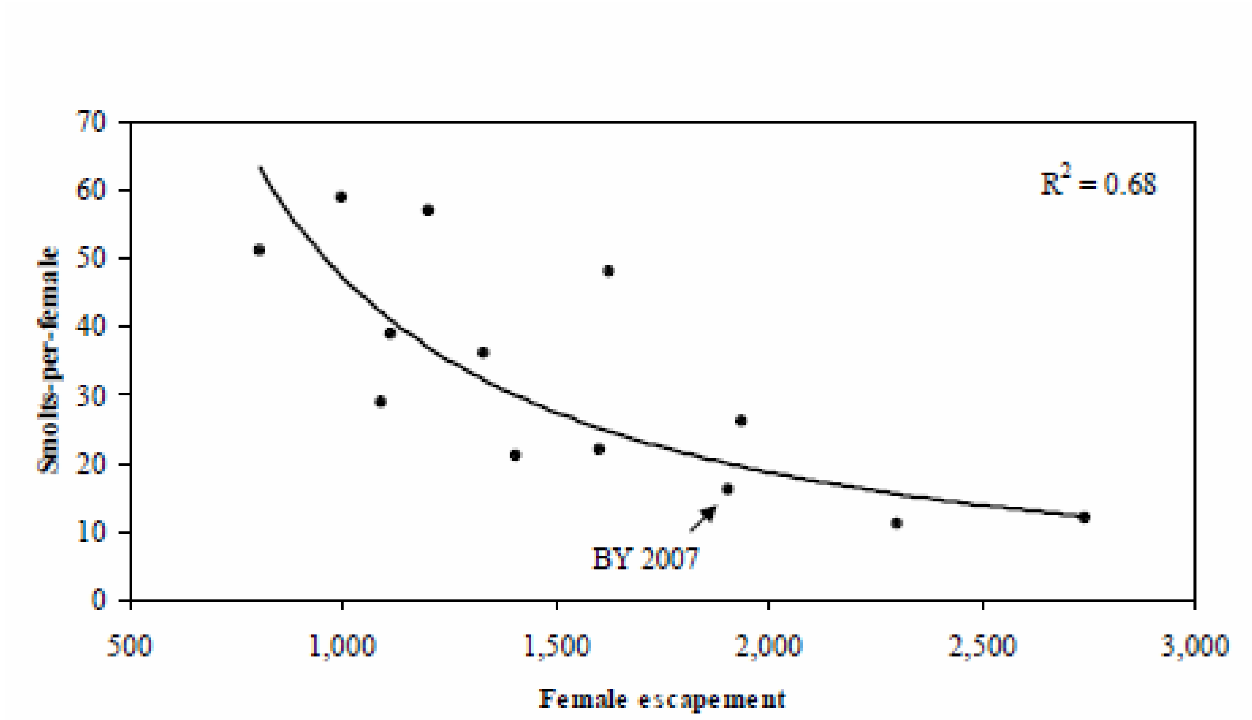

Figure 6. Relationship between female spawning escapement and smolts-per-female for Umatilla River summer steelhead, brood years 1993 – 2007 (Figure 11 from Hanson et al. 2010).

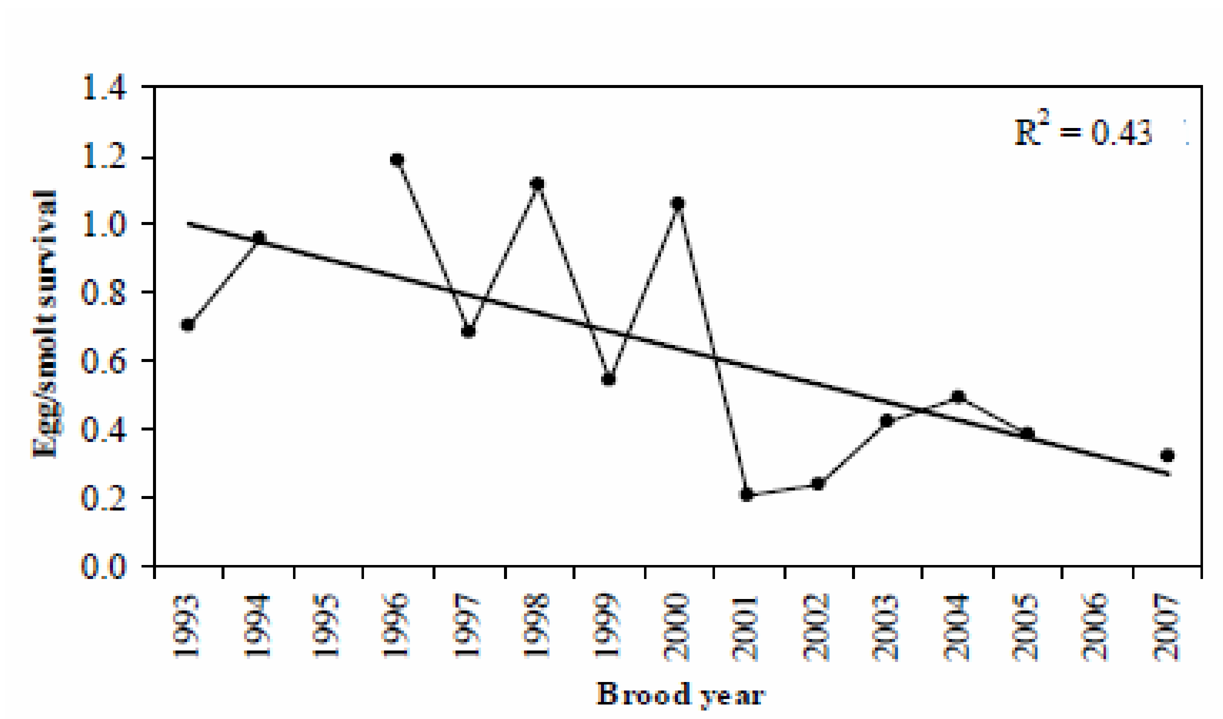

Figure 7. Egg-to-smolt survival for Umatilla River summer steelhead, brood year 1993 – 2007 (from Hanson et al. 2010).

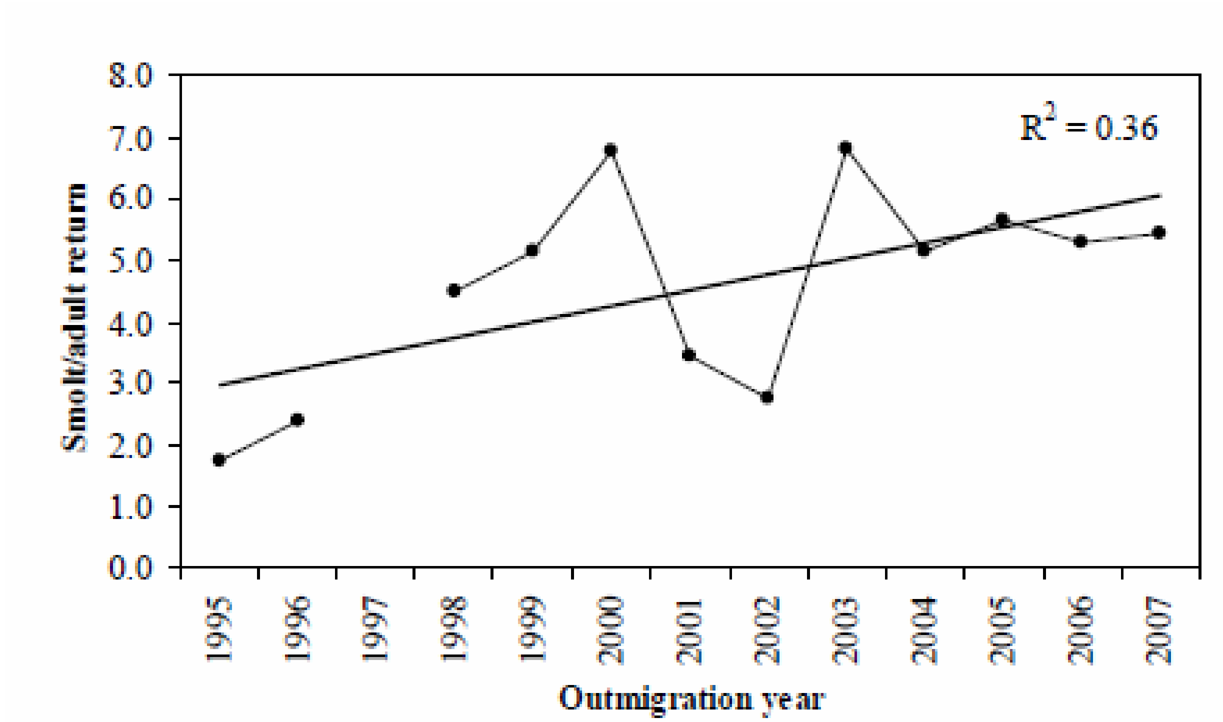

Figure 8. Smolt-to-adult return for Umatilla River summer steelhead, outmigration years 1995 – 2007 (from Hanson et al. 2010).

Spring Chinook

Hatchery Production

Spring Chinook broodstock were collected at Three Mile Falls Dam adult trapping facility, transferred to South Fork Walla Walla Hatchery for holding and spawning, green eggs transferred to Umatilla Hatchery for incubation and rearing. In some years eyed eggs were transferred to Little White Salmon Hatchery for hatching and rearing. Juveniles have been transferred to Imeques acclimations facilities for acclimation and release. Past annual broodstock collection goal was 280 pairs of adults without distinction (hatchery or wild) and 28 jacks. The 2011 plan is to produce 660,000 hatchery x hatchery smolts (for harvest) and 150,000 wild x wild conservation smolts, for a total production of 810,000 smolts. The plan is to transfer 217,500 harvest smolts to Imeques and Thornhollow sites in November, and to transfer an additional harvest 225,000 smolts to Imeques in January. All will be released into the Umatilla River in April. In addition, 150,000 conservation smolts will be released directly into the Umatilla River in April. Anticipated survival from egg take (spawning) to release from the acclimation ponds is 80%.

The spring Chinook program has generally met the broodstock collection, egg take, and smolt release goals. For run years beginning in 1997 and continuing through 2009 the collection of adults ranged from 194 to 600, with an arithmetic mean of 529 (Contor and Reznicek 2010).

Smolt releases from brood year 1991 through 2009 ranged from 225,883 to 1,738,421 (geometric mean, 897,612) (Appendix Tables 5, 6, and 7 in Clarke et al. 2011).

Post Release Survival, Adult Returns to the Umatilla River, Straying and Harvest
Hatchery spring Chinook Adult Returns, Straying, and Harvest. Adult hatchery-origin spring Chinook returning to the mouth of the Umatilla River ranged from 13 in 1988 to 5,463 in 2002, averaging 2,948 for the run-years from 1996 through 2010 (Table 6, Clarke et al. 2011). This average run-size is about half the subbasin plan goal of 6,000 hatchery spring Chinook. For brood-years 1996 - 2005, 87% of adult spring Chinook returned to the Umatilla River and 13% were believed to have been harvest or strayed to other locations (Table 5 and Appendix Table 8 in Clarke et al. 2011). The stray rate for Umatilla hatchery spring-Chinook is 1.3%. Most of the straying salmon are identified in the Snake River basin. In the Tucannon River, stray Umatilla spring Chinook have exceeded the 5% maximum level established for ESA listed populations, necessitating external marking for all released juveniles.

Umatilla Hatchery spring Chinook have been observed in U.S. ocean commercial harvest, Columbia River tribal commercial and ceremonial harvest, Columbia River and Umatilla River non-tribal recreational fisheries, but none are reported in Umatilla River Tribal recreational or ceremonial fisheries (Appendix Table 9 in Clarke et al. 2011). For run-years 1992 through 2008 the total number of spring Chinook estimated in the harvested in all fisheries ranged from 4 to 1930 (geometric mean, 198), substantially below the 6000 fish harvest goal in the subbasin plan. The average disposition of the run over the years 1997 through 2010 is shown in Figure 9.

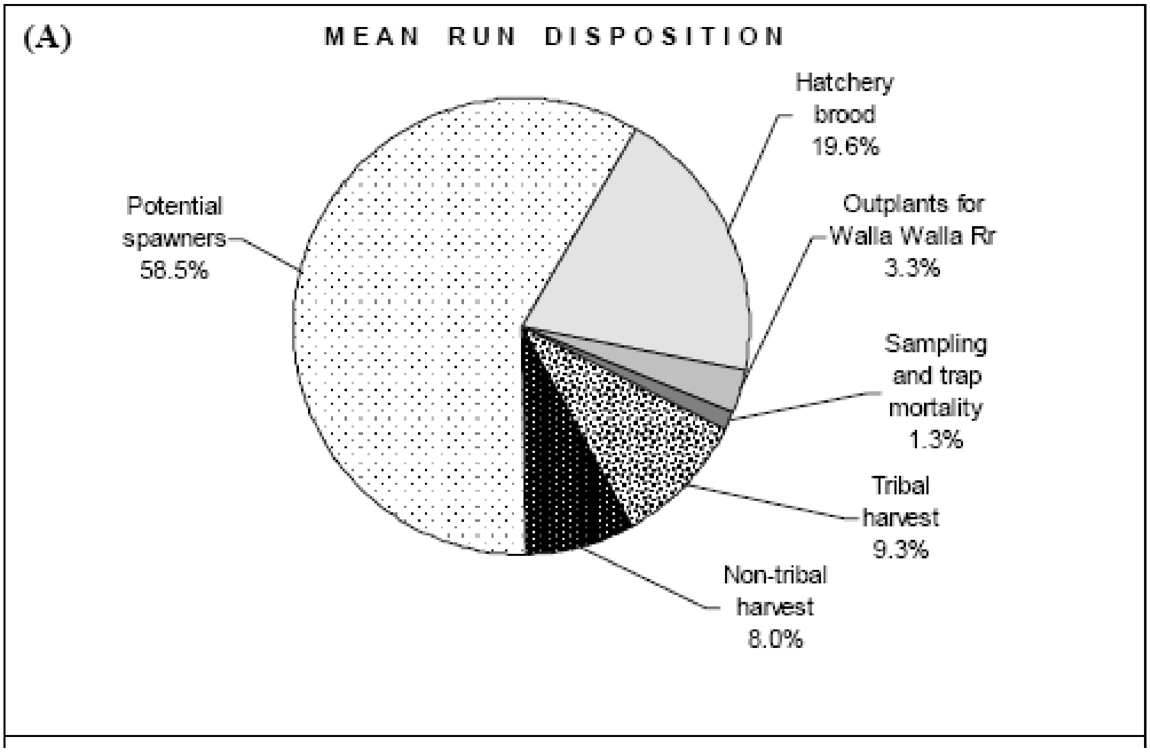

Figure 9. Disposition of the spring Chinook run over the years 1997 through 2010 (from Clarke et al. 2011).

Natural Production Reintroduction Success Status

Natural spring Chinook Adult Returns to the Umatilla River. Abundance of Umatilla natural-origin spring Chinook adults arriving at the Umatilla river mouth in return-years 1996 through 2010 ranged from 22 to 351 (arithmetic mean, 194). Natural-origin spring Chinook abundance has been substantially below the 2000 fish goal established in the subbasin plan (Figure 10).

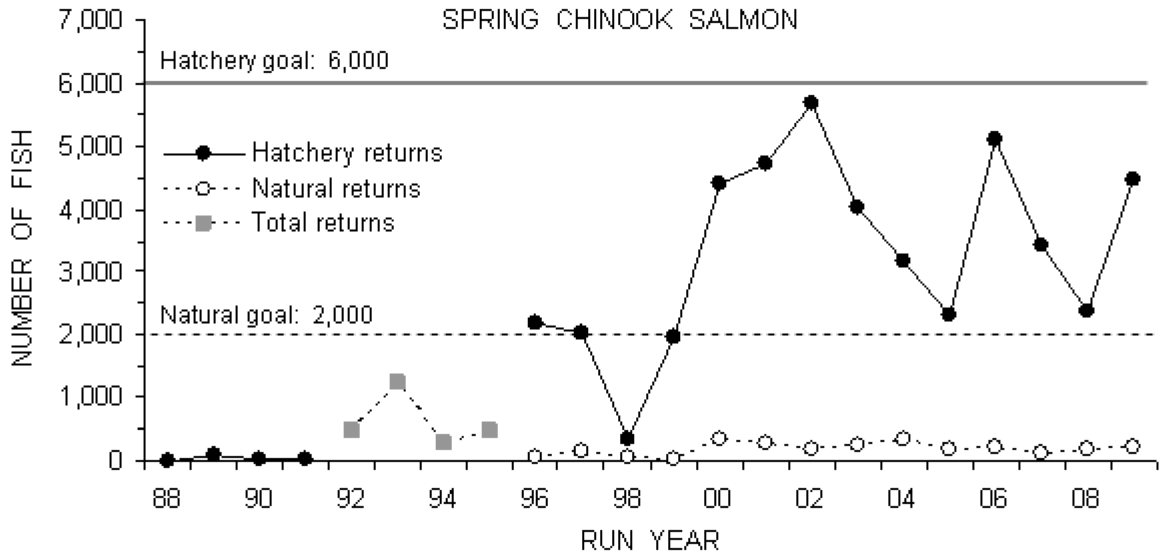

Figure 10. Adult and jack spring Chinook salmon returns to Three Mile Falls Dam (river mile 3.7) on the lower Umatilla River, 1989-2009 (from proposal 1990-005-00).

HOR and NOR Spawning. Since the 1997 run-year spring Chinook spawning escapement has averaged 58% of the adults returning to Three Mile Falls Dam, the remainder were harvested, collected for broodstock, or out-planted to the Walla Walla River. Spawning escapement ranged from 64 in 1989 to 3,598 in 2002 (Contor and Reznicek 2010), and was composed of approximately 85% hatchery-origin adults (proposal 1990-005-00). Redds observed ranged from 14 in 1989 to 828 in 2002 with a significant relationship between the number of redds observed and escapement (Contor and Reznicek 2010). Pre-spawning mortality of adult females has been large, averaging approximately 31% annually. In 2009 pre-spawning mortality was 73% (Contor and Reznicek 2010). This prespawning mortality is high, and needs to be incorporated into an improved understanding of habitat limitations.

Smolt Production, Smolts-per-Spawner, and Adult Progeny to Parent Ratios. Spring Chinook smolt abundance for migration years 1997 through 2007, estimated at Three Mile Falls Dam, ranged from 603 fish in 1997 to 52,645 in 2003, averaging 16,373 (Hanson et al. 2010). None of the Umatilla RME projects report smolts-per-spawner for spring Chinook; this is an important metric that requires evaluation. Progeny-to-parent ratios for natural production ranged from 0.16 to 2.3 (mean = 0.5) (Figure 11). Progeny-to-parent ratios for hatchery origin salmon ranged from 0.06 to 17.3 (mean = 6.7), producing a 13 fold adult production benefit from the hatchery program (Clarke et al. 2010). Progeny to parent ratio for natural production needs to equal or exceed 1 to complete reintroduction of spring Chinook into the Umatilla River.

Figure 11. Progeny-to-parent ratios for hatchery- and naturally-produced Umatilla spring Chinook, brood years 1991 – 2005 (from Figure 7, page 32, Clarke et al. 2010).

Fall Chinook

Hatchery Production

Fall Chinook were reintroduced to the Umatilla River using lower Columbia River Spring Creek and Up River Bright (Priest Rapids) stocks. At this time sufficient hatchery-origin salmon return and broodstock are collected at Three Mile Falls Dam adult trapping facility, held and spawned at the Three Mile holding and spawning facility, and green eggs transferred to the Umatilla Hatchery for incubation. Based on the 2011 Umatilla Hatchery Operations Plan, 1,400,000 green eggs are obtained, in October. From this pool of eggs, 600,000 subyearling smolts are direct released into the Umatilla River at 40 fish/pound the following May and 537,000 eyed eggs are transferred to Bonneville Hatchery in March. From the 537,000 eggs transferred to Bonneville, 240,000 yearling smolts will be released from the Thornhollow and Pendleton acclimation sites at 10 fish/pound the following March. The 2011 plan further specifies that 50% of the Bonneville yearling production will be from wild x hatchery crosses for conservation and 50% hatchery x hatchery crosses for harvest. The entire subyearling release group will be hatchery x hatchery crosses for harvest. The current annual broodstock collection goal is 768 adults and no jacks. Anticipated survival from egg take (spawning) to release from the acclimation ponds is 77%.

The fall Chinook program has generally met the broodstock collection, egg take, and smolt release goals. For run years 2000 through 2009 smolt production for the 600 K subyearling release was met in 8 of 9 years and the 480 K yearling release averaged 473 K in the past 8 years (Appendix Table 18 and 19 in Clarke et al. 2011).

Post Release Survival, Adult Returns to the Umatilla River, Straying and Harvest

Hatchery fall Chinook Adult Returns, Straying, and Harvest. Adult hatchery-origin fall Chinook returning to the mouth of the Umatilla River from 1985 to 2009 ranged from 6 in 1985 to 2,541 in 2004, averaging 1,167; average marked (hatchery) adults numbered 1,047 and unmarked adults numbered 120 (Table 22 in Clarke et al. 2011). This average run-size is much less than the subbasin plan goal of 4,000 hatchery and 4000 natural fall Chinook. For brood-years 1990 - 2004, smolt-to-adult survival (SAS) averaged 0.64% for yearling releases and 0.08% for subyearling releases. The goals were 0.75% and 0.30% for yearlings and subyearlings, respectively. SAS has not achieved program goals for either rearing strategy.

Hatchery-reared fall Chinook salmon from Umatilla River releases stray beyond the Umatilla River and are recovered in the upper Columbia and Snake rivers. In the 1980s, high stray rates (86% for adults from subyearling smolts, 58% for adults from yearling smolts) were observed for yearling returns that strayed to Snake River and subyearling returns that strayed to the Upper Columbia River. Mean percent of returns that strayed declined considerably after Phase II pumping began in 1995 for both subyearlings (86.0% to 46.1%) and yearlings (57.8% to 22.9%). For yearling returns, stray rate declined considerably in the Snake River (42.3% to 14.6%), but less in the Upper Columbia River (15.5% to 8.3%).

Co-managers were not able to determine the relative influence that acclimation and Phase I and II flow enhancement had on straying because these two management strategies were implemented concurrently. Strays that escape to spawning grounds above Lower Granite Dam in the Snake River are the primary concern of NOAA Fisheries ESA managers. High numbers of Umatilla origin strays into the Snake River prompted NOAA to mandate 100% wire-tagging of hatchery fall Chinook production to facilitate their removal by a wire-activated fish trap at Lower Granite Dam. From 1984 to 1995, Umatilla strays accounted for an unacceptability high proportion of the escapement past Lower Granite Dam (11.0%) but have since declined to only 1.9%.

Estimated total number of fall Chinook salmon adults and jacks from the Umatilla subyearling and yearling hatchery programs recovered in fisheries averaged 3,209 annually. Out-of-basin harvest predominated, averaging 3,157 fish annually. Nearly all out-of-basin harvest was in ocean and Columbia River fisheries. For both programs and all broods, tribal and non-tribal harvest comprised 33% and 67% of all out-of-basin harvest, respectively. In Columbia River fisheries, proportional harvest was 69% tribal and 31% non-tribal.

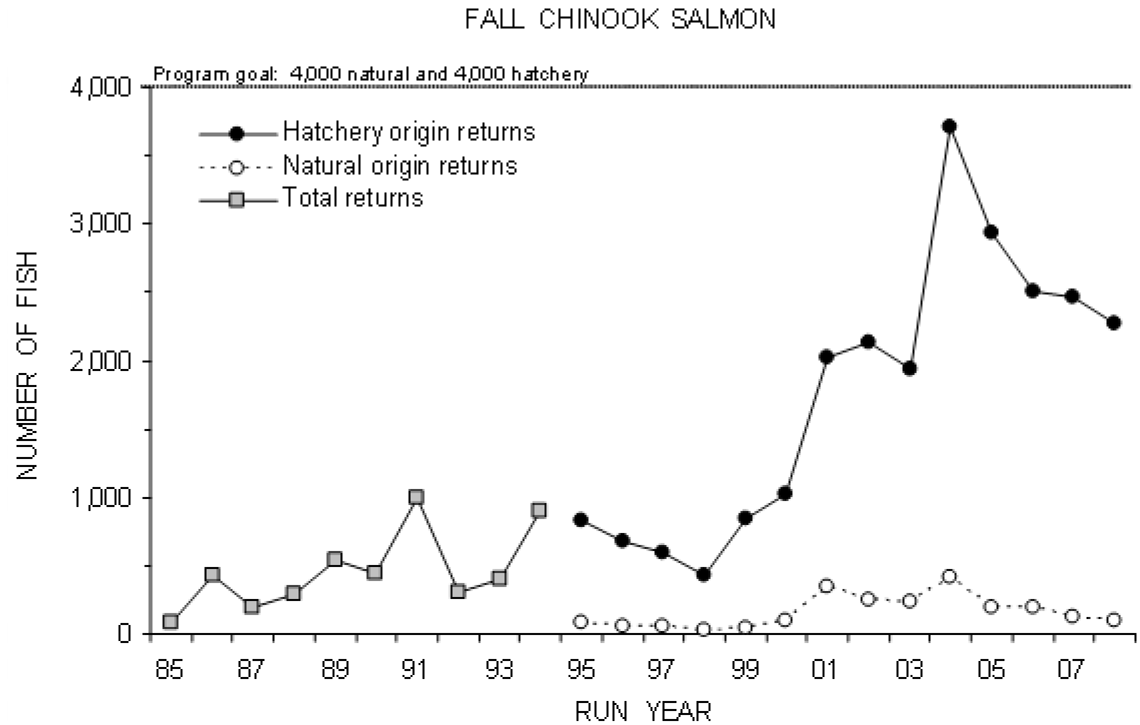

Figure 12. Fall Chinook adult returns to the Umatilla River 1985 – 2008.

Natural Production and Reintroduction Success Status

Natural fall Chinook Adult Returns to the Umatilla River. Abundance of Umatilla unmarked (presumably natural-origin) fall Chinook adults arriving at the Umatilla river mouth in return-years 1993 through 2009 ranged from 16 to 300 with a mean of 120 (Table 22 in Clarke et al. 2010). Natural-origin fall Chinook abundance has been substantially below the 4,000 fish goal established in the subbasin plan.

HOR and NOR Spawning, natural smolt production. Since the program's inception an average of 1,148 adult fall Chinook return to Three Mile Falls Dam, in the most recent five years the average has been 1,937 fish. About 770 adults are currently collected for broodstock, with the remainder passed above the dam to spawn naturally. Estimates are that no more than 53% of females passed above the dam successfully spawn. Abundance estimates for fall Chinook smolts for outmigration years 1995 – 2007 ranged from 169 (1996) to 242,100 (1998), averaging 41,807 (Hanson et al. 2010). Counts of naturally-produced fall Chinook smolts outmigrating past Three Mile Falls Dam have been below what would be expected based on redd counts; from 1994-2005 the number of smolts per spawner has ranged from 0.4 to 267.5 (proposal 1990-050-00).

The Umatilla Master Plan estimated that 85% of the spawning substrate for fall Chinook salmon was above Pendleton (Grant et al. 2007). The program assumed high natural production of fall Chinook salmon due to the estimated large amount of spawning and rearing habitat above Pendleton. However, few fall Chinook salmon adults spawn above Pendleton. Flow augmentation from McKay Reservoir releases, which provides cool water to the relatively warmer Umatilla River, might be affecting the upriver migration of spawners at times by creating a large temperature differential in the mainstem below Pendleton (proposal 1990-050-00).

Habitat conditions in the Umatilla basin likely limit natural spawning and smolt production. The Umatilla River often has high flows in the winter from rain-on-snow events in mid-elevations which lead to increased mortality in incubating fall Chinook salmon eggs and pre-emergent life stages from scouring (proposal 1990-050-00). As a result the progeny-per-parent ratio has been below 1 for all years except 1998, which means that the natural population is not replacing itself. Until average progeny-per-parent ratios exceed 1 over successive generations, the Umatilla fall Chinook reintroduction cannot be considered complete (proposal 1990-050-00).

Yakima River Subbasin

Project Number	Title	Proponents
199506325	Yakima/Klickitat Fisheries Project	WDFW, Yakima Confederated Tribes, and Oncorh Consulting

Background

This project is an umbrella proposal for monitoring and evaluation of natural production, harvest, ecological, and genetic impacts for spring Chinook, fall Chinook, and coho fisheries enhancement projects in the Yakima Basin. Monitoring and evaluation results guide adaptive management decisions.

The objectives are: (1) to monitor and evaluate ecological impacts of supplementation on non-target taxa, and impacts of strong interactor taxa on productivity of targeted stocks, (2) monitor and evaluate genetic change due to domestication and potential genetic change due to in-basin and out-of-basin stray rates, (3) monitor and evaluate changes in harvest of YKFP targeted stocks, and (4) determine if supplementation and habitat actions increase natural production. Evaluate changes in natural production with specified statistical power.

Results

Spring Chinook

The Cle Elum Supplementation and Research Facility (CESRF) collected its first spring Chinook brood stock in 1997, released its first fish in 1999, and age-4 adults have been returning since 2001, with the second F2 generation (offspring of CESRF and wild fish spawning in the wild) returning as adults in 2009. In these initial years of CESRF operation, recruitment of hatchery origin fish has exceeded that of fish spawning in the natural environment (BPA annual reports).

Preliminary results indicate that significant differences have been detected among hatchery and natural origin fish in about half of the traits measured in the monitoring plan and that these differences can be attributed to both environmental and genetic causes. For example, they have detected differences in hatchery and natural origin fish after only one generation of hatchery exposure for the following variables measured on adults: age composition, size-at-age, sex ratio, spawning timing, fecundity, egg weight, and adult morphology at spawning (Busack et al. 2007; Knudsen et al. 2006, 2008). With respect to spawning success, no differences were detected in the egg deposition rates of wild and hatchery origin females, but pedigree assignments based on microsatellite DNA showed that the eggs deposited by wild females survived to the fry stage at a 5.6% higher rate than those spawned by hatchery-origin females (Schroder et al. 2008); behavior and breeding success of wild and hatchery-origin males were found to be comparable (Schroder et al. 2010). Significant differences in juvenile traits have also been detected: food conversion efficiency, fry length-weight relationships, agonistic competitive behavior, predator avoidance, and incidence of precocious maturation (BPA annual reports; Larsen et al. 2004, 2006). Most of the differences have been 10% or less. The rate of mini-jacks (precocious male salmon that do not go to sea) at the Cle Elum Hatchery averaged 41% during 1997-2007. Research is continuing into factors that influence production of mini-jacks, given that these fish do not contribute to harvests and they may compete with native fishes or consume them.

Redd counts in the 2001-2009 period have increased significantly in both the supplemented Upper Yakima and unsupplemented Naches control systems relative to the pre-supplementation period (1981-2000), but the average increase in redd counts in the upper Yakima (236%) was substantially greater than that observed in the Naches system (163%; BPA annual reports). Spatial distribution of spawners has also increased as a result of acclimation site location, salmon homing fidelity, and more fully seeding preferred spawning habitats (Dittman et al. 2010). Semi-natural rearing and predator avoidance training have not resulted in significant increases in survival of hatchery fish (Fast et al. 2008; BPA annual reports). Growth manipulations in the hatchery appear to reduce the number of precocious males produced by the YKFP and consequently increase the number of smolt out-migrants, however post-release survival of treated fish appears to be significantly lower than conventionally reared fish (Larsen et al. 2006; Pearsons et al. 2009; BPA annual reports). Genetic impacts to non-target populations appear to be low because of the low stray rates of YKFP fish (BPA annual reports). Ecological impacts to valued non-target taxa were generally within containment objectives, or impacts that were outside of containment objectives were not caused by supplementation activities (Pearsons et al. 2007; Pearsons and Temple 2007; BPA annual reports). Reductions in rainbow trout abundance and biomass were observed in a tributary watershed where hatchery-origin fish were released, but the trout may have been simply displaced to other areas (Pearsons and Temple 2010). Fish and bird piscivores consume large numbers of salmonids in the Yakima Basin (Fritts and Pearsons 2004, 2006; Fritts et al. 2007; Major et al. 2005; BPA annual reports). Natural production of Chinook salmon in the upper Yakima Basin appears to be density dependent under current conditions and may constrain the benefits of supplementation (BPA annual reports). However, such constraints could be countered by YKFP habitat actions (see summary below). Additional habitat improvements implemented by other entities, including the Conservation Districts, counties and private interests are also continuing in the basin (e.g., YBFWRB 2010). Harvest opportunities for tribal and non-tribal fishers have also been enhanced, but are variable among years (BPA annual reports).

Fall Chinook

The YKFP is presently studying the release of over 2 million Upriver Bright fall Chinook smolts annually from the Prosser and Marion Drain Hatcheries. These fish are a combination of in-basin production from brood stock collected in the vicinity of Prosser Dam plus out-of-basin Priest Rapids stock fish reared at Little White National Fish Hatchery and moved to Prosser Hatchery for final rearing and release. Marion Drain broodstock are collected from adult returns to a fishwheel in the drain. These fish contributed to the improved returns of fall Chinook to the Columbia River in recent years. The YKFP is investigating ways to improve the productivity of fish released from Prosser Hatchery and to improve in-basin natural production of fall Chinook. For example, rearing conditions designed to accelerate smoltification of Yakima Basin fall Chinook have resulted in smolt-to-smolt survival indices that exceeded those of conventionally reared fall Chinook in five of the six years for which results are available.

A Master Plan is being developed that proposes to: 1) transition out-of-basin brood source releases from the Little White Salmon National Fish Hatchery to Priest Rapids Hatchery (consistent with USFWS and HSRG hatchery program review recommendations) and release these fish from acclimation sites in the lower Yakima River below Horn Rapids Dam, 2) continue development of an integrated production program above Prosser Dam using locally collected brood stock, 3) re-establish a summer-run component using an appropriate founder stock, and 4) upgrade existing brood collection, production and acclimation facilities to accommodate changes in production strategies. The total number of fish released would remain similar to existing levels. The Master Plan is expected to be submitted to the NPCC's Three-Step Review process within the next 1-2 years.

Coho

The YKFP is presently studying the release of over 1 million coho smolts annually from acclimation sites in the Naches and Upper Yakima subbasins. These fish are a combination of in-basin production from brood stock collected in the vicinity of Prosser Dam plus out-of-basin stock generally reared at Willard or Eagle Creek National Fish Hatcheries and moved to the Yakima Subbasin for final rearing and release. YKFP monitoring of these efforts to re-introduce a sustainable, naturally spawning coho population in the Yakima Basin have indicated that adult coho returns averaged over 3,600 fish from 1997-2009 including estimated returns of natural coho averaging nearly 1,400 fish since 2001. This is an order of magnitude greater than the average for years prior to the project. Coho re-introduction research has demonstrated that hatchery-origin coho, with a legacy of as many as 10 to 30 generations of hatchery-influence, can reestablish a naturalized population after as few as 3 to 5 generations of outplanting in the wild (Bosch et al. 2007). The project is working to further develop a locally adapted broodstock and to establish specific release sites and strategies that optimize natural reproduction and survival. A Master Plan is being developed and is expected to be submitted to the NPCC's Three-Step Review process within the next 1-2 years.

Habitat

The project objectives include habitat protection and restoration in the most productive reaches of the Yakima Subbasin. The YKFP's Ecosystem Diagnosis Treatment (EDT) analysis will provide additional information related to habitat projects aimed to improve salmonid production in the Yakima Subbasin. Major accomplishments to date include protection of 1,300 acres of prime floodplain habitat, reconnection and screening of over 20 miles of tributary habitat, substantial water savings through irrigation improvements, and restoration of over 80 acres of floodplain and side channels. Restoration designs are now complete for the middle reaches of Taneum and Swauk Creeks. Restoration designs for lower Swauk Creek are being finalized. A road alternatives analysis has been developed, including preliminary cost estimates for relocating a portion of a USFS road in the little Naches watershed. Appraisals have also been completed on important habitat properties, and the proponents are trying to purchase these. Additional habitat improvements implemented by other entities, including the Conservation Districts, counties, and private interests are continuing in the basin (e.g., YBFWRB 2010).

ISRP Comments

In our RMEAP Category Review (ISRP 2010-44), we found that the overall implementation of the project was adequate but noted that our Yes (Qualified) rating did not represent ISRP endorsement of the interpretations of data and results. Specifically, we recommended that in the future the project use standardized calculations/metrics for determining impacts of supplementation, as presented in the Ad Hoc Supplementation Work Group reports and ISRP supplementation reports (e.g., incorrectly using total number of redds before and after supplementation efforts, rather than number of redds from wild spawned returning adults before and after treatment). The project needs to assess response to supplementation of the *wild* population...and to do that, the calculations will need to include a method of estimating proportions of wild to hatchery fish in reference versus treatment streams.

3. Upper Columbia subregion (Wenatchee, Entiat, Methow, Okanogan)

Mid-Columbia coho reintroduction

Project Number	Title	Proponent
1996-040-00	Mid-Columbia Coho Reintroduction Feasibility	Yakama Nation

Background

Coho salmon were extirpated from mid-Columbia River tributaries in the early 1900s owing to harvest in the lower Columbia; subsequent water system (dams and irrigation), agriculture, and forestry practices limited opportunities for maintaining runs with hatchery production and reestablishing meaningful natural production. The Yakama Nation began a reintroduction feasibility investigation in 1996 by releasing lower Columbia hatchery coho smolts in the Methow and later in the Wenatchee River following acclimation, and using any adults returning from these releases to establish a mid-Columbia coho stock. The initial goal was to produce sufficient adult returns from Wenatchee and Methow smolt releases to support a self-sustaining anadromous hatchery program. That initial phase is complete. The next step in the reintroduction program is to establish production in the upper Wenatchee (above Tumwater Dam) and provide for natural production. The desired end is a self-sustain natural population with 1500 natural-origin adults returning to both the Wenatchee and Methow rivers. The program is developed in the Mid-Columbia Coho Restoration Master Plan (YNFRM 2009). Briefly, the approach in both rivers is divided into four discrete stages: broodstock development phase I, and II, natural production implementation phase, and natural production support phase. The Wenatchee River is expected to be in broodstock development phase II from 2007 through 2011. The Methow River is expected to be in broodstock development phase I from 2007 – 2009.

Table 13. Mid-Columbia Coho Reintroduction: Master Plan Production and Goals for 2008 - 2010.

Wenatchee River	
Broodstock Collection	Smolt Release
1321 Adults 50:50 Dryden/LNFH:Tumwater	1 Million 50:50 upper Wenatchee: Icicle Creek
Methow	
Broodstock Collection	Smolt Release
656 Adults Wells Dam	500 K 250 – 350 K, WNFH[1], 150 – 250 K Other[2]

1. Winthrop National Fish Hatchery
2. Wells Dam, Methow, Twisp, and/or Chewuch river acclimation sites

Summary of Results

Table 14. Mid-Columbia Coho Reintroduction: Broodstock collection and smolt release.

Wenatchee River							
Broodstock Collection					Smolt Release		
Year	Dryden	LNFH	Tum-water	Total	Upper Basin	Lower Basin	Total
2008	580	265	146	991	458,197	567425	1,025,622
2009	549	136	371	1056			
Methow							
Broodstock Collection					Smolt Release		
Year	WNFH	Wells D	Wells FH	Total	WNFH	Other	Total
2008	179	160	54	393	258,077	271,907	529,984
2009	195	18	294	507			

Post release survival

Table 15. Mid-Columbia Coho Reintroduction: Release to McNary Dam survival, and smolt-to-adult survival rates, brood years 1997 – 2007 (replicate of Table 21, 2010 Annual Report).

Brood Year	**Release Year**	**Methow Smolt Survival**	**Lower Wenatchee Survival**	**Upper Wenatchee Survival**	**Return Year**	**Methow SAR**	**Wenatchee SAR**
1997	1999	n/a	54%	n/a	2000	n/a	0.21% – 0.38%
1998	2000	33%	63%	n/a	2001	0.17%-0.27%	0.17%-0.86%
1999	2001	10%	22%	n/a	2002	0.03%	0.03%-0.13%
2000	2002	n/a	87%-78%	39%	2003	0.15%	0.32%-0.51%
2001	2003	n/a	63%	37%	2004	0.16%	0.33%-0.55%
2002	2004	26%-29%	56%-61%	30%-36%	2005	0.19%	0.29%-0.47%
2003	2005	n/a	33%-44%	16%-18%	2006	0.18%	0.15%-0.37%
2004	2006	n/a	37%-51%	16%-47%	2007	0.13%-0.47%	0.11%-0.74%
2005	2007	n/a	39%-87%	45%-53%	2008	0.13%-0.38%	0.03%-0.33%
2006	2008	28%	40%-63%	46%-71%	2009	0.16%-0.47%	0.12%-0.60%
2007	2009	40%-49%	44%-50%	34%-60%	2010	n/a	n/a

Survival estimates with multiple values represents the range observed with releases from different locations and primary hatchery rearing sites.

In addition to the smolt survival to McNary Dam and smolt-to-adult survival, the project estimates adult hatchery returns to each subbasin, estimates natural spawning (redd counts), and cooperates on some natural smolt abundance estimates. The following are major findings reported by the proponent in the 2010 annual report:

- Between September 1 and November 6, YN collected 1,056 coho at Dryden Dam, Leavenworth NFH, and Tumwater Dam on the Wenatchee River. At Winthrop NFH and Wells Dam, 445 coho were collected for the Methow River program between September 23 and December 5. Excess coho for the Methow program were returned to the river to naturally spawn. Broodstock goals for both basins were to collect enough females to fulfill future acclimation release needs of 500,000 juveniles in the Methow River and 1,000,000 juveniles in the Wenatchee River.

- YN spawned 1,002 coho at Entiat NFH and 393 at Winthrop NFH. An eye-up rate of 87.7% was calculated for the Wenatchee program and 84.1% for the Methow program. Increased eye-up rates and improved eyed-egg quality should lead to improved survival from the eyed stage to smolt release.

- During spawning ground surveys in the Wenatchee Basin for 2009, YN found a total of 1,601 coho redds; 818 redds in Icicle Creek, 482 redds in the Wenatchee River, 14 redds in Nason Creek and a combined 286 redds in Brender, Mission, and Peshastin creeks. The 2009 season marked the first coho redd identified in Beaver Creek.

- During spawning ground surveys in the Methow Basin for 2009, YN found a total of 283 coho redds, of which, 269 were identified in-basin. Of the total in-basin redds, 151 were on the Methow River, 77 in Spring Creek (WNFH back-channel), 35 in the WDFW Methow FH outfall, 1 in Gold Creek, 2 in Beaver Creek, and 1 in Libby Creek. Out-of-basin totals were as follows: 12 redds in Beebee Springs and 2 in Foster Creek.

- YN estimated that in-basin smolt-to-adult survival rate (SAR) for BY2006 hatchery coho smolts released in the Wenatchee River basin was 0.49% (4,787 adults and jacks) for all release groups. However, the smolt-to-adult survival rate varied between release groups (range 0.12% - 0.60%). Using scale analysis for verification of fish origin, they estimated the SAR for naturally produced coho to be 1.36%.

- In the Methow River, the overall SAR for brood year 2006 hatchery coho was estimated to be 0.32%. The SARs for each release group ranged from 0.16% to 0.47% (1,647 adults and jacks). These SARs calculations included releases from Wells FH that contributed to the majority of fish collected in the analysis. Natural origin verification has not been finalized yet and will be submitted in an amended report once completed.

ISRP Conclusions and Recommendations

The Yakama Nation effort to reintroduce coho salmon to the Wenatchee and Methow subbasins is achieving success at culturing fish and returning sufficient numbers of adults to each subbasin to maintain a self-sustaining hatchery program. Returning hatchery adults are spawning and constructing redds in the natural environment. The data and analysis provided in the annual report is not sufficient to evaluate progress toward natural production goals or for determining whether progress is being made toward adaptation to the upper Wenatchee watershed. The report provides a co-manager evaluation of smolt production from Nason Creek, which is valuable. However, natural production of smolts from the entire Wenatchee and Methow are needed for a thorough evaluation. Additionally, the report needs to estimate natural coho adult production in an explicit way. There is some effort to present natural production as those individuals removed from traps for spawning that were unidentified. But, this assumes these fish are representative of the distribution basinwide, which needs to be verified. The interpretation of the abundance of fish collected at Dryden versus Icicle Creek and Tumwater is complicated by not knowing what portion of the fish collected at Dryden would have arrived at Icicle Creek or Tumwater had they not been removed. Table 2 (page 5) in the annual report provides the release location for each of the fish used in spawning, but there is no indication of the release location of the fish that returned to Icicle Creek or Tumwater. The report reveals that very few redds were constructed above Tumwater Dam (15 of 1601), but it is not clear whether this simply reflects an absence of fish. The report indicates that all robust coho adults were removed at Tumwater. The report does not indicate whether any fish were passed up stream. To track progress toward adaptation some effort will be needed to determine whether fish released from the Nason Creek acclimation sites that return to Tumwater and are used as parents produce progeny that return to Tumwater in greater proportion than parents that returned to Icicle Creek, or were progeny of fish released from lower river sites and returned to lower river sites (Icicle Creek). It is not clear how progeny from adults collected from Dryden can be used to make inferences regarding adaptation to the upper watershed.

Given the low SARs it is unlikely that egg-to-smolt survival will be large enough to achieve a natural population that is near replacement for the foreseeable future. These are incredibly low survival rates for coho salmon. For example, SAR of Puget Sound wild coho was 5-20% from 1990-2009, Georgia Strait wild coho SAR was 1-5% and Georgia Strait coho is considered in poor condition; SAR of wild South Eastern Alaska (SEAK) coho was 10-25%. Sustainable wild coho populations need a much higher survival rate than observed in the mid-Columbia coho reintroduction program because they have lower fecundity than other salmon species and they spend a year in freshwater. Given the exceptionally low SARs it is highly unlikely that a sustainable natural coho population would develop. Even the SAR of 1.36% for the natural BY2006 is probably too low.

4. Snake River Basin Subregion

Grande Ronde, Imnaha River Subbasins

Italicized projects are contextual.

Number	Title	Proponent
1998-007-02	*Grande Ronde Supplementation Operations and Maintenance (O&M) and Monitoring and Evaluation (M&E) on Lostine River*	*Nez Perce Tribe*
1988-053-01	Northeast Oregon Hatchery Master Plan	Nez Perce Tribe
2007-132-00	NEOH Monitoring & Evaluation Implementation (Formerly a component of 198805301)	Nez Perce Tribe
1988-053-05	Northeast Oregon Outplanting Facilities	ODFW
1998-007-04	Grande Ronde Spring Chinook on Lostine/Catherine Creek/ Upper Grande Ronde Rivers	ODFW
1998-007-03	Grande Ronde Supplementation O&M on Catherine Creek/Upper Grande Ronde River	Umatilla Confederated Tribes (CTUIR)
2007-083-00	Grande Ronde Supplementation Monitoring and Evaluation (M&E) on Catherine Creek/Upper Grande Ronde River	Umatilla Confederated Tribes (CTUIR)
1992-026-04	Grand Ronde Early Life History of Spring Chinook and Steelhead	ODFW
2007-404-00	Spring Chinook Captive Propagation-Oregon	ODFW
1997-015-01	Imnaha River Smolt Monitoring	Nez Perce Tribe

Background

The Grande Ronde River Basin historically supported large populations of fall and spring Chinook (*Oncorhynchus tshawytscha*), sockeye (*O. nerka*), and coho (*O. kisutch*) salmon and steelhead trout (*O. mykiss*). The decline of Chinook salmon and steelhead populations and extirpation of coho and sockeye salmon in the basin was, in part, a result of construction and operation of hydroelectric facilities, over fishing, and loss and degradation of critical spawning and rearing habitat. Hatcheries were built in Oregon, Washington, and Idaho under the Lower Snake River Compensation Plan (LSRCP) to compensate for losses of anadromous salmonids. Lookingglass Hatchery (LGH) on Lookingglass Creek, a tributary of the Grande Ronde River, was completed under LSRCP in 1982 and has served as the main incubation and rearing site for Chinook salmon programs for Grande Ronde and Imnaha rivers in Oregon. However, continued declining population trends in the mid-1980s to mid-1990s indicated that Grande Ronde River basin spring Chinook salmon were in imminent danger of extinction.

In response to this decline, the Grande Ronde Endemic Spring Chinook Salmon Supplementation Program (GRESCSP) was developed in order to prevent extinction, enhance natural production, and provide some level of harvest. The GRESCSP was implemented in three Grande Ronde River basin tributaries: the Lostine and upper Grande Ronde rivers and Catherine

Creek. The GRESCSP employs two broodstock strategies utilizing captive (BPA projects 199801001 and 199800106) and conventional (projects 199800702 and 199800703) brood sources. The captive brood component was implemented to minimize the imminent demographic risk of extinction, whereas the conventional component exists as a long-term strategy to balance the captive component and increase production while reducing the genetic risk of artificial selection. The captive brood component began in 1995, with the collection of parr from the three tributary areas. The conventional broodstock component of the program began in 1997 with the collection of natural adults returning to these tributary areas and in 2000 with the acclimation of smolt production from these areas. Due to low numbers of returning adults, no conventional broodstock were spawned from either Catherine Creek or the upper Grande Ronde River until 2001. The current production levels have been agreed to and incorporated into the U.S. v. Oregon Interim Management Agreement. This effort involves collaboration among Confederated Tribes of the Umatilla Indian Reservation (CTUIR), Nez Perce Tribe (NPT), and Oregon Department of Fish and Wildlife (ODFW). Bonneville Power Administration's Fish and Wildlife program is an adjunct to the LSRCP with the intent of modifying the mitigation aspect of the program to an integrated supplementation program so that hatchery produced fish can be experimentally used as a salmon recovery tool while providing fish for harvest.

The captive broodstock component provided the anticipated boost to adult returns and contributed to the understanding of this technique for restoring Pacific salmon populations. The captive broodstock component was recently phased down to a "safety net" program with a reduced production component and without any monitoring and evaluation. The Captive Broodstock Program for the Catherine Creek and Lostine River populations ended in 2010, as they have met the goal of a consistent return of 150 adults spawning in nature. The Captive Broodstock Program for the Grande Ronde stock will end with completion of the 2007 brood year. This program will be followed by the Safety Net Program (SNP), co-managed by ODFW and CTUIR. The Safety Net Program focuses exclusively on the Upper Grande Ronde River stock, which remains in danger of extirpation. Eyed eggs will be collected each year from the Upper Grande Ronde River Conventional Program at Lookingglass Fish Hatchery and reared to adulthood in captivity.

Habitat restoration is a component of the effort to restore anadromous salmonid populations in the Grande Ronde subbasin. Some habitat restoration efforts are funded by BPA, such as Project 198402500 (ODFW Blue Mountain Fish Habitat Improvement) and Project 199608300 (Grande Ronde Subbasin Restoration, CTUIR), while other habitat projects are coordinated and funded through Project 199202601 (Grande Ronde Model Watershed Program).

The Imnaha River subbasin is located adjacent to the Grande Ronde subbasin. The mainstem Imnaha River flows north for 128 km from its headwaters in the Eagle Cap Wilderness Area (elevation 3,048 m) to its confluence with the Snake River at river kilometer (Rkm) 309 (elevation 288 m). It encompasses an area approximately 1,577 km^2. The Imnaha River is part of the National Wild and Scenic Rivers System with sections classified as wild, recreational, and scenic. The Imnaha Smolt Monitoring Project provides estimation of juvenile abundance, survival, arrival timing and travel time to dams, biological characteristics and SARs for hatchery and natural origin Chinook salmon and steelhead in the Imnaha River. This watershed has a longer time series of supplementation monitoring than does the Grande Ronde watershed.

Fish Production Goals

Within hatchery performance goals and post-release performance goals for spring Chinook salmon released into the Grande Ronde and Imnaha rivers are summarized in Table 16.

Table 16. ISRP assessment of the reporting of objectives and performance metrics in Grande Ronde and Imnaha hatchery program reports prepared for the 2010 LSRCP Spring Chinook Program Review (ISRP 2011-14)

A. Hatchery Performance				
Metric	*Imnaha*	*Grande Ronde*	*Catherine Creek*	*Lostine*
Broodstock Collection Goals	NR	NR	NR	NR
Years Achieved	NR	NR	NR	NR
Pre-spawning Mortality Goal	<20%	<20%	<20%	<20%
Years Achieved	8/10	7/9	8/8	NR
Egg to Smolt Goal	>70%	>70%	>70%	>70%
Years Achieved	9/10	8/8	7/8	NR
Smolt Release Goal	0.36M	0.25M	0.15 - .25M	0.25M
Years Achieved	6/10	1/10	0/10	2/10
B. Post-Release Performance				
Survival to LGD Goal	NR	NR	NR	NR
Survival to LGD[2]	52-75%	18-56%	25-48%	45-70%
SAS Goal	3.25%	3.25%	3.25%	NR
Years Achieved	0	0	0	---
Lower Col & Ocean Harvest Goal	16,050	NR	NR	NR
Years Achieved	0	---	---	---
SAR Goals	0.65%	0.65%	0.65%	0.10%
Years Achieved	8/10	1/6	0/6	8/8
Return to LGD Goal	3,210	1,617	1,617/970	NR
Years Achieved	3	0	0	
Tribal Harvest Goals	NR	NR	NR	NR
Years Tribal Harvest	NR	NR	NR	NR
Sport Harvest Goals	NR	NR	NR	NR
Years of Sport Harvest	NR	NR	NR	2/10
Weir Abundance Goals	NR	NR	NR	NR
Years Achieved				
Spawning Escapement Goals	NR	NR	NR	250
Years Achieved				9/10
C. Interaction Performance[3]				
Age Structure	Yes	Yes	Yes	Yes
Run Timing	Yes	Yes	Yes	Yes
NOR Abundance	Yes	Yes	Yes	Yes
NOR Productivity	Yes	Yes	Yes	Yes
BACI Assessment	Yes	No	No	No

Metric	Imnaha	Grande Ronde	Catherine Creek	Lostine
Supplementation Effectiveness Evaluation[5]	No	Yes	Yes	No
RRS Assessment[4]	No	No	Yes	No
Genetic Assessment	No	No	No	No

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

Summary of Results

Hatchery Performance

The captive broodstock program prevented extirpation of spring Chinook in the Grande Ronde subbasin and is now ending because it has met its goal of 150 adults spawning in Catherine Creek and Lostine River. A safety net program will continue for the Upper Grande Ronde River where the population is still in danger of extirpation.

Performance goals within the hatchery (pre-spawning mortality and egg-to-smolt survival) were typically met. However, smolt release goals were not met in most years because it was difficult to obtain broodstock owing to poor survival after release and limited water supply at LGH. Therefore, the initial Chinook release goal for the Imnaha River was reduced from 0.49 million to the current interim goal of 0.36 million smolts. ISRP report 2011-14 noted that hatcheries should address ambiguities in broodstock collection goals.

Post Release Survival, Adult Returns

Juvenile Migration and Survival

No goal has been set for survival from hatchery release to Lower Granite Dam (LGD), yet data indicate survival is highly variable and can be low in some years. For example, range in survival of Lostine and Upper Grande Ronde hatchery spring Chinook to LGD was approximately 45-70%

and 18-56%, respectively (www.fws.gov/lsnakecomplan/) indicating the need to identify factors that cause large swings in survival before smolts reach the dams.

Smolt production in streams exhibited signs that the quantity and/or quality of habitat was inhibiting increased smolt production when spawning escapement in response to supplementation had increased (Figure 13). The density-dependent pattern was shown in Catherine Creek and in the Upper Grande Ronde River. Additional effort is needed to identify the mechanisms leading to this pattern, e.g., food versus space limitations. Genetic effects do not seem to be responsible because NOAA Fisheries provided evidence that fitness of smolts produced by hatchery adults spawning in the streams was similar to that of natural-origin adults (E. Berntson, NMFS, www.fws.gov/lsnakecomplan/). More detail is needed in the annual reports when describing how total smolt equivalents produced from a watershed is estimated, especially since many juveniles emigrate from the watershed during fall and experience overwinter mortality prior to smolting. How much error is introduced in the smolt equivalent estimates when converting fall migrants to smolts?

None of the watersheds had a spawning escapement goal except Lostine River. This is surprising because the supplementation efforts should have a goal for the total number of spawning adult salmon (hatchery and natural) that would potentially lead to maximum adult returns or maximum smolt production.

Hatchery spring Chinook typically met their goal for smolt-to-adult return (SAR) survival (revised downward from 0.87% to 0.65%) in the Imnaha and Lostine rivers but rarely met the goal in Catherine Creek and the Upper Grande Ronde River (Table 16). Differences in SAR values among the watersheds should be discussed.

Hatchery steelhead released into the Imnaha River experienced 33% higher SAS when acclimated to the river prior to release compared with smolts released directly from the truck without acclimation, a result that was not consistent with studies in other regions (Clarke et al. 2010). Investigations such as this are important for continuing to improve salmon production.

Annual project reports by investigators in these watersheds typically provided updates through 2009 or 2010 field seasons. However, the 2010 report for the Imnaha smolt monitoring project (199701501) only covered data collected through June 2008. More recent data for this project were provided by ODFW (R. Carmichael, ODFW; www.fws.gov/lsnakecomplan/). It would be worthwhile if project investigators uploaded all associated reports and journal publications to the Taurus webpage so that all information associated with the effort is located in one location.

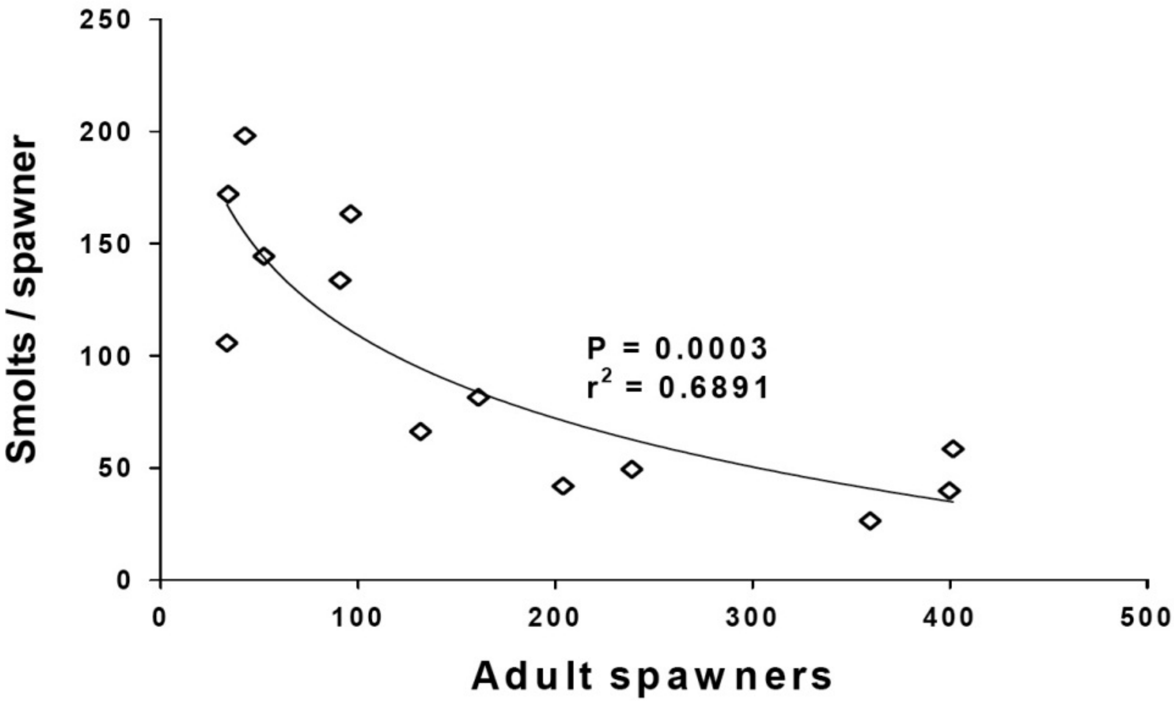

Figure 13. Evidence for potential density dependence among spring Chinook salmon in Catherine Creek suggesting capacity of habitat may constrain further benefits from supplementation. The pattern was also observed in the Upper Grande Ronde River (from R. Carmichael).

Adult Returns, Straying, and Harvest

Total adult Chinook returns to the watersheds rarely met their goal, and in most years the adult returns were well below the goal (Table 16). Supplementation efforts have contributed significant numbers of hatchery fish to natural spawning areas, e.g., 50-83% of total spawners in Catherine Creek since 2002 were hatchery origin (Figure 14). However, as noted above, these additional spawners have not led to greater numbers of smolts leaving the watersheds.

Adult recruits per spawner (R/S) of hatchery spring Chinook salmon was typically much greater than one (i.e., replacement), indicating a sustainable hatchery population (Figure 15). R/S of hatchery salmon was considerably greater than that of natural spawning salmon (Figure 15), as expected given the relatively low mortality of salmon while in the hatchery. Although hatchery salmon experienced higher mortality after release than natural salmon, this mortality did not significantly offset the high survival experienced in the hatchery. Interestingly, survival of hatchery releases was lower than survival of natural salmon even though hatchery salmon matured at a younger age and therefore experienced less time to interact with sources of mortality.

A key goal of a successful supplementation program is to rebuild the natural population and enhance natural productivity so that the supplementation effort can be eventually reduced or eliminated. Supplementation of populations such as Catherine Creek and Upper Grande Ronde Chinook salmon have prevented extirpation. However, the total life cycle productivity (R/S) of these supplemented populations is well below one, indicating the populations are not yet sustainable without intervention. Furthermore, R/S of natural-spawning Chinook salmon in the Imnaha River has declined since supplementation began (R. Carmichael, ODFW; www.fws.gov/lsnakecomplan/; Figure 15). The apparent density-dependent relationship among smolts (noted above) is one factor within the watershed that inhibits productivity and prevents the population from growing. Although these relationships are well documented in some of the reports, a key gap is the mechanism(s) leading to this relationship. For example, in the Umatilla River, a strong density-dependent relationship was observed in steelhead smolts and further evaluation indicated length at age decreased and age-at-smoltification increased with parent spawner abundance (Hanson et al. 2010). This type of analysis provides critical information indicating that food availability is one key limiting factor, which can then be used to inform habitat restoration efforts. In these watersheds, where habitat is degraded, success of supplementation efforts is ultimately dependent on improving habitat quality and quantity so that salmon productivity (e.g., smolts per spawner) can be increased.

Evidence suggests straying of these hatchery stocks is somewhat low, although the estimates are likely to be biased low if effort is low (effort was not documented). Investigators defined a stray hatchery salmon to be one that was caught or captured outside its normal migration pathway; supplementation fish would not be counted as strays. Estimates of straying among hatchery spring Chinook released into specific watersheds were as follows: Imnaha River (1%), Catherine Creek (4%), Upper Grande Ronde (7.5%), and Lostine (1.8%) (M. Schuck, WDFW; www.fws.gov/lsnakecomplan/). The percentage of stray hatchery salmon spawning among the local fish was not reported, except for small numbers in the Minam and Wenaha rivers. The straying index for hatchery steelhead released into the Imnaha River was 42% lower when fish were acclimated to the river prior to release compared with smolts released directly from the truck without acclimation (Clarke et al. 2010). Efforts to reduce unintentional straying from hatcheries are highly important given the growing evidence on adverse effects of hatchery fish on fitness of wild salmon.

Exploitation rates on hatchery spring Chinook salmon produced in the Grande Ronde and Imnaha rivers is low. In recent years, 78% of hatchery adults escaped fisheries and returned to Catherine Creek. The highest exploitation rate was in lower Columbia River sport fisheries (~14% of the run), followed by tribal fisheries (2.7%), commercial net fisheries in the Columbia (2.4%) and ocean fisheries (0.4%) (R. Carmichael, ODFW, www.fws.gov/lsnakecomplan/). Approximately 88% of Chinook salmon escaped fisheries and returned to the Imnaha River during recent years. The distribution of harvest was similar to that of Catherine Creek. Numbers of harvested hatchery and/or natural origin fish were not provided. There is no surplus of natural-origin Chinook salmon available for harvest in these watersheds because the R/S is below 1 (replacement). The lower Grande Ronde River yielded a steelhead harvest of 999 hatchery-origin fish during run year 2006-2007; 56% of 1,455 fish caught and released were of wild origin (Flesher et al. 2009).

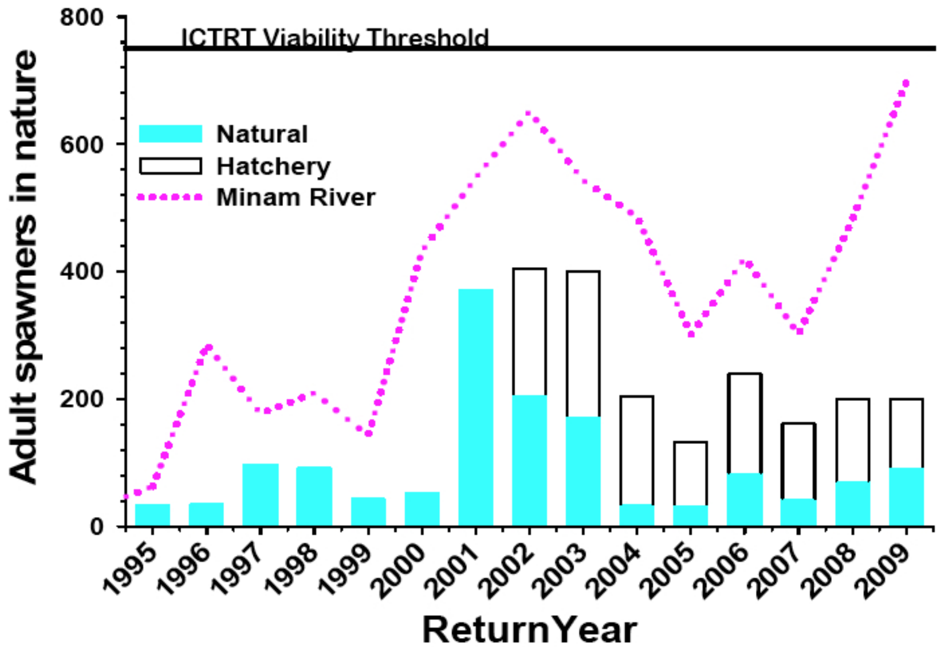

Figure 14. Natural-origin and hatchery-origin (supplementation) adult spring Chinook spawner abundances in Catherine Creek. Supplementation fish have represented 50-83% of total spawners since 2002. Minam River values represent natural origin spawners in a nearby unsupplemented watershed. (R. Carmichael, ODFW, www.fws.gov/lsnakecomplan/)

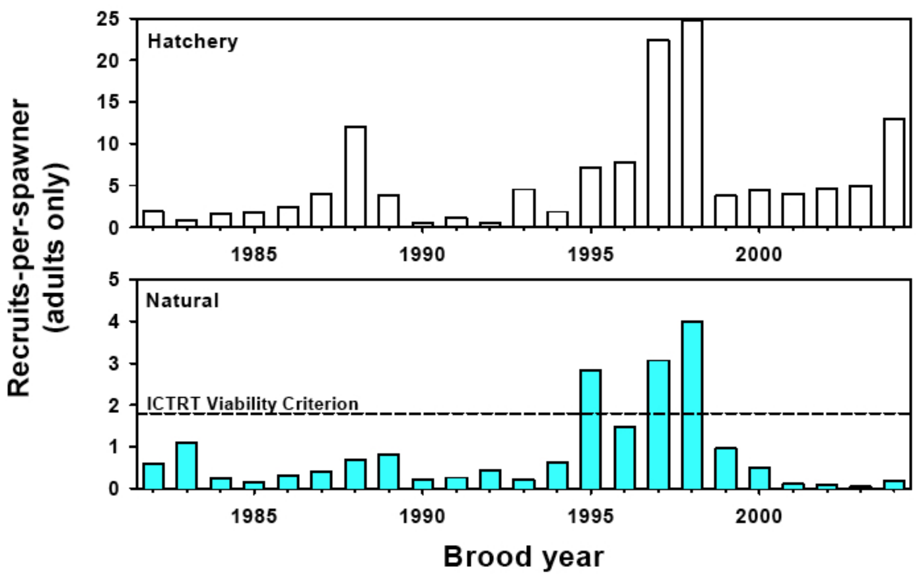

Figure 15. Imnaha River Chinook salmon recruits per spawner (excluding jacks) for hatchery and natural spawning (natural-origin and hatchery origin) adults. (R. Carmichael, ODFW, www.fws.gov/lsnakecomplan/)

Fitness of Supplementation Salmonids
The relative reproductive success (RRS) of hatchery spring Chinook spawning in Catherine Creek relative to natural-origin spawners was essentially equal up to the parr and juvenile migrant stage, but fitness of progeny produced by hatchery fish spawning in the creek and returning as adults was only 0.77 that of natural-origin salmon (E. Berntson, NMFS, www.fws.gov/lsnakecomplan/). Sample size of the adult finding was considered low. Relative fitness of hatchery x wild crosses returning as adults tended to be lower, but sample size was low. The RRS of hatchery steelhead in the Imnaha River watershed was approximately 0.4 of that of wild steelhead.

Conclusions

A wealth of useful information and data has been produced on spring Chinook salmon in the Grande Ronde and Imnaha watersheds. Less information was available on steelhead and fall Chinook, at least as reported by the aforementioned projects on the Taurus website. Most of the data and analyses simply report trends in data within each specific watershed. A key need is a comprehensive synthesis of data and information involving both hatchery and natural Chinook salmon and steelhead. The synthesis should attempt to address factors affecting growth, movement patterns, age at smoltification and maturation, survival, population dynamics, and other characteristics of salmonids. For example, given the range in SAR values, how many smolts per spawner are needed to produce a viable natural population? Environmental variables and habitat should be included in the analyses. For example, Chinook salmon smolt production in two watersheds exhibited signs of density-dependence that may inhibit benefits of supplementation. A key next step is to further evaluate why these relationships are being expressed at relatively low population numbers, and to evaluate what might be done to improve conditions. Likewise, in the Imnaha watershed, ODFW discussed factors that may be inhibiting supplementation effectiveness in that watershed. This is good information, and the ISRP encourages the proponents and the Council to further investigate new and emerging ideas on factors that are affecting salmonid production within these watersheds. If effort of this nature is ongoing, then existing annual reports should refer to those associated efforts. Although hatchery supplementation efforts seem to be aware of ongoing habitat restoration efforts, there is a need to better integrate supplementation with habitat restoration efforts because successful supplementation and rebuilding of natural populations will ultimately depend on improving habitat quality and quantity.

R/S must exceed 1 on a consistent basis to achieve the ultimate goal of a self-sustaining natural population. Until this happens, supplementation is only a life support system. In those circumstances where there is density dependent constraint on natural abundance, genetic risks for loss of natural spawning fitness are significant without any attendant benefit.

Clearwater River Subbasin

Project Number	Title	Proponent
1983-350-00	Nez Perce Tribal Hatchery O&M	NPT
1998-035-03	NPT Tribal Hatchery M&E	NPT

Background

Lewiston Dam, constructed at the mouth of the Clearwater River in 1927 and removed in 1973, effectively prevented passage of spring and fall Chinook salmon from 1927 through 1940. Lewiston Dam removal restored a portion of the Clearwater River to free-slowing conditions. Efforts were initiated in the 1950s to reintroduce Chinook salmon populations to the Clearwater River. Spring Chinook reintroduced using Rapid River hatchery stock has resulted in naturally reproducing populations in Lolo Creek and in the mainstem and tributaries of the Lochsa, Selway, and South Fork Clearwater watersheds. Fall Chinook have also begun to colonize the lower portions of the Clearwater River (Ecovista 2003).

The Nez Perce Tribal Hatchery in Juliaetta, Idaho, located along the banks of the Clearwater River, is used to rear fall and spring Chinook for the purpose of mitigating the Federal Columbia River Hydropower System. The goal is to produce and release juvenile salmon that will survive to adulthood, provide harvest, and spawn in the Clearwater River contributing to natural production. The Nez Perce Tribal Hatchery Complex (NPTHC) includes the primary hatchery, Sweetwater Springs rearing facility, and five acclimation/release facilities – Luke's Gulch, Cedar Flats, North Lapwai Valley, Newsome Creek and Yoosa/Camp Creek. The hatchery was completed in October 2002 and began operations in 2003.

Fall Chinook production at NPTHC was begun in 2003 using Snake River fall Chinook eggs and fry from Lyons Ferry Hatchery; 500,000 fall Chinook subyearlings were released in 2003. Currently broodstock for the fall Chinook program employs fish collected at Lower Granite Dam and volunteers to the NPTH fish ladder; 500,000 juveniles are released from NPTH into the Clearwater River, 500,000 released from North Lapwai Valley Acclimation Facility into Lapwai Creek, 200,000 released into the Selway River from Cedar Flats Acclimation Facility and 200,000 released into the South Fork Clearwater River from Luke's Gulch Acclimation Facility.

The Nez Perce Tribal Hatchery spring Chinook program purpose is to develop locally-adapted broodstocks to provide juveniles to supplement natural production in Lolo, Newsome, and Meadow Creek populations. In Lolo and Newsome creeks, adults are trapped using weirs and held streamside or transferred to NPTH. Spawning is performed streamside or at NPTH, and egg incubation takes place at NPTH. Juvenile salmon are transferred to the Sweetwater Springs for grow-out, and finally to acclimation ponds located along each stream for final rearing and release. Experiments have been conducted comparing conventional hatchery rearing with NATURES protocols intended to produce juveniles with size and experience (cover and feeding) similar to the natural environment. In the Meadow Creek watershed there is not an adequate weir for adult capture and no acclimation facilities. Salmon parr are released by helicopter. Adults for Meadow Creek production are produced by releasing smolts directly into the Clearwater River from NPTH, and collecting broodstock as volunteers to the NPTH fish ladder. When broodstock from supplementation streams or returning to NPTH is inadequate, fish or eggs are supplied by the Idaho Department of Fish and Game Clearwater Fish Hatchery or the U.S. Fish and Wildlife Service Dworshak Fish Hatchery. In Lolo and Newsome creeks pre-smolts are delivered to treatment stream acclimation ponds in late summer and released into the streams in fall. In Meadow Creek parr are direct released into the treatment stream by helicopter.

This summary reports the operation and evaluation of the spring Chinook component of the NPTH, drawing information from the RMEAP Category Review proposals and annual reports available through Taurus.

Summary of Results – Spring Chinook

Table 17. NPTH Spring Chinook Hatchery Production Goals.[1]

Production Goals	Meadow Creek	Lolo Creek	Newsome Creek
Broodstock Collection	392 (146 M & F)	110 (55 M & F)	56 (28 M & F)
Egg Production			
Juvenile Production	400 K parr - Meadow	150 K pre-smolts	75 K pre-smolts
	200 K smolt - NPTH		
Adult Production	676	329	171
Broodstock	322	136	69
Natural Spawning	248	63	42
Harvest	106	130	60
1. Numbers taken from various sections of proposal 1983-350-00. There are inconsistencies in objectives for broodstock collection number and broodstock production numbers not explained in the proposal or reports.			

Hatchery Production

Essential hatchery performance metrics include broodstock collection, spawning, egg incubation, and juvenile production; results of these activities from brood years (BY) 2002 through 2010 are presented in Table 17 above from proposal 1983-350-00.

The spring Chinook program has not been able to achieve broodstock collection and egg take goals from Lolo or Newsome creeks in any year; collection of broodstock at NPTH for release in Meadow Creek was accomplished in 2010. Figures 16-19 below, taken from proposal 1983-035-00, use results from Lolo Creek as a representative example of the broodstock collection and spawning efforts, use of USFWS Dworshak or Idaho Fish and Game Clearwater spring Chinook in

NPTH production, and the frequency of achieving juvenile fish release goals. In all years, broodstock collection and egg take were less than required to meet production. Secondary fish contributed variable, but appreciable, to production. Release numbers were achieved most years by substituting progeny from secondary sources.

In Newsome Creek, the number of females spawned is many less than the females trapped for spawning in several years (2007, 2008, 2010). No explanation is provided in the proposal or annual reports. Numbers of juveniles released into Newsome Creek nearly achieved program goals in each year except 2006. Juvenile production for Meadow Creek has been approximately 70% of the 400,000 release goal in most years. No fish were released in Meadow Creek in 2005 and releases in 2006 and 2007 were substantially below the program goals.

Fertilization of eggs and survival to the eyed stage and subsequent hatch is above 90%, which is excellent (see Table 18 and Figure 20).

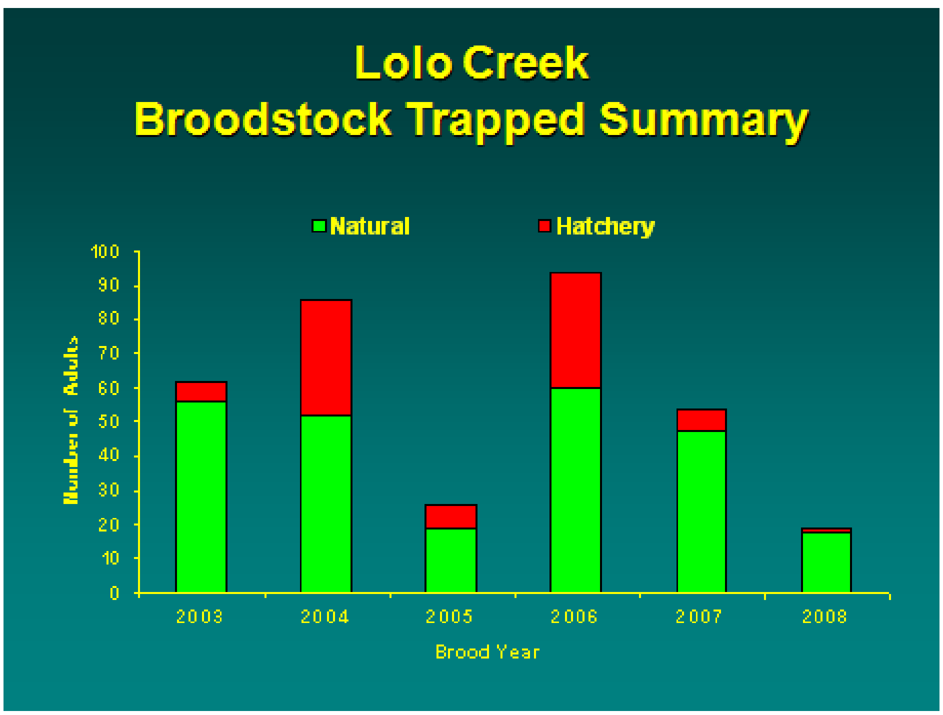

Figure 16. The Lolo Creek broodstock collection goal is 110 salmon (55 males and 55 females). This has not been achieved for the 2003 through 2008 brood years (from proposal 1983-350-00).

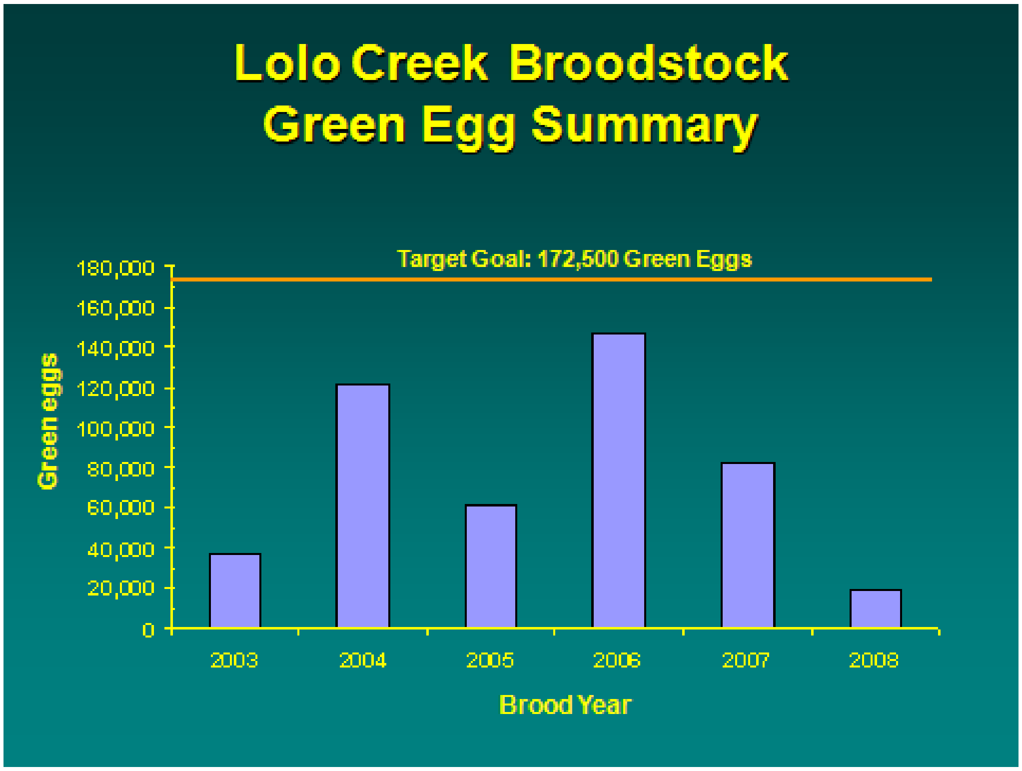

Figure 17. Lolo Creek Broodstock Green Egg Summary (from proposal 1983-350-00).

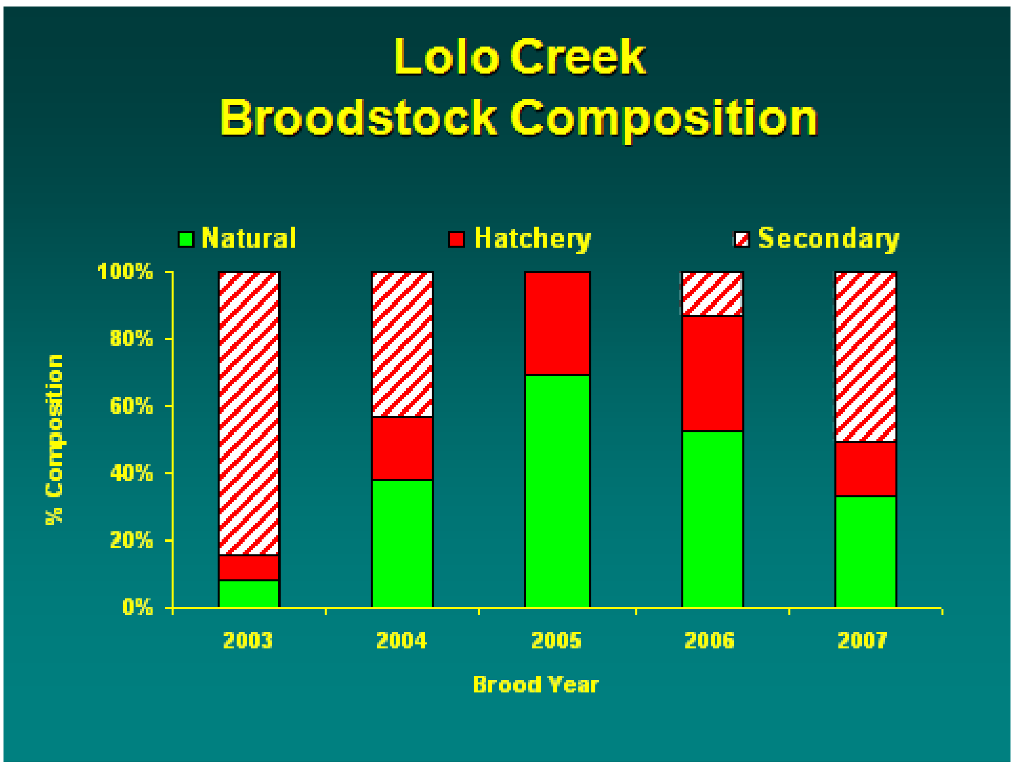

Figure 18. Lolo Creek Broodstock Composition (from proposal 1983-350-00).

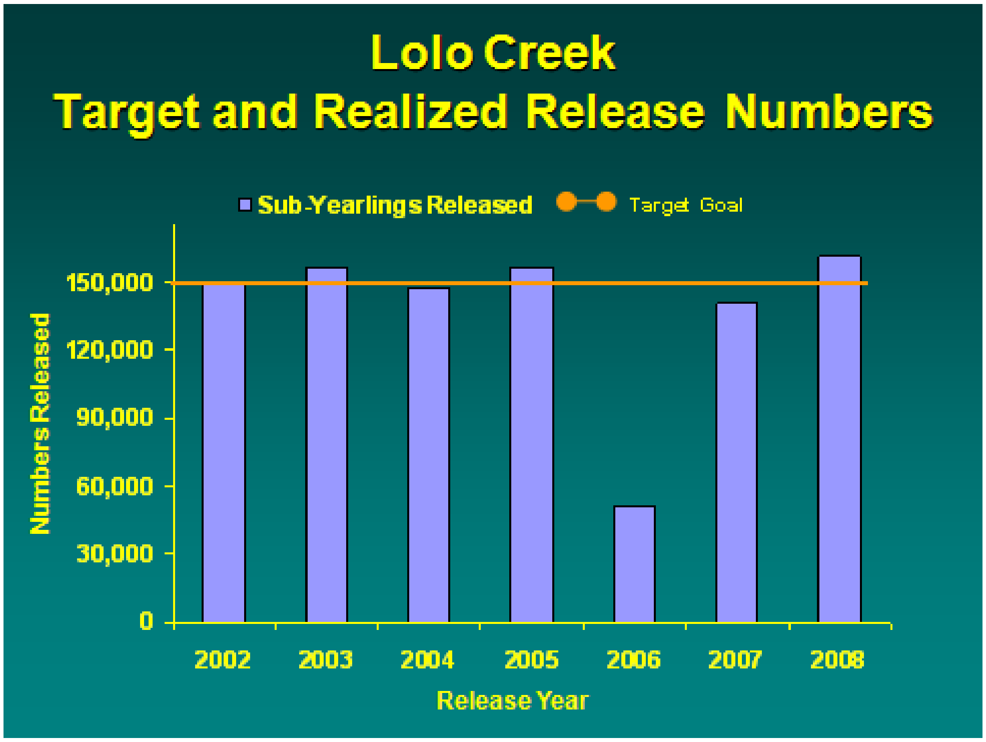

Figure 19. Lolo Creek Target and Realized Release Numbers (from proposal 1983-350-00).

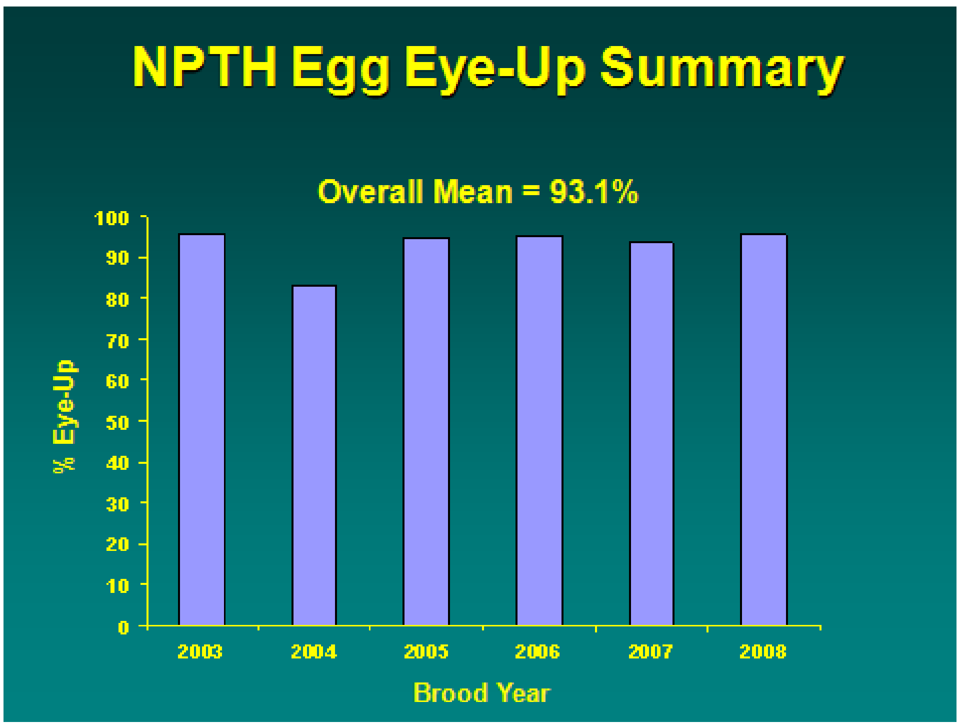

Figure 20. NPTH Egg Eye-Up Summary (from proposal 1983-350-00).

Table 18. NPTH Complex Spring Chinook Salmon Production Summary.

Brood Year		2002	2003	2004	2005	2006	2007	2008	2009	2010
Broodstock Captured										
	Lolo			101	28	117	56	26	38	27
	Newsome			76	36	36	34	64	49	53
	NPTH			70	7	48	79	178	152	752
Females Trapped										
	Lolo				NR	NR	29	17	20	12
	Newsome				NR	NR	24	30	32	30
	NPTH				2	22	29	95	52	373
Females Spawned										
	Lolo		9	41	15	41	19	6	17	10
	Newsome		7	13	15	22	1	8	24	3
	NPTH		128		2	16	15	64	32	228
	Other		17			10	43	55	147	
Egg Take										
	Lolo		37,026	120,960	61,724	147,079	80,621	19,708	71,280	37,857
	Newsome		28,749	35,933	52,947	71,348	3,241	30,880	101,440	12,298
	NPTH		405,598		6,963	58,665	60,081	244,351	141,792	942,537
	Other		56,721	897,053		39,953	170,435	297,168	653,062	
% Eyed										
	Lolo		97	85	93	96	96	96	95	84
	Newsome		95	89	98	95	90	95	92	94
	NPTH		NR		98	97	95	94	91	91
	Other		>90	NR		92	95	94	91	

Brood Year		2002	2003	2004	2005	2006	2007	2008	2009	2010
Number of Sac Fry										
	Lolo				53,841	141,014	77,176	18,918	63,569	
	Newsome				38,559	67,478	3,221	29,239	91,975	
	NPTH				6,836	55,380	56,810	232,063	106,659	
	Other					37,716	158,422	273,325	493,891	
Juveniles Released										
	Lolo	156,310	146,962	156,626	51,228	140,284	161,019	158,093	149,806	(2011)
	Newsome	68,917	69,137	68,685	49,639	77,371	79,330	82,090	75,644	(2011)
	Meadow	390,303	309,555	396,735	0	53,425	39,455	291,059	278,580	(2011)
	NPTH	225,430				126,317	132,734	160,608	(2011)	

Hatchery and Natural Juvenile Survival, Smolt Equivalents, and Adult Returns

Natural and hatchery juvenile migration survival and smolt equivalent estimates

The Nez Perce Tribal Hatchery spring Chinook supplementation program evaluation requires estimating hatchery-origin adult production from hatchery releases, documenting the fraction of natural- and hatchery-origin adults in mixed spawning populations, and subsequent adult production from this supplementation treatment (ISRP/ISAB 2005-15). A complement to this assessment framework based on adult production is documenting smolts-per-spawner for natural production and smolt-to-adult-survival (SAR) for both hatchery and natural components of the population. The smolts-per-spawner provides an evaluation of freshwater spawning and early rearing capacity, and SAR provides a composite of mainstem and ocean survival. Estimating these derived parameters requires establishing smolt abundance.

In spring Chinook populations with a yearling smolt life-history, juveniles leave natal tributaries as parr (in the first spring), as pre-smolts (in the first fall), or as smolts (in the following spring). To estimate smolt abundance for this entire cohort juveniles are captured in traps in tributary streams and mark/recapture methods are used to estimate the numbers of migrating juveniles. A subsample of these individuals is also PIT-tagged as parr/pre-smolts/smolts in the tributary streams and then detected at the lower Snake River dams. From these PIT detections survival estimates for juvenile salmon can be established. These survival estimates multiplied times the migrant abundance provides an estimate of smolt abundance at Lower Granite Dam. Similarly, PIT-tagged hatchery salmon released into treatment streams and then detected at lower Snake River dams provides an estimate of juvenile hatchery salmon survival. This survival estimate multiplied times the number of fish released provides an estimate of hatchery-origin smolt abundance at Lower Granite Dam.

Survival estimates for pre-smolt and smolt natural- and hatchery-origin juveniles from Lolo, Newsome, and Meadow creeks are provided in Table 19 below.

Table 19. Survival of Natural and Hatchery Juveniles from Clearwater River tributary streams to Lower Granite Dam (estimated using SURPH).

Migration Year	Lolo Creek		Newsome Creek		Meadow Creek	
	Natural	Hatchery	Natural	Hatchery	Natural	Hatchery
2002 Fall	0.17		0.12		0.33	0.042
Spring	0.72	0.60	0.51	0.57	0.61	0.70
2003 Fall	0.08		0.07		0.18	0.08
Spring	0.72	0.36	0.32	0.52	0.53	0.58

Migration Year	Lolo Creek		Newsome Creek		Meadow Creek	
2004 Fall	0.13	0.09	0.10	0.01	0.33	0.16
Spring	0.68		0.5		0.65	0.59
2005 Fall	0.25	0.56	0.15	0.03/0.07	0.32	0.13
Spring	0.68		0.45	0.47	0.68	0.69
2006 Fall	0.26	0.002/0.01[a.]	0.26	0.05/0.08	0.44	
Spring	0.74		0.46		0.74	
2007 Fall	0.30	0.003/0.015	0.25	0.097/0.10	0.35	
Spring	0.73	0.28	0.25	0.655	0.72	
2008 Fall	0.31	0.08/NA	0.11	0.09/0.17	0.44	0.37
Spring	0.69	NA	NA	0.12	0.72	

a. NATURES/Conventional hatchery juvenile survival probability

The primary observations from these survival estimates are 1) natural juveniles typically exhibit larger survival rates than hatchery juveniles, 2) fall pre-smolt migrants exhibited a smaller survival than spring smolt migrants, especially from a single cohort, and 3) there is not a quantifiable benefit yet documented for NATURES rearing.

Table 20 below provides smolt equivalent estimates for natural and hatchery production from each of the treatment streams for migration years 2002 through 2008 (the latest year reported).

Table 20. Smolt production from Clearwater River supplementation streams (smolt equivalents estimated at Lower Granite Dam).

Migration Year	Lolo Creek		Newsome Creek		Meadow Creek	
	Natural	Hatchery	Natural	Hatchery	Natural	Hatchery
2002	20,057	89,519	8,983	42,496	4,822	128,842
2003	26,794	53,096	6,416	38,541	4,860	12,098
2004	36,591	14,068	6,043	1,378	3,239	62,448
2005	21,859	27,996	6,663	1,383	6,626	40,241
2006	28,741	120	3,176	2,876	21,854	0
2007	8,173	282	1,641	4,964	11,851	0
2008	2,200	12,645	30	7,364	6,814	3,551

Adult Hatchery and Natural spring Chinook Abundance and Spawning Escapement
The NPTH spring Chinook program has established goals for the numbers of hatchery-origin adults expected to be migrating to project streams, and their use for subsequent hatchery broodstock, natural spawning, and harvest. A portion of the evaluation of the NPTH spring Chinook program is whether these objectives have been achieved.

Returning natural, NPTH-hatchery, and stray-hatchery adult salmon are distinguished using coded wire tags with and without associated fin clips at counting weirs on Lolo and Newsome creeks and during spawning ground carcass surveys on Lolo, Newsome, and Meadow creeks. Broodstock collection/adult interrogation weirs provide an opportunity to make a direct count of individual fish. Adults passed above weirs are also marked to facilitate a mark/recapture abundance estimate of adults since weirs do not capture all migrating salmon. Adults per redd from above weirs based on redd counts and mark/recapture adult escapement estimates are used to estimate adult abundance below weirs based on redd counts from spawning surveys. Proportions of natural, NPTH hatchery, and stray-hatchery are established using weir counts and carcass inspections during spawning surveys.

Figures 21 and 22 below summarize adult spring Chinook escapement to Lolo and Newsome creeks and were copied from proposal 1983-035-00 and illustrate the change over time observed in the adult escapement estimates from 2002-2009. Eight year geometric means for the two streams are 467 (Lolo) and 136 (Newsome). In both cases these means fall short of the viable threshold goals as described in the draft strategic management plan (1,000 for Lolo and 300 for Newsome).

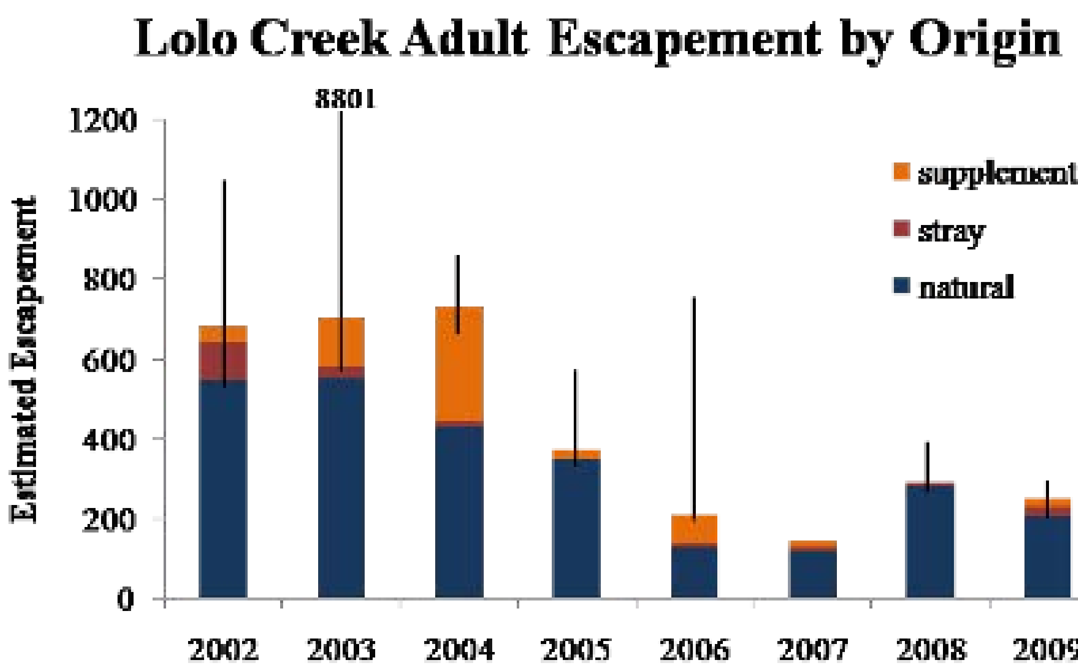

Figure 21. Estimated adult escapement to Lolo Creek from 2002 to 2009. Each bar is divided by adult origin type: blue=natural, red=stray, orange=supplement. 95% confidence intervals were calculated using the hypergeometric distribution and are shown as black vertical lines (from proposal 1998-035-03).

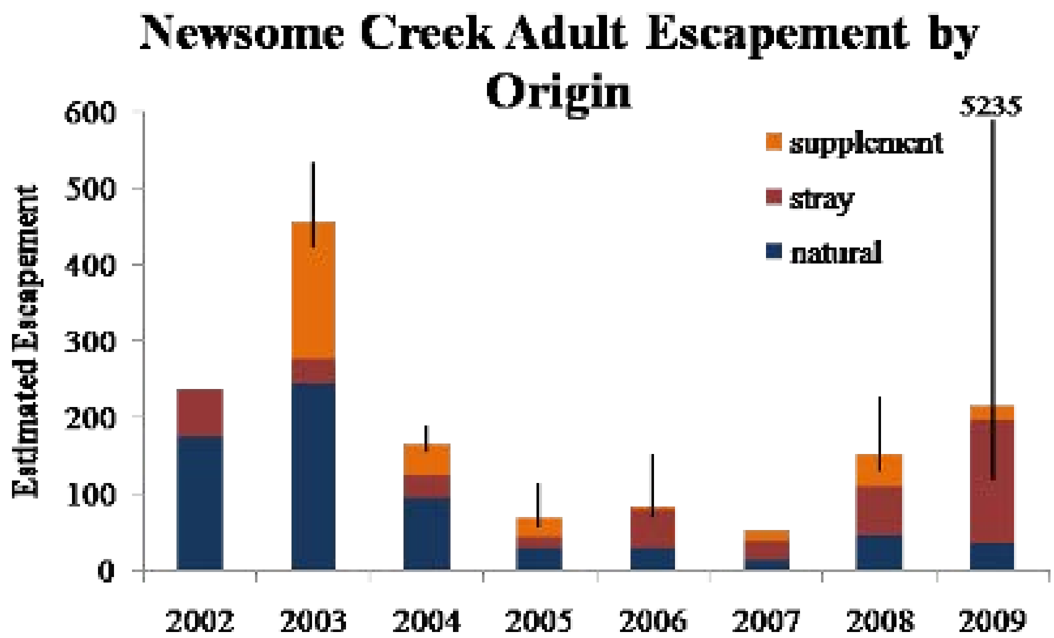

Figure 22. Estimated adult escapement to Newsome Creek from 2002 to 2009. Each bar is divided by adult origin type: blue=natural, red=stray, orange=supplement. 95% confidence intervals were calculated using the hypergeometric distribution and are shown as black vertical lines (from proposal 1998-035-03).

Large numbers of NPTH hatchery-origin supplementation salmon were only observed in Newsome Creek in 2003 and Lolo Creek in 2004. In release of brood year 1999 juveniles in Newsome Creek and the release of brood year 2000 juveniles in Lolo Creek were smolts, whereas the current release program uses pre-smolts.

Spring Chinook Natural Production

Evaluating the effect of the NPTH production (releases and subsequent adult returns) on the abundance and productivity of each treatment stream requires an understanding of natural production (aka recruitment) of juvenile and adult salmon in treatment streams. NPT has presented natural production in three points in the life cycle: smolts-per-spawner (also called recruits-per-spawner), smolt-to-adult return rate (SAR), and progeny-per-parent (adult progeny produced by naturally spawning hatchery- and natural-origin adult salmon). Smolts-per-spawner is a measure of freshwater habitat capacity and quality, SAR is a measure of mainstem, estuary, and ocean survival. Progeny-per-parent is the product of the two production metrics. These metrics are calculated using estimates of spawner abundance in the streams and smolt abundance at Lower Granite Dam.

Table 21. Recruits (smolts) per spawner estimates for Lolo and Newsome Creeks, brood years 2002 – 2007.

Lolo Creek			
Brood Year	Spawner Abundance	Smolt Abundance	Smolts per Spawner
2002	674	36,283	54
2003	598	11,020	18
2004	625	27,817	45
2005	340	8,312	24
2006	108	2,200	20
2007	81	7,795	96
Newsome Creek			
Brood Year	Spawner Abundance	Smolt Abundance	Smolts per Spawner
2002	230	5,843	25
2003	378	10,185	27
2004	84	20,086	239
2005	30	934	31
2006	8	30	4
2007	11	623	57

Table 22. Smolt-to-Adult return rate (SAR) estimates for Lolo and Newsome creeks, brood years 2003 and 2004.

Lolo Creek							
BY	Source	Smolt No.	I-Ocean	II-Ocean	III-Ocean	Total	SAR %
2003	Natural	11,020	3	27	12	42	0.38
	Hatchery	NA	2	3		5	
2004	Natural	27,817	47	220	29	296	1.06
	Hatchery	807	6	0	3	9	1.16
Newsome Creek							
BY	Source	Smolt No.	I-Ocean	II-Ocean	III-Ocean	Total	SAR %
2003	Natural	10,185	1	3	2	6	0.06
	Hatchery	4,770	0	3	2	5	0.10
2004	Natural	20,086	5	36	5	46	0.23
	Hatchery	3,522	6	34	2	42	1.19

Smolt-to-adult return rate is calculated using smolt abundance from smolt-per-spawner estimates for a broodyear and adult returns assigned to a broodyear using weir, redd counts, and carcass surveys to establish the age class structure and origin of adult salmon. SAR rates are available for two completed brood years of salmon from Lolo and Newsome creeks – 2003 and 2004.

Table 23. Progeny-per-Parent ratios for natural production in Lolo and Newsome creeks, brood years 2003 and 2004.

Lolo Creek					
BY	Spawner No.	I-Ocean	II-Ocean	III-Ocean	P:P
2003	596	3	27	12	0.07
2004	625	47	220	29	0.47
Newsome Creek					
BY	Spawner No.	I-Ocean	II-Ocean	III-Ocean	P:P
2003	378	1	3	2	0.02
2004	84	5	36	5	0.55

Progeny-per-parent is substantially below replacement (1.0) in both brood-years in both treatment streams, and the P:P ratio was higher in both streams in 2004 compared to 2003. NPT concludes that cause-and-effect for the increase from 2003 to 2004 cannot be established from the current data.

Supplementation Effectiveness

No demographic analysis of supplementation effectiveness has been provided in either proposal 1983-035-00, 1983-035-03, or project annual reports. The ISRP provides a preliminary assessment in the ISRP comments below.

ISRP Comments on NPTH spring Chinook supplementation
Developing an artificial production program involves a planning phase, infrastructure construction phase, testing implementation phase, and a long-term implementation phase. The length of time in years, or salmon generations, is unknown at the beginning and largely determined by the fate of the effort to implement each phase. The NPTH spring Chinook program, in the view of the ISRP, is several years into a testing implementation phase.

Early testing has demonstrated that the primary hatchery facility water supply is not as large as planned and that challenges exist with the hatchery water filtration system. The extent to which the water volume limits can be addressed is unknown to the ISRP; we anticipate that filtration system difficulties can be addressed. These sorts of infrastructure limits have occurred elsewhere with hatchery construction and should be expected.

There have been disease outbreaks – bacteria and protozoan parasites – at the treatment stream acclimation sites. In some years juveniles have been released early because the fish did not respond to prophylactic treatments. Based on smolt abundance estimates at Lower Granite Dam, it appears that these releases effectively yielded no smolt outmigration. The source of the infections is not clear to the ISRP. Either the fish are infected when they arrive at the acclimation sites, or they are picking up bugs after arrival. This needs to be determined and remedial action taken, if it is possible. The ISRP is not aware of whether disinfection of the water supply is possible at the acclimation sites.

In the proposal 1983-035-03 and associated project annual reports the presentation of adult return data did not include an explicit reconstruction of the adults arriving at a tributary in any given adult migration year, or reconstructing the adult production from either hatchery or natural spawning in any given brood year to evaluate whether the abundance goals for adult returns from NPTH actions or the extent to which broodstock collection, natural spawning, and harvest objectives were achieved.

If the ISRP correctly understands and interprets the information provided in proposals 1983-035-00 and 1983-035-03, the adult yield for brood years 2003 and 2004 releases was respectively 5 and 9 salmon for Lolo Creek and 5 and 42 salmon for Newsome Creek (adult yield from SAR estimate table above). These are substantially below the objective of 396 and 171 adult salmon for Lolo and Newsome creeks, respectively.

From a supplementation perspective, one question is whether the adults removed for hatchery spawning and juvenile production would have had larger yield if left in the stream. A preliminary answer to this question can be addressed using the natural parent-to-progeny ratio observed for each broodyear, and examining whether the hatchery fish removed for spawning produced more adults than naturally spawning adults. For this calculation, we use 2x the number of females spawned, since the natural P:P is based on total abundance, not females, and multiply this number by the natural P:P and determine whether that yield is larger or smaller than the adjusted estimated adult return of hatchery-origin production. The adjustment of adult returns reduces the observed returns to account for juveniles added to the release from secondary sources using the proportion of eggs taken from treatment stream spawners relative to the number of juveniles released.

Table 24. ISRP Preliminary Evaluation of NPTH Supplementation.

Lolo Creek				
BY	2x Females	Natural P:P	Exp Natural Yield	Adj Obs Yield
2003	18	0.07	1.3	1.5
2004	81	0.47	38	6.9
Newsome Creek				
BY	2x Females	Natural P:P	Exp Natural Yield	Adj Obs Yield
2003	14	0.02	0.28	2.1
2004	26	0.55	14	21

These calculations suggest that adult salmon returning to Lolo Creek and used in hatchery production produced approximately the same number of adult progeny as naturally spawning adults in 2003 (1.5 versus 1.3) and fewer adult progeny in 2004 (6.9 versus 38); and that adult salmon returning to Newsome Creek and used in hatchery production produced more adult progeny than naturally spawning adults in both 2003 (2.1 versus 0.28) and 2004 (21 versus 14).

When additional years of production data are available an evaluation of production in these treatment streams compared to reference locations with regard to total spawning abundance, smolt production, natural-origin spawning abundance, and productivity is needed to quantify any benefits or costs from supplementation.

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