Cost Savings Workgroup Report: Relative Reproductive Success Projects

Background

On October 13, 2016, the Northwest Power and Conservation Council (Council) and the Bonneville Power Administration (BPA) held an all-day public workshop on Relative Reproductive Success (RRS) projects within the Fish and Wildlife Program. RRS projects are studies used to evaluate the potential effects of hatchery fish on the ability of wild populations to spawn successfully if genetic intermingling occurs. Studies for both chinook and steelhead are underway. The RRS workshop had two purposes:

- Knowledge sharing and retention as some of the RRS projects close out;
- Cost savings that can be identified and repurposed for other emerging priorities in the future.

A letter was sent to all project sponsors of RRS projects on September 15, in preparation for the October workshop. Summaries of each RRS project were compiled by the workgroup and attached to the letter. The summaries were written in a common format and included project-specific questions identified by the workgroup. The project sponsors were asked to consider their responses to the questions common to all RRS project that the workgroup proposed in the letter, as well as their project-specific question in the project summary. The questions that all project sponsors were asked to consider are:

- How does this project inform (1) the Council's Research Plan and (2) the Council's Fish and Wildlife Program objectives?
- Can any results from this study be extrapolated to other geographic locations or other populations?
- How does the Idaho Supplementation Study (1989-098-00) inform this project?
- Please provide the following information relative to this project:
    (a) A scientific question;
    (b) A hypothesis;
    (c) A specific time frame within which to answer the question posed.
- How did you determine which species or geographic area to study?
- How are you working or collaborating with other RRS projects on aspects of your study (methodology, data and conclusions)?
- How does *density dependence* factor into your studies moving forward?

The RRS workshop provided time for introductory comments from the Council, BPA, and a representative of the Columbia River Inter-Tribal Fish Commission (CRITFC); ten 25-minute slots for each project starting with the project sponsor(s) providing an overview presentation on the project followed by questions from the workgroup and other workshop attendees; and wrapped up with a lengthy group discussion addressing what was heard in the workshop and what seem like the logical next steps for this group of work. The workshop was well-attended with over 30 project sponsors and others in

the room, and many on the phone, from the Council (central and state offices), BPA, NOAA Fisheries, US Fish and Wildlife Service, Washington Department of Fish and Wildlife, Oregon Department of Fish and Wildlife (ODFW), Idaho Department of Fish and Game, Yakama Nation, Nez Perce Tribe, CRITFC, Upper Columbia Salmon Recovery Board, University of Washington, and Oregon State University. Brief notes were taken at the workshop, primarily focused on the discussion. The notes can be found below, and the presentations can be found on the Council's website.

The ten BPA-funded RRS projects form a discrete group, some of which are closed, or are heading towards closure. Those RRS projects closing out are generating identifiable cost savings. With the RRS workshop, the workgroup gained a better understanding of each of the ten RRS projects and facilitated knowledge and expertise sharing among the sponsors. The workgroup felt this was important to do before any of the RRS knowledge and expertise is irretrievably lost as principal researchers move on once the project is closed.

At the close of the meeting, the workgroup committed to composing a report to share with the Council's Fish and Wildlife Committee that would put forth recommendations on the RRS body of work. Since the workshop, the workgroup compiled staff notes and created this report for Committee consideration. Additionally, the workgroup is meeting one-on-one with RRS project sponsors to further discuss their projects. The workgroup will follow up with the Fish and Wildlife Committee if any further action is necessary.

Additional Information

In 2016, the Independent Science Advisory Board (ISAB) and the Independent Scientific Review Panel (ISRP) produced the report *Critical Uncertainties for the Columbia River Basin Fish and Wildlife Program* (ISAB/ISRP 2016-1), which contains background text that summarizes and expands on the information shared at the RRS workshop. This excerpt from the ISAB/ISRP report provides a general overview of the Basin's RRS studies and gives reviews of the recent annual reports produced by each RRS project. This excerpt from the report discusses the current status and progress made on the seven critical artificial propagation uncertainties that were listed in the Council's 2006 Research Plan.

Staff Analysis and Cost Savings Workgroup Recommendations

The Council and BPA have funded a number of important RRS studies, and these studies are leading the way on this complex topic. Significant progress has been made, but progress also leads to new questions. For example, RRS studies have shown some genetic effects on wild fish due to artificial propagation, reduced productivity of hatchery fish in the wild, some density effects on steelhead populations, higher RRS for wild

Chinook than hatchery Chinook, geographic and species differences in RRS results, and more; however, the more that is learned, the more uncertainties are raised.

A considerable amount has been learned and the ongoing studies that were presented at the RRS workshop are set to provide the region with additional valuable information. It is important to note that project sponsors stressed that not all RRS studies can be applied elsewhere, as there are various geographic, watershed conditions, species, and study differences at each location. Topics and questions that appear to Council staff to be the most pertinent to explore at this time are:

a) Examine further the RRS of Chinook and other species, and how they relate or differ from the RRS of steelhead;
b) Identify the long-term effects of supplementation on the relative fitness, abundance, productivity, and capacity of wild stocks;
c) Evaluate if better hatchery management practices could result in reduced genetic impacts, and determine if and how the results of RRS studies inform and improve hatchery practices;
d) Identify and tease apart environmental effects from genetic effects;
e) Examine whether surplus hatchery fish could be harvested to benefit both the wild population and fisherman.

Based on the information gathered prior to the workshop and the discussion held at the workshop, the workgroup developed the following recommendations for the Council's Fish and Wildlife Committee to consider as recommendations to the Council.

- The Council will coordinate an annual RRS meeting to facilitate further knowledge sharing between RRS project sponsors in order to improve and advance this body of work. The ISAB/ISRP 2005-15 report *Monitoring and Evaluation of Supplementation Projects* proposed that such a meeting should occur to develop a Basin-wide plan to evaluate the effects of supplementation, and could be used to coordinate efforts among researchers in the Basin to answer outstanding questions about supplementation. The RRS project sponsors also requested at the RRS workshop that similar meetings be planned for the future.
- The workgroup found that the initial study design for the US Fish and Wildlife Service's project (#2003-063-00) *Natural Reproductive Success and Demographic Effects of Hatchery-origin Steelhead in Abernathy Creek, Washington* was unable to be met in the time that the work has been conducted. Considering this, the project sponsors began to rescope the project, which they shared at the RRS workshop. The workgroup recommends that the Fish and Wildlife Committee recommend a smart close-out for this project, and that the funds be allocated to the cost savings budget for future use on a new project or research.

Meeting Notes

The following are brief meeting notes pertaining to the discussion portions of the October 13 RRS workshop. These notes are intended to summarize comments from the RRS project sponsors and workshop participants and do not reflect any views of the Council or BPA.

RRS Workshop Notes

October 13, 2016
Northwest Power and Conservation Council central office – large and small conference rooms

Cost Savings Workgroup members present: Jennifer Anders, Tony Grover, Bryan Mercier, Kerry Berg, Lynn Palensky, and Laura Robinson

Agencies represented in the room and/or on the phone: The Council (central and state offices), BPA, NOAA Fisheries, US Fish and Wildlife Service, Washington Department of Fish and Wildlife, Oregon Department of Fish and Wildlife, Idaho Department of Fish and Game, Yakama Nation, Nez Perce Tribe, CRITFC, Upper Columbia Salmon Recovery Board, University of Washington, and Oregon State University

Opening comments provided by Jay Hesse on behalf of the Columbia River Inter-Tribal Fish Commission:

- Hatchery effectiveness assessments are complex and being implemented for varying reasons, but generally are designed to assess if mitigation targets are being met.
- Urge the Council and BPA to gather multiple perspectives at the technical level and mold that into a policy decision rather than just focusing on policy. The review for the RRS Workshop was not technically comprehensive, nor were all parties presented, therefore judgement of the projects should be reserved for a more comprehensive technical and policy review with all parties involved.

Project 2003-050-00: Evaluate the Reproductive Success of Wild and Hatchery Steelhead in Natural and Hatchery Environments

- This project focuses on Forks Creek hatchery in Willapa Bay and is conducted by the University of Washington.
- The RRS of hatchery and wild fish in the wild could not be measures. According to presenter, Todd Seamons, they were an “utter failure” at meeting their objective. The weir was not effective, only catching a tiny fraction of fish. When they realized that their primary objective was not achievable, they withdrew from BPA funding. They re-thought their hypothesis and went for a different objective and research plan that did not have a nexus to the hydrosystem and they therefore sought funding elsewhere.
- As Tony stated, negative results are as good as positive results in information sharing and understanding of RRS projects.

Project 2003-063-00: Natural Reproductive Success and Demographic Effects of Hatchery-Origin Steelhead in Abernathy Creek, Washington

- Much has been learned about conservation hatchery practices over the two decades of this project.
- A minimum of four years is needed to finish their current research which focuses on how to minimize domestication selection.
- Density dependence has been difficult to assess due to its complexity, and the sponsors are uncertain how habitat restoration efforts nearby will or have effected their study.
- Steelhead were chosen for this study given that they can get over barriers quickly and have a diversity of life history. Dan Rawding added that the mid- to late-90s saw a significant drop in natural-origin steelhead returning to this area so it was seen as a location to test how supplementation would impact the population numbers.
- There is a need to understand steelhead population dynamics and structures to effectively assess RRS.
- While there has been no focused coordination of this project with other RRS projects, the sponsors do learn from the other project sponsors.
- The focus of any future research would be conservation nutrition, measures that reduce the potential for negative interactions between hatchery and wild fish, and spawning and rearing protocols to reduce disturbance.
- WDFW works within this broad research question: *how can we make hatchery fish more like wild fish?*

Project 2007-299-00: Investigation of Relative Reproductive Success of Stray Hatchery & Wild Steelhead & Influence of Hatchery Strays on Productivity in the Deschutes

- This project chose steelhead as the species of interest because the Deschutes steelhead population was considered at-risk for extinction due to straying out-of-basin Snake River hatchery fish.
- This project uses a BACI design with Bakeoven Creek as the treatment site and Buck Hollow as the control. Hatchery fish are blocked from accessing Bakeoven, while in Buck Hollow hatchery fish are counted and allowed upstream. After five years, hatchery fish will be blocked from both streams, so they will both be treatment streams. This approach is taken to determine where stray steelhead are spawning, track parentage, and understand the population dynamics.
- Complete brood years are needed before the study questions can be answered. Those steelhead will not be returning until at least next year and so this study is considered on-going and incomplete at this point. Two to three more years is needed to complete the study.
- 60% of the hatchery fish can be assigned to their hatchery of origin.
- The project sponsors have addressed the Council recommendations in their reports to BPA. The project sponsors have committed to working with BPA on a

report responsive to the ISRP request, and the Cost Savings Workgroup has agreed to meet with the project sponsors to go over this project in further detail.

Project 2003-054-00: Evaluate the Relative Reproductive Success of Hatchery-Origin and Wild-Origin Steelhead Spawning Naturally in the Hood River

- This 19-year study has shown that hatchery fish have much lower fitness than wild fish and that there is evidence of rapid adaptation to captivity. The project sponsors found that a fish born from two hatchery parents performs worse in the wild and better in the hatchery.
- The cause of RRS is different between species, and different RRS has only been shown to have a genetic component in steelhead.

Project 1996-043-00: Johnson Creek Artificial Propagation Enhancement

- The methods used to estimate RRS in this study are different that all other RRS studies. At Johnson Creek only parents that had offspring were included. When the more common method for studying RRS was used, the RRS of hatchery fish was lower than the RRS of wild fish.
- A total of 25 years of funding is expected for this study, with eight years remaining. What happens after the study is complete? The limiting factors have not been mitigated for so it is unlikely that artificial production would cease for this area. Additionally, given that no populations in the Snake Basin have achieved recovery or been delisted, it is unlikely that this population will, so supplementation is likely in the long-term plan.
- Johnson Creek does not have a density dependence issue, though when jacks are present the spawning success is poor.
- The Idaho Supplementation Studies (ISS) used Johnson Creek data to inform results.
- Information from this study can be applied to others so long as the same impacts/effects are applied such as weir use, study design, etc.
- The project sponsors emphasized that the perception of the RRS workshop was to find funds to cut, so the sponsors are feeling defensive. They also expressed interest in the Council continuing these workshops with the intent for sponsors to continue to share information and learn from one another.

Project 2003-039-00: Monitoring the Reproductive Success of Naturally Spawning Hatchery and Natural Spring Chinook Salmon in the Wenatchee River

- NOAA has several RRS studies in the Basin – the others are not funded by BPA.
- This project uses a BACI design and has run from 2004 continuing to 2018 to examine a total of 3 generations of spawners.
- They have found that male fitness is lower than female fitness.
- Not much has been seen of genetic effects on RRS but the project sponsors would like to keep studying this.

- This project is concurrent with a steelhead RRS study in the basin, though this project focuses only on spring Chinook.
- This study replicates the Hood River study looking at broodstock makeup, and almost exactly replicates those results.
- The project sponsors are hoping to nail down the genetic effects difference between steelhead and spring Chinook before wrapping up the study in 2018.

Project 1989-096-00: Genetic Monitoring and Evaluation (M&E) Program for Salmon and Steelhead

- This is a long-term monitoring project with an RRS component. RRS is studied at various geographic scales.
- Year-to-year variation is seen based on in-basin and out-of-basin factors.
- The longer the stock is exposed to the hatchery, the more effect seen.
- At Sheep Creek, the RRS of steelhead has shown to be lower than wild since 2000. At Catherine Creek, the RRS has been equal when examining adults to juveniles, and slightly less in adult to adult.
- There is a good relationship between the sponsors of this project and the other RRS studies in the basin. Additionally, this project received a lot of input from the state FW managers doing similar work.

Project 2010-033-00: Study Reproductive Success of Hatchery and Natural Origin Steelhead in the Methow

- This study has examined RRS at multiple life history stages to see which is most effected and has found that all life stages show differences.
- Project sponsors plan to continue to evaluate:
    - RRS of Wells broodstock;
    - the effects of density and pHOS on RRS; and
    - RRS of local broostock program.
- Juveniles will be collected through 2025 for this study.

1995-063-25: Yakima River Monitoring and Evaluation – Yakima/Klickitat Fisheries Project (YKFP)

- RRS measurements in the spawning channel is complete, but measurements of RRS in the river is ongoing until 2018 with a few additional years of analysis and writing to follow.
- There have been four generations of adult returns from Roza Dam that have been used in this study. Differences were seen in traits and morphology. Project sponsors are now looking at jacks and so far the findings are consistent with the ISS studies.
- This project is providing information for CRITFC's project examining Basinwide genetic effects from supplementation.
- Fast et al 2015 has a summary of program findings, specifically:

    - Spawner abundance, Spatial distribution, and harvest increased;
    - Natural-origin returns were maintained;
    - Managed gene flow reduced genetic divergence;
    - Ecological Interactions parameters were maintained within established guidelines;
    - Habitat and water management factors continue to limit natural productivity; supplementation likely necessary until these factors are fully addressed;
    - Results very consistent with Venditti et al. ISS final report.

2009-009-00: Basinwide Supplementation Evaluation

- This is a multi-faceted project measuring the RRS of reintroduction Chinook in the Hood River.
- Natural-origin fish have shown greater productivity and higher fitness.
- Using genetic testing components for lamprey translocation work, enough is known to start understanding parentage for lamprey. You should be able to assess successful spawning by watching the juveniles.
- CRITFC is working with member tribes to do RRS studies in various locations in the basin.
- The tribes significantly rely on CRITFC for the genetics lab work, which is a portion of the Haggerman Genetics Laboratory.

Discussion – lessons learned, future implementation directions, policy implications, and follow-up needed

- Before any decisions are made by the Council and BPA on the RRS projects, project sponsors asked that the question, “where are we at with hatchery evaluations?” be considered, and then from there examine, “where are we at with the RRS process?”
- The region has been working very hard to standardize technical information from the bottom up and the top down. The technical folks have people working on the data and the Council has the dashboards – some additional work to clarify common metrics for common decision points is still needed. It was suggested by a meeting attendee that an opportunity is needed to create an integrated hatchery evaluation strategy and study design along with a plan for information sharing.
- There was enthusiasm in the group to continue a similar workshop to facilitate discussions like what was heard at this meeting, and to brainstorm standardization of information. Both AFS and PSMFC meetings have provided opportunities for RRS sponsors to come together and have technical discussions but common metrics have not been determined and decided on. It is going to take effort to come to an agreement on standardized metrics and multiple perspectives will be needed from the technical group to policy folks.
- The longer the projects continue their work, the more information is found between species and across basins. There are many factors that affect RRS,

there is no one thing. A forum like this, on a regular basis, could help answer a lot of the questions that projects sponsors have by facilitating open communication and information sharing.

- Species differences in RRS are clear and fall Chinook should be considered in an RRS study. Additionally, it is unclear what causes jack rates in Chinook.
- Steelhead are challenging and intriguing. The group knows a fair amount on effects of hatchery fish on steelhead, but we don't know the casual mechanisms which should be understood better.
- What is a heritable effect vs an environmental effect? The heritable long term effects are probably relatively small. Coho are highly adaptable to their environments. Opportunity equates to natural selection. Hatcheries were brought in because the fish populations were/are depressed. If the hatcheries help to alleviate that, then it's a matter of habitat suitability and availability. The concern is that hatcheries are leading to long-term effects on natural fish.
- BPA would like to ensure that the project portfolio for RRS, within the RME budget, is the right mix in order to optimize investments of the $85 million RME budget. Meeting attendees expressed that since this is the second largest category of spending in the program, it needs to be better understood. Many of these projects are separate in the basin; they need to be more integrated from a study design perspective and from an information sharing basis. Also, project sponsors feel that they receive mixed signals from the Council – first they are told that the Council wants to hear what is needed from the project sponsors but then the Council says they do not want to spend any more money on RME.
- What are the effects of density on relative fitness? Fitness is exacerbated at higher densities – is this a competition problem and is there anything we can do about this?
- Is fitness loss genetic for Chinook? If not HSRG recommendations may be detrimental.
- Member Karier expressed concern that the group could be going backwards and that the region should be focusing on examining the hatcheries for practices that affect success.
- How do we retrofit current hatcheries to fix the issues that we know? First there would be small changes but we would need to be prepared for larger changes. More natural areas, more feeding. How do we implement changes in a practical way?
- Member Norman said it would be good to know the long-term and short-term effects that hatchery fish have on natural populations. Can any of that be un-done? Are there ways that we can change the hatchery practices to reduce the negative traits?

Additional feedback and thoughts from Council representatives attending the workshop:

Hatchery management practices:

- How does data from the RRS studies inform/improve hatchery management practices for both mitigation and conservation focused programs?

    - Best broodstock management approach by species and watershed?
    - Supplementation-when, where, how much, how long?
    - Best rearing and release strategies for mitigation and supplementation programs?
- Future research data that would put a finer point on the HSRG guidelines, specific to particular programs in particular watersheds, would be a significant benefit with regard to developing future hatchery strategies.
- Certainly the answers to the hatchery management questions are specific to the conditions in each watershed with regard to habitat productivity and capacity (and the ability to improve and expand), the status of the population, other limiting factors outside of the tributary of origin, and other legal/social factors such as treaty fishing rights.
- We generally know enough to make many precautionary management decisions. For example, we should harvest segregated hatchery fish in order to minimize interbreeding with natural fish (especially important for steelhead), as recommended by the HSRG. This will require additional discussions by stakeholders and changes in the current fishing approach.

Density effects:

- Density effects have been shown to influence steelhead success in at least one hatchery. A couple of projects discussed density dependence, but density has not been part of many RRS studies of salmon in the wild. In Catherine Creek males were found to be more affected than females regarding density; enough to consider moving the females higher up in the basin.

Genetic effects:

- An important issue is to tease apart genetic versus ecological/environmental effects associated with RRS of hatchery salmonids spawning in streams. Most RRS studies have not isolated genetic versus ecological effects, such as hatchery fish spawning in degraded habitat. However, adverse genetic effects have been shown for steelhead and these effects can appear rapidly, as shown in recent papers involving steelhead. More studies could be conducted with steelhead to determine if genetic effects occur in other steelhead populations, especially those that vary in the level of integration with the wild stock. But so far, the evidence indicates a clear genetic effect associated with steelhead in a hatchery setting. Long rearing in fresh water by steelhead (compared with other salmonids) might contribute to the seemingly stronger RRS effect shown by steelhead versus other salmon. Hatcheries should examine approaches to increase RRS--both genetic and ecological factors--as discussed at the meeting.
- The goal of RRS is to evaluate whether or not hatchery fish spawning in the wild reduce the productivity of the natural stock. The mechanism of impact (genetic versus ecological) is important to know because adverse genetic effects are longer lasting. Nevertheless, lower RRS due to ecological issues (e.g., hatchery fish spawning in degraded areas) is important too because lower productivity of the population equates to lower potential harvest rate (sustainable harvest rates depend directly on life cycle productivity).

- Can alterations in breeding programs and rearing treatments reduce genetic changes in fish being reared in supplementation programs? Can changes in rearing protocols be applied in existing hatchery infrastructure? At the workshop we heard some very interesting ideas regarding changes in diets to reduce early maturation rates and the possible use of other physical changes, e.g., increasing currents in rearing vessels. Also, increasing the number of parent fish used as broodstock and controlling family sizes at ponding. Genetic tools are available to examine the effects of these and other possible treatments to control genetic differentiation due to hatchery conditions.

Long-term effects and uncertainties:

- The studies to date have shown reduced productivity of hatchery fish in the wild, but the long-term effects are uncertain. It seems that is a key question that would be of value in a benefit/risk analysis with regard to supplementation strategies.
- If the focus is to supplement wild populations to reduce risk due to low abundance until factors of decline are adequately addressed; those decisions (when, where, how much, how long?) would benefit from a better understanding of the long-term consequences with regard to fitness. For example: we would consider using hatcheries to address abundance risk more frequently if studies suggested long-term consequences were minimal.
    - This would require a longer-term (several generation) study and species specific info.
- The idea of expanding research on hatchery broodstock and rearing strategies to minimize productivity differences compared to wild fish is compelling.
- RRS of hatchery versus wild salmon has been a key uncertainty for many decades, though the assumption of many (but not all) scientists has been that hatchery fish have lower RRS when spawning in streams due to both genetic and ecological factors. New genetic tools are now allowing a more detailed examination of this important question.
- How long might it take for hatchery fish to re-adapt to natural conditions (i.e. for natural selection to act on hatchery fish)? How long should supplementation programs last and will this vary by species?

Species differences:

- Among the few studies conducted to date, RRS of hatchery Chinook appears to be lower than RRS of wild Chinook, but this may be due more to ecological than genetic factors. The lower RRS of hatchery Chinook is not as strong as shown by hatchery steelhead. More research is needed to isolate genetic versus ecological influences on RRS of Chinook and other species of salmon.

Integrated versus segregated hatcheries:

- The PNI approach described by the HSRG is an important tool for managing hatcheries and fisheries. The approach is logical, but we do not have detailed studies showing the tradeoff between the PNI value and genetic fitness of the wild stock. This is a very tough question to address, as noted in the ISAB/ISRP Critical Uncertainties Report. But the PNI relationship and other

recommendations by the HSRG provide the basis for a precautionary approach when balancing the desire of people to have more fish to harvest with the needs of maintaining productive and diverse wild populations.

- For hatcheries that use an integrated approach and where the intent is to encourage some natural spawning of these fish (supplementation), hatchery fish in excess of what is needed to fully seed the spawning grounds should be harvested. One reason for this is that an integrated approach, as described by HSRG, requires a self-sustaining population in the stream. However, as described in the ISAB report on density dependence, some stocks are not self-sustaining because spawning density is too high (i.e., return per spawner exceeds one when density is low but not when it is high). There is some evidence (see NOAA studies) that an integrated hatchery approach might cause a higher level of precocious maturation (mini-jacks) in Chinook salmon.

General thoughts:

- Is there a way to harvest surplus hatchery fish to benefit both the natural stock and fishermen? This is a very complex issue involving both fisheries science and social issues, as described in the ISAB report. Additional dialog in the Basin and new approaches might help move this idea forward.
- What are the effects of supplementation on the abundance, productivity, and capacity of natural populations & how are these effects linked to density dependent effects and by the species being supplemented? Looking at the effects of supplementation must be done in an ecological context.
- What factors are responsible for differences in RRS in hatchery and natural origin fish? How important are spawning locations, spawn timing, size & age at maturation (all factors that can be influenced by hatchery environmental conditions) on the reproductive success of hatchery fish vs. genetic effects caused by domestication?