Project for Addressing FCRPS BIOP Action 184: Synthesis of Existing Analytical Approaches, Or Development of a New Analytical Approach, for Determining the Effects of Hatchery Reforms on Extinction Risk and Recovery

A Tool for Evaluating Risks and Benefits of Reform Actions in Hatchery Programs

April 11, 2003

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Project/Program Summary

We propose to develop a general risk evaluation tool that can use quantitative and qualitative information on artificial propagation —especially those existing in hatchery genetic management plans (HGMPs) and the Artificial Production Review and Evaluation (APRE) databases, subbasin summaries, and ecoystem diagnosis and treatment (EDT) analyses—to identify benefits and assess risks of hatchery programs in the context of salmon recovery and viability. We will use qualitative and quantitative risk assessment techniques to develop a consensus model that will allow managers to identify different levels of risks to salmon and steelhead populations under culture and to those indirectly impacted by culture from four different sources: genetic hazards, ecological hazards, demographic hazards, and facility hazards. Ultimately, determining what levels of the various types of risk are acceptable given the potential benefits are policy decisions. This tool will help hatchery managers evaluate the value of potential reform actions in their programs in reducing risk and help policy makers frame the broader discussions of the role of hatcheries in recovery, while not preempting those processes or decisions. It will be designed to use, build on, and complement the Northwest Power Planning Council's APRE review and development of HGMPs. This means that the tool may be used almost immediately to provide realistic risk assessments without waiting for 10-12 years for the completion of rigorous studies on the reproductive success of hatchery and wild fish.

Project /Program Description

General Approach

Success for hatchery programs means attaining an acceptable balance between risks and benefits. As indicated in request for studies (RFCS) to address RPA Action 184, one approach is to evaluate risks and benefits for their "effects on population viability and the status of ESU". Population viability depends on four parameters: abundance, population growth and trends, spatial distribution, and diversity (McElhany et al. 2000). Population viability analyses (PVA) provide a useful metric (probability of extinction) for quantifying effects of hatchery actions on population growth rate (lambda) and abundance, but they suffer from two problems. First, most algorithms used for salmon populations (e.g. SimSalmon, McElhany and Payne in prep.) only address two of the four characteristics of population viability (abundance and population growth rate). They ignore spatial distribution and diversity. Second, too few data are available to provide case-specific assessments. For example, in order to conduct PVAs on threatened species of salmon in the Willamette/Lower Columbia River and Puget Sound domains, lack of long-term data forced the National Marine Fisheries Service (NMFS) technical recovery teams (TRT) to combine available data from many different populations to identify a variance for population growth that was needed to use the models (Puget Sound TRT 2002). Consequently, the results were not population specific. Even fewer data exist for the effects of hatchery reform actions on population growth. As noted in the RFCS for this study, isolating the effects of these actions requires controlled studies. An RFCS for these controlled studies has only recently appeared, consequently results for these will not be available for 10-12 years and too few (2-4 per ESU) may be conducted to develop suitable statistical distributions of the expected results to be broadly useful.

Despite the lack of adequate data, public and regulatory scrutiny of hatchery programs is increasing the demand to collect information on hatchery goals and practices and initiate monitoring and evaluation (e.g., ISAB 2000). Rather than develop an analytical approach that depends on data that will not be available in the foreseeable future to provide precise, realistic assessments, we propose an analytical approach that can use data from existing processes, such as HGMPs, the APRE databases, and EDT analyses, to qualitatively assess risks and benefits (Figure 1). This approach emphasizes generality (broad applicability) and realism at the cost of precision (Levins 1966), which might be provided by PVAs when there are adequate data. It is founded on the principles of probabilistic risk assessment and attempts to estimate risk as a function of the probability that different events might occur and their possible consequences (Bedford and Cooke 2001). Our objective is to develop a consensus model of the distribution of different risks associated with artificial propagation that can be compared to values from individual hatchery programs to assess the degree of risk (Figure 2). Risk values are summarized qualitatively, however, for example from "low" to "high" or on a scale of 1-10, rather than quantitatively. This does not affect the usefulness of the analysis, because whether the risk is expressed as "moderate," "5", or as a reduction in population growth rate, a reduction in risk signals an increase in viability. In addition, the decision about whether a level of risk is acceptable does not depend on the units it is measured in but on policy considerations.

A simple example may illustrate these concepts more clearly. Greater than 5% straying of non-native hatchery fish into a wild population is currently considered a "high" risk (Grant 1997). Although scientists agree that straying and interbreeding is a risk (e.g., Busack and Currens 1995, Campton 1995), technical agreement on what levels are "low," "moderate," or "high" has been confounded by policy implications of whether such risks are acceptable and whether it is statistically or meaningful to distinguish between 3%, 5%, or 7% straying. Using a probabilistic risk assessment calculation, however, if we knew that 5% straying and subsequent interbreeding of non-native hatchery fish and wild fish reduced fecundity of chinook salmon by 1000 eggs and there was a 80% chance that of 5% straying and a 20% chance of no straying, then the expected risk (in terms of loss of fecundity) at that level of straying is 0.80 x 1000, or 800 eggs. In reality, the direct consequences of straying and interbreeding have not been well documented, levels of straying and interbreeding will vary annually and among populations and species, and the same level of interbreeding will not always produce the same level of effect. Consequently, any risk assessment needs to incorporate the uncertainty in these values.

We propose using numerically-based qualitative risk assessment techniques (Koller 1999, 2000) to 1) develop a consensus model of risk, 2) identify the variables contributing to different kinds of risk that are in available databases, and 3) describe uncertainty of likelihoods of different events occurring and their effects using broadly based expert interpretations of scientific literature and principles. Developing a consensus model among scientists and for different situations allows the model to be widely applicable. Identifying the factors that contribute to risk and the variables described in HGMPs or APRE databases that can quantify those factors allows the approach to be used without waiting for more rigorous studies. Using a broad base of expert interpretation of the likelihood and effects of different actions allows uncertainty to be incorporated in the analysis. Rather than focus only on demographic risk (e.g. population growth and abundance), our approach allows us to focus on four sources of risk that more broadly address the four characteristics of viability. The four sources of risk are genetic, ecological, demographic, and facility in origin. Genetic affects include effective population size depression, gene flow and domestication. These address risks to diversity, abundance, and population growth rates. Ecological affects include predation, competition, and disease, which address spatial structure, diversity, abundance, and population growth. Demographic affects include recruitment rate of released hatchery fish and reproductive success of hatchery fish on the spawning grounds. These address abundance and population growth rates. Likewise, facility hazards include passage impediment, screening of intakes, and catastrophic failures in the hatchery and their effects on abundance and population growth.

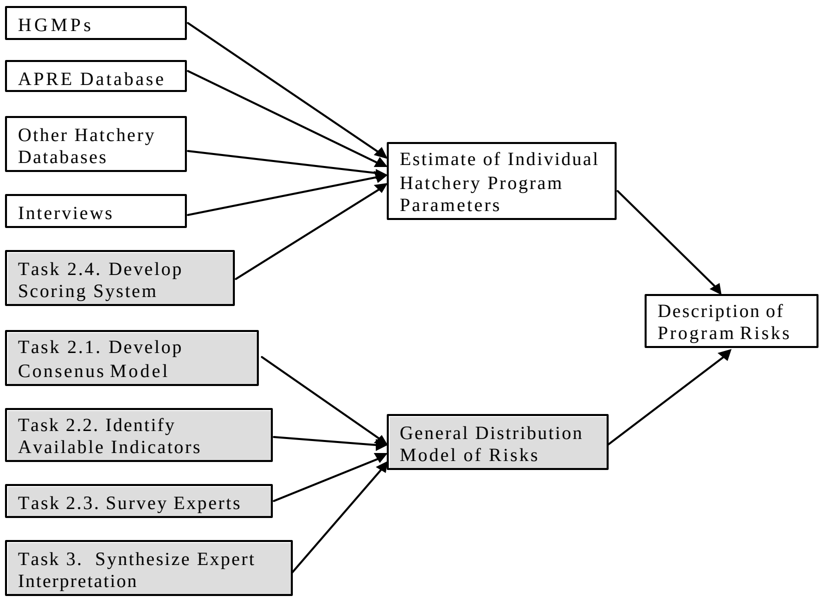

Figure 1. Relationship of proposed work to other sources of information on hatcheries. Shaded boxes are the focus of this project.

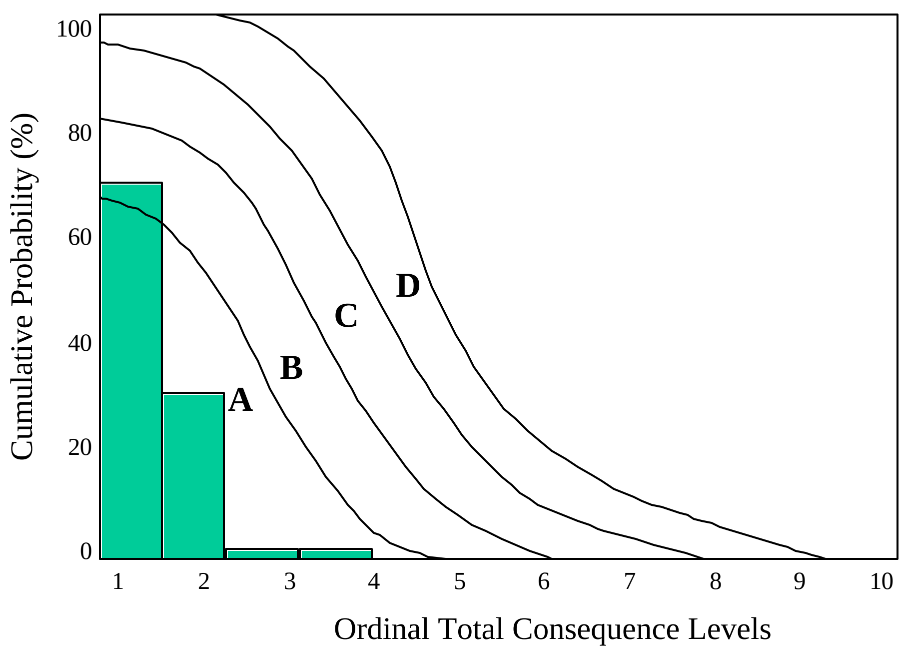

Figure 2. Consensus model of distribution of risk and hypothetical values for a hatchery program. Consequence levels and cumulative probability of occurrence are measured on a scale of 1-10 and 0-100, respectively, based on broad base of expert interpretation of scientific literature, scientific theory, and experience. Each of the four curves describes a hypothetical zone of risk (A, B, C, and D). Shaded bars are hypothetical values for a single hatchery program, indicating that the evaluator believes the program has a 75% chance of a level 1 consequence, a 25% chance of a level 2 consequence, minor chance of level 3 and 4 consequences. Overall, the hatchery program would have a "B" level of risk because at least one of the values falls in the "B" zone.

Recent experience with qualitative risk assessments (Ford and Currens 1999, Washington Department of Fish and Wildlife Benefit-Risk Assessment Procedure, unpublished) indicated that this kind of approach could provide systematic, repeatable, transparent and flexible treatment of risks and benefits. It also informed our current approach and will allow us to avoid potential pitfalls that might not be apparent to others. For example, it illustrated the importance of using a steering committee formed by experts from different disciplines and representing a diverse group of agencies. Developing risk assessments without getting the appropriate participation to identify the appropriate context for risk significantly limits their usefulness and chance of success (National Research Council, 1996). In our experience, one of the biggest challenges in developing a risk tool is in arriving at an understanding of risk among scientists that is widely acceptable. Our experience also convinced us that surveys of expert interpretations of risk and hatchery operations need to be developed professionally to reduce ambiguity, misunderstanding, and minimize wasted time. We also developed a sense of how much precision is necessary to characterize risk to be useful. Characterizing risk with too broad of a brush stroke (e.g. "low" versus "high") ignores important differences, details of individual facilities, and specifics of hatchery operations. In contrast, too much precision requires more data than are available.

In consideration of all our experience with risk assessment just described, we propose to develop a refined risk assessment tool that will be more suitable for more general use in two important respects:

1) It will be sufficiently generalized and comprehensive to be useful for all species of salmon and trout in the Region, for a wide array of program types and purposes, and for a wide variety of users.

2) The tool will reflect the diversity and variation of scientific opinion about genetic, ecological, demographic, and facility risks. We believe this will minimize technical disagreement about risks, which often hinders effective decision-making. Ultimately, although the tool may not give the precise conclusions of any one expert, it will include all opinions by using the variation in scientific opinion to capture the uncertainty around different issues.

Tasks

This work consists of three major tasks, with an optional fourth task (Figure 1):

Task 1. Identify and organize an interdisciplinary work group of scientists, biometricians, and hatchery experts to direct the refinement of the tool.

The purpose of the interdisciplinary workgroup is to ensure that we have a scientifically sound, broadly based tool that is realistic, addresses the many different issues that arise in hatchery programs, and that will have broad utility for different agencies. We will identify potential members with expertise in genetics, ecology, fish culture, and risk analysis from Washington Department of Fish and Wildlife, U.S. Fish and Wildlife Service, the tribes, and Batelle Pacific Northwest Laboratories. We already have commitments from three additional geneticists, Dr. Andre Talbot of the Columbia River Intertribal Fish Commission, Dr. Don Campton of the U.S. Fish and Wildlife Service, and Dr. Jeff Hard of NOAA Fisheries; and a hatchery facilities expert, Howard Fuss of WDFW.

Task 2: Develop methods for combining expert opinions to characterize risk and uncertainty associated with hatchery activities.

Risk and uncertainty arise from many different sources in hatchery programs and have many different attributes that interact. Asking experts to assess "risk" directly would require that each expert would have to integrate these interactions individually and the relationships would not be immediately transparent or testable. Instead, we will use the expertise of the interdisciplinary workgroup to develop a consensus model of how different risks are propagated in hatchery programs. We will then use expert opinion to capture the uncertainty associated with the sources and outcomes of different scenarios of risk for which we lack data. This information will then be incorporated into the model or framework for analyses, using techniques developed from risk assessment and decision analysis. Five subtasks are identifiable:

Subtask 2.1. Develop consensus model. The interdisciplinary workgroup will identify the hazards that need to be addressed, the variables contributing to risk from that hazard, and how to combine and weight the factors to arrive at a value for a risk.

Subtask 2.2. Identify indicators. The interdisciplinary workgroup will identify the indicators that can be readily used to quantify the variables contributing to risk based on review of HGMPs, APRE database, and experience in hatchery operations.

Subtask 2.3. Gather information on risk distributions. Using professional survey assistance, the interdisciplinary workgroup will develop and conduct a web-based survey to gather a broad base of expert interpretation of the distribution of potential consequences of a hazard and their likelihood.

Subtask 2.4. Develop a scoring system for evaluating hatcheries. Subtasks 2.1-3 are steps in developing a general consensus distribution of risks. Subtask 2.4 focuses on developing a fine-scaled scoring system that will permit an evaluator to examine hatchery data and translate it into likelihoods of different consequences.

Task 3: Compile and synthesize expert opinion on genetic, ecological, demographic, and facility risks and benefits associated with hatcheries into products. Once the survey of expert interpretation is available, individual interpretations will need to be combined into a consensus distribution. We will use methods from Bedford and Cooke (2001) to accomplish this.

Task 4: (optional) Develop software to allow the tool to be easily and widely used. Web-based access, support, and distribution of the tool will make this tool most useful, because it will allow these analyses to be linked with hatchery databases. We envision a system in which users can answer a questionnaire interactively on line, and have the risk assessment be incorporated. The long-term goal would be to revise the APRE questionnaire so that the APRE database contains all the pertinent information, and then have the risk assessment completed automatically and made part of the APRE database. We are not proposing to do this in this proposal, but we believe it should be considered for future work if the tool is to be useful. Task 4, development of software, would take 6-12 additional months, depending on the desired level of sophistication and integration with web-based databases.

Proposed Timeline

We expect to complete this project within nine months. The project will be divided into seven phases as follows:

Activity	*Duration*
1 Informal Scoping	2 months
2 Facilitated Formal Group Process	2 months
3 Survey Development	1 month
4 Initial Survey Response	1 month
5 Final Survey Response	1 month
6 Preparation of Draft Products	1 month
7 Preparation of Final Products	1 month

We would be available for additional work following the initial contract period as needed.

Budget

We expect to complete this project for $122,500. The main expenses are expected to be a project manager (0.25 FTE), group facilitation, professional preparation of the web-based survey, professional review of the risk assessment framework, salary for support staff from WDFW and the Northwest Indian Fisheries Commission (0.25 FTE), and travel and per diem for interdisciplinary workgroup members. It includes overhead to WDFW at 25%.

Personnel

For tasks 1-3 the basic workforce will consist of the four principal investigators, supported by their staffs, and a project manager. The project manager will be responsible for all administrative details, data compilation and document production. All interdisciplinary work group meetings will be facilitated, either by the project manager or a professional facilitator. We will hire, as needed, consultant help on the topics of risk assessment, group decision-making, and survey design.

In addition to the four principals, we expect the interdisciplinary work group to consist of three additional geneticists, two additional ecologists, two hatchery experts, and a fish health expert. All the people we are considering are located within 200 miles of Olympia, WA.

Task 4 would require a professional programmer/database developer.

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Washington Department of Fish and Wildlife (WDFW). 2001. Benefit-Risk Assessment Procedure for Washington Department of Fish & Wildlife Artificial Propagation Programs: Overview for Comanager Technical Review. Unpublished report. WDFW, Olympia, WA.

Qualifications of Participants

The four principal investigators have been involved in assessment of hatchery risks and benefits in the Northwest, and specifically in the Columbia Basin, for many years. The applicants (through Washington Department of Fish and Wildlife) are willing to cooperate in environmental compliance as required by the National Environmental Policy Act (NEPA), the Endangered Species Act (ESA), the National Historic Preservation Act (NHPA), and other laws as applicable and the applicant meets the BPA contractual requirements.

Dr. Craig Busack is a geneticist specializing in salmon recovery and hatchery risk assessment and monitoring. He heads the Conservation Biology Unit of the Washington Department of Fish and Wildlife (WDFW). He was the primary developer of WDFW's Benefit-Risk Assessment Process (BRAP) for evaluation of hatchery operations. He serves as WDFW's genetics lead on the

Yakima/Klickitat Fisheries Project and is a member of the Lower Columbia/Upper Willamette Technical Recovery Team. Pertinent publications:

Busack, C., B. Watson, T. Pearsons, C. Knudsen, S. Phelps, and M. Johnston. Yakima Fisheries Project Spring Chinook Supplementation Monitoring Plan. Report DOE/BP-64878-1, Bonneville Power Administration, Portland, OR.

Busack, C. A., and K. P. Currrens. 1995. Genetic risks and hazards in hatchery operations: fundamental concepts and issues. American Fisheries Society Symposium 15:71-80.

Currens, K. P., and C. A. Busack. 1995. A framework for assessing genetic vulnerability. Fisheries 20(12):24-31.

Dr. Ken Currens is geneticist specializing in salmon recovery and hatchery risk assessment and monitoring. He currently heads the Genetics and Ecology Program at the Northwest Indian Fisheries Commission. He co-developed (with M. Ford of NOAA Fisheries) a risk assessment tool that served as the foundation of WDFW's Benefit/Risk Assessment Process (BRAP) for evaluation of hatchery operations. He chairs the Washington Independent Science Panel, has recently participated in the Columbia Basin Artificial Production Review and Evaluation, and is a member of the Puget Sound Technical Recovery Team. Pertinent publications:

Brannon, E. L., K. P. Currens, D. Goodman, J. A. Lichatowich, W. E. McConnaha, B. A. Riddell, and R. N. Williams. 1999. Review of Artificial Production of Anadromous and Resident Fish in the Columbia River Basin, Part I: A Scientific Basis for Columbia River Production Program, Northwest Power Planning Council Report 99-4, Northwest Power Planning Council, Portland, OR.

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Currens, K. P., and C. A. Busack. 1995. A framework for assessing genetic vulnerability. Fisheries 20(12):24-31.

Dr. Todd Pearsons is a fish ecologist specializing in ecological interactions associated with hatchery supplementation project. He heads the Hatchery/Wild Interactions Unit of the Washington Department of Fish and Wildlife (WDFW), and is WDFW's technical lead on the Yakima/Klickitat Fisheries Project. Pertinent publications:

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

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Dr. Lars Mobrand is a biometrician long associated with Columbia Basin production issues, both natural and artificial. He is founder and CEO of Mobrand Biometrics, Inc. He is currently chariman of Washington's Hatchery Scientific Review Group and directs the Northwest Power Planning

Council's Columbia Basin Artificial Production Review and Evaluation database effort. Pertinent publications/products:

Hatchery Scientific Review Group (HSRG)-L. Mobrand, J. Barr, L. Blankenship, D. Campton, T. Evelyn, C. Mahnken, P. Seidel, L. Seeb, and W. Smoker. 2003. Hatchery reform recommendations for the Puget Sound and Coastal Washington Hatchery Reform Project. Long Live the Kings, Seattle, WA. (available online at: www.lltk.org/hatcheryreform.html).

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The participation of the four principals indicates the strong collaboration between the State of Washington, tribal comanagers, and the private sector on this project. We also expect to have participation on the expert panel from NOAA Fisheries, the Columbia River Intertribal Fish Commission, and the U.S. Fish and Wildlife Service.