



E: Research Priorities for Hatchery Reform

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Introduction

Application of sound genetic and ecological principles is central to the management of salmon and steelhead hatcheries. Research to promote and evaluate actions stemming from these principles is a necessary priority in support of hatchery reform. Without the refinement and application of these principles, the sustainability of salmon and steelhead populations in Pacific Northwest watersheds will be compromised, and the goals of hatchery reform will not be achieved.

However, determining the correct focus for hatchery reform research is not an easy task. Various groups have undertaken to produce hatchery operational guidelines and research plans in the past (RASP 1992; SRT 1998; APR 1999; ISAB 2003; APRE 2003; NWFSC 2001, 2004). A common approach in these documents is the description of a vast number of operational parameters and research topics that are deemed relevant to understanding the risks and benefits associated with hatchery operations, and using hatcheries to supplement natural populations.

In these research guidance documents, statements about necessary reforms in hatchery technology often imply that research must encompass problems encountered in all life history stages of salmon, and that reform of current practices should be approached by applying several scientific disciplines including genetics, physiology, behavior, nutrition, and microbiology. Direction and guidance is often provided in diverse areas of fish genetics, culture, health and nutrition; hatchery release strategies; ecological interactions (competition, predation); nutrient enhancement; habitat improvements in estuary, migration corridor, and in tributary spawning and rearing habitats; carrying capacity dynamics; etc. However, most of these past plans have provided little or no prioritization among these extensive areas of possible research, to focus on the actions most necessary to achieve hatchery goals.

We are reaching a point in the Pacific Northwest where the number of possible questions is expanding, while the funding available to study all aspects of salmon recovery is diminishing. A number of metrics and evaluators need to be used in determining how to prioritize actions necessary to resolve the key questions pertaining to where supplementation efforts will add to—rather than reduce—the total natural production of salmon and steelhead. As a result of our recent technical discussions, this group suggests that the following criteria should be the primary metrics used to prioritize hatchery research. In the present funding climate, it would seem most appropriate to focus available resources on research topics that fit these four parameters:

- 1) The *context* for the research and the importance of the question to be resolved.
- 2) The *degree of uncertainty* associated with the question.
- 3) The *tractability* of defining an answer to the question.
- 4) How *generally applicable* the results of the research will be.

In applying these parameters to our discussion of hatchery research priorities, we found two areas that are foundational to hatchery reform: 1) application of genetically integrated and segregated hatchery



operational principles to the management of hatcheries; and 2) application of physiological and ecological principles to produce hatchery fish following a wild fish template, which we hypothesize is the appropriate approach to promote ecological integrity. The genetic goal for hatchery reform is to ensure that hatchery operations do not affect the genetic constitution of natural stocks resident in these watersheds. Instead, hatchery operations should be designed so that the natural environment is the driving force in determining the genetic make-up of natural stocks within these watersheds. Secondly, hatchery operations should be consistent with ecological principles that meet the ecological objectives of the program. It is essential, therefore, that hatchery fish be reared on life history trajectories that mimic natural trajectories and releases sized so that they do not: 1) exceed the carrying capacity of the available riverine, estuarine and marine habitat; 2) displace natural stocks that also depend on that habitat; 3) overwhelm the food base present in that habitat, and 4) diminish the productivity of natural stocks through predation. Areas of focus for these genetic and ecological research topics are described below.

Background and Recommended Research Relating to Stock Genetics

Adaptation to watersheds by the salmonid populations resident in them is critical to the sustainability of these populations. It is also important that the diversity of populations in any given watershed be respected and preserved. Hence, populations should be afforded the opportunity to adapt to the conditions in the watersheds and extended environments they inhabit.

Hatchery practices that inhibit adaptation are inconsistent with long-term goals for both naturally-spawning and hatchery stocks. The frequent past practice of transferring hatchery broodstock among watersheds should be phased out. Instead, hatchery broodstock should be collected from returnees to the watershed where the offspring will be released. Further, all phases of hatchery operations should be consistent with and/or supportive of the continuous process of local adaptation.

Hatchery programs should be operated as either genetically integrated or segregated. Both of these strategies are designed to promote local adaptation and minimize fitness loss of both naturally-spawning and hatchery populations. A critical question is whether segregated and integrated hatchery programs will prove effective, over the long term, in accomplishing this important goal of promoting local adaptation. It is important, therefore, that key natural- and hatchery-origin stocks be monitored over the long-term for evidence of fitness loss or gain attributable to hatchery/natural population interactions. The development of practical methods to quantify fitness loss or gain in salmonid populations should be a high research priority.

In river systems where the infrastructure will permit it, well-controlled experiments to measure rates of adaptation in integrated or segregated populations should be undertaken. These experiments might, for instance, be modeled after genetic monitoring protocols employed in the breeding of other animals. For example, the fitness or breeding values of fish from a founder population that has been allowed to adapt to local conditions for a number of generations might be compared with that of portions of the same population (derived by using cryo-preserved gametes) that have not had the chance to adapt to local conditions for as many generations. Alternatively, fitness changes might rely on identification and monitoring of quantitative trait loci in thoroughly mapped genomes of salmon and steelhead trout populations. Such experiments should be able to identify phenotypic traits that will prove useful as indexes of domestication and adaptation, if the experiments encompass the diversity of ecosystems and the variety of species and life history patterns found in the region.



Background and Recommended Research Relating to Ecological Principles

In planning hatchery programs, the co-managers of the salmonid resource are often confronted with questions relating to the nature (e.g., the type and purpose of the programs, and the strategies used for releasing fish in order to maintain life history patterns of the reared species) and size (in terms of numbers of juvenile fish released) that their hatchery programs should assume. These questions arise because of uncertainties about the amount of suitable habitat available, the size and nature of the natural salmonid populations and other species dependent on the habitat, the capacity of the habitat to provide adequate feed for both natural- and hatchery-origin fish, and behavioral, physiological, and morphological differences between natural and hatchery raised fish.

In conducting research to resolve these questions, the research priority should be the development of qualitative and quantitative models that describe ecological processes and outcomes that could be tested and used as tools for making informed decisions on hatchery release sizes and strategies. These models should be based on general biological principles (i.e., the needs and behavior of salmonids and of the species with which they interact), so that it can take into account site-specific circumstances and be applied to all hatchery programs. In developing these models, monitoring will be needed to provide input data that may be lacking. Monitoring to check the performance of the models will also be required, so that appropriate adjustments can be made to improve the accuracy of the outcomes predicted by the models, with respect to hatchery/wild fish interactions.

Another area of ecological research that is of high importance, but did not seem as tractable, has to do with the role of hatchery fish in freshwater and marine food webs. Salmon are important determinants of aquatic and marine community structure, both as sources of abundant prey and as keystone predators. In some cases, hatchery fish may compensate for natural salmon population decline and help maintain community structure. In other cases, hatchery salmon may disrupt an existing balance. A better understanding of the role that hatchery salmon play in food webs is very important in determining the overall effect of hatchery programs. Further discussion with ecologists and other experts may help us develop tractable approaches to this research in the future.

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