ARTIFICIAL PRODUCTION REVIEW - ECONOMICS ANALYSIS PHASE I

PART I. RESEARCH APPROACH, FINDINGS, AND RECOMMENDATIONS

A. Context and Evaluation Framework

Spending on artificial production projects accounted for $312 million of the Northwest Power Planning Council's fish and wildlife program budget during 1978-1999[1]. Because spending is so large and because hatchery-reared fish may adversely affect wild salmon, the salmon artificial production program in the Columbia river basin has become the focus of intense technical scrutiny. In their review of salmon restoration in the Columbia basin, the Council's Independent Scientific Group (1996) summarized and re-emphasized the conclusions of earlier scientific reviews which called for "significant changes in the approach, operation and expectations from artificial propagation", and they recommended that "the federal hatchery system be integrated into a support role for ecosystem management, including restoration of ESA stocks." (p. 377). In its most recent fish and wildlife plan the NPPC noted that the "critical issue that the region faces on artificial production is whether artificial production activities can play a role in providing significant harvest opportunities throughout the basin, while also acting to protect and even rebuild naturally spawning populations."[2]

In July 1997, Congress directed the Northwest Power Planning Council to conduct a thorough review of all federally funded artificial production programs in the Columbia river basin. With the assistance of the Independent Scientific Advisory Board (ISAB) the Council developed a set of six recommendations and ten policies to guide the use of artificial production. The recommendations and policies from the Artificial Production Review Process (Council Document 99-15) are now being implemented through the actions of an Artificial Production Advisory Committee (APAC). The APAC is setting out to evaluate 120 to 140 facilities and programs in the basin. The overall questions being asked by the APAC concern whether the program is meeting its stated purposes and whether the program makes sense in today's circumstances. Another question of concern it whether program objectives are achieved at reasonable cost.

In June of 2001 the Northwest Power Planning Council agreed to complement the scientific review of hatcheries with a cost-effective analysis. The Independent Economic Analysis Board proposed a two-part study to develop a cost-effectiveness analysis for new artificial production projects proposed in the Council's Fish and Wildlife Program. The overall study would include (a) a full and objective study of the costs associated with a wide variety of artificial production projects that have been funded by the Council, and (b) a cost analysis capable of assessing pre-project cost estimates which can then be used to judge the cost-effectiveness of new proposals. "Phase I" of this study includes a partial review of available information, collaboration with the Council's scientific advisors, and meetings or discussions

1 According to the Inaugural Annual Report of the Columbia Basin Fish and Wildlife Program, 1978-1999.

2. "2000 Columbia River Basin Fish and Wildlife Program." Northwest Power Planning Council. November 30, 2000. p. 22.

with a few hatchery administrators. From that information, the IEAB was to assess the costs per adult fish return and to assess the feasibility of developing a useful cost model for hatchery cost assessment.

The following is a summary of the results of the Phase I effort.

Framework for Economic Analysis of Artificial Production Facilities

This economic assessment of artificial production facilities accommodates and recognizes the following issues:

1. Economic evaluation of artificial production facilities can follow one of three analytic frameworks: benefit-cost analysis, cost-effectiveness analysis, or simple cost analysis. A simple cost analysis seeks to document the categories of costs, the magnitudes of those cost elements, and perhaps the relationships between cost levels and determining conditions. For example, a cost analysis might show how the total cost is related to the volume of fish produced. A cost-effectiveness analysis evaluates the cost of attaining a known objective or the degree to which an objective can be achieved within the confines of a given budget. For example, a C/E analysis would determine whether a particular hatchery design or hatchery location would generate the most production for the cost expended (i.e. the “Biggest Bang for the Buck”). A benefit-cost analysis would attempt to quantify economic benefits of salmon production as well as the costs, in an attempt to determine whether the benefits exceed the costs. <u>This study is limited to the first two frameworks: cost analysis and cost-effectiveness analysis</u>.

2. Costs of rearing salmon depend, in part, upon the characteristics of the production facility. At a workshop organized by IEAB in August, 2001, we found that major determinants of the cost of producing salmon juveniles include: the purpose of the facility (e.g. restoration/ supplementation or run augmentation) , species reared, size at release, location of facility (especially relating to water supply and housing), and rearing technology. For example, we find cost per release to be higher for yearling smolts (spring chinook and summer steelhead) than for 0 age fish (fall chinook). And more complex rearing designs (such as NATURES rearing or complex genetic management) will be more expensive per fish released than traditional designs.

3. Survival rates are a major determinant of cost per adult returned or per fish harvested. For any given fish rearing cost, higher smolt to adult return rates (SAR) imply lower cost per adult fish. Hence, cost per adult is affected by any factor that impacts survival. Generally, upstream facilities experience lower SARs than more downstream facilities (all else equal). Hence, we expect that production costs per adult will be higher in the upper Columbia or Snake river basins than in more down stream locations. But, at any given location, survival to adult varies widely among years as river and ocean conditions vary with El Ninos and other phenomena.

4. The relevance of costs to hatchery funding decisions depends on decision-making circumstance. Decisions concerning the design, construction, and operation of new facilities should consider both the up-front capital costs associated with establishing the facility and all costs incurred in operating and maintaining the facility. On the other hand, short term decisions

concerning whether to continue operating an existing facility, or to modify a facility, should ignore the “sunk costs” associated with the original construction and past upkeep.

5. Salmon hatcheries are given distinct purposes by legislation, historical policy, funding sources, treaty obligations, and agency traditions. For a run augmentation hatchery, the purpose may be simply fishery enhancement, and hatchery effectiveness can be judged solely by the increased harvests due to the hatchery. Mitigation hatcheries often seek to increase the run size of distinct stocks. For example, the McCall hatchery aims to increase the number of summer chinook returning to the south fork of the Salmon river in Idaho. In this case the appropriate measure of effectiveness would be the number of adult hatchery fish that return to the particular river. In other cases, the objective is to restore or supplement a depleted or threatened stock in a particular sub-basin or tributary. In these cases the appropriate measure of effectiveness may be the increase in local naturally spawning population attributable to the facility.

6. Hatcheries aimed solely at harvest augmentation generally have a fixed annual production target, and could be evaluated in a benefit-cost framework. Because we can gauge the benefits of harvest by commercial fishing (based upon market value of fish minus cost of harvest) and recreational fishing (based on estimated value per angler day), the gross benefits of augmentation hatcheries are relatively clear. However, interactions between wild stocks and hatchery fish, due to genetic mixing or harvest regulations, need to be considered, and these factors may reduce the net economic benefits of the hatcheries. We do not attempt to evaluate net benefits or these interaction effects in this report.

7. The geographic distribution of harvests varies among species and stocks released (e.g. fall chinook tend to stay near the coast while Spring chinook and steelhead tend to stay further offshore) and upon hatchery location. The geographic patterns of harvest contributions from a new hatchery facility may be inferred from the distribution of harvests from similar hatcheries in nearby locations. But harvest rates are also dependent on treaty obligations and fishery regulations. Hence, it is important that proposals for augmentation be evaluated for fish migratory patterns and fishery contributions.

8. Restoration (supplementation) hatcheries differ from augmentation hatcheries. Instead of having a fixed annual production target, restoration is supposed to boost the population growth rate for a wild fish stock that has unutilized spawning/rearing habitat. The hatchery would release genetically selected fish into the natural habitat to augment the rate of increase in run size. We would expect a restoration project proposal to contain an estimate of the habitat carrying capacity, natural rate of increase for the stock, and an estimate of how the restoration effort would shorten the time until the stock is rebuilt to capacity. Viewed as an investment in natural spawning stock size, the principal benefit of restoration is shorter stock rebuilding time. The costs of such a hatchery would end when the stock is rebuilt.

9. A cost effectiveness analysis cannot answer the policy questions concerning whether to augment, mitigate or restore a particular stock, or to compensate for loss of habitat with hatchery production. It can help in weighing various alternatives to achieving agreed objectives.

Quantifiable Measures of Effectiveness

Among the hatchery projects selected for this Phase I study, the predominant objectives are increased fishery harvest or tributary run size (Spring Creek hatchery, Clatsop Economic Development Council Fisheries Project, Priest Rapids hatchery, and Leavenworth hatchery complex). These are augmentation (or production) and mitigation (or compensation) hatcheries. The two Lower Snake River Compensation Program hatcheries (Irrigon and McCall) are mitigation hatcheries, because they aim to return fish to tributaries of the Snake river in numbers sufficient to mitigate for habitat lost to the four lower Snake river dams. The non-production oriented projects are the Yakima Fisheries Project, which is largely a research and supplementation or restoration facility for spring chinook and coho runs in the Yakima basin, and the Nez Perce Tribal hatchery which aims to restore spring and fall chinook salmon in the Clearwater and Selway rivers.

We evaluate the augmentation hatcheries by the following three criteria:

a. Cost per fish released
b. Cost per fish surviving to adult
c. Cost per fish caught in ocean and river fisheries

Although the restoration (or supplementation) hatcheries also have a cost per release and per adult, the more complex objectives for supplementation hatcheries are best evaluated using the long term target increase in tributary run and the time schedule for achieving that restoration target. Neither of the restoration facilities reviewed in this Phase I study have a significant record of run size supplementation. Hence, neither can be evaluated fully for cost-effectiveness at this time.

B. Review of 8 Columbia River Basin Projects

We selected a sample of eight projects that range geographically from near the river mouth (Clatsop County Economic Development Council's Fisheries Project in Youngs Bay, OR) to the upper Columbia (Leavenworth, WA complex) and the upper Salmon river (McCall, Idaho). The selected hatcheries produce five varieties of salmon (coho, fall chinook, summer chinook, spring chinook, and summer steelhead), and they are operated by States, tribes, local governments, and the Federal government. Table 1 below lists the main aspects of our selected sample of projects. Average annual costs for these hatcheries, along with estimated costs per release, per adult survivor, and per fish caught are displayed in Table 2. This is too small a sample of projects to assess the influence of location or species or operating agency on the outcomes.

The Spring Creek hatchery produces sub-yearling tule fall chinook with the objective of enhancing the salmon fishery in the ocean and lower river. This is an old, large volume facility with a relatively low cost of production ($0.14 per smolt released) and moderate cost per adult survivor ($46 per fish). The project most similar to Spring Creek in operation is the Priest Rapids hatchery, which produces upper river bright fall chinook above the four lower Columbia river dams. Priest Rapids hatchery has been producing around 6.2 million 0-age chinook per year at a low cost of $0.08 per each smolt release. Of the eight projects reviewed for this report, Priest Rapids had the lowest estimated cost per adult survivor ($12) and the lowest cost per contribution to the fishery ($23). The Clatsop Economic Development Council (CEDC) has a relatively low cost per release for fall and spring chinook, but these costs cover just the acclimation in net pens. Assuming that they could get 0-age fish for acclimation at a cost equivalent to the Spring Creek rearing cost, the total cost per release would still be at a reasonable $0.37 to $0.42 per fish. The CEDC's cost for the full rearing cycle for coho, however, is very modest $0.18 per fish.

The Leavenworth hatchery complex produces spring chinook smolts and some summer steelhead for between $0.33 and $0.47 per fish. Given that these fish are kept and reared in the hatchery for1.5 years, instead of the 6 months for fall chinook, it is understandable that the cost per release would be higher than the costs incurred for fall chinook releases at Spring Creek or Priest Rapids. Survival rates for these upper Columbia fish are, however, relatively low, raising the cost per adult to $192 for Leavenworth hatchery chinook and steelhead, and up to $1,361 - $1,615 for Entiat and Winthrop hatchery chinook and steelhead.

The Irrigon hatchery complex raises summer steelhead which are released at several places in the Grand Ronde and Imnaha river basins. With trapping/hatching operations at Little Sheep Creek, Wallow hatchery and Big Canyon; rearing at Irrigon; and finally acclimation and release at the satellite facilities, this is a relatively complex operation in comparison to the Priest Rapids, Spring Creek, or Leavenworth projects. Hence, it is perhaps unsurprising that the cost per fish released is higher -- $1.30 on average and roughly four times the cost at the Leavenworth facility. The relatively low survival of steelhead reared at Irrigon makes the cost per adult a moderately high $203. With less than half the fish caught in fisheries, the cost per fish harvested is $453, a figure that is slightly higher than that for Leavenworth hatchery fish, but substantially below the cost experienced at Leavenworth's satellite facilities at Entiat and Winthrop. The McCall summer chinook hatchery has a similar degree of operational complexity to the Irrigon hatchery, but it enjoys a somewhat lower cost per fish released of $1.09. Survival to the South Fork of the Salmon river, where McCall fish are trapped and released, is fairly low, however, causing the cost per adult fish to rise to $272 per fish. Further, very few of these fish are documented as being caught in fisheries, thus causing the cost per fish harvested to increase to $1,051.

C. Using this Information to Screen Artificial Production Proposals

The IEAB economic assessment framework, the basics of hatchery cost structure developed at our hatchery manager workshop in August 2001, and the review of 8 hatchery projects/programs (details in the Appendix), combine to provide a useful first-cut analysis of hatchery costs and effectiveness. This analytical approach, if expanded with a broader hatchery cost data base, could be used to screen new artificial production proposals. For each such proposal, the objectives would need to be expressed clearly and quantifiably. That is, an augmentation (production) hatchery would be assessed based on expected costs of producing adult fish relative to known costs of existing facilities. A restoration (supplementation) hatchery would be assessed based upon expected costs of getting a specific level of enhancement in a specific stream or tributary. A research hatchery, or an experimental hatchery program would be more difficult to appraise in the cost-effectiveness framework, simply because the objectives are more subjective or the outcomes of the project are uncertain. It would also be possible to use existing hatchery performance as a "yardstick" for new project performance, with the objective of achieving lower cost operations where possible through adoption of what are sometimes referred to as "best practices."

No single number or analysis will provide a comprehensive review of artificial production projects. For a specific project the appropriate criteria for evaluating economic performance could be (a) the cost of rearing and releasing smolts, (b) the cost per adult fish returning to the river of origin, or (c) the cost of enhancing the salmon fishery. Further, the Council and other funders will clearly have additional criteria in mind, such as whether the project helps an ESA-listed stock or whether the enhanced stock contributes to a particular tributary or fishery. However, to the extent that hatcheries have in common the production of fish, it should be possible to make useful comparisons across artificial production projects.

D. Findings and Recommendations

Findings

- **The overall costs of hatchery construction and operation are generally well-documented and understood.** We examined budget information for eight hatchery and acclimation programs provided by the operating agencies in order to summarize the cost of rearing fish. Overall annual costs of the eight hatchery programs ranged from $527 thousand for the Priest Rapids hatchery to $5.25 million for the Nez Perce tribal hatchery. This variation in cost is associated with the location, size, and complexity of the hatchery programs.

- **We calculated a first indicator of cost-effectiveness -- the cost of rearing and releasing fish -- for all the hatcheries.** Measured as cost per smolt released over a period of years (which differs among projects studied), the cost for fall chinook ranged from about $ 0.08 at the Priest Rapids hatchery, to $0.14 at Spring Creek hatchery. Spring and summer chinook releases, which are more expensive due to longer rearing periods, range from $0.33 per fish at Leavenworth hatchery, to $1.09 at McCall hatchery to $2.60 at the Nez Perce tribal hatchery. Summer steelhead smolt released at the Irrigon hatchery cost $1.30 per release.

- **The second indicator of cost-effectiveness – cost per surviving adult fish – was found, as expected, to be highly variable among hatchery programs.** We focused on each hatchery's total costs and total production for the period over which we had reliable data and survival estimates. The lowest costs were for fall chinook produced at Priest Rapids hatchery ($12) and the Spring Creek hatchery ($46). For spring and summer chinook ,the cost per adult ranges from $192/fish at Leavenworth hatchery, to $272 at McCall, to $1,615 at Winthrop hatchery. Summer steelhead from the Irrigon hatchery cost $203 per fish. These estimates rely on return rates calculated from tag return data bases, returns to tributary fisheries, and returns to hatcheries.

- **Augmentation and mitigation hatcheries, which seek to enhance fish harvests, can be judged by the cost incurred per additional fish harvested.** The costs per harvested hatchery fish ranged from $23 for Priest Rapids fall chinook, to $55 per Spring Creek fall chinook, to $453 for Irrigon hatchery summer steelhead, to $1,051 for McCall summer chinook, to $4,800 - $68,031 at the Leavenworth hatchery complex. These estimates rely on catch rates calculated from tag return data bases and the reported harvests in tributary fisheries.

- **This cost analysis has given us a basis for optimism that more extensive cost-effectiveness study of specific project proposals for the Council cost will provide useful information**.

- **To provide a reliable tool for evaluation of hatchery proposals we would need to expand the data base for hatchery costs and production, and we would need some additional analysis of relationships between costs, hatchery purpose, and physical conditions at the hatchery site (water source and location factors).**

<u>Data Gaps and Needs</u>

- **There are at least two remaining unresolved issues concerning interpretation of hatchery costs.** First, where several stocks are reared in the same facility, we have not found a way to separate costs into stock-specific components using readily available information. Second, we have not examined sufficient information to understand accurately the costs for newer, more natural restoration and conservation hatcheries. These types of hatcheries have a short history and are experimental in nature. This includes the Yakima and Nez Perce facilities.

- **Not all groups of released fish (species and age) are tagged. This forced us to make rough assumptions about survival rates or to leave some hatchery releases out of the cost calculations.** More extensive tagging of fish from each release group would be desirable for both biological and economic assessment of the hatchery programs. Some assessment of the tag return rates and associated monitoring programs would seem a logical adjunct to a hatchery assessment project. We have not assessed the cost of expanded tagging efforts, but cost certainly would be a key design factor in tagging programs.

- **To extend the cost-effectiveness analysis to cover restoration (supplementation) and research hatcheries, such as the Nez Perce and Yakima facilities, we would need an in-depth assessment of objectives, proposed stock restoration schedule, and time schedule of restoration activities.** Currently, there are too few examples of these kinds of operations to support a comparative cost-effectiveness analysis.

Recommendations

- **The IEAB recommends that the Council consider funding a Phase II Economics Analysis of Artificial Production to more fully investigate a wide range of hatchery objectives and cost configurations.** This would involve developing a larger data base of cost and production information, to support evaluation of separable costs for rearing individual stocks and species at hatcheries having multiple stocks and purposes. The study could be broadened to involve some collaboration between the economists and biological analysts in order to broader the assessment of costs associated with augmentation, mitigation, restoration, and other ESA-related objectives.

- **To extend the project assessment process into cost-benefit analysis, a review and expansion of available information on economic values associated with increased harvests and increased tributary run sizes would be needed.** We recommend that the Council consider supporting a review of existing information and assessment of needs for better accounting of economic benefits from the hatchery program.

Table 1. Description of Artificial Production Facilities Reviewed in Phase I.

Name	**Operator/Funder**	**Location**	**Production Goal**
Spring Creek Hatchery	USFWS (operator) Corps of Engineers & NMFS funds	30 miles upstream of Bonneville dam.	release 15 million sub-yearling tule fall chinook
Clatsop Economic Development Council	Clatsop County BPA, NPPC, and ODFW funds	Youngs Bay	180,000 fall chinook smolts 850,000 spring chinook smolts 3.4 million coho smolts
Nez Perce Tribal Hatchery	Nez Perce Tribe BPA funds	Clearwater R Selway R.	1.4 million fall chinook smolts 625,000 spring smolts
Yakima Fisheries Project, spring chinook and coho	Yakama Tribe BPA funds	Cle Elum, WA	810,000 spring chinook smolts 700,000 coho smolts
Leavenworth Hatchery Complex	USFWS – operator US Bureau of Reclamation funds	Leavenworth, WA Entiat river, WA Winthrop, WA	3 million spring chinook smolts 200,000 summer steelhead smolts
Priest Rapids Hatchery	WDFW – operator Grant Co. PUD funds	Columbia R. just below Priest Rapids dam	3.7 million up river bright fall chinook smolts
Irrigon Hatchery	Oregon DFW operator US FWS funds	Near Irrigon on mid-Columbia R.	1.7 million summer steelhead smolts
McCall Hatchery	Idaho DFW US FWS funds	McCall Idaho	8,000 adult summer chinook in So. Fork Salmon River

Table 2. Costs and Cost per Unit Production

Name	Annual Cost	Ave. Cost per Release	Ave Cost per Adult	Ave. Cost per Fish Harvested
Spring Creek Hatchery fall chinook	$2.07 million	$ 0.14	$46	$55
Clatsop County Economic Development	Acclimation Costs: Fall Chin: $41,753 Spr. Chin: $241983 Coho: $98,440 Full Cycle Costs” Coho $124,249	 $ 0.23 $0.28 $0.04 $0.18	 $66 $233 $ 3 $13	 $66 $233 $3 $14
Nez Perce Tribal Hatchery, spring and fall chinook	$5,250,025	$2.60	$1,434 - $3,707	$5,736 - $14,828
Leavenworth Hatchery Complex spring chinook and summer steelhead	L: $863,192 E: $328,754 W: $430,052	$ 0.33 $0.46 $0.47	$192 $ 1,361 $ 1,615	$ 4,800 $ 68,031 $ 23,068
Priest Rapids Hatchery, fall chinook	$ 527, 144	$ 0.08	$12	$23
Irrigon Hatchery, summer steelhead	$ 1.95 mil.	$ 1.30	$ 203	$ 453
McCall Hatchery, summer chinook	$898,606	$1.09	$272	$1,051