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aquaculture notes

ECONOMIC FEASIBILITY OF PRIVATE NONPROFIT SALMON HATCHERIES: AN INTRODUCTION

by

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The present hatchery construction activity in Alaska, and the apparent high level of interest in additional hatchery development in many of the State's coastal areas, suggest that significant resources will be committed to salmon aquaculture in Alaska over the next several years. The present early phase of these developments, and the high degree of uncertainty associated with them, raise questions about the economic viability of hatchery enterprises. The question of economic feasibility of private nonprofit salmon ranching in Alaska is being addressed in a University of Alaska-Sea Grant pilot study of the Prince William Sound Acquaculture Corporation's (PWSAC) experience. Another study, which is to assess the economics of public hatcheries, is being conducted by the National Marine Fisheries Service (NMFS) at Juneau under the direction of economist Howard Ness. Both the University of Alaska and the NMFS studies are being coordinated with related research projects at Oregon State University and the University of Washington.

This report is designed to acquaint interested parties with the concept and some of the basic determinants of economic feasibility. Another purpose is to develop the economic implications of the private nonprofit corporate form of business organization required of hatchery firms by the Alaska Legislature. The second topic will be addressed first.

Alaska Salmon Hatchery Institutional Arrangements and Their Implications

Since 1974 the Alaska Department of Fish and Game has been authorized to issue permits to operate private salmon hatcheries.[1] An application for a nontransferable permit must satisfy the following conditions: (1) That the hatchery firm be a nonprofit corporation, (2) that the firm possess technical, financial and managerial resources sufficient to provide a reasonable opportunity for successful use of seed stock, (3) that the hatchery site be located on a stream that is either depleted or

[1] Alaska Statutes, 16.10.400-16.10.470

a non-significant producer of salmon, and, (4) that the management of wild stocks will not be unduly affected by the hatchery.[2] The first of these requirements has particular relevance to the economic incentives for developing a successful hatchery operation. Would not the incentive be greater if we were to allow investors the opportunity to earn profits from their investments in a hatchery? While this question cannot be answered categorically, there are at least two reasons why the institutional form (nonprofit corporation) adopted by the Alaska Legislature may induce *greater* investments in hatcheries than would be forthcoming from private profit-seeing corporations.

First, there is considerable uncertainty associated with private hatchery development. This uncertainty is derived from the unknowns surrounding the survival rate of hatchery fish in the natural environment, the difficulty in forecasting future market conditions for inputs and outputs of hatcheries, and the extreme sensitivity of economic feasibility to both of these factors. In one important respect a profit-oriented institution does not have as great a potential for spreading the risk of financial loss as does a nonprofit corporation; the latter can more readily obtain subsidies (grants and assessments) from the public and private sectors which reduce the amount, concentration and riskiness of private investment.[3]

A second and probably more important reason why the nonprofit form of business might result in greater hatchery development in Alaska derives from the fact that a significant part of the benefits from a successful hatchery operation are to be received by the common-property fishery, and those benefits will be dispersed over a large number of independent recipients. External benefits will not accrue as revenue to the hatchery firm, nor will there be sufficient concentration of these external benefits to create an incentive in the recipents for individual profit-seeking investment in hatcheries. This situation of significant, highly dispersed external benefits weakens the profit incentive and lends logical support for an alternative to the profit-oriented form of

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[2] Alaska Department of Fish and Game, "Statement of Policy on Permitting Nonprofit Salmon Hatcheries in Alaska". Juneau, October 1974. pp. 2-3.

[3] In 1975 the Alaska Legislature amended A.S. 16.10.300(a)(1) to provide for State loans for the construction of hatchery facilities and A.S. 16.10 to add 16.10.443 directing the Department of Fish and Game to "advise and assist...in the planning, construction or operation of salmon hatcheries".

business organization, one which can organize the large number of small incentive centers into effective group action. The nonprofit corporation has this ability, given that sufficient leadership exists within the group of potential beneficiaries. The nonprofit corporation, then, which on the surface may seem to discourage investment in hatcheries, may in fact be an effective means of stimulating hatchery development under present conditions in Alaska of high risk and significant, widely-dispersed external benefits.

The suggestion that the private nonprofit form of organization may be a more effective way of harnessing incentives to invest in hatcheries further suggests that *the economic feasibility of hatcheries may be enhanced* by this form of organization. It does so by allowing and encouraging a broadening of the constituency to which the hatchery firm is responsible over that which would exist in a normal profit-oriented firm. Thus, under the Alaska institutional approach, a hatchery firm may formally represent, through its management and board of directors, fishermen, processors, sportfishing groups and the local community[4]. These are precisely the groups that will be receiving that part of the benefits from increased salmon runs which will be external to the hatchery firm itself. "Internalizing" benefits in this way creates an incentive and ability for the hatchery firm to partially "charge" those receiving benefits (in the form of assessments, grants, etc.) and creates an incentive for the latter to pay in the event that revenues from the sale of returning adult salmon are not sufficient to cover all costs of the hatchery firm (developmental, construction, operating and maintenance costs). Indeed, it is reasonable to believe that a primary purpose of the nonprofit hatchery form of organization is one of providing a mechanism for the exchange of money for some of the external benefits received. A private profit-seeking firm does not have the ability of charging for external benefits nor would the recipients of such benefits have an incentive to pay.

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[4]Some individuals or groups may, of course, be represented by the hatchery in more than one of these capacities.

Another potential advantage of the private nonprofit form of business organization is that, to the extent that it is successful in attracting broad participation, there is a potential for minimizing conflict between a hatchery firm and the fishermen operating in the affected common-property fishery when difficult management decisions have to be made. That there is a potential for such conflict is suggested by the following policy statement of Alaska Department of Fish and Game: "If complexities arise in managing mixed stocks, including both hatchery fish and wild fish, it will be State policy to manage the collective resource in a manner that favors protection of the wild stock"[5]. In practice this would appear to mean that when "complexities" do not arise, a relatively large share (50% or greater) of the returning hatchery salmon will be harvested in the common-property fishery, and when "complexities" do arise, a relatively large share of the salmon will return to the hatchery for harvesting. If hatcheries do not in some way broadly represent the common-property fishery, it is easy to see how conflict could surround management decisions in this area.

It is important to emphasize that, although the nonprofit form of business organization appears to be more conducive to hatchery development under conditions presently existing in Alaska, the specification that all hatchery firms must take a nonprofit form may cause some potentially beneficial hatcheries to not be developed. For example, profit-oriented hatchery firms might develop potential hatchery sites in areas that would be unattractive to nonprofit firms due to the absence of an established fishery in those areas. Were such sites developed, all or most of the initial benefits would accrue to the hatchery firm. Such a distribution of benefits would mute the nonprofit incentive (which depends in large part on the level of external benefits to be received) but stimulate the profit incentive. The latter incentive is not operative, and would not result in potentially beneficial hatchery investments, under the present nonprofit restriction.[6]

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[5] Alaska Department of Fish and Game op. cit., p. 3.

[6] If a profit-oriented hatchery was allowed to respond, it is likely that a common-property fishery would develop in response to the hatchery runs. A profit-seeking firm would respond to the *perception* that most benefits would be internal over the life of the hatchery when, in fact, given sufficient time for development of an offshore fishery, a significant part of the benefits might become external benefits.

Another case where economically feasible hatcheries might not be developed if profit-seeking firms are barred is where, for one reason or another, there is lacking sufficient group cohesiveness or identity among those potentially receiving external benefits to allow the formation of a broadly-representative nonprofit firm. In such a case both profits *and* external benefits would be denied as a result of the present institutional restruction.

This analysis is only suggestive of the types of situations in which significant benefits from hatchery developments might have to be foregone, perhaps needlessly, as a result of the present policy of restricting hatcheries to nonprofit firms. It would appear that a preferable approach would be to allow both profit and nonprofit hatchery firms so that the peculiar pattern of benefits associated with each potential hatchery can be exploited by the type of business organization most capable of success. In a situation where most or all of the hatchery fish would be returning to the hatchery, a profit-seeking firm would have greater incentive to develop a hatchery and at least as great a chance of success as a nonprofit firm.

Levels of Economic Feasibility

The above discussion concerning the broad representation potentially provided by nonprofit hatchery firms implies a need to make a clear delineation of the levels of meaning of the term "economic feasibility". The discussion will distinguish three levels of feasibility which are convenient for analysis of hatchery development in Alaska.

A conceptual problem facing the analysis of economic feasibility is the proper treatment of non-sales revenues (assessments and grants) in a nonprofit hatchery corporation's receipts. If, traditionally, there had been enforceable property rights to a fishery, or parts thereof, in each region, then hatchery enhancement of stocks would yield benefits *exclusively to the owners* in the form of sales revenues. That is, hatcheries would be developed by owners of the traditional fisheries and revenues

resulting from increased runs would accrue to owners either from their catch in the traditional fishery or from harvest at the hatchery site. Since the actual institutional arrangement is one of nonownership in the traditional fishery, the dichotomy between internal and external benefits from a hatchery is relevant and gives rise to the necessity of distinguishing between the benefits which are *created* by a hatchery and the extent to which they are *received* by the hatchery firm itself. A hatchery investment might give rise to benefits (both internal and external) which greatly exceed its cost, and in this sense it is economically feasible, but, if the hatchery firm is not capable, under existing institutional arrangements, of internalizing sufficient of those external benefits to cover its costs, then the hatchery firm will not survive, and in this sense the investment would not be economically feasible. Identifying feasibility at several levels is a way of treating systematically the distinction between total benefits created and benefits received by the hatchery.

"Level-One" Feasibility

Economic feasibility exists in a traditional private profit-oriented firm when the sale of the firm's output generates sufficient revenues over time to cover all costs of development, construction, maintenance and operation, including a competitive profit on the owners' investment. This criterion will be one of the criteria used to judge the feasibility of Alaska hatchery ventures but it may be relaxed somewhat to allow for the nonprofit nature of Alaska hatchery firms. While the University of Alaska study is not yet far enough along to judge "level-one" feasibility, it does appear at this point that the attainment of feasibility in this sense may be marginal. If the analysis eventually substantiates this expectation, it should not be of undue concern as long as the nonprofit hatchery firm is capable of internalizing enough of the external benefits through non-sales revenues to cover costs ("level-two" feasibility) and as long as the "level-three" feasibility criterion (discussed below) is satisfied.

"Level-Two" Feasibility

At another level of meaning of the term, a hatchery will be feasible if it is capable of generating a sum of revenue (from sales and other sources) over time that is great enough to cover the cost of all resources employed. This is "level-two" feasibility.

The capability for generating non-sales revenues derives from the fact that, at least in the case of the PWSAC venture (and the likelihood that others will develop similarly), the nonprofit hatchery firm represents a broad constituency, including the common-property commercial and sport fisheries, processors and local governments. Non-sales revenues from the private sector can be properly treated in this case as an implicit sale of "rights" to the beneficiaries of hatchery operations, on the grounds that the benefits received would not be forthcoming in the absence of the hatchery operations. In the case of governmental grants, which are conceptually more difficult to handle, the "rights" are "sold" to granting agencies to insure the maintenance and/or restoration of salmon runs for the public benefit in exchange for the public sector having reduced responsibility (and reduced costs) in this area, and in exchange for the induced economic development and the direct and indirect expansion of the tax base resulting from hatchery development and operations.

It is true that, in general, private development, say, for example, a new industrial firm locating in the Cordova area, also creates induced benefits for which the public sector is not typically expected to pay. The benefits received from such developments, however, are much more likely to be accompanied by significant induced costs and by the importation of a significant part of the work force. A hatchery firm, in contrast, enhances and/or rehabilitates a renewable resource upon which the local economy has been traditionally dependant. As a consequence it is much less likely to be environmentally, economically, and socially disruptive and its employment impacts are much more likely to be locally based. Thus governments may justify grants to hatchery firms in exchange for which the pattern of economic development is affected in a manner consistent with community preferences.

"Level-Three" Feasibility

Economic feasibility analysis is not restricted to identifying "level two" feasibility; that the hatchery firm is capable of generating sufficient revenues to cover the opportunity cost of all resources it employs. It is also useful to compare information on the total benefits and costs (both internal and external) resulting from hatchery investments; this is "level-three" feasibility analysis. Assuming that hatchery investments prove to be feasible at either level one or level two, it will be necessary to continually monitor "level-three" feasibility (the total benefit and cost comparison) over time to insure that *additional* hatchery investments are warrented. If, as is likely, subsidies (in the form of guaranteed or low-interest loans, grants and assessments) become institutionalized, it would be possible for incremental investments in hatcheries to pass the "level two" feasibility test without passing the crucial "level-three" test. It is important to emphasize that these feasibility criteria will give inconsistent signals about feasibility only to the extent that subsidies become inflexible with respect to the external benefits actually realized.

Determinants of Economic Feasibility

General Considerations

The economic feasibility of salmon ranching is a function of the interaction of environmental and biological constraints, technology, and the functioning of resource and product markets. Consequently, natural scientists, engineers and economists working in the area of salmon ranching can each contribute toward the success of salmon ranching ventures. Scientists contribute to feasibility by providing a basic understanding of the constraints imposed by nature, by determining how to best operate within those constraints and by discovering ways to relax or modify constraints in such a way as to increase the natural

productivity of the fishery. Engineers enhance feasibility by assisting in the discovery and application of the best production techniques. They also provide developing hatcheries with cost assessments necessary for decision making.

Both of these groups contribute to economic feasibility directly by affecting the natural and physical constraints on productivity. Economists, on the other hand, provide the link between what is possible or feasible in a physical sense and what is desirable or feasible in the context of the human valuation of resources used up and outputs produced. In the case of salmon ranching, the physical ability to successfully produce additional food supplies must meet the test of the market: that the resources consumed in the process (the real cost) are not of greater value (in alternative uses) than the value of the additional salmon produced.

Economic feasibility analysis, then, must establish what these costs are and estimate all the resulting benefits. It must also consider the possibility of changes in the basic physical (environmental, biological and technological) and economic determinants. This is accomplished by "feeding into" a feasibility model, constructed with existing productivity, costs and prices, anticipated future productivity, cost and price changes. Such an analysis will provide a picture not only of the survivability of the hatchery firms under existing natural and market conditions, it will also provide an assessment of the ability of the hatchery firm to withstand changes in these conditions.

Environmental-Biological Determinants of Feasibility

The most concise way of demonstrating the importance of the constraints on feasibility imposed by nature is to examine the reporduction and survival factors associated with the rearing of salmon in a hatchery environment[7]. The relevent factors are the size and potential size of the brood stock, the number of eggs per female adult salmon and the male-female ratio required for fertilization, the survival rate from

[7] The author relied heavily in this section on information obtained verbally and in written form from Dr. William J. McNeil, NMFS, Juneau, Alaska, and from discussions with Wallace Noerenberg, Executive Director, and Armin Koernig, President, of the PWSAC. See McNeil, W.J. and J.E. Bailey, *Salmon Rancher's Manual*, NMFS, Seattle, 1975. This publication is a must for anyone contemplating the construction and operation of a salmon hatchery.

eggs to fry, and the survival rate from fry to returning adult salmon. The first constraint, the size of the brood stock, is a function of the many determinants of the natural capacity of a particular area to produce salmon, natural predation, and the past success of the commercial and sport fisheries. It can be expected that, in most localities, there will be significant constraints on egg sources initially but that this constraint will diminish as the hatchery succeeds in increasing runs. Once overcome, a second-order constraint on capacity may be imposed under existing technology by the volume of water flow at each hatchery-stream site.

The second factor, the number of eggs per female adult salmon and the required ratio of males to females, is probably a fixed constraint for each species of salmon.

The survival rate from eggs to fry can initially be viewed as fixed (at around 80 per cent), but this constraint will probably be relaxed with the discovery and application of new knowledge that will be gained through experience and research. Because of the already high survival rate from eggs to fry and the very low survival rate from fry to returning adults (discussed below) there will be relatively little leverage on productivity from future improvement in this productivity factor.

The survival rate from fry to returning adults (around 2 per cent), however, is a more likely significant dimension of change in ocean ranching productivity. A doubling, tripling or even quadrupling of this survival rate is conceivable as new knowledge on its determinants is acquired. Of these determinants, the ones (although they are not independent) most likely to be favorably controlled by hatchery scientists are the size of the fry at the time of release, the timing of release with nutriant buildup in the receiving waters, the timing of release to minimize initial predation, the early introduction of salinity into the fry holding environment, and perhaps others.

Technological Determinants of Feasibility

The existing state of technology is built into a hatchery when it is initially designed and constructed. The economic implications of this technology are assessed through the costs and productivity (both of which are encompassed in per unit capital and operating costs) of the hatchery. Thus, the consideration of costs as an economic dimension of feasibility (discussed below) implicitly accounts for the effect of technology on feasibility.

The effects of technology as an independent force is most conspicuous when some change in technology occurs. While it is difficult to anticipate specific technological changes that can have an impact on economic feasibility of hatcheries, it is possible to identify two probable categories of technological change and to suggest the possible impacts of such change. One type of technological change is the discovery of new and less expensive ways of accomplishing existing tasks within the hatchery operation. For example, the substitution of an artificial substrate for gravel may result in a significant reduction in labor required for cleaning during the "down" months of the hatchery. Another example would be the introduction of a more efficient (labor or capital saving) means of capturing returning adult salmon and segregating out the brood stock.

Second, economic feasibility may be enhanced by a change in technology that alters the natural constraints on productivity. For example, the introduction of a new incubator substrate could increase the survival rate from eggs to fry or the quality of fry. Another example of this type of technological change would be the introduction of an efficient recirculating and filtering system capable of overcoming the capacity constraint on a hatchery with a limited water flow.

Oversimplifying somewhat, the first type of change enhances feasibility by lowering the costs associated with a particular level of output, the second by increasing the output associated with a given level of costs.

Economic Determinants of Feasibility

Feasibility has economic as well as physical and technological dimensions. The economic variables affecting feasibility are: the costs of inputs to the firm, the degree of utilization of the firm's plant, the scale of operations and the expected price of the firm's output. In feasibility analysis, a desirable point of departure is a firm set of engineering valuations so that the analysis can be based on reliable cost estimates. Once the cost framework is constructed, the effects of actual or anticipated changes in costs, say from an increase in the price of fuel, can be readily evaluated. In the short run, increases in the price of inputs reduce the likelihood that a particular existing hatchery investment will yield positive net returns to the hatchery firm. In the long run, however, price increases of particular inputs can hasten desirable input substitutions that enhance earnings prospects.

An important consideration for some, if not all, new hatchery investments is that the initial egg-supply constraint will prevent the full utilization of the hatchery's capacity. This means a lower level of efficiency in the early years of operation because fixed costs must be spread over fewer units of output (pounds of salable salmon). For example, a twenty million egg hatchery that is restricted to ten million eggs from natural sources must await returning adult hatchery fish to utilize the facility at optimum capacity. In the mantime, sales receipts will be deferred and the cost per unit of output will be above the level attainable at capacity operation. Thus, one of the decision trade-offs in selecting hatchery sites is the relationship between the optimal scale of operations (size) of a hatchery facility (determined by technology and perhaps by the volume of streamflow) and the available supply of eggs from natural sources.

Another important, and related, consideration in hatchery efficiency is the scale of operations, or the capacity, built into a hatchery facility. Can a 50 million egg hatchery operating at optimal capacity produce salmon at a lower unit cost than a 20 million egg facility and a

100 million egg facility at lower unit cost than the 50 million egg hatchery? If so, then larger hatcheries are more desirable than smaller ones, assuming that egg-supply and stream-flow constraints can be overcome at low enough cost so that the advantages of large scale are not eliminated. It is not possible to make a priori judgments about scale economies for salmon hatcheries and research on this point to date is inconclusive.[8] One of the future objectives of the research underway at the University of Alaska is to determine the shape of the long-run average cost curve; the shape of this curve will show the extent, if any, of scale economics. Cost analysis of several hatchery sites of substantially different scale will be undertaken for this purpose.

The most straightforward of the list of economic determinants of feasibility is the price of the hatchery's output. While the direction of the influence of price on feasibility is obvious, the projection of the future price(s) at which the hatchery can expect to sell its output is probably the most tenuous part of feasibility analysis. The best approach for obtaining the near-term forecast is to rely on a conservative estimate based on past price behavior and short-term forecasts of supply and demand conditions. For the longer term estimates, however, a more sophisticated quantitative approach is desirable so that the trends in the natural fishery and the aggregate effects of many independent hatchery investments on price, as well as the effects of changes in population, income and the prices of other food fishes, can be systematically taken into account. The Oregon State University study will be developing, through statistical demand analysis, some of the information necessary for the longer-run price forecast.

Approaches to Economic Feasibility Analysis

The study of the economic feasibility of Alaska private nonprofit hatchery ventures will utilize two appraoches: benefit-cost analysis and a comparison of per-unit cost and revenue. The "level-one" and "level-

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[8] One study, based on Oregon's public hatcheries, suggests that constant returns to scale may be characteristic of salmon hatcheries. See Mattox, B. A Partial Economic Analysis of Hatchery Propagation and Commercial Harvest of Salmonid Resources in Oregon. Doctoral Dissertation, Oregon State University, 1971. p. 46.

two" tests will utilize both techniques, while the "level-three" test will, of necessity, rely exclusively on benefit-cost analysis.

Benefit-cost analysis is useful for establishing feasibility because it allows a meaningful comparison in the present period of benefits and costs that accrue from an investment over a long period of time; and it lends itself to the inclusion of external, as well as internal, costs and benefits. It is also useful for choosing among hatchery sites that differ with respect to: (1) initial egg supply (and therefore with repsect to the timing of returns), (2) volume of waterflow (and therefore potential capacity), and (3) the species of salmon that will be enhanced (the selection of species affects the size of the investment and the timing of returns due to differences in the length of the fresh-water phase of the life cycle and differences in the length of the entire life cycle).

Feasibility can also be assessed by comparing per unit cost and revenues. This approach is particularly useful for visualizing the impacts of changing marketing conditions because it will, in effect, provide an estimate of the price which will be necessary for the firm to cover all cost. It is also the more useful approach for identifying the existence and extent of economies of scale by providing the information necessary for comparing unit costs of hatcheries of differing size.

Summary

Salmon ranching is potentially an important new dimension in Alaska's salmon fisheries. Given the nonprofit form of business organization that hatchery firms must adopt, and the likelihood that these firms will attract significant subsidies from both the private and public sectors, the question of economic feasibility deserves and is receiving close examination. The application of the concept of economic feasibility to the special case of nonprofit firms, whose activities will generate significant benefits outside the firm for which there will be no direct remuneration, requires that feasibility be defined and analyzed at three

levels. For each of these levels, the benefits and costs associated with hatchery development will be categorized in such a way as to best obtain answers to the most pressing questions about the economic feasibility of private nonprofit hatchery firms: Are they feasible in their own right? If not, are they feasible with subsidy? Under what conditions and in what amounts is subsidy justified? Insight will also be gained for answering another important question about subsidies if they are shown to be necessary and justified. Namely, what groups can reasonably be asked (required) to pay subsidies?

Economic feasibility is determined by a number of natural (biological and environmental), technological and economic variables, all of which must be accounted for in feasibility analysis. The influence of each of these determinants on economic feasibility has been discussed in general. An important consideration for the long run is the ability of hatchery firms to remain viable in the face of possible adverse changes in the basic determinants of economic feasibility. Analysis of feasibility under existing conditions provides the basis for evaluating the impact on the hatchery firm of possible changes in those conditions in the future

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