Alaska Sea Grant Program
University of Alaska
Fairbanks, Alaska

School of Management

The Economic Feasibility of Private Nonprofit Salmon Hatcheries

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SEA GRANT REPORT 77-4
JUNE 1977

This publication is the result of research sponsored by the Alaska Sea Grant Program, cooperatively supported by NOAA Office of Sea Grant, Department of Commerce, under Grant #04-7-158-44006 and by the University of Alaska with funds appropriated by the State of Alaska.

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ABSTRACT

In recent years Alaska's salmon fisheries have been in a severely depressed state. Proposals for restoration range from complete closures of commercial salmon fisheries to crash enhancement programs. The latter has in its favor that it is a positive approach which would rely on modern scientific and engineering knowledge to enhance the natural productivity of a fishery. Nevertheless, economic uncertainties, deriving from biological as well as economic variables, and the need for institutional experimentation caution for a moderate and reasoned pace of development.

This report evaluates the economic feasibility of salmon enhancement production (as opposed to research) units for one institutional form--the private nonprofit firm. Limited inferences about other institutional forms are made as well. The analysis of economic feasibility proceeds from generalizations about the economic incentives facing potential developers of nonprofit salmon ranching firms, primarily fishermen, to specific quantitative statements based on a pilot study of the Port San Juan hatchery of the Prince William Sound Aquaculture Corporation. These generalizations about economic incentives and quantitative statements about feasibility are then related to present and proposed public policies toward salmon enhancement in Alaska.

Economic incentives to invest private funds in salmon ranching ventures are reduced by the free-rider problem and extreme uncertainty. The latter is exacerbated by failure of the public sector to clearly establish policies which allow reasonable estimates of private benefits.

The following conclusions concerning the economic feasibility of private nonprofit salmon ranching ventures are based on present knowledge about biological

productivity, costs (as established for the first hatchery of the Prince William Sound Aquaculture Corporation), and price: Hatchery investments will yield positive net economic returns to the common-property fishery and fishing communities at 1) eighty percent egg survival, 2) slightly greater than two percent ocean survival, and 3) the 1976 price of pink salmon in Cordova, Alaska. However, under these conditions, hatchery firms cannot generate sufficient revenues from the sale of surplus fish to cover the costs of all resources employed in the production process. The survival of private nonprofit firms, therefore, will require assessment payments from those common-property fishing units benefiting from the hatchery runs. The existence of positive net economic benefits to the common-property fishery establishes the economic justification for an assessment program.

The adverse effects on economic incentives caused by the free-rider problem and uncertainty may discourage nonprofit firms from being formed and necessary assessment programs from being arranged. Given that the State of Alaska has decided to produce salmon through enhancement efforts, and that hatchery investments appear on the basis of present information to be economically feasible, state incentive subsidies to the private sector to create and operate enhancement production units are both economically justified and will require significantly smaller outlays of public funds than the creation and operation of comparable production units by the state. Furthermore, private nonprofit hatchery units will have relatively strong economic incentives to be efficient and to discover cost-saving and productivity-increasing techniques, a characteristic which holds the potential for significant long-run benefits. The relative merits of two additional institutional forms, not presently allowed by statute, are discussed.

ACKNOWLEDGEMENTS

The author wishes to acknowledge the contributions of others to the research effort embodied in this report. The Prince William Sound Aquaculture Corporation generously agreed to provide data and Armin Koernig, President, deserves special recognition for his support and his constant urging that the research be made relevant to the decision-making process within salmon hatchery firms as well as to the public sector. Mark Kazazean, Business Manager, and Deniva Jones, Accountant, assisted the author with data collection. Mark Kazazean wrote a summary of the major pieces of equipment, by function, that were required at the Port San Juan hatchery. This summary appears as Appendix Table A-1. Wallace Norenberg, consulting biologist to the Prince William Sound Aquaculture Corporation, assisted the author in becoming educated about the biological dimensions of salmon enhancement production units.

Special appreciation is extended to the following individuals for their thorough and thoughtful review of an earlier draft of this report: Kwang Im, Economist, Oregon State University; E. Thomas Robinson, Assistant Professor, Department of Accounting, University of Alaska; Donald H. Rosenberg, Director, Alaska Sea Grant Program; Wayne Thomas and Bill Workman, Economists, Agriculture Experiment Station, University of Alaska; and Jack Van Hyning, Private Biological Consultant. Any errors or omissions are the sole responsibility of the author.

Finally, the contributions of several members of the staff of the Alaska Sea Grant Program are gratefully acknowledged: John Martin, presently a graduate student at Oregon State University, assisted with the collection of cost data and evaluating revenue flows under alternative sets of assumptions; Nina Hussey cheerfully bore the entire burden of typing the manuscript; and the fine editing work of Fran Sweet is also thankfully recognized.

CHAPTER I

PRIVATE NONPROFIT HATCHERY FIRMS AND ECONOMIC INCENTIVES

Introduction

Presented in this report is an analysis of the economic feasibility of private nonprofit ocean-ranching ventures. Qualified generalizations concerning feasibility are derived from a pilot study of the Prince William Sound Aquaculture Corporation's (PWSAC) hatchery facility at Port San Juan on Evans Island in Prince William Sound, Alaska. The Evans Island hatchery, the construction of which was approximately eighty percent complete by year end 1976, has a designed capacity of 25 million pink or chum salmon eggs per year and is the first of several hatcheries in a plan to create a total salmon incubation capacity of 300 million eggs per year in Prince William Sound.

Since the formation of PWSAC in 1974, five additional nonprofit hatchery firms have received site permits and eight permit applications are outstanding as of December, 1976 (Lindstrom, 1977). The only other private nonprofit hatchery in place is a two million egg facility constructed by Sheldon Jackson Community College in Sitka, Alaska. As its size and location suggest, this hatchery is primarily intended as an educational, rather than a production, hatchery. Nevertheless, the college is depending on revenues from the sale of surplus returning adult salmon to help defray the cost of the program, and there are plans to expand this facility to a capacity of six-to-ten million eggs (Lindstrom, 1977).

Beginning with enabling legislation in 1974, the Alaska Legislature has attempted to develop an atmosphere conducive to private nonprofit hatchery development. The 1975 Alaska Legislature extended the state's small business loan program to hatchery firms. This financing assistance was replaced by the 1976 legislature with a much larger loan program designed exclusively for private nonprofit hatchery firms.[1] There is every reason to believe that the state's policy toward private sector involvement in salmon enhancement will continue to evolve as knowledge is gained and as problems are presented for solution through the political process.

Alaska had an early and unspectacular history of efforts to enhance salmon stocks (McNeill and Bailey, 1975). This fact, along with adverse economic incentives, probably explains why Alaska has been relatively slow, compared to other salmon producing states in the Pacific Northwest, Japan and Canada, in responding to depressed salmon stocks through enhancement efforts. In 1972 the Division of Fisheries Rehabilitation, Enhancement and Development (FRED Division) was formed within the Alaska Department of Fish and Game (ADF&G). This unit is responsible for all public commercial salmon-enhancement activities and for assisting private hatchery firms in various ways (Orth, 1976b). A description of existing and planned facilities may be found in the FRED Division's report to the 1977 Alaska Legislature (Alaska Department of Fish and Game, 1977).

The State of Alaska, then, presently has a public and private-sector salmon hatchery program. This duality will be considered in Chapter III because it

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[1]For a compilation of these statutes see E. Thomas Robinson, Alaska Statutes: Commercial Fishing Loan Act, Salmon Hatcheries and Fisheries Enhancement Loan Program, *Aquaculture Notes* November 1976.

implicitly raises questions concerning the viability and general applicability of the private nonprofit enhancement approach, the distribution of the benefits from and costs of salmon enhancement, and the possible displacement of other policy options with respect to institutional forms.

Approach

The feasibility analysis presented in this report has been conducted in a manner designed to focus on the explicit and implicit policy issues associated with Alaska's salmon enhancement program. This approach was adopted because the primary alternative, a narrowly focused feasibility analysis of a particular hatchery investment, is of relatively limited interest, would not be of representative value (for reasons discussed below) for all or most ocean ranching investments in Alaska, and for both these reasons would be of little value to the public decision-making process. It was decided instead to use the pilot study of the Port San Juan hatchery as a vehicle for drawing out and suggesting alternative courses of action for important policy issues.

Accepted economic theory played at least an equal role with empirical measurement in this report. The reason that empirical measurement of the dimensions of economic feasibility at the Port San Juan site did not serve as the sole basis for drawing conclusions about feasibility and the policy issues associated with it is that the Port San Juan hatchery is not entirely representative; each hatchery site and each hatchery firm will have unique physical and institutional characteristics. In addition to uniqueness, there are several other reasons why the cost figures shown in this report may not be representative. First, when this study was conceived, 1975 was believed to be the first production year, not 1976 as actually transpired. For this reason, *estimates* of operating costs were utilized instead of cost data based on actual operating experience. The same is true, in lesser degree, of construction cost information. Second, the first PWSAC hatchery was constructed using an old set of buildings that once made up a fish-processing facility. This site was chosen because it was the only potential site in Prince William Sound located on patented land; all other potential sites would have required U.S. Forest Service permits, the acquisition of which at the time would have required months of delay and considerable expense. Third, initial engineering reports were somewhat misleading with respect to the investment required to upgrade the existing buildings for use as a hatchery complex. It is now believed that a hatchery site developed from the ground up would have been considerably less costly. Fourth, the PWSAC development has occurred over a period of time in which considerable uncertainty existed with respect to the most desirable incubator and egg tray design. Future hatcheries will be developed under conditions of less uncertainty and this should allow a reduction in costly experimentation. Finally, and perhaps most important in terms of the impact on cost, is the fact that PWSAC was the first hatchery firm to actually develop a hatchery under the state's nonprofit hatchery program. Consequently, it had to break new ground for a *production* hatchery in engineering, construction, incubator design, beneficiary-group organization, nonprofit firm management organization and financing. In addition, PWSAC has been very active politically in attempts to obtain those modifications in the state's policies which it considered essential to the survival of nonprofit hatchery firms. The resultant travel cost and opportunity cost of top management's time has been substantial.

It would appear that development costs associated with "newness" will decline with each succeeding nonprofit hatchery firm. As for PWSAC, most of these costs are appropriately distributed over all hatcheries built. However, because it is uncertain whether additional hatcheries will be built, the approach utilized in this report is to charge all of the development costs incurred by PWSAC to the Port San Juan hatchery. While clearly debatable, it was judged that a conservative approach of not distributing these costs over *planned* hatcheries would be prudent at this stage of the development of Alaska's private hatchery program.

Given these disclaimers, it is desirable to summarize the author's views as to what are the appropriate applications of the analyses contained in this report. First, as already stressed, is the use of feasibility analysis to draw out policy issues related to Alaska's public and private-nonprofit hatchery programs. Second, this analysis will suggest alternative courses of policy action and provide some of the information needed to evaluate them. Third, even though the cost experiences of the Port San Juan hatchery and PWSAC generally may not be representative in terms of specific values, they do provide order-of-magnitude estimates for the present formulative stage of the nonprofit hatchery program. Finally, this report has specific relevance to other hatchery firms for evaluating contemplated hatchery investments in that it presents a logical framework for evaluating the principal parameters of economic feasibility--biological factors, technology (costs), size and distribution of benefits, and institutional constraints.

Organization

The remainder of Chapter I will be devoted to an analysis of the economic incentives presently facing existing members and potential entrants of the private salmon enhancement "industry." Since this analysis has been presented elsewhere (Orth, 1975, 1976a, 1976b) it will only be summarized here. Chapter II contains a presentation of the feasibility analysis of PWSAC's Evans Island hatchery. Chapter III considers the efficiency and equity implications of public investment in private nonprofit hatcheries and in public hatcheries. Chapter IV summarizes and concludes this report.

Economic Incentives

The economic incentives facing potential investors in salmon hatcheries diverge significantly from those generated by less complex market environments. This divergence can be explained by vaguely-defined property rights, free-rider problems, and extreme uncertainty. The implications of each of these factors for investment incentives are discussed below.

Property Rights

Private property rights in artificially-propagated salmon stocks are primarily a function of institutional arrangements and economic forces. In the former category must be placed binational and multinational agreements, unilateral extended jurisdiction,and domestic limited-entry schemes. In the latter category must be placed the economic forces which, given the institutional arrangements, determine the amount of competitive fishing effort actually exerted in a particular area during a fishing season. Property rights may also be affected by fish straying to other than the "home" stream, by fish passing through distant fisheries before returning to the area from which they were implanted, and at the processor level, by the entry into an area of "buyer boats" from other areas. The latter may reduce the incentive of processors in an area to contribute to hatchery investments.

Two general types of property-rights situations exist or potentially exist in Alaska's salmon fisheries. First, there is the case of the established regional fishery into which access is restricted. In this case individual permit-holding fishermen have limited property rights--limited by the degree of competition as determined by the number of fishing units allowed in an area under the limited-entry law; the greater the entry allowed,the less the average property right of individual fishermen. Given that the number of fishing units that are allowed to enter is constant over long periods, an individual fisherman would have an incentive to invest in stock enhancement activities as long as the incremental cost to him is exceeded by the expected incremental revenue, and the greater the excess the greater the incentive to invest.

Two generalizations follow from this situation: First, some form of joint action would be required to induce *shared* investment by entry-permit holders on the principle that because returns will be shared among a large number of independent units, costs must also be generally shared. The second generalization is that a "free-rider" problem exists which must be overcome in some way (e.g., peer pressure, social coersion, or subsidies) before effective joint action will be possible. Free riders are those who know that they cannot be excluded from benefiting from enhanced stocks if they do not contribute to the joint action, and the existence of free riders blunts the incentive of those who would otherwise contribute but who do not want to pay for benefits enjoyed by noncontributors. A large number of free riders would have the effect of causing efforts to create joint action break down.

This first situation (an established fishery with restricted access), which is characteristic of all *established* Alaska salmon fisheries, favors private nonprofit hatchery firms supported financially by fishermen and processors (because external benefits -- those enjoyed by the offshore fishery[2] -- will be a large proportion of the total benefits). The free-rider problem is significant in all such cases, however, so that the public sector will probably need to become involved in some way to affect incentives for creating and financing nonprofit firms. Alternately, the public sector could invest directly in the construction and operation of state hatcheries, financing those investments from general revenues or specific taxes on beneficiaries. The justification for both forms of government intervention is considered in Chapter III.

The second type of property-rights situation exists in areas where there is no established fishery but where considerable physical potential for enhancement exists. In this situation, property rights to returning hatchery fish would initially be exclusive to the firm investing in a hatchery. The generalization which follows from this situation is that, since there is no established fishing fleet to form a non-profit firm, either investment by private profit-seeking firms or the public sector would be required. However, the public sector would presumably have difficulty justifying hatchery investments in areas not having an established user group and private profit-seeking hatchery firms are not allowed under existing state law. Thus, even though biological and economic conditions might warrant development of such sites, present institutional arrangements will prevent their potential from being realized.

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[2]The term "offshore fishery" is used here to mean the conventional seine and gill net fisheries, and it is contrasted with the harvest of salmon (whether by conventional means or not) by the shore-based hatchery.

In summary, property rights in artificially propagated fish accrue, in varying proportions depending upon the circumstances, to the hatchery firm and the offshore fishery, and indirect benefits from enhancement accrue to processors and regional economies. An important determinant of the success of the private nonprofit hatchery approach provided for under the statutes of the State of Alaska is the ability to obtain sufficient support among the beneficiary groups to form, and then support financially, a nonprofit hatchery firm.

The revenue and cost flows associated with private ocean-ranching ventures are depicted in Figure 1.

Uncertainty

A high degree of uncertainty is another factor affecting private incentives to invest in hatcheries. Uncertainty is derived from the unknowns surrounding the survival rate of hatchery fish in the natural environment, the difficulty of forecasting future market conditions for the inputs and the output of hatcheries, and the high degree of sensitivity of economic feasibility to both of these factors. Additional uncertainty derives from the instability of the evolving policies of the state with respect to resource management, the relative roles of the public and private hatchery programs and the methods and level of funding.

In short, there are few givens in the biological, technological, political,, and market dimensions with which a hatchery enterprise must be concerned. The combination of these uncertainties with those resulting from vaguely defined property rights and the free-rider problem creates an extremely uncertain economic environment for nonprofit hatchery firms. The practical significance of this uncertainty is, of

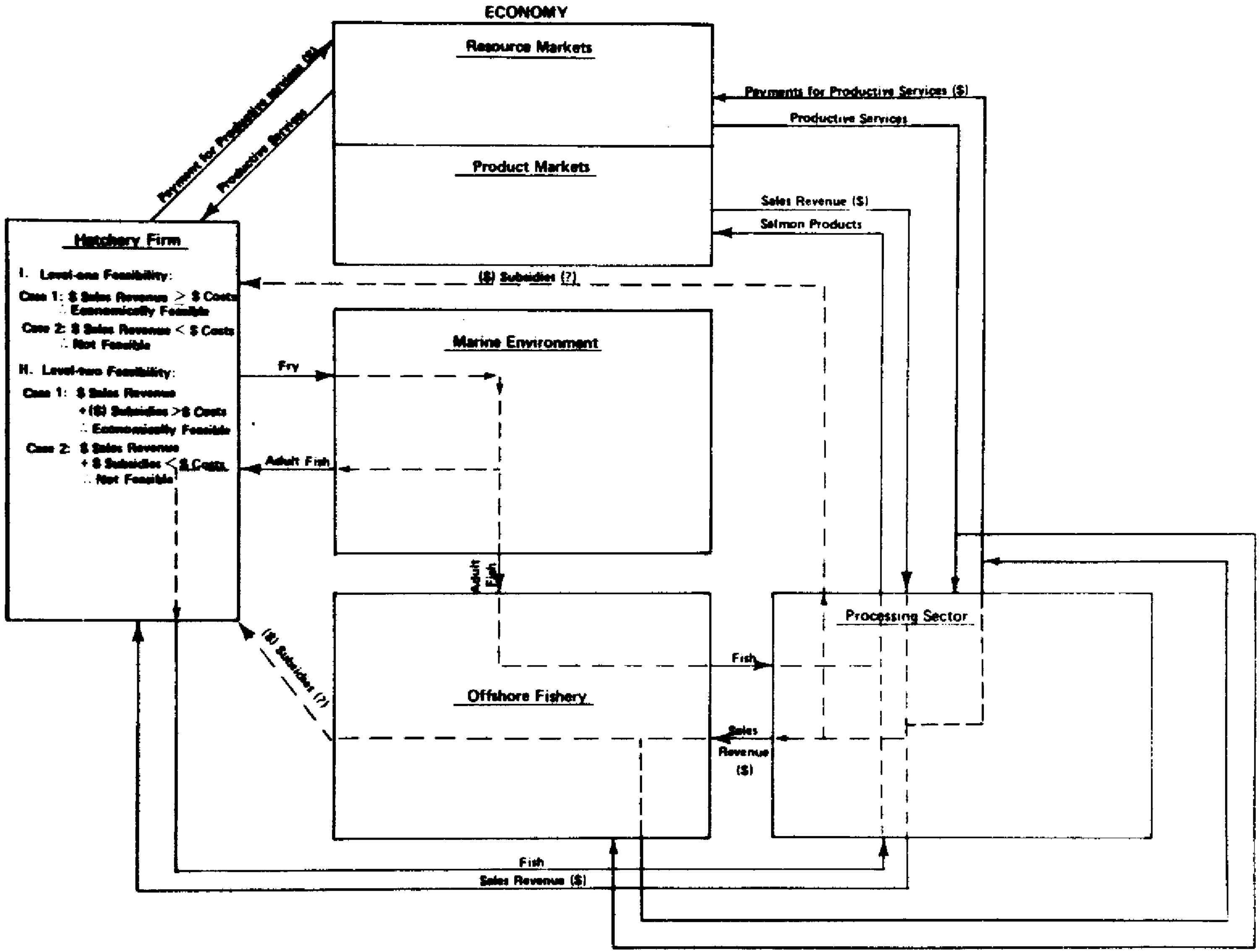

Figure 1. Revenue and Cost Flows of Hatchery Firms

course, that potential private investors (contributors) have little basis for projecting rates of return in comparison to other investment alternatives. Furthermore, the present nonprofit restriction forecloses the normal market mechanisms for obtaining high-risk capital and managerial talent (Orth, 1976a).

CHAPTER II

ECONOMIC FEASIBILITY OF THE PORT SAN JUAN HATCHERY

Introduction

The feasibility analysis presented in this chapter utilizes a conceptual framework that assigns three different meanings to the term "economic feasibility" in recognition of the fact that the benefits (revenues) *created* by a hatchery will, in normal circumstances, exceed the benefits (revenues) *received* by the hatchery firm. If one is willing to accept the proposition that economic feasibility exists when benefits (revenues) exceed costs, then the feasibility of a salmon hatchery may well turn on how broadly one defines benefits. For example, 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 firm. Three criteria by which economic feasibility should be judged are apparent:

1. Level-one feasibility: Feasibility exists when the revenues received by the hatchery firm from the sale of surplus adult salmon are just equal to, or exceed, the opportunity cost of all resources required to construct and operate a hatchery. To carry out level-one feasibility analysis one must abstract from the

problem of sources of financing for the hatchery firm. The basic question being addressed is whether or not hatchery investments, however financed and however they are organized institutionally, are capable of earning a positive rate of return, one that is competitive with alternative investment opportunities. In areas where there is an established fishery and where, therefore, external benefits are large relative to internal benefits, level-one feasibility is very unlikely given present costs (technology) and present knowledge about biological returns to salmon hatcheries.

2. Level-two feasibility: Feasibility exists when the sum of the revenues received by the hatchery firm from the sale of surplus adult salmon, plus the non-sales revenue from fishermen and processor assessments and from grants, are just equal to, or exceed, the opportunity cost of all resources required to construct and operate a hatchery. Level-two feasibility is of practical interest in part because, at this level of analysis, it is appropriate to consider sources of financing explicitly. The quantitative difference between level-one and level-two feasibility is the amount of external subsidy required to insure feasibility.

One purpose of a formal distinction between levels of feasibility is to assist in establishing the amount of external support that may be required for each nonprofit hatchery investment to be economically feasible so that this amount can be compared to estimates of external benefits. Indeed, the economic criterion by which one would evaluate the justification for external support is that the dollar value of the external benefits must be equal to, or greater than, the amount of subsidy required. A crucial question remains, if subsidies are justified, concerning who should pay the subsidies and how their collection should be organized.

3. Level-three feasibility: Feasibility exists when the sum of benefits, primary (internal and external) and induced (external), is equal to or exceeds all costs associated with the construction and operation of a hatchery. This is the basic benefit-cost analytical framework that requires the estimation of induced economic benefits and costs in the local or regional economy,[1] as well as state-local tax revenue impacts.[2] The analysis of level-three feasibility is not undertaken in this study due to resource constraints and due to the considerable redundancy with level-two feasibility analysis. For reasons discussed elsewhere, level-three feasibility analysis will become crucial as Alaska's salmon hatchery program matures (Orth, 1975, p. 8). For the present, establishing level-two feasibility is probably sufficient to also establish the existence, but not the magnitude, of level-three feasibility (see p. 66).

Level-One Feasibility

Economic feasibility defined at "level one" encompasses only those revenues and costs that are internal to the hatchery firm. It excludes those revenues which accrue to the offshore fishery from the capture and sale of hatchery-originated salmon, and, on the cost side, it considers the opportunity cost of all resources used. The scope of the revenue and cost components of the analysis will subsequently be modified for level-two feasibility analysis.

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[1] Induced benefits and costs are those occurring in sectors of the Alaskan economy other than those directly related to the salmon industry. The well-known and often exaggerated "multiplier" concept has its source in induced responses.

[2] It is also relevant for policy makers to consider, but difficult to quantify, the socio-economic benefits associated with the expansion of an industry upon which a regional or local economy (and its resident employees) has been traditionally dependent. Some observers would also want to consider the "psychic" income associated with expanded employment opportunities in commercial fishing as a favored employment.

Revenue Flows to Hatchery Firms: Price and Productivity

The primary source of sales revenue for private hatchery firms will be from the sale of surplus adult salmon (in excess of brood stock requirements) harvested at, or in close proximity to, the hatchery site.[3] A secondary source of revenue will be from the sale of spawned-out carcasses for use in nonhuman consumption products.

One basic dimension of sales revenue determination is the biological productivity of a hatchery. Productivity determines the quantity of surplus fish (per million eggs) available for sale. This quantity and the other basic dimension of sales revenue determination, price, jointly determine the sales revenue of the hatchery firm.[4] The analysis of economic feasibility at the present early stage of development of Alaska's enhancement program can safely abstract from the price effects of increased supplies. Such abstraction is justified by the uncertainty associated with the eventual success of ocean ranching and by the negligible incremental impact of the early hatcheries on total production. Long-run price forecasts, not attempted in this report, will in some way have to account for the American, Canadian, Japanese, and Russian salmon enhancement programs and the uncertainties associated with their long-run impacts.

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[3]The value of salmon eggs from the surplus fish will be treated in this report as a part of the value of the fish in round weight. This treatment is consistent with one of the several methods of price determination used in Prince William Sound. It may develop that hatcheries will eviscerate salmon prior to sale, selling eggs separately to enhance their price.

[4]A fact often misunderstood is that, if the Alaska and other salmon-enhancement programs eventually lead to very large percentage increases in supply of salmon and downward pressure on price, total revenue to hatchery and offshore harvesters ***may either increase or decrease*** depending upon the coefficient of the price elasticity of demand, or its reciprocal, the price-flexibility coefficient. That is, a *decrease in the price of salmon* due to the increased supplies from enhancement programs, ***does not necessarily mean a fall in total revenue*** to harvesters.

Table 1 contains a description of terms and notation used in the feasibility analyses presented in this report. On the assumption that spawned-out salmon have no market, the revenue of a hatchery (in level-one feasibility analysis where only sales revenue derived from surplus salmon is considered) for period t is given by:

$$R^*_t = S_t \cdot v_t \qquad (1) \text{ where}$$

$$S_t = P \cdot E_{t-g} \qquad (2) \text{ where}$$

$$P = efh - \frac{1+m}{n} \qquad (3)$$

Table 2 shows the derivation of survival rates, $e \cdot f$, for a pink salmon hatchery under alternative assumptions concerning egg-to-fry survival and fry-to-adult survival for unfed and fed fry. Table 3 combines these survival rates with alternative assumptions about the escapement rate of adult fish through the off-shore fishery to the hatchery, h, to arrive at productivity coefficients, $P = efh - \frac{1+m}{n}$. The term $\frac{1+m}{n}$ gives the brood-stock necessary for a given egg stock requirement, E. For example, a 25 million egg hatchery would require $S'_t = 20{,}833$ each period if the ratio of males to females required for fertilization is 1/3, m = 1/3, and there are 1600 eggs per female on the average, n = 1600; $S'_t = \frac{1 + 1/3}{1600} . 25{,}000{,}000 = 20{,}750$. The brood stock requirement acts as a drain on productivity in the sense that it decreases the hatchery surplus of high-valued bright fish in year t; it is, of course, a necessary input into the productivity of the hatchery two years hence (t + 2).

Because there is a significant degree of uncertainty associated with estimates of survival rates and hatchery escapement rates, it is possible for critics to challenge any particular set of assumptions underlying a "P" value used in feasibility analysis. As the array of values for P shown in Table 3 makes clear, however, there is some

Table 1

Glossary of Notation

P	= "productivity coefficient" encompasses egg-to-fry survival, fry-to-adult survival, escapement to hatchery, and brood stock assumptions
e	= egg-to-fry survival rate
f	= fry-to-adult survival rate
h	= hatchery escapement rate
$(1-h)$	= common-property fishery escapement rate
m	= ratio of males to females used in fertilization
n	= average number of eggs per female
E	= hatchery egg stock
S	= hatchery surplus of bright salmon
S'	= brood-stock requirement
R^*	= annual hatchery revenues from sale of surplus salmon
PVR^*	= present value of hatchery revenues
R^F	= annual common-property fishery net revenues from sale of hatchery-originated salmon
PVR^F	= present value of net revenues to common-property fishing units
R^T	= total revenues to hatchery and common-property fishery from the sale of hatchery-originated salmon
PVR^T	= present value of total revenues
v	= price per fish
v^*	= price per fish at which hatchery investment becomes economically feasible
C^I	= initial investment cost
C^O	= annual operating cost
PVC^O	= present value of annual operating cost
C	= total annual cost
PVC	= present value of cost
MC^F	= marginal cost incurred by common-property fishery from harvesting hatchery-originated salmon
NPV	= net present value
B/C	= benefit/cost ratio
N	= number of time periods
t	= time period
g	= number of years in life cycle of species of salmon being evaluated
H	= annual harvest by common property fishery
i	= interest rate or discount rate

TABLE 2

Derivation of Survival Rate (e · f)

Egg-to-Fry Survival (e)	Fry-to-Adult Survival (f): Unfed Fry .01	.015	.02	Fed Fry .03	.04	.05
.70	.00700	.01050	.01400	.02100	.02800	.03500
.75	.00750	.01125	.01500	.02250	.03000	.03750
.80	.00800	.01200	.01600	.02400	.03200	.04000

TABLE 3

Derivation of Productivity Coefficients[1] ($P = e \cdot f \cdot h - \frac{1+m}{n}$)

Unfed Fry: Survival Rate (e·f)	Productivity Coefficient @ h = 30%	h = 40%	h = 50%	Fed Fry: Survival Rate (e·f)	Productivity Coefficient @ h = 30%	h = 40%	h = 50%
.00700	.00127	.00197	.00267	.02100	.00547	.00757	.00967
.00750	.00142	.00217	.00292	.02250	.00592	.00817	.01042
.00800	.00157	.00237	.00317	.02400	.00637	.00877	.01117
.01050	.00232	.00337	.00442	.02800	.00757	.01037	.01317
.01125	.00255	.00367	.00480	.03000	.00817	.01117	.01417
.01200	.00277	.00397	.00517	.03200	.00877	.01197	.01517
.01400	.00337	.00477	.00617	.03500	.00967	.01317	.01667
.01500	.00367	.00517	.00667	.03750	.01042	.01417	.01792
.01600	.00397	.00557	.00717	.04000	.01117	.01517	.01917

[1]For pink salmon a conservative estimate of the brood stock requirement is given by:

$$\frac{1+m}{n} = \frac{1+1/3}{1600} = .00083\,333 \approx .00083$$ times the number of eggs required.

degree of central tendency in the value of P which makes possible the selection of a reasonable range of values for P. The central tendency derives from the fact that, for example, a relatively high assumed value of "e" combined with a low assumed value for "f" and a mid-range value for "h" will yield approximately the same P value as, say, a relatively low value for both "e" and "f" and a relatively high value of "h" (if e = .8, f = .01, and h = .4, P = (.8) (.01) (.4) - .00083 = .00237; and if e = .70, f = .01 and h = .45, P = (.7) (.01) (.45) - .00083 = .00232). Thus, while events may prove that an analyst's assumption with respect to fry survival is excessively optimistic (pessimistic), his assumption with respect to egg-to-fry survival and the hatchery escapement rate may have been excessively pessimistic (optimistic) resulting in an assumed productivity rate approximate to that actually realized; such trade-offs are more likely if central values of P are chosen for feasibility analysis.

Table 4 shows the revenue flows of a 25-million egg pink salmon hatchery over a range of prices and productivity rates. The productivity rates utilized for the feasibility analyses include a low range, mid range and high range for both the unfed and fed fry assumptions. Thus six alternative productivity rates are used and these span the range of "reasonable pessimism" to "reasonable optimism." "Cautious optimism" is achieved by relying on the mid-range productivity factors. The author shares the reader's probable amusement or aggravation, as the case may be, because it is generally accepted that the reasonableness of assumptions built into feasibility analyses can only be evaluated *ex post* in light of actual experience. The productivity rates do span the central tendency of present knowledge, however, and this seems to be as sound a basis as any for evaluating reasonableness of assumptions *ex ante*.

TABLE 4

Annual Revenues[1] (R*) for a Pink Salmon Hatchery
With a Twenty-Year Life
By Prices and Productivity Rates

Productivity[2] Coefficient	Annual[3] Surplus	Price Per Fish, v = ($)[4]							
		($0.95)	($1.14)	($1.33)	($1.52)	($1.71)	($1.90)	($2.09)	($2.28)
Unfed Fry									
.00127	31,750	$30,163	$36,195	$42,228	$48,260	$54,293	$60,325	$66,358	$72,390
.00367	91,750	87,163	104,595	122,028	139,460	156,893	174,325	191,758	209,190
.00717	179,250	170,288	204,345	238,403	272,460	306,518	340,575	374,633	408,690
Fed Fry									
.00547	136,750	$129,913	$155,895	$181,878	$207,860	$233,843	$259,825	$285,808	$311,790
.01117	279,250	265,288	318,345	371,403	424,460	477,518	530,575	583,633	636,690
.01917	479,250	455,288	546,345	637,403	728,460	819,518	910,575	1,001,633	1,092,690

[1]Rounded to nearest dollar.

[2]Brood stock requirement for years 21 and 22 is deducted in the same manner as for years 1-20 on the assumption that reinvestment will occur.

[3]For an assumed hatchery capacity of 25 million eggs; derived by multiplying 25 million by productivity coefficient.

[4]In the pink salmon life cycle (see Figure 2), year one begins in August-September with egg-take and fertilization, followed by a period of incubation lasting until April and fry release in May or June. Fish return at the end of year two, having spent year two maturing in the ocean. For example, eggs taken in August-September 1976 will produce fry by April 1977 and mature fish by August-September 1978. Thus year one is July 1976 through June 1977 and year two is July 1977 through June 1978. Year three begins with harvest/egg-take and would yield the first surplus and revenue to the hatchery. These revenue estimates abstract from the necessity that may characterize some hatchery sites of building an egg source internally from a small doner stock.

The price alternatives built into Table 4 are price per pink salmon assuming 3.8 pounds per fish, the long-term Prince William Sound average. The eight alternative prices shown center on the 1976 average price for pink salmon in Prince William Sound of between $.40 and $.45 per pound. Thus to choose for feasibility analysis purposes a price below $1.52-$1.71 range per fish is to assume that future real prices will be below the 1976 price, and vice versa. A reasonably conservative approach, given that real price has been increasing, would be to utilize the high estimate of $1.71 for 1976 as the basic real-price assumption for the feasibility analysis.

Table 5 presents the revenue flows shown in Table 4, discounted to present value, at several discount rates, i, for a 20-year assumed life of the hatchery investment.[5] Current-period (constant) prices over the 20-year period are utilized rather than inflation-adjusted prices because current-period costs will be used for the feasibility analyses. In addition, as mentioned above, real price forecasts are not made; rather a range of prices are provided from which can be selected the price upon which economic feasibility is judged. An important limiting factor in this feasibility analysis is the selection of a particular real price from this range which is then treated as constant for the life of the hatchery. This approach was adopted in recognition of the limitations associated with long range real-price forecasts in a rapidly changing economic environment.[6]

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[5]Discounting to present value is necessary whenever a comparison is made between revenue flows and cost flows which are incurred at different rates through time. Conceptually, discounting to present value is the opposite of compounding to future value. For a thorough discussion of the discounting concept see Edward Shapiro, *Macroeconomic Analysis*, Third Edition, 1974, pp. 158-163.

[6]These limitations derive not only from the normal difficulties associated with forecasting the future on the basis of data which reflect economic relationships of past time periods, but also from an inadequate data base for measuring the movement of relevant variables over past time periods.

Table 5

Present Value of Hatchery Revenue (PVR*)[1]

Price/Fish @ 3.8 lb/Fish (for v/lb. = $.25-.60)	Productivity Coefficient					
	Unfed Fry @ P = ( )			Fed Fry @ P = ( )		
i = .08	(.00127)	(.00367)[2]	(.00717)	(.00547)	(.01117)[2]	(.01917)
v = $0.95	253,912	733,738	1,433,484	1,093,608	2,233,194	3,832,614
1.14	304,690	880,481	1,720,176	1,312,324	2,679,828	4,599,132
1.33	355,475	1,027,232	2,006,876	1,531,049	3,126,470	5,365,658
1.52	406,253	1,173,974	2,293,568	1,749,765	3,573,104	6,132,176
1.71	457,038	1,320,725	2,580,269	1,868,490	4,019,747	6,898,703
1.90	507,816	1,467,468	2,866,960	2,187,207	4,466,380	7,665,220
2.09	558,602	1,614,219	3,153,661	2,405,932	4,913,023	8,431,747
2.28	609,379	1,760,961	3,440,352	2,624,648	5,359,656	9,198,264
i = .10						
v = $0.95	212,227	613,279	1,198,146	914,068	1,866,566	3,203,406
1.14	254,668	735,930	1,437,771	1,096,877	2,239,875	3,844,083
1.33	297,116	858,589	1,677,404	1,279,694	2,613,192	4,484,768
1.52	339,557	981,241	1,917,029	1,462,503	2,986,501	5,125,445
1.71	382,006	1,103,899	2,156,661	1,645,319	3,359,817	5,766,129
1.90	424,447	1,226,551	2,396,286	1,828,129	3,733,126	6,406,806
2.09	466,895	1,349,209	2,635,918	2,010,945	4,106,442	7,047,490
2.28	509,336	1,471,861	2,875,543	2,193,754	4,479,751	7,688,167
i = .12						
v = $0.95	179,621	519,056	1,014,065	773,632	1,579,790	2,711,240
1.14	215,541	622,863	1,216,874	928,355	1,895,744	3,253,484
1.33	251,468	726,677	1,419,690	1,083,083	2,211,705	3,795,735
1.52	287,388	830,484	1,622,499	1,237,806	2,527,659	4,337,979
1.71	323,315	934,298	1,825,315	1,392,535	2,843,620	4,880,230
1.90	359,235	1,038,105	2,028,124	1,547,258	3,159,574	5,422,474
2.09	395,162	1,141,919	2,230,940	1,701,987	3,475,535	5,964,725
2.28	431,082	1,245,726	2,433,749	1,856,709	3,791,489	6,506,969

[1] Rounded to nearest dollar. Derived from:

$$PVR^* = \sum_{t=(1+g)}^{N} \left[\frac{R^*_t}{(1+i)^t} \right] = \sum_{t=3}^{22} \left[\frac{R^*_t}{(1+i)^t} \right] = \frac{R^*_3}{(1+i)^3} + \frac{R^*_4}{(1+i)^4} + \cdots + \frac{R^*_{22}}{(1+i)^{22}}$$

[2] These columns are the basis for the NPV calculations in Table 9.

Figure 2 is designed to orient the reader who is unfamiliar with the pink salmon life cycle with the several time dimensions that are pertinent to the analyses contained in this report. As shown, parts of three production cycles (and three calendar years) are included in the two-year pink-salmon life cycle. This explains the rationale for the time subscripts in the formula used to derive the values in Table 5 where July, 1976 is the beginning of the first time period (production year) t = 1. The present value of revenue is expressed mathematically as:

$$PVR^* = \sum_{t=(1+g)}^{N} \left[\frac{R^*_t}{(1+i)^t} \right] = \sum_{t=3}^{22} \left[\frac{R^*_t}{(1+i)^t} \right] = \frac{R^*_3}{(1+i)^3} + \frac{R^*_4}{(1+i)^4} + \cdots + \frac{R^*_{22}}{(1+i)^{22}} \quad (4),$$

where PVR* is present value of revenue, R^*_t is revenue accruing to the hatchery in year t, i is the rate of discount, and g is the length of the life cycle of the species of salmon being evaluated.

Cost Flows of Hatchery Firms

Level-one feasibility analysis includes the opportunity cost of all resources used by the hatchery firm. As discussed in detail in Chapter 1, the cost data available for this study are imperfect in many respects and should only be interpreted as order-of-magnitude estimates. It is appropriate, therefore, to use the feasibility analyses based on these data for generalizing about the economic feasibility (or other policy questions) of private nonprofit salmon aquaculture only if the limitations of the cost data, and the difficulty these create for comparability, are kept in mind.

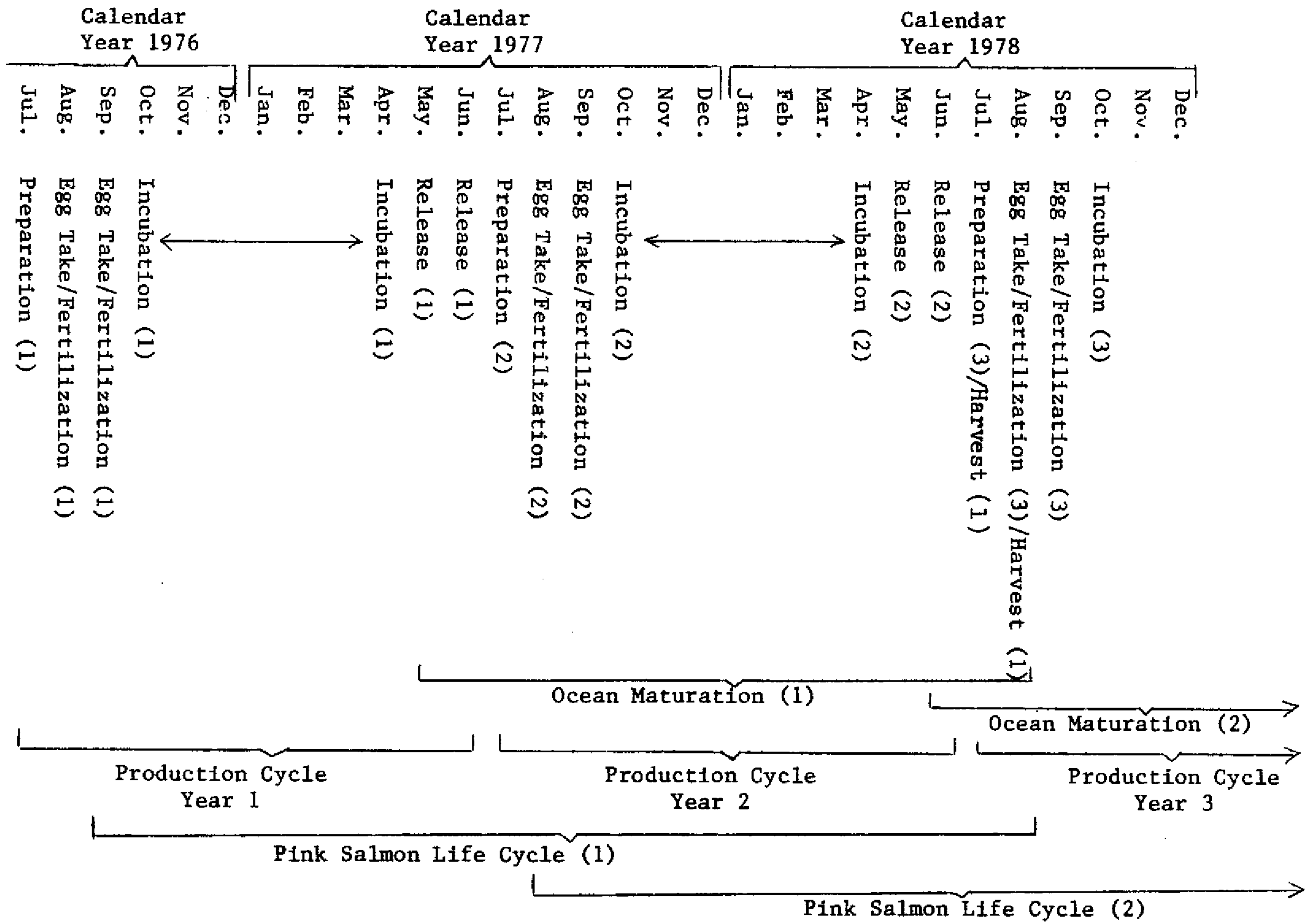

FIGURE 2: Production Cycles for Pink Salmon Hatchery

Note: Numbers in parentheses refer to the generation of salmon for production, ocean maturation, and life cycles, as indicated.

Construction Cost. Estimated construction costs are shown in Table 6. Included are all costs of materials and labor, project administration and general hatchery firm administration,[7] the estimated market value of donated services and materials used in construction (included in the miscellaneous category), the explicit interest cost on borrowed funds incurred over the construction period (January 1, 1975 - December 31, 1976), and the implicit interest cost on contributed capital over this period (included in the interest category). Contributed capital, including a $440,720 EDA grant, several smaller grants totalling $63,870, and fishermen-processor self assessments of $205,030 in 1975 and $220,060 in 1976, amounts to $929,680. The opportunity costs of contributed capital is treated as a cost even though the hatchery firm incurs no obligation to repay directly. To do otherwise would be to deny that: 1) these resources have alternative uses and 2) they were "contributed" with the expectation of receiving indirect benefits at least equal in value to the direct return these resources were capable of earning had they been employed elsewhere.

For the information of those readers who may be interested in greater detail, Appendix A, Table A-1, provides a description of each of the major cost categories shown in Table 6; Table A-2 describes, and lists the estimated value of, donated services and materials; and Table A-3 shows the calculation of implicit interest on contributed capital.

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[7]Under most circumstances it would be expected that hatchery construction would be conducted on a contract basis with project administration costs incurred directly by the general contractor. In the case of the Port San Juan hatchery, P.W.S.A.C. incurred these costs directly because it was in effect the general contractor; hatchery firm general administration is only a minor part of the total costs shown in Table 6 as administration.

Table 6

Hatchery Construction Costs by Category

Category	Labor	Materials	Total to Nov. 1976	Est. % Completion	Est. Total at Completion
Water System	$106,894	$ 96,176	$ 203,070	85	$ 238,906
Incubation/Production System	54,098	113,638	167,736	90	186,373
Hatchery Building	115,523	55,574	171,097	95	180,102
Utility System					
Waste Treatment	33,324	17,887	51,211	98	52,256
Electrical Power Generation/Distribution	40,696	81,109	121,805	70	174,007
Miscellaneous	38,080	52,283	90,363	85	257,245[1]
Camp Cost	78,673	56,917	135,590	66	205,439
Engineering	52,131	-	52,131	90	57,923
Administration	192,436	135,905	328,341	-	511,499
General Administration	117,753	22,523	140,276	65	215,809[2]
Acquisition, Shipment & Distribution of Materials	74,683	90,806	165,489	80	206,861
Interest	-	22,576	22,576	85	88,829[3]
Undistributed Construction Costs[4]	9,205	96,013	105,218	70	150,311
TOTAL: Unfed Fry	$726,989	$694,070	$1,421,059[5]		$ 2,014,061
Fed Fry[6]	4,000	48,000			52,000
TOTAL: Fed Fry	730,989	742,070			2,066,061

[1]Includes estimated market value of donated services and materials of $150,936 (see Appendix Table A-2).
[2]Includes general hatchery firm administration during construction period.
[3]Includes estimated implicit interest on contributed capital of $62,222 (see Appendix Table A-3).
[4]Multiple-use construction items, e.g., concrete, plywood, nails, etc., that had not been allocated to specific categories, e.g., water system, by the time this report was written.
[5]This total becomes $1,630,723 when amounts in footnotes 1 and 3 to this table are included; the weighted average estimated percent completion is therefore 1,630,723/2,014,061 = 81%.
[6]Estimated costs of short-term fry holding and feeding facilities; to be constructed during 1977.

Operating Costs. Annual operating and maintenance cost estimates for the Port San Juan hatchery, including hatchery-firm administration, are based partially on experience with certain phases of the production cycle and partially on budget estimates. Consequently, there is considerable uncertainty about how representative of future experience these cost estimates are. Table 7 breaks out these costs by cost categories and functional phases of the production cycle. The opportunity cost of working capital is included; it is calculated at ten percent from the initial month of each period in the production year.

Table 8 shows annual operating costs C_t^o, over the 20-year life of the hatchery, discounted to present value for alternative assumed discount rates of 8, 10 and 12 percent. Shown separately is the cost of harvesting only, discounted to present value, for years 21 and 22. Note that estimated annual operating cost for the Port San Juan hatchery (from Table 7, rounded to the nearest one thousand) constitutes the mid-range estimate shown in Table 8 for years one through 20; the high-range and low-range are ± $75,000 of the mid-range estimate. For years 21 and 22, the mid-range estimate is $50,000, with ± $25,000 for the high and low-range estimates respectively. There are some bases for expecting that the estimated annual operating costs (the mid-range estimate) for a 25 million egg hatchery are higher than that which may be representative of other hatchery sites of comparable capacity and remoteness, and that for less remote sites the overstatement is considerable.(see pp. 3-5). Thus, the low and mid-range estimates are preferred for long-range feasibility analysis over the high-range estimate.

Table 7

Estimated Annual Operating and Maintenance Costs

	Cleaning and Repair (July)	Egg Take and Harvest (Aug-Sept)	Care and Incubation of Eggs (Oct-Apr)	Holding, Feeding and Release (May-June)	Total
Labor:	$ 5,621	$ 32,113	$ 38,442	$10,342	$ 86,518
Permanent	4,500	9,000	31,500	9,000	54,000
Temporary	1,121	23,113	6,942	1,342	32,518
Materials	4,000	8,951	5,360	37,850	56,161
Transportation and Freight	1,000	20,000	7,500	1,500	30,000
Administration	13,610	27,220	105,270	27,220	173,320
Lease	770	1,540	5,390	1,540	9,240
Utilities	115	230	805	230	1,380
Maintenance	100	200	700	200	1,200
Insurance	1,000	2,000	7,000	2,000	12,000
Permits/Licenses	25	50	175	50	300
Consulting Fees	3,000	6,000	30,000	6,000	45,000
Salaries	7,000	14,000	49,000	14,000	84,000
Office, Misc.	1,100	2,200	7,700	2,200	13,200
Travel	500	1,000	4,500	1,000	7,000
TOTAL	$24,231	$88,284	$156,572	$76,912	$345,999
Plus: Opportunity cost of operating & maintenance cost at 10% (from initial month)	2,423	8,093	11,743	1,282	23,541
TOTAL	$26,654	$96,377	$168,315	$78,194	$369,540

Table 8

Present Value of Estimated Hatchery Operating and Maintenance Costs[1]

Discount Rate	Low Range $295,000 Years 1-20	Low Range $25,000 Years 21-22	Low Range Total	Mid Range[2] $370,000 Years 1-20	Mid Range[2] $50,000 Years 21-22	Mid Range[2] Total	High Range $445,000 Years 1-20	High Range $75,000 Years 21-22	High Range Total
i = .08	$ 2,896,310	$ 9,565	$2,905,875	$ 3,632,660	$ 19,130	$3,651,790	$ 4,369,010	$ 28,695	$4,397,705
i = .10	2,511,630	6,448	2,518,078	3,150,180	12,895	3,163,075	3,788,730	19,343	3,808,073
i = .12	2,203,355	4,380	2,207,735	2,763,530	8,760	2,772,290	3,323,705	13,140	3,336,845

[1]Derived from

$$PVC^o = \sum_{t=1}^{N}\left[\frac{C_t^o}{(1+i)^t}\right] + \sum_{t=(N+1)}^{(N+g)}\left[\frac{C_t^{o'}}{(1+i)^t}\right] = \frac{C_1^o}{(1+i)} + \frac{C_2^o}{(1+i)^2} + \cdots + \frac{C_{20}^o}{(1+i)^{20}} + \frac{C_{21}^{o'}}{(1+i)^{21}} + \frac{C_{22}^{o'}}{(1+i)^{22}}$$

, where C_t^o is annual operating costs for "normal" operating years of 1 through 20 and $C_t^{o'}$ is reduced annual operating cost for years 21 and 22; this amount is necessarily incurred to harvest returning fish of years 19 and 20 respectively and is estimated to be $50,000 (± 25,000) in each year.

[2]From Table 7, rounded to nearest one thousand.

Net Present Value and Level-One Feasibility

Having developed estimated ranges of revenues and costs for the Port San Juan hatchery, it is possible to evaluate level-one feasibility for private nonprofit hatchery firms by calculating the net present value corresponding to each set of assumptions about productivity, price, discount rate, and operating costs. Net present value is defined as the difference between the discounted present value of revenues earned from the sale of surplus salmon over the life of the investment minus capital costs and the discounted present value of annual operating and maintenance costs. This is shown in equation form as:

$$NPV = PVR^* - PVC \qquad (5)$$

, where NPV is net present value, PVR* is present value of revenue {as defined on p. 24, equation (4)} and PVC is present value of costs.

$$PVC = C^I + \sum_{t=1}^{N} \left[\frac{C_t^O}{(1+i)^t} \right] \qquad (6)$$

, where C^I is the initial investment (construction) cost incurred in $t = 0$, C_t^O is the operating and maintenance costs in year t. Substituting (4) and (6) into (5) we get:

$$NPV = \sum_{t=(1+g)}^{N} \left[\frac{R_t^*}{(1+i)^t} \right] - C^I - \sum_{t=1}^{N} \left[\frac{C_t^O}{(1+i)^t} \right] \qquad (7)$$

Assuming that the scrap value of the investment is zero in twenty years and given that the discount rate, i, reflects the competitive rate of return for investments of comparable risks, then a zero or positive NPV reveals that the hatchery investment is economically feasible. Table 9 shows the NPV at 1) discount rates of .08, .10 and .12, 2) alternative prices (v) from \$0.95 to \$2.28 per fish, 3) productivity coefficients (P)

Table 9

Net Present Value (NPV) of Port San Juan Hatchery: Level-One Feasibility[1]

	P = .00367[2]			P = .01117[3]		
Mid Range O & M Costs	i = .08	i = .10	i = .12	i = .08	i = .10	i = .12
v = $0.95	$-4,984	$-4,616	$-4,319	$-3,485	$-3,363	$-3,259
1.14	-4,837	-4,493	-4,215	-3,038	-2,989	-2,943
1.33	-4,691	-4,371	-4,112	-2,591	-2,616	-2,627
1.52	-4,544	-4,248	-4,008	-2,145	-2,243	-2,311
1.71	-4,397	-4,125	-3,904	-1,698	-1,869	-1,995
1.90	-4,250	-4,003	-3,800	-1,251	-1,496	-1,679
2.09	-4,104	-3,880	-3,696	- 805	-1,123	-1,363
2.28	-3,957	-3,757	-3,593	- 358	- 749	-1,047
v*	$ 7.40	$ 8.10	$ 8.86	$ 2.43	$ 2.66	$ 2.91
Low Range O & M Costs						
v = $0.95	$-4,238	$-3,971	$-3,755	$-2,739	$-2,718	$-2,694
1.14	-4,091	-3,848	-3,651	-2,292	-2,344	-2,378
1.33	-3,945	-3,726	-3,547	-1,845	-1,971	-2,062
1,52	-3,798	-3,603	-3,443	-1,399	-1,598	-1,746
1.71	-3,651	-3,480	-3,339	- 952	-1,224	-1,430
1.90	-3,504	-3,358	-3,236	- 506	- 851	-1,114
2.09	-3,358	-3,235	-3,132	- 58	- 478	- 798
2.28	-3,211	-3,112	-3,028	388	- 104	- 482
v*	$ 6.44	$ 7.10	$ 7.82	$ 2.11	$ 2.33	$ 2.57
High Range O & M Costs						
v = $0.95	$-5,730	$-5,261	$-4,884	$-4,231	$-4,008	$-3,823
1.14	-5,583	-5,138	-4,780	-3,784	-3,634	-3,507
1.33	-5,437	-5,016	-4,676	-3,337	-3,261	-3,191
1.52	-5,290	-4,893	-4,572	-2,891	-2,888	-2,875
1.71	-5,143	-4,770	-4,469	-2,444	-2,514	-2,559
1.90	-4,996	-4,648	-4,365	-1,997	-2,141	-2,243
2.09	-4,850	-4,525	-4,261	-1,551	-1,768	-1,927
2.28	-4,703	-4,402	-4,157	-1,104	-1,394	-1,611
v*	$ 8.37	$ 9.10	$ 9.89	$ 2.75	$ 2.99	$ 3.25

[1]In thousands of dollars.

[2]Assumes egg-to-fry survival rate of 75%, fry-to-adult survival rate of 1.5%, hatchery escapement rate of 40%, and brood stock requirement rate of .00083 (or 830 fish per one million eggs required--623 females and 207 males).

[3]Assumes egg-to-fry survival rate of 75%, fry-to-adult survival rate of 4%, hatchery escapement rate of 40%, and brood stock requirement of .00083.

of .00367 and .01117 (see Table 2 and Table 3 and footnote 2 to Table 5), and 4) the three ranges of estimated operating costs. Table 9 also gives v*, which is the approximate minimum price required for feasibility, for the productivity coefficient, discount rate, and operating and maintenance cost range shown in each column. Since R^*_t is $v_t \cdot S_t$ and $S = P \cdot E_{t-2}$, where E_{t-2} is the number of eggs incubated two years earlier, v* is obtained from the formula for NPV, equation (7), by setting NPV = 0 and by assuming that R*, and its components v and S, are the same in each year. The latter assumption is consistent with the treatment of revenue in Tables 4 and 5.

$$NPV = \sum_{t=(1+g)}^{N} \left[\frac{vS}{(1+i)^t} \right] - PVC \qquad (8)$$

$$O = v^*S \sum_{t=(1+g)}^{N} \left[\frac{1}{(1+i)^t} \right] - PVC \qquad (9)$$

$$v^* = \frac{PVC}{S \sum_{t=(1+g)}^{N} \left[\frac{1}{(1+i)^t} \right]} \qquad (10)$$

, where PVC can be obtained from Tables 6 and 8, S from Table 4 and $\sum_{t=(1+g)}^{N} \left[\frac{1}{(1+i)^t} \right]$ is the series present worth factor. For a discount rate of ten percent, the present value of the mid-range operating and maintenance cost is $3,163,075 (Table 8), and the series present worth factor is 7.036. Given an annual surplus of 91,750 salmon (Table 4) and construction costs of $2,066,061 (Table 6), a break-even price (v*) of v* = $8.10 can be derived by substituting these values into equation (10).

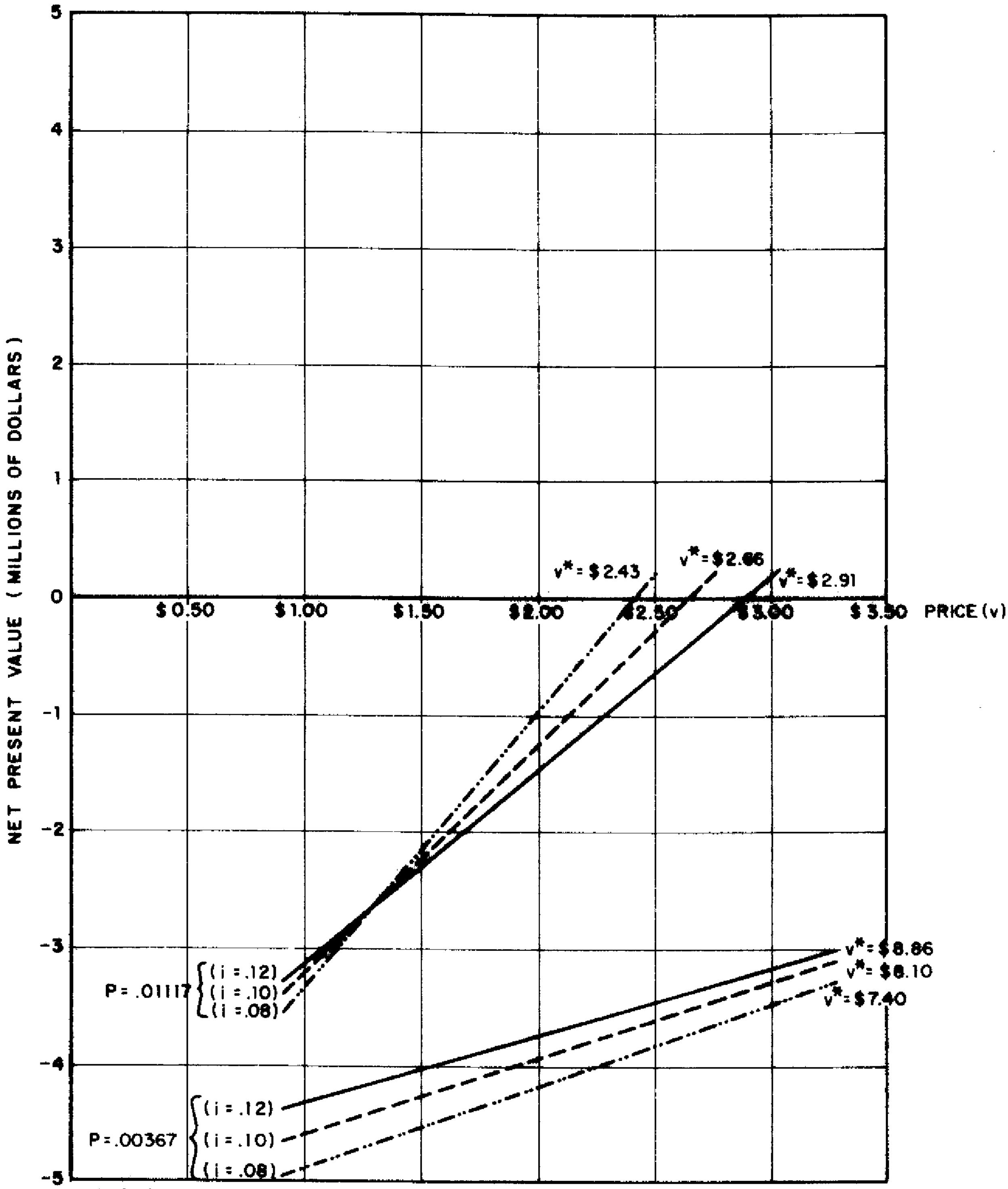
$$v^* = \frac{5,229,136}{91,750 \times 7.036} = \frac{5,229,136}{645,533} = \$8.10$$

This formula can also be utilized to derive the productivity coefficient required for feasibility given price and cost conditions or, alternatively, to derive the cost level required for feasibility given price and productivity.

Figures 3 - 5, corresponding to Table 9, show net present value as a function of productivity, price and discount rate for the three ranges of estimated operating and maintenance costs. At a given discount rate it is possible to determine the effect of price on economic feasibility for each operating and maintenance cost range; alternatively it is possible to determine the effects on feasibility of variation in the discount rate at a particular price for each operating and maintenance cost range. Similarly, comparisons between Figures 3 - 5, for each combination of productivity, price and discount rate, reveal the effect of the operating and maintenance costs levels on feasibility. Compared to the other determinants of feasibility the productivity coefficient is conspicuous in its importance.

Table 9 summarizes the NPV approach to level-one feasibility analysis for the Port San Juan hatchery. It is apparent that level-one feasibility is not assured at any of the three discount rates for conservative assumptions about price, costs and productivity. An optimistic set of assumptions concerning price, ($v^* = \$2.11$), cost level (low range), and productivity ($P = .01117$) is required to attain level-one feasibility at an 8 percent discount rate.

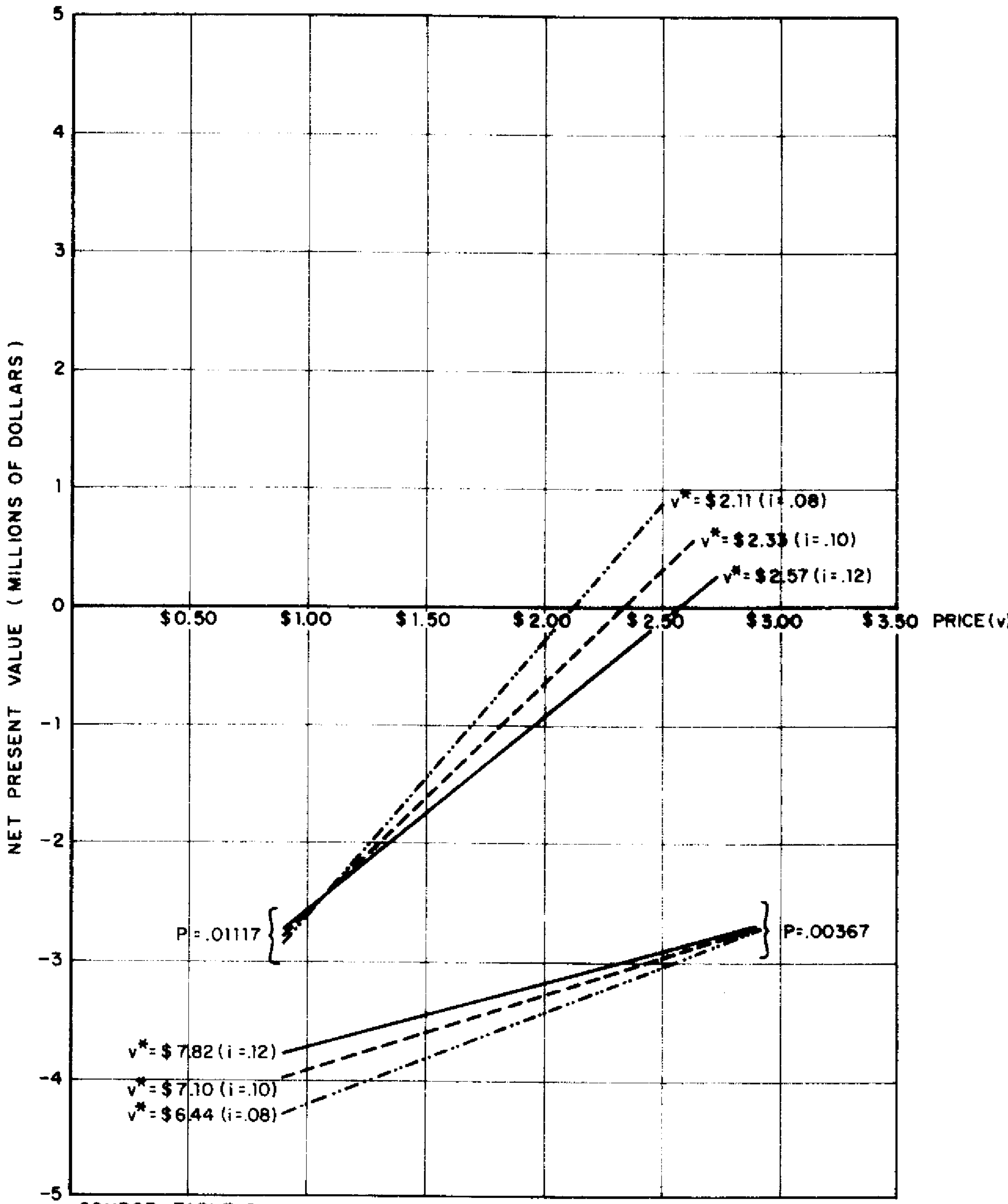
The reader is cautioned that a failure to pass the level-one feasibility test is not necessarily a statement that private, nonprofit ocean ranching is economically unfeasible (see pp. 13 and 14); rather, it is a statement that sales revenues (from the sale of surplus fish) alone are not sufficient to cover all costs. This is not especially surprising inasmuch as 50-70 percent of the revenues generated from returning adult fish will normally accrue outside the hatchery firm.



SOURCE: TABLE 9

FIGURE 3

NET PRESENT VALUE AS A FUNCTION OF PRODUCTIVITY, PRICE, AND DISCOUNT RATE FOR MID-RANGE COST ESTIMATE



SOURCE: TABLE 9

FIGURE 4

NET PRESENT VALUE AS A FUNCTION OF PRODUCTIVITY, PRICE, AND DISCOUNT RATE FOR LOW-RANGE COST ESTIMATE

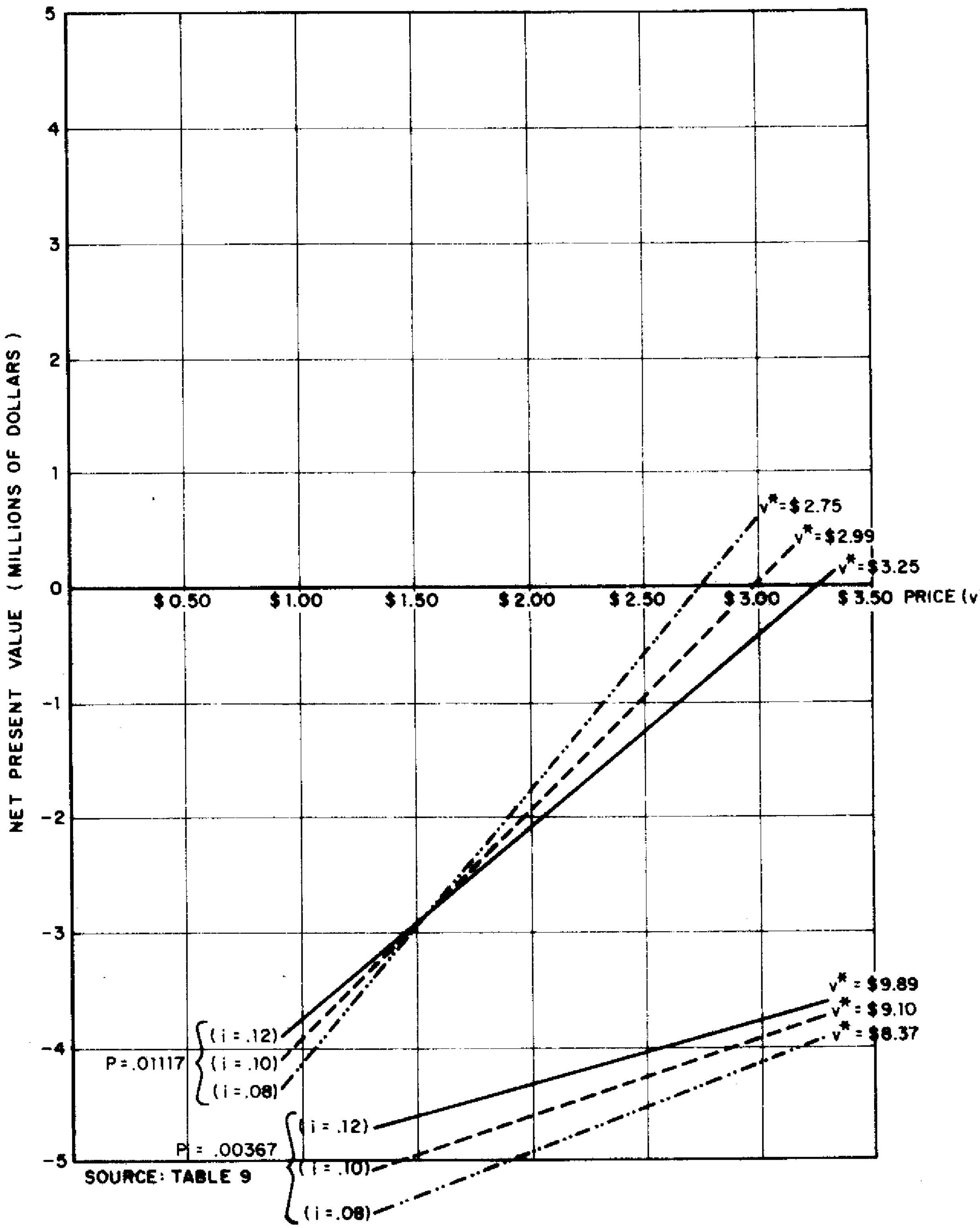


FIGURE 5

NET PRESENT VALUE AS A FUNCTION OF PRODUCTIVITY, PRICE, AND DISCOUNT RATE FOR HIGH-RANGE COST ESTIMATE

Unit Price and Cost Comparison and Level-One Feasibility

It is often helpful to compare costs and revenue in a short-run per-unit context as well as on a long-run, discounted-total basis. The former approach is shown in Table 10 where costs data from Tables 6 and 7 are allocated to fixed costs (costs that do not change with changes in the level of production) and variable costs (costs that are affected by changes in the level of production). The reader is cautioned against placing a high level of confidence in the allocations of the costs from Table 7 to the fixed and variable cost categories. There is always a degree of arbitrariness to such allocations, the degree of which increases when, as here, experience with a given production process is lacking. The format of Table 10 represents a useful breakdown of information for managerial decision making, however, and the design of an accounting information system by aquaculture firms should allow for meaningful allocations to this framework. An example of useful applications can be found in a study of Pacific oyster seed hatcheries (Im, Johnston and Langmo, 1976).

As can be seen in Table 10, a price per fish of \$6.67 when S = 91,750 (and \$2.19 when S = 279,250) is required to break even in each year. These prices are not strictly comparable to those derived from equation (10) for the otherwise comparable ten percent discount rate, .00367 and .01117 productivity coefficients, mid-range operating and maintenance cost cases (see v*, Table 9, middle columns under i = .10) because the latter takes into consideration the *timing* of receipts and expenditures. That is, the break-even price of \$6.67 in Table 10 implicitly assumes that R* of \$612,220 (≈\$6.67 x 91,750) would be received in each of the first twenty years, whereas R* of zero will actually be received during the first two production years, and the full amount will be received in years 21 and 22. When allowing for the annual cost of the

Table 10

Estimated Annual Fixed and Variable Costs[1]

	Cleaning and Repair	Egg Take and Harvest	Care and Incubation of Eggs	Holding, Feeding, and Release	Total
Fixed Costs					
Capital Amortization @ 10%[2]	$ -	$ 44,124	$154,432	$ 44,124	$242,680
Lease	770	1,540	5,390	1,540	9,240
Maintenance	100	200	700	200	1,200
Insurance	1,000	2,000	7,000	2,000	12,000
Permits and Licenses	25	50	175	50	300
Utilities	115	230	805	230	1,380
Consulting Fees	3,000	6,000	30,000	6,000	45,000
Administrative Salaries	7,000	14,000	49,000	14,000	84,000
Travel	500	1,000	4,500	1,000	7,000
Office Expenses	1,100	2,200	7,700	2,200	13,200
Opportunity Cost of O&M Costs @ 10%	2,423	8,093	11,743	1,282	23,541
Total	16,033	79,437	271,445	72,626	439,541
Variable Costs					
Labor	5,621	32,113	38,442	10,342	86,518
Materials	4,000	8,951	5,360	37,850	56,161
Transportation and Freight	1,000	20,000	7,500	1,500	30,000
Total	10,621	61,064	51,302	49,692	172,679
Total Costs	26,654	140,501	322,747	122,318	612,220
Unit Costs (per 1000 fry)[3,4]					
Fixed Costs per Unit	.86	4.24	14.48	3.87	23.44
Variable Costs per Unit	.57	3.26	2.74	2.65	9.21
Total Costs per Unit	1.42	7.49	17.21	6.52	32.65
Unit Costs (per surplus salmon)[3]					
S = 91,750[5]					
Fixed Costs per Unit	.17	.87	2.96	.79	4.79
Variable Costs per Unit	.12	.67	.56	.54	1.88
Total Costs per Unit	.29	1.53	3.52	1.33	6.67
S = 279,250[6]					
Fixed Costs per Unit	.06	.28	.97	.26	1.57
Variable Costs per Unit	.04	.22	.18	.18	.62
Total Costs per Unit	.10	.50	1.16	.44	2.19

[1]Cost data taken from Table 7; capital amortization from Table 6.

[2]Allocated to the functional phases of the production year according to the proportion of the year occupied by each phase excluding the "Cleaning and Repair" phase. The data did not allow less arbitrary breakdown; however, the time distribution did appropriately allocate most of the capital costs to the phase "Care and Incubation of Eggs."

[3]Individual amounts may not add to totals due to rounding.

[4]At 75% survival 25,000 eggs gives 18,750 fry.

[5]At P = .00367, S = 91,750.

[6]At P = .01117, S = 279,250.

resultant working-capital requirements (see Table 15) the unit prices required to break even are $8.10 and $2.66 as in Table 9 and Figure 3.

Summary. Level-one feasibility analysis has been developed above to determine whether or not private nonprofit hatchery firms could survive without external support. The conclusion is that, as judged by the Port San Juan pink salmon hatchery, they cannot survive independently with present technology and price levels. It must be emphasized again, however, that in level-one feasibility analysis the revenues being compared to costs are only those that accrue to the hatchery firm from the sale of surplus salmon, or roughly 40 percent of the total revenues being created by the productive activity for which the costs are incurred. A more meaningful comparison of revenue and costs is the purpose of the level-two feasibility analysis which follows.

This is the appropriate place to make another point about level-one economic-feasibility analysis. Level-one analysis is an *economic analysis* structured so that the opportunity cost of all resources are included; it is not a *cash-flow analysis* structured to include only explicit cost, and designed to determined whether a hatchery firm can survive in the sense that it can pay all explicit costs through time. Cash-flow feasibility is possible for any investment, even economically infeasible ones, if the firm is sufficiently subsidized. Level-one economic-feasibility analysis seeks to determine whether subsidization is required, and level-two economic-feasibility analysis evaluates the economic justification for subsidy and attempts to identify the external beneficiaries who should pay the subsidies, if they are shown to be justified.

Level-Two Feasibility

The primary differences between level-one and level-two feasibility analysis derive from 1) an increase in the scope of the revenue side of the analysis, and 2) an explicit recognition of the differential incidence of revenues and costs and the institutional implications of differential incidence.[8] The level-two feasibility test is the more flexible and appropriate tool for evaluating feasibility in a common-property environment.

The Definition of Revenues for Level-Two Feasibility Analysis

It will be recalled that for level-one feasibility analysis revenues were defined by equations (1) - (4):

$$R^*_t = S_t \cdot v_t \qquad (1), \text{ where}$$

$$S_t = P \cdot E_{t-g} \qquad (2), \text{ where}$$

$$P = efh - \frac{1+m}{n} \qquad (3), \text{ and}$$

$$PVR^* = \sum_{t=(1+g)}^{N} \frac{R^*_t}{(1+i)^t} \qquad (4).$$

Revenues must now be broadened to include those earned from the harvest and sale of hatchery-originated salmon by fishing units in the common-property fishery. Let the latter be represented by R^F where:

$$R^F_t = H_t \cdot v_t - MC^F_t \qquad (11),$$

where H represents the harvest by the common-property fishery, v_t is the price per fish as before, and MC^F_t is the marginal cost of catching the hatchery-originated fish.[9]

$$H_t = ef(1-h)E_{t-g} \qquad (12),$$

where all terms are as previously defined.

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[8] Incidence refers to the economic entities which have legal property rights in the case of revenues and legal liability in the case of costs. Differential incidence exists when the entity (ies) to which revenues accrue is (are) different, in whole or in part, from the entity (ies) to which the liability for payment of costs accrues.

[9] Marginal cost refers to the incremental or additional costs associated with harvesting hatchery-originated salmon; it excludes those harvesting costs which would have been incurred in the absence of hatchery-produced fish.

The total revenue, R_t^T, resulting from the productive activity of the hatchery is given by:

$$R_t^T = R^*_t + R_t^F \qquad (13).$$

The present value of revenue is similarly given by:

$$PVR^T = \sum_{t=(1+g)}^{N} \left[\frac{R_t^T}{(1+i)^t} \right] \qquad (14).$$

The marginal cost incurred by the common-property fishing units from harvesting hatchery-originated salmon, MC^F, can vary between zero and the total cost of a trip to fish a given location for a given number of days; it is more conveniently treated as a deduction from revenue than an increase in cost, as shown in equation (11). MC^F will be zero, or very close to zero, if hatchery fish are harvested incidental to trips and settings which would have occurred even in the absence of the hatchery run. In those cases where trips or settings (or part thereof) are the result of the presence of hatchery-originated salmon, MC^F will assume a significant positive value.

Discussions with fishermen from Prince William Sound reveal an expectation that Port San Juan hatchery salmon will be caught incidentally to trips and settings; or at most they will require settings that would not otherwise have occurred, but remain incidental to trips. Table 11 shows R_t^F for the returns attributable to the Port San Juan hatchery assuming levels of MC^F from \$.00 to \$.05 per fish and prices of \$0.95 to \$2.28 per fish. MC^F would, of course, be much higher if the harvest of hatchery-originated salmon requires trips that would not otherwise be taken. This is assumed not to be the case for the Port San Juan hatchery. Table 12 gives the discounted present value of the annual net revenues shown in Table 11 for MC^F = \$.02 and \$.05.

TABLE 11

Annual Net Revenues to Common-Property Fishing Units From Port San Juan Originated Salmon[1]

Price/Fish @3.8 lb/Fish (for v/lb. = \$.25 - .60)	MC^F = ( ) per Fish					
	(\$.00)	(\$.01)	(\$.02)	(\$.03)	(\$.04)	(\$.05)
H = 168,750[2]						
v = \$0.95	\$160,313	\$158,625	\$156,938	\$155,250	\$153,563	\$151,875
1.14	192,375	190,688	189,000	187,313	185,625	183,938
1.33	224,438	222,750	221,063	219,375	217,688	216,000
1.52	256,500	254,813	253,125	251,438	249,750	248,063
1.71	288,563	286,875	285,188	283,500	281,813	280,125
1.90	320,625	318,938	317,250	315,563	313,875	312,188
2.09	352,688	351,000	349,313	347,625	345,938	344,250
2.28	384,750	383,063	381,375	379,688	378,000	376,313
H = 450,000[3]						
v = \$0.95	\$427,500	\$423,000	\$418,500	\$414,000	\$409,500	\$405,000
1.14	513,000	508,500	504,000	499,500	495,000	490,500
1.33	598,500	594,000	589,500	585,000	580,500	576,000
1.52	684,000	679,500	675,000	670,500	666,000	661,500
1.71	769,500	765,000	760,500	756,000	751,500	747,000
1.90	855,000	850,500	846,000	841,500	837,000	832,500
2.09	940,500	936,000	931,500	927,000	922,500	918,000
2.28	1,026,000	1,021,500	1,017,000	1,012,500	1,008,000	1,003,500

[1]Derived from $R_t^F = H \cdot v_t - MC^F$

[2]Derived from $H = ef\ (1-h)E_{t-g}$, where e = .75, f = .015, (1-h) = .60 and E_{t-g} = 25 million.

[3]Derived from $H = ef\ (1-h)E_{t-g}$, where e = .75, f = .04, (1-h) = .60 and E_{t-g} = 25 million.

Table 12

Present Value of Net Revenues to Common-Property Fishing Units (PVR^F)[1]

Price/Fish @3.8 lb/Fish (for v/lb. = $.25 - .60	MC^F = ( ) per Fish					
	i = .08		i = .10		i = .12	
	($.02)	($.05)	($.02)	($.05)	($.02)	($.05)
H = 168,750						
v = $0.95	$1,321,104	$1,278,484	$1,104,216	$1,068,593	$ 934,566	$ 904,416
1.14	1,591,002	1,548,390	1,329,804	1,294,188	1,125,495	1,095,351
1.33	1,860,908	1,818,288	1,555,399	1,519,776	1,316,430	1,286,280
1.52	2,130,806	2,088,194	1,780,988	1,745,371	1,507,359	1,477,215
1.71	2,400,713	2,358,092	2,006,583	1,970,960	1,698,295	1,668,144
1.90	2,670,611	2,627,999	2,232,171	2,196,555	1,889,224	1,859,080
2.09	2,940,517	2,897,897	2,457,766	2,422,143	2,080,159	2,050,009
2.28	3,210,415	3,167,803	2,683,355	2,647,738	2,271,088	2,240,944
H = 450,000						
v = $0.95	$3,522,933	$3,409,290	$2,944,566	$2,849,580	$2,492,168	$2,411,775
1.14	4,242,672	4,129,029	3,546,144	3,451,158	3,001,320	2,920,928
1.33	4,962,411	4,848,768	4,147,722	4,052,736	3,510,473	3,430,080
1.52	5,682,150	5,568,507	4,749,300	4,654,314	4,019,625	3,939,233
1.71	6,401,889	6,288,246	5,350,878	5,255,892	4,528,778	4,448,385
1.90	7,121,628	7,007,985	5,952,456	5,857,470	5,037,930	4,957,538
2.09	7,841,367	7,727,724	6,554,034	6,459,048	5,547,083	5,466,690
2.28	8,561,106	8,447,463	7,155,612	7,060,626	6,056,235	5,975,843

[1]Derived from $PVR^F = \sum_{t=(1+g)}^{N} \left[\frac{R_t^F}{(1+i)^t} \right] = \frac{R_3^F}{(1+i)^3} + \frac{R_4^F}{(1+i)^4} + \cdots + \frac{R_{22}^F}{(1+i)^{22}}$

Level-two feasibility analysis takes into account the revenues earned by the hatchery ($R^* = vS$) and those earned by fishing units in the common-property fishery ($R^F = vH - MC^F$). The sum of these revenue flows, discounted to present value, are given in Table 13.

The Definition of Costs for Level-Two Feasibility Analysis

Costs must be defined to include the opportunity cost of all resources employed by the hatchery firm for the production and recapture of surplus salmon, and by the common-property fishing units for the harvest of hatchery-originated salmon in the offshore fishery. The costs incurred by the hatchery firm that are to be included for the level-two feasibility test are identical to those used for the level-one analysis. Thus, Tables 6-8 provide the hatchery firm cost information needed for the evaluation of level-two feasibility. The other component of costs, the costs of harvesting hatchery-originated salmon incurred by the common property fishing units, has been treated as a deduction from revenue to arrive at net revenue, as discussed above and as shown in Table 11.

Net Present Value and Level-Two Feasibility

The information contained in Tables 6, 8, and 13 provides the basis for calculating net present value. Level-two feasibility exists when $NPV \geq 0$. By expanding equation (7) we get:

$$NPV = \sum_{t=(1+g)}^{N} \left[\frac{R^*_t}{(1+i)^t} \right] + \sum_{t=(1+g)}^{N} \left[\frac{R^F_t}{(1+i)^t} \right] - C^I - \sum_{t=1}^{N} \left[\frac{C^O_t}{(1+i)^t} \right] \quad (15).$$

Table 14 contains net present value for $MC^F = \$.02$ at each of the three levels of

Table 13

Present Value of Total Revenues (PVR^T)[1]

Price/Fish @3.8 lb/Fish (for v/lb. = \$.25 - .60)	Low-Productivity Case: S = 91,750 and H = 168,750			High-Productivity Case: S = 279,250 and H = 450,000		
	(i = .08)	(i = .10)	(i = .12)	(i = .08)	(i = .10)	(i = .12)
MC^F = \$0.02						
v = \$0.95	\$ 2,054,842	\$1,717,495	\$1,453,622	\$5,756,127	\$4,811,132	\$4,071,958
1.14	2,471,483	2,065,734	1,748,358	6,922,500	5,786,019	4,897,064
1.33	2,888,140	2,413,988	2,043,107	8,088,881	6,760,914	5,722,178
1.52	3,304,780	2,762,229	2,337,843	9,255,254	7,735,801	6,547,284
1.71	3,721,438	3,110,482	2,632,593	10,421,636	8,710,695	7,372,398
1.90	4,138,079	3,458,722	2,927,329	11,588,008	9,685,582	8,197,504
2.09	4,554,736	3,806,975	3,222,078	12,754,390	10,660,476	9,022,618
2.28	4,971,376	4,155,216	3,516,814	13,920,762	11,635,363	9,847,724
MC^F = \$0.05						
v = \$0.95	\$2,012,222	\$1,681,872	\$1,423,472	\$5,642,484	\$4,716,146	\$3,991,565
1.14	2,428,871	2,030,118	1,718,214	6,808,857	5,691,033	4,816,672
1.33	2,845,520	2,378,365	2,012,957	7,975,238	6,665,928	5,641,785
1.52	3,262,168	2,726,612	2,307,699	9,141,611	7,640,815	6,466,892
1.71	3,678,817	3,074,859	2,602,442	10,307,993	8,615,709	7,292,005
1.90	4,095,467	3,423,106	2,897,185	11,474,365	9,590,596	8,117,112
2.09	4,512,116	3,771,352	3,191,928	12,640,747	10,565,490	8,942,225
2.28	4,928,764	4,119,599	3,486,670	13,807,119	11,540,377	9,767,332

[1] $PVR^T = PVR^* + PVR^F$. PVR^* is given in Table 5 and PVR^F is given in Table 12.

Table 14

Net Present Value (NPV): Level-Two Feasibility at MC^F = \$0.02/Fish[1]

Price/Fish @3.8 lb/Fish (for v/lb. = \$.25 - .60)	Low-Productivity Case: S = 91,750 and H = 168,750			High-Productivity Case: S = 279,250 and H = 450,000		
	(i = .08)	(i = .10)	(i = .12)	(i = .08)	(i = .10)	(i = .12)
Mid Range O & M Costs						
v = \$0.95	\$-3,663,009	\$-3,511,641	\$-3,384,729	\$ 38,276	\$ -418,004	\$ -766,393
1.14	-3,246,368	-3,163,402	-3,089,993	1,204,649	556,883	58,713
1.33	-2,829,711	-2,815,148	-2,795,244	2,371,030	1,531,778	883,827
1.52	-2,413,071	-2,466,907	-2,500,508	3,537,403	2,506,665	1,708,933
1.71	-1,996,413	-2,118,654	-2,205,758	4,703,785	3,481,559	2,534,047
1.90	-1,579,772	-1,770,414	-1,911,022	5,870,157	4,456,446	3,359,153
2.09	-1,163,115	-1,422,161	-1,616,273	7,036,539	5,431,340	4,184,267
2.28	-746,475	-1,073,920	-1,321,537	8,202,911	6,406,227	5,009,373
v*	2.61	2.85	3.11	0.93	1.02	1.11
Low Range O & M Costs						
v = \$0.95	\$-2,917,094	\$-2,866,644	\$-2,820,174	\$ 784,191	\$ 226,993	\$ -201,838
1.14	-2,500,453	-2,518,405	-2,525,438	1,950,564	1,201,880	623,268
1.33	-2,083,796	-2,170,151	-2,230,689	3,116,945	2,176,775	1,448,382
1.52	-1,667,156	-1,821,910	-1,935,953	4,283,318	3,151,662	2,273,488
1.71	-1,250,498	-1,473,657	-1,641,203	5,449,700	4,126,556	3,098,602
1.90	-833,857	-1,125,417	-1,346,467	6,616,072	5,101,443	3,923,708
2.09	-417,200	-777,164	-1,051,718	7,782,454	6,076,337	4,748,822
2.28	-560	-428,923	-756,982	8,948,826	7,051,224	5,573,928
v*	2.27	2.50	2.76	0.81	0.89	0.98
High Range O & M Costs						
v = \$0.95	\$-4,408,924	\$-4,156,639	\$-3,949,284	\$ -707,639	\$-1,063,002	\$-1,330,948
1.14	-3,992,283	-3,808,400	-3,654,548	458,734	-88,115	-505,842
1.33	-3,575,626	-3,460,146	-3,359,799	1,625,115	886,780	319,272
1.52	-3,158,986	-3,111,905	-3,065,063	2,791,488	1,861,667	1,144,378
1.71	-2,742,328	-2,763,652	-2,770,313	3,957,870	2,836,561	1,969,492
1.90	-2,325,678	-2,415,412	-2,475,577	5,124,242	3,811,448	2,794,598
2.09	-1,909,030	-2,067,159	-2,180,828	6,290,624	4,786,342	3,619,712
2.28	-1,492,390	-1,718,918	-1,886,092	7,456,996	5,761,229	4,444,818
v*	2.95	3.20	3.48	1.05	1.14	1.24

[1] Derived from: $NPV = PVR^T - C^I - PVC^O$, where $PVR^T = PVR^* + PVR^F$. PVR^T is given in Table 13, C^I is given in Table 6, and PVC^O is given in Table 8.

operating and maintenance costs (Table 8); v*, the break-even price, is also given. Figures 6-8 show net present value as a function of productivity, price, and discount rate. A comparison of these with Figures 3-5 provides a direct comparison of level-one and level-two feasibility for the Port San Juan hatchery. For the "low-productivity case" considerable real price increase would be required, even with the low-range cost estimates, for level-two feasibility. For the "high-productivity case," level-two feasibility exists at almost all price, discount rate, and cost range combinations. Once again, the biological productivity of a hatchery stands out as the most crucial determinant of economic feasibility.

Net Present Value for the Moderate-Productivity Case

As discussed above (pp.17-20) the limits of the range of reasonable assumptions have been built into the low-productivity and high-productivity cases. However, Tables 2 and 3 are designed to allow choice among a large number of alternative combinations of assumptions. While this approach is intended to provide the reader with flexibility in choosing those assumptions (about survival rates, prices, cost levels, etc.) which appear to be most realistic, it has not brought out explicitly the implications for feasibility of what many observers would consider to be the most reasonable set of assumptions. The exercise which follows may be helpful to many readers in that it will start from the beginning and work through the feasibility analysis step by step. It is hoped that doing so will enhance the reader's ability to make use of the full range of information that is built into the tables for evaluating the effects on feasibility of changing assumptions. This will become an important exercise as new information, particularly about survival rates and hatchery costs, is acquired.

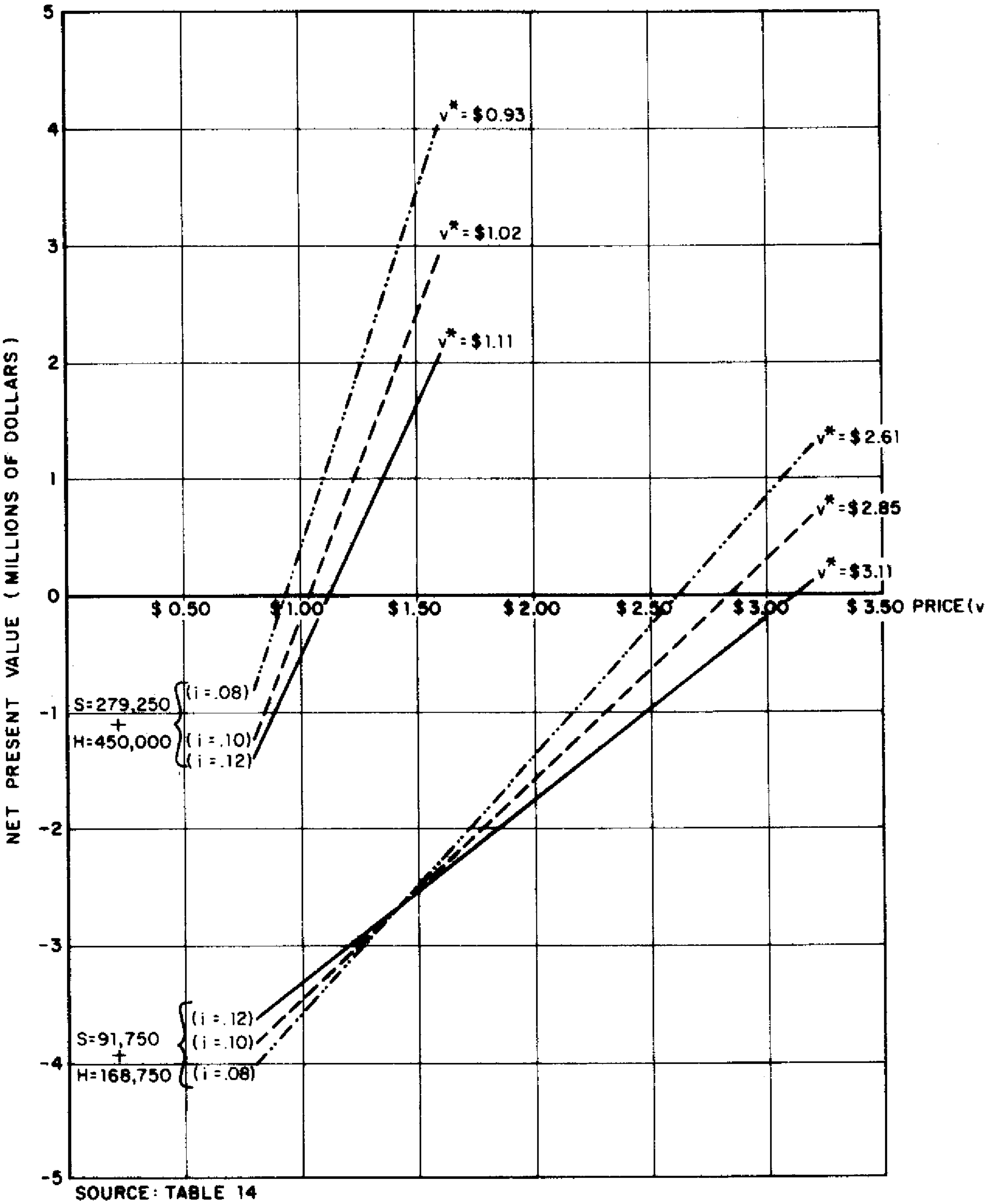
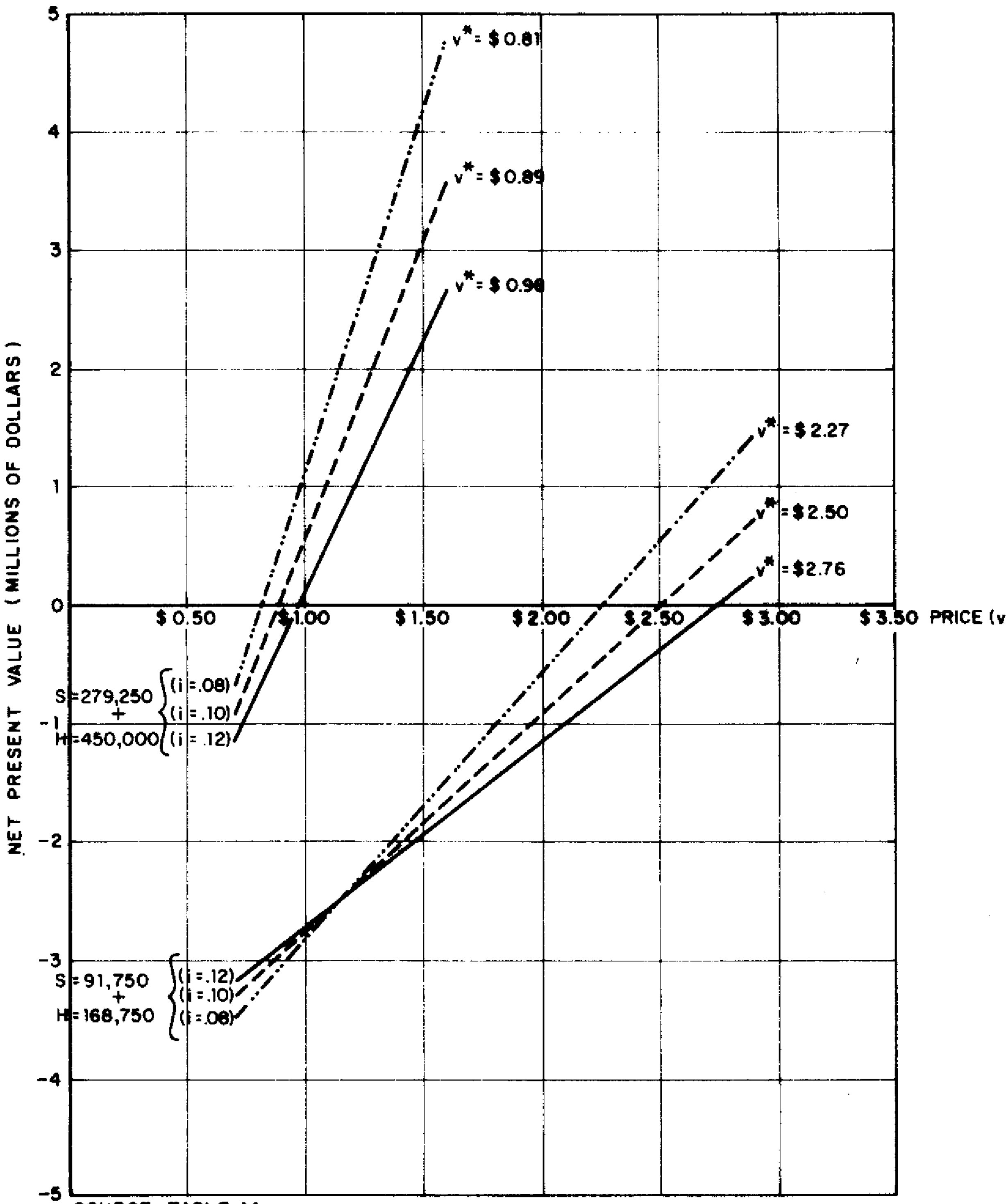


FIGURE 6

NET PRESENT VALUE AS A FUNCTION OF PRODUCTIVITY, PRICE, AND DISCOUNT RATE FOR MID-RANGE COST ESTIMATE



SOURCE: TABLE 14

FIGURE 7

NET PRESENT VALUE AS A FUNCTION OF PRODUCTIVITY, PRICE, AND DISCOUNT RATE FOR LOW-RANGE COST ESTIMATE

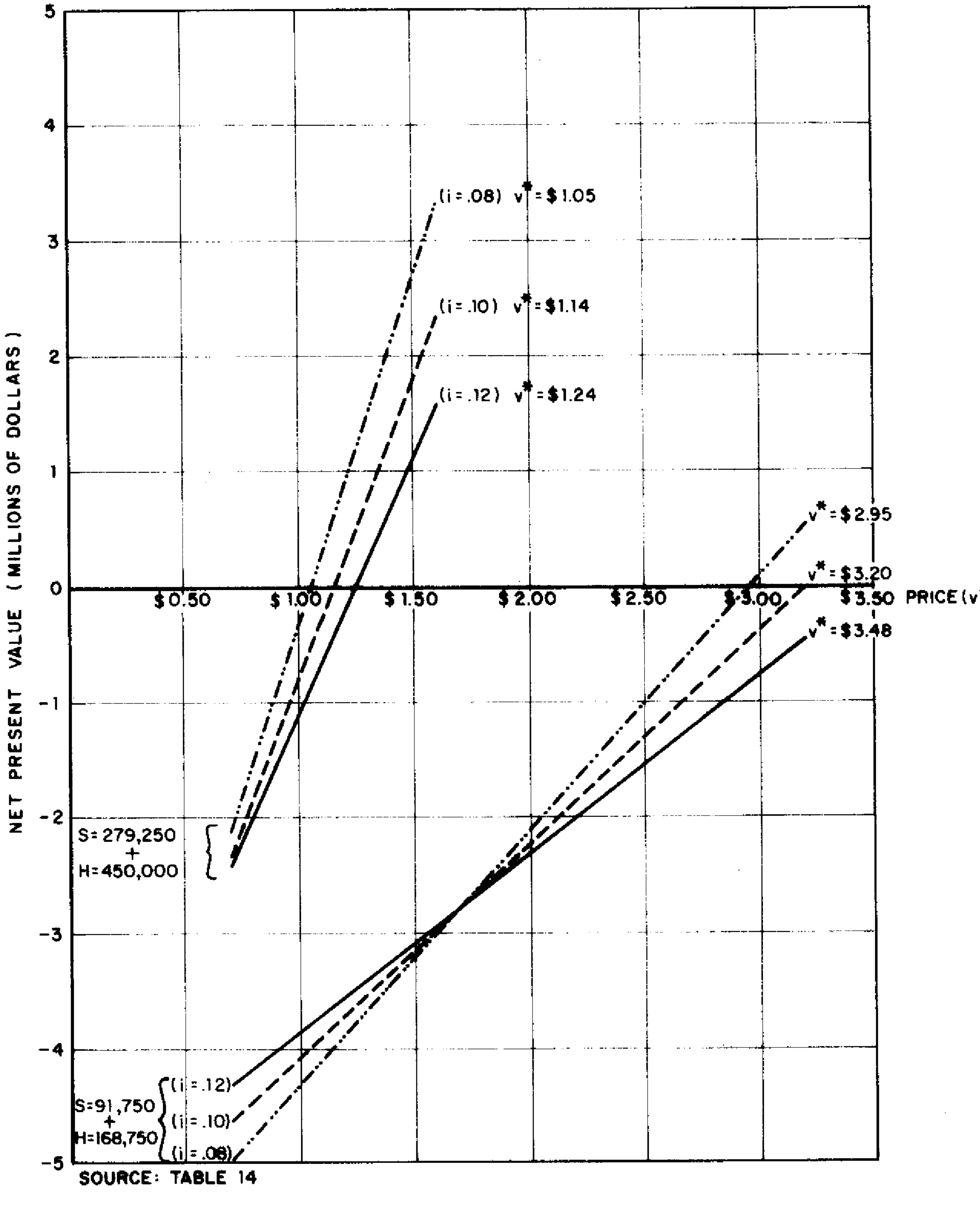


FIGURE 8

NET PRESENT VALUE AS A FUNCTION OF PRODUCTIVITY, PRICE, AND DISCOUNT RATE FOR HIGH-RANGE COST ESTIMATE

Table 15 contains the feasibility analysis for the moderate-productivity case. While each assumption is shown explicitly, several warrant explanation. First, with existing techniques the survival rate from egg to fry will probably typically fall between 80-90 percent (although it can be lower if the initial egg supply is collected a long distance from the hatchery under poor weather conditions); the assumed rate here will be 80 percent. This contrasts with the assumed rate of 75 percent used in both the low- and high-productivity cases. The fry-to-adult survival rate for fry which have undergone short-term rearing, and whose release is timed with favorable estuarine, temperature and nutrient conditions, will probably typically fall within the 2-4 percent range; 2.5 percent is utilized here. This contrasts with 1.5 percent for the low-productivity case and 4 percent for the high-productivity case evaluated above. As shown in Table 15, under these assumptions, 300,000 pink salmon are available for harvest by the common-property fishing units and 179,250 are available to the hatchery after allowing for brood stock requirements of 20,750 (15,563 females and 5,187 males) for a total hatchery-originated harvest of 479,250. At an assumed price of $1.71 per salmon, total revenues of $819,518 per year result for years 3-22; of this $513,000 (300,000 x 1.71) accrues to the offshore fishing units and $306,518 (179,250 x 1.71) to the hatchery.[10] The present values of these flows at a 10 percent rate of discount are $5,766,129, $3,609,468, and $2,156,661 respectively.

The costs incurred by the hatchery may be classified into three general categories: the cost of the initial investment $2,066,061 (from Table 6), the cost of operation and maintenance of $370,000 per year for years 1-20 and $50,000 per year

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[10] This exercise abstracts from the nominal marginal cost of harvesting hatchery-originated salmon under the assumption that the harvest of these fish will be incidental to trips and settings which would otherwise have taken place.

Table 15

Economic Feasibility for Moderate-Productivity Case

Productivity

Beginning egg stock, pink salmon		25,000,000
Egg-to-fry survival @ 80%		20,000,000
Fry-to-adult survival @ 2.5%		500,000
Common-property harvest @ 60%		300,000
Hatchery escapement @ 40%	200,000	
Hatchery brood-stock requirements @ .00083[1]	20,750	
Hatchery surplus $(P = efh - \frac{1+m}{n} =$ .80 x .025 x .4 - .00083 = .00717 x 25,000,000=)		179,250
Total harvestable salmon		479,250

Level-Two Feasibility

Market value @ $1.71 per fish (total annual revenue)		$ 819,518
Present value of annual revenue	@ 8%	6,898,702
	@ 10%	5,766,129
	@ 12%	4,880,230
Present value of costs (mid range)[2]	@ 8%	$ 5,717,851
	@ 10%	5,229,136
	@ 12%	4,838,351
Net present value	@ 8%	$ 1,180,851
	@ 10%	536,993
	@ 12%	41,879

Conclusion: Hatchery investment feasible at level two for each rate of discount

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[1]See Table 3.

[2]$2,066,061 + PVC^{O} = PVC; see Tables 6 and 8.

(Continued on next page)

Level-One Feasibility

Hatchery surplus		179,250
Market value @ $1.71 per fish (hatchery annual revenue)		$ 306,518
Present value of hatchery revenue	@ 8%	2,580,269
	@ 10%	2,156,661
	@ 12%	1,825,315
Present value of hatchery costs (mid range)[2]	@ 8%	$ 5,717,851
	@ 10%	5,229,136
	@ 12%	4,838,351
Net present value	@ 8%	$-3,137,582
	@ 10%	-3,072,475
	@ 12%	-3,013,036

Conclusion: Hatchery investment not feasible at level one

Level-One Feasibility with Assessment

Common-property fishery annual revenues (300,000 x $1.71)	$ 513,000
Present value of $513,000 @ 10% for 20 years (years 3-22)	3,609,468
Excess of present value hatchery costs over present value of hatchery revenues (see above under net present value @ 10%)	-3,072,475
Net present value to common-property fishery ($3,609,468 - 3,072,475)	536,993
Annual net revenue flow to common-property fishery[3]	76,321

[2]$2,066,061 + PVC^o = PVC; see Tables 6 and 8.

[3]Obtained by amortizing $536,993 @ 10% (years 3-22), or by subtracting annual assessments paid from annual revenue.

(Continued on next page)

Table 15 (cont'd.)

Summary

		Hatchery	Common-Property Fishery
Surplus harvest		179,250	300,000
Revenue @ $1.71/fish (years 3-22)		$306,518	$ 513,000
Annual costs (years 1-20)		743,197	-
Operating and maintenance[4]	$370,000		-
Investment amortized @ 10%[5]	242,680		-
Working capital @ 10%[6]	130,517		-
Revenue less annual costs		(436,679)	513,000
Annual assessments received (paid)[7]		436,679	(436,679)
Annual net revenue[3]		0	76,321

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[3]Obtained by amortizing $536,993 @ 10% (years 3-22), or by subtracting annual assessments paid from annual revenue.

[4]See Table 7.

[5]Investment of $2,066,061 amortized @ 10% for 20 years.

[6]Amortization (@ 10% for years 3-22) of amount needed to finance annual working-capital requirements. See Appendix Table A-4.

[7]Paid in years 3-22; the present value of this stream of payments @ 10% is $3,072,475, which is the excess of PVC over PVR* experienced by the hatchery firm (level-one test).

for years 21 and 22 (from Tables 7 and 8), and the cost of working capital for years 1-2, financed by equal annual payments of $130,517 for years 3-22. The present value of these three categories of costs at a 10 percent rate of discount is $5,229,136.

Level-one feasibility is obtained when $NPV \geq 0$, where NPV = PVR* - PVC, or where the benefit-cost ratio is equal to or exceeds one, B/C = PVR*/PVC ≥ 1. Note that for the level-one feasibility test, which is designed to determine whether the hatchery investment is feasible without external support, only the revenues earned by the hatchery firm from the sale of surplus salmon are included. That is, no grants or assessments of any kind are included in hatchery-firm revenues. The level-one test is the standard test for economic feasibility for a private-sector investment. It is not the most appropriate single test for judging the feasibility of private nonprofit salmon enhancement ventures, however, because there are a significant amount of benefits (revenues) excluded from the test. The excluded revenues are, of course, those that accrue to the offshore fishery. What this test does show, however, is whether or not a private nonprofit hatchery firm is capable of covering all costs from its own sales revenues.

The information provided in Table 15 shows that at a discount rate of 10 percent level-one feasibility is not obtained. NPV is -3,072,475 ($2,156,661 - $5,229,136) or the benefit-cost ratio is $2,156,661/$5,229,136 = 0.41243. Nor is the investment feasible at either an 8 or 12 percent discount rate or even at any of the three discount rates combined with the low-range (rather than the mid-range) operating and maintenance cost assumption.

Level-two feasibility exists when $NPV \geq 0$ or $B/C \geq 1$, where NPV = PVR* + PVR^F - PVC and B/C = PVR* + PVR^F/PVC. As can be seen in Table 15, level-two feasibility exists at the three discount rates since NPV 0 for each. At a discount rate of 10 percent NPV = $536,993 ($5,766,129 - $5,229,136) and B/C = $5,766,129/ $5,229,136 = 1.10269. In this case the present value of hatchery revenues, PVR*, is $2,156,661 as shown above and the present value of the offshore fishery revenues, PVR^F is $3,609,468. If the units in the offshore fishery agree to assess themselves (or arrange a comparable means of support) to cover the excess of hatchery costs over hatchery revenues of $3,072,475 (see above, NPV for level-one test at 10 percent), then NPV to the hatchery is zero (the investment becomes feasible) and NPV to the offshore fishery is $536,993 ($3,609,468-$3,072,475). The required annual assessment (paid in years 3-22) would be $436,679; since annual revenues are $513,000 (300,000 salmon x $1.71) the net annual revenues are $76,321 ($513,000 - $436,679), the present value of which is $536,993 as above.

Tables 16 and 17 repeat the analysis of Table 15 for fry-to-adult survival rates of 2 and 3 percent respectively. It is apparent that level-two feasibility requires fry-to-adult survival of slightly greater than 2 percent, or a combination of egg-to-fry and fry-to-adult survival that will yield approximately 435,000 hatchery-originated salmon for sale.

Differential Incidence of Costs and Benefits

The significance of differential incidence is now clear. The hatchery firm assumes liability for the cost of enhancement (PVC = $5,229,136 at 10%) but receives less than 40 percent of the revenues (the 40 percent assumed escapement must also provide for brood stock). Under the values assumed in this moderate-productivity case NPV = -$3,072,475; the hatchery firm cannot survive without external support.

Table 16

Economic Feasibility for Low-Moderate Productivity Case

Productivity

Beginning egg stock,		25,000,000
Egg-to-fry survival @ 80%		20,000,000
Fry-to-adult survival @ 2.0%		400,000
Common-property harvest @ 60%		240,000
Hatchery escapement @ 40%	160,000	
Hatchery brood-stock requirements @ .00083[1]	20,750	
Hatchery surplus ($P = efh - \frac{1+m}{n}$ = .80 x .02 x .4 - .00083 = .00557 x 25,000,000 =)		139,250
Total harvestable salmon		379,250

Level-Two-Feasibility

Market value @ $1.71 per fish = total annual revenue		$ 648,518
Present value of annual revenue	@ 8%	5,459,225
	@ 10%	4,562,973
	@ 12%	3,861,925
Present value of costs (mid range)[2]	@ 8%	$5,717,851
	@ 10%	5,229,136
	@ 12%	4,838,351
Net present value	@ 8%	$- 258,626
	@ 10%	- 666,163
	@ 12%	- 976,426

Conclusion: Hatchery investment not feasible at level-two for each rate of discount. The hatchery investment should not be made because there is no level of assessment payments to the hatchery firm which would both 1) allow the hatchery firm to cover costs and 2) yield positive net benefits to the common-property fishery.[3]

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[1]See Table 3.

[2]$2,066,061 + PVC^o = PVC; see Tables 6 and 8.

[3]Note that this conclusion is based on the mid-range operating cost and 1976 price-level assumptions. If the low-range operating cost estimate is utilized, the investment becomes feasible at an 8% discount rate but not at 10% or 12%.

Table 17

Economic Feasibility for High-Moderate Productivity Case

Productivity

Beginning egg stock		25,000,000
Egg-to-fry survival @ 80%		20,000,000
Fry-to-adult survival @ 3.0%		600,000
Common-property harvest @ 60%		360,000
Hatchery escapement @ 40%	240,000	
Hatchery brood-stock requirements @ .00083[1]	20,750	
Hatchery surplus ($P = efh - \frac{l+m}{n} = .80 \times .03 \times .4 - .00083 = .00877 \times 25{,}000{,}000 =$)		219,250
Total harvestable salmon		579,250

Level-Two Feasibility

Market value @ $1.71 per fish = total annual revenue		$ 990,518
Present value of annual revenue	@ 8%	8,338,181
	@ 10%	6,969,285
	@ 12%	5,898,535
Present value of costs (mid range)[2]	@ 8%	$5,717,851
	@ 10%	5,229,136
	@ 12%	4,838,351
Net present value	@ 8%	$2,620,330
	@ 10%	1,740,149
	@ 12%	1,060,184

Conclusion: Hatchery investment feasible at level-two for each rate of discount.

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[1]See Table 3.

[2]$2,066,061 + PVC^{o} = PVC; see Tables 6 and 8.

(Continued on next page)

Table 17 (cont'd.)

Level-One Feasibility

Hatchery surplus		219,250
Market value @ $1.71 per fish (annual revenue)		$ 374,918
Present value of hatchery revenue	@ 8%	3,156,060
	@ 10%	2,637,923
	@ 12%	2,232,637
Present value of hatchery costs[2]	@ 8%	$5,717,851
	@ 10%	5,229,136
	@ 12%	4,838,351
Net present value	@ 8%	-2,561,791
	@ 10%	-2,591,213
	@ 12%	-2,605,714

Conclusion: Hatchery investment not feasible at level one.

Level-One Feasibility With Assessment

Common-property fishery annual revenues (360,000 x $1.71)	$ 615,600
Present value of $615,600 @ 10% for 20 years (years 3-22)	4,331,362
Excess present value hatchery costs over present value of hatchery revenues (see above under net present value @ 10%)	-2,591,213
Net present value to common property fishery (4,331,362 - 2,591,213)	1,740,149
Annual net revenue flow to common-property fishery[3]	247,327

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[2]$2,066,061 + PVC^o = PVC; see Tables 6 and 8.

[3]Obtained by amortizing $1,740,149 @ 10% (years 3-22) or by subtracting annual assessments paid from annual revenue.

(Continued on next page)

Table 17 (cont'd.)

Summary

		Hatchery	Common-Property Fishery
Surplus harvest		219,250	360,000
Revenue @ $1.71/fish (years 3-22)		$347,918	$ 615,600
Annual costs (years 1-20)		743,197	-
Operating & maintenance[4]	$370,000		-
Investment amortized @ 10%[5]	242,680		-
Working capital @ 10%[6]	130,517		-
Revenue less annual costs		(368,273)	615,600
Annual assessments received (paid)[7]		368,273	(368,273)
Annual net revenue[3]		0	247,327

[3]Obtained by amortizing $1,740,149 @ 10% (years 3-22) or by subtracting annual assessments paid from annual revenue.

[4]See Table 7.

[5]Investment of $2,066,061 amortized @ 10% for 20 years.

[6]Amortization (@ 10% for years 3-22) of amount needed to finance annual working-capital requirements.

[7]Paid in years 3-22; the present value of this stream of payments @ 10% is $2,591,213 which is the excess of PVC over PVR* experienced by the hatchery firm (level-one test).

One apparent source of external support is from the common-property fishing units. Even with assessment payments of $3,072,475 (in present value) the offshore fishery would receive net benefits of $536,993 (in present value). This amount would be in addition to a 10 percent return on any part of the initial investment that has been financed by contributed capital from fishermen's assessments, because a 10 percent rate of return on capital is built into the hatchery's costs.[11] Of course, the greater the proportion of the initial investment financed by contributed capital from fishermen the smaller the annual assessment payments required of fishermen and the higher their *retained* net benefits.[12] Total net benefits to fishermen would be independent of the proportion of the initial investment financed by fishermen's contributed capital, however, because a fishermen's investment has an opportunity cost, assumed here to be 10 percent, just as does that of a financial institution. If fishermen can earn 10 percent in alternative investments as assumed, then the decision to invest in the hatchery is one which affects the *source* of fishermen's total income (that from fishing and other sources) but not the *amount*, assuming that other sources of financing for the hatchery can be found. If either the preceding assumption is invalid, or the rate of return on an investment in hatcheries exceeds that which can be earned in other investments of equal risks (the first of which is likely, and the second of which is

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[11]In Table 15 capital costs are amortized at ten percent for years 1-20.

[12]Interest on contributed capital is an implicit cost which requires no explicit payments by the hatchery firm. The present application of the implicit cost concept may be unique in that in the absence of an obligation to explicitly pay interest the assessments required for hatchery-firm survival are reduced in equal amount and the retained revenue of offshore fishing units would be higher by that amount. That is, the hatchery firm not incurring an obligation to pay certain costs allows an equal retention of revenues by the offshore fishery. In practical terms this means that there is a need to depreciate contributed capital instead of amortizing at some positive interest rate as is required for borrowed or equity capital.

uncertain), then hatchery investments are preferable because the amount as well as the source of income is affected.

Given any combination of either the moderate- or high-productivity cases and either the mid- or low-range of operating and maintenance costs, hatchery investments are economically feasible at level two but not at level one. As demonstrated by the moderate-productivity case described in Table 15, however, hatchery investments failing the level-one test can survive if outside support is provided, and the latter is economically justified by the passage of the level-two feasibility test. What, then, stands in the way of the successful creation and maintenance of private nonprofit hatchery firms? The answer was suggested by the analysis of economic incentives in Chapter 1: The primary barriers to private sector salmon enhancement are the free-rider problem and extreme uncertainty. Thus, while level-two feasibility justifies and is a necessary condition for private nonprofit hatcheries to exist, it alone may not be sufficient to overcome the effect on economic incentives of these barriers. The next chapter evaluates the role of government in affecting economic incentives facing private nonprofit firms and considers other possible governmental responses to economically feasible salmon enhancement potential.

CHAPTER III

PUBLIC POLICY TOWARD PRIVATE SALMON ENHANCEMENT

Introduction

As discussed in Chapter I, the State of Alaska has cast itself in an active role in the area of salmon enhancement. An important and evolving dimension of the state's policy is to encourage some private sector investment in hatcheries. The economic feasibility of private nonprofit salmon hatcheries has been evaluated above without explicit recognition of the potential role of the state. What is clear from that evaluation is that the degree to which the state encourages the private sector will be an important determinant of the level of private-sector investment in enhancement facilities. This fact raises a number of questions: Is public-sector investment in hatcheries economically justified? If so, what insitutional options are open to the state for channeling funds into investments in salmon hatcheries? What are the comparative costs to the state of these options? Can the options be ranked on efficiency grounds? Can they be ranked on equity grounds? It is the purpose of this chapter to develop tentative answers to these questions.

Economic Justification for Public-Sector Investments

The basic economic criterion by which it is appropriate to judge the desirability of public-sector expenditures on investment projects is that the benefit-cost ratio be equal to or exceed one. As used here, benefit-cost analysis is equivalent to level-three feasibility analysis (see p. 15); that is, it includes all significant categories of benefits and costs.

Given that level-two feasibility is established for the moderate-productivity case (see Table 15) it is very probable that level-three feasibility, the broad benefit-cost criterion, is satisfied. This assertion is based on the fact that benefits are more likely to be affected significantly by moving to the broader framework than are costs. Additional benefits are 1) those derived by the processing sector from improving capital utilization and therefore profitability, 2) those net benefits derived by the local economy from greater income-expenditure flows, and 3) those derived by the local and state governments from greater tax revenues. On the cost side, the only significant categories of extra cost, commensurate with the broader scope of the analysis, are those incurred by the state for management of hatchery stocks, and for providing technical assistance to private nonprofit firms.[1] Incrementally, these costs are likely to be quite small.[2] Therefore, a tentative conclusion, based on the existence of level-two feasibility and based on the above statements concerning the relative increases in benefits and costs associated with moving to a broader analytical framework is that public-sector investment is economically justified.

Given that public investment appears to be justified on the basis of a comparison of benefits and costs, does it necessarily follow that the public sector should in-

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[1]For state hatcheries the comparable cost of technical assistance should be charged as a direct cost of the hatchery unit.

[2]It is not possible to assess the negative impacts on the wild stocks of hatchery stocks competing for food and space in the ocean environment.

vest independent of other rationale? The answer in general is negative because, in general, where benefits exceed costs the private sector will recognize sufficient profitability and the investment would become the domain of private enterprise. In the specific instance of salmon enhancement in Alaska, however, there are three reasons for believing that public investment is necessary. First among these is a political constraint which may be summarized as follows: The majority of Alaska residents appear to have a long-standing dislike for any arrangements resulting in processor control over harvesting units in the salmon fishery. This attitude apparently derives from pre-statehood Federal management of the salmon resources and in particular from the use of traps. It is widely believed among fishermen, a group that is very active politically, that legalizing private profit-seeking enhancement ventures would quickly lead to processor domination of hatchery investments; and it is further believed that processor investments in hatcheries would have a negative impact on the marketing position of fishermen. It is also likely that in areas where an established offshore fishery exists intense conflict would surround management decisions (the determination of appropriate escapement levels) if processors did indeed own the hatcheries. It is unlikely that management biologists could function effectively in such conflict situations. Given these problems, or anticipated problems, the Alaska Legislature opted for private *nonprofit* hatchery firms on the apparent expectation that groups of fishermen and small-scale entrepreneurs would be attracted, the latter responding to the opportunity for full-time employment in a remote area.[3] There apparently was no explicit consideration given to the adequacy

[3] A profit-seeking entrepreneur can be attracted to an investment in a "nonprofit" firm if the sum of the payments for his (her) labor services and the psychic income derived from enjoyable employment exceed the sum of these payments and implicit interest on "contributed capital" in alternative employments. The excess is "economic rent" or "economic profit."

of economic incentives or to the economic viability of either type of nonprofit firm.

The second reason why state investment will be necessary, given that the basic economic justification exists (B > C), is that among fishermen, the primary beneficiaries of hatcheries investments, there is a very substantial free-rider problem. The reasons for this have been discussed above (pp. 6-9); it should suffice here merely to point out that with a significant free-rider problem there is no assurance that even with level-two feasibility the self interest of fishermen will be sufficiently aroused to put together and finance a salmon hatchery firm. Thus, investments by the state, in the form of incentive subsidies to nonprofit firms, may be necessary to overcome the disincentive effects of the free-rider problem.

Third, for reasons that are biological, technological and economic (see pp. 9-11). there is considerable uncertainty on the part of fishermen about the returns that will be associated with potential hatchery investments. There are two areas of policy action by the state that have contributed to the otherwise great uncertainty. One of these derives from the reluctance of the Alaska Department of Fish and Game to establish interim escapement targets which would assist potential investors in determining expected revenue flows. Second, the state is emphasizing that both public hatcheries and private hatcheries have a place in the enhancement program without clearly assigning roles to either. The financial responsibility assumed by fishermen is much more explicit and immediate for private nonprofit hatchery than for a state hatchery and this creates an incentive to wait for a state hatchery, i.e., not support an effort to develop a nonprofit firm. This is true even though the apparent political reality is that the state will pay for its hatchery program by increasing fish taxation. The proponents of a dual hatchery program are not emphasizing this point at present.

To summarize, public sector (state) investment in hatcheries, public or private, can be justified on the following grounds: 1) that benefits exceed costs (this is the fundamental economic justification), 2) that, for political-economic reasons, private profit-seeking hatchery firms have been disallowed by state law and 3) that there are significant economic disincentives, created by free-rider problems and uncertainty, to private-sector investments in hatcheries through nonprofit firms. Given these justifications for state support of an enhancement program, the institutional options open to the state for investing in hatcheries and the ranking of these on efficiency and equity grounds remain to be addressed.

Institutional Options Under Present Statutes

Ideally, there are a wide range of options with respect to the institutional forms for salmon enhancement from which policy makers can choose, ranging from private profit-seeking ventures of any size that can survive, to restricted-stock firms or cooperatives, to nonprofit firms, to state owned and operated hatcheries. The range of practical choice has been narrowed considerably by legislation to choosing among three forms--nonprofit hatchery firms which broadly represent beneficiaries in a region, these are often referred to as regional nonprofit associations; "nonprofit" hatchery firms which represent an entrepreneur or small group of entrepreneures; and state owned and operated hatcheries. The desirability of modifying legislation to increase the range of choice is discussed in the next section.

There are several problems one encounters in attempting to evaluate the relative merits of the primary alternative forms--regional nonprofit hatchery firms and state hatcheries.[4] One is the need to distinguish between hatcheries intended primarily for production purposes and those which can be classified as primarily research and development hatcheries. And for production hatcheries it is necessary to distinguish between exempt and nonexempt species (areas). The former are those for which private-sector development of production hatcheries must be delayed until certain bio-technical problems are overcome, the latter are those which can be readily developed by either sector. There is also the question of whether hatcheries on the rivers of interior Alaska are economically feasible and whether special institutional and equity considerations obtain to these situations. This would appear to be the case given that there is a domination by subsistence fisheries along the lengths of the major rivers, although commercial fisheries do exist.

The preceding suggests that it might be appropriate for the state to divide enhancement efforts between state hatcheries and regional, private nonprofit hatcheries according to function and specific circumstances. Under those circumstances where it would appear improbable that private-sector investment would be forthcoming (purely research hatcheries, species or areas where enhancement may be accompanied by serious bio-technical problems, and interior hatcheries) a public-sector investment should be made assuming that economic feasibility of the specific site has been es-

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[4]The small private nonprofit hatchery firm, organized for the personal gain of one or several entrepreneures, will not be significant in the near term due to the obvious difficulties of obtaining venture capital for nonprofit firm. Over the long term, these firms may be the source of significant technical advances.

tablished.[5] *For all other circumstances, production hatcheries should be built and operated by private nonprofit firms.*

This suggested division of responsibilities between state and private nonprofit hatcheries is based on the premise that there are in total more economically feasible demands on state funds than can be financed and that private-sector investment in hatcheries is preferred where it can be induced with a lesser commitment of public funds than would be required for an equivalent state hatchery. The preference for the private sector, implicit in this approach, is based on three considerations. First is the principle that the attainment of any given level of enhancement at minimum cost is desirable. Cost minimization over time can be obtained only if enhancement production units are housed in institutions that a) are sufficiently flexible and have sufficiently strong economic incentives to respond to changes in market conditions and changing technology, b) will suffer directly (economically) if management fails to be cost conscious, and c) have sufficient incentive to carry out productive research and development. It would appear that cost minimization is much more likely to be approximated by private nonprofit hatcheries, in comparison to state hatcheries, in that the firm's management is answerable to the group whose net economic benefits from the hatchery (into which they are paying assessments) are directly and discernably affected by management decisions. In contrast, cost control in state hatcheries will be relatively difficult to maintain and there will be comparatively less incentive to be cost conscious.

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[5]Investments by the state in state production hatcheries should be evaluated as to their economic feasibility, but it would be impossible and undesirable to require this for research hatcheries (see, for example, Zvi Griliches, Research Costs and Social Returns: Hybrid Corn and Related Innovations, *Journal of Political Economy*, Vol. LXVI, 1958.

The second basis for the implied preference for the private sector in the approach suggested above is that of economic equity. The equity principle is that those who receive the benefits from enhancement should pay the costs of the enhancement program. Given the present structure of fish taxation and the present or proposed state loan programs the private nonprofit hatchery would clearly be preferred on equity grounds also.[6] The preference for private-sector hatcheries for equity reasons would be less convincing if, accompanying investments in state hatcheries, there were flexible tax programs designed to recapture a high percentage of investment and operating costs. The primary danger of such a state hatchery and tax program is that, without effective cost control in the state hatchery program, the net benefits to the common fishery could be absorbed in taxes. This is in effect a restatement, in different terms, of the proposition above that whenever possible hatchery production units should be institutions that are flexible and have the appropriate economic incentives. For the state to finance *state* production hatcheries with fish taxes may be to endanger the original purpose of the enhancement program--to maximize net benefits to the common-property fishing units and the communities in which they reside--yet, equity requires that, if state production hatchery investments are made, there must be taxation of the intended beneficiaries to pay the costs. Given that there is a reasonable alternative to such an arrangement, it is difficult to see the justification for the present dual enhancement approach *unless* it follows the research-production and exempt-nonexempt dichotomies discussed above.

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[6]The proposed state loan program is discussed on pp. 76-81.

The third basis for preferring private-sector production units concerns the marketing conflicts that are likely to develop between the state and the common-property fishery when returns to state hatcheries exceed the need for brood stock. It is easy to discount this *ex ante* but experience elsewhere suggests that it may become a significant problem.

To summarize, the approach suggested above for selecting between the public-sector and private-sector options, that of giving preference to private-sector hatchery investments unless there are compelling reasons to have a public hatchery (primarily research function, exempt species, located on interior river, etc.). This approach would allocate to the public and private sectors the roles shown in Table 18. The justifications

Table 18

Alaska Salmon Enhancement Program:

Suggested Institutional Distribution of Functions

Public-Sector Enhancement Functions	Private-Sector Enhancement Functions
Issue hatchery permits to nonprofit corporations	Organize regional nonprofit firms
Monitor hatchery operations	Arrange self-assessment and loan financing
Management of natural and hatchery stocks	Construct and operate production hatcheries for nonexempt species
Construct and operate research hatcheries	Make policy recommendations on state enhancement programs
Disseminate research results	
Construct and operate production hatcheries for exempt species	
Make policy recommendations on state enhancement programs	

for this division of responsibility are three: 1) that cost control is more likely to be achieved by private nonprofit hatcheries structured around the economic incentive of self-interest, 2) that achieving economic equity is accomplished in nonprofit firms without compulsory taxation because beneficiaries accept financial responsibility for hatchery investment and operating costs, and 3) that for state owned and operated hatcheries there is the potential for serious marketing conflicts with the common-property fishery.

Other Institutional Options

The present statutes of the State of Alaska foreclose institutional options which may, under certain circumstances, be superior to either of the primary alternatives discussed above. Generalizing on the principles developed above, the more an institutional form incorporates the self-interest incentive the more likely it will be operationally efficient and progressive, and the greater the financial responsibility accepted by beneficiaries the more equitable and the more accute the self-interest incentive. These generalizations suggest that there are at least two additional institutional forms worthy of consideration, in that both are likely to be superior to presently authorized alternatives.

The first is the explicit profit-seeking firm. Accepting the political constraint discussed above as a given,[7] there is at least one circumstance where the spirit of that constraint can be retained without prohibiting explicit profit-seeking firms. This circumstance exists in areas where there is no established common-property fishery but where there appears to be considerable physical potential for enhancement. In such areas, as discussed on page 8, there is little incentive for either the state or

[7]It will be recalled that the political opposition is based on an almost universal belief among fishermen that their marketing position would be undercut by processor-controlled hatcheries, were profit-seeking hatchery firms legalized (see discussion on p. 67).

private nonprofit firms to develop a hatchery, but it is precisely to such areas where profit-seeking firms would be attracted. It could be argued that this option is already provided for by the entrepreneural type of nonprofit firm which is widely recognized as a form of profit-seeking firm. If this is the case, perhaps it would be better to allow these firms to take an explicit profit-seeking form. What is not widely appreciated is the fact that this change would represent a change of substance rather than merely a change of label. The economic substance of such a change would be that, by explicitly allowing profit-seeking firms in the undeveloped areas under consideration, venture capital and managerial skills could be attracted to the salmon enhancement program in amounts that are not likely to be approached under any of the other institutional options. Both venture capital and managerial skills are highly scarce resources in Alaska. It could be expected that, in time, a common-property fishery would develop off such sites and that after some period escapements to the hatchery would be reduced to the point where the profit-seeking firms would wish to sell their assets to regional nonprofit firms established by the newly formed offshore fishery.

The second potentially beneficial institutional option for private-sector hatchery development not presently allowed under state law is the restricted-stock profit-seeking firm, or cooperative. This form would retain the advantage of broad representation of the benefiting fishermen characteristic of the regional nonprofit firm, but it would enhance the self-interest incentive to be efficient and to progress. One way to ensure the success of this form would be to make the ownership of an entry permit conditional upon the ownership of a specified amount of stock and to make the stock transferable only with the transfer of the entry permit. Certain legal questions relating to this approach may need to be resolved, but it has great economic appeal.

Comparative Cost to the State

This section develops the implications for state expenditures of investments by the state in state and private nonprofit hatcheries under the present and proposed financial assistance programs for nonprofit firms. As discussed briefly in Chapter I, the present state program is one of providing long-term (25-year maximum) low-interest (eight-percent maximum) loans for hatchery construction to regional nonprofit firms of up to three million dollars but not to exceed 75 percent of the total project costs, and to other nonprofit firms of up to $300,000 per hatchery but not to exceed 75 percent of total project cost. Interest and principal payments may be deferred for up to six years, with interest compounding over the deferment period. The proposed program provides development grants of $100,000 per regional association and up to an additional $100,000 on a 50/50 cash matching basis. In addition, it would provide long-term (25-year maximum), low-interest (eight-percent maximum) loan equal in amounts to the existing program (except that they could be for up to 100 percent of total project cost within these ceilings) with a six-year deferment of repayment, and interest forgiveness over the six-year period. Table 19 shows the comparative direct commitment of public funds by the state for a private nonprofit hatchery, under these programs and for a state hatchery. These hatcheries are assumed to be identical in every respect, a reasonable assumption inasmuch as this exercise is designed to evaluate public and private hatchery investments as alternative institutional means of developing a specific hatchery site, for a specific species and capacity. It is legitimate, therefore, to look only at the cost side in this evaluation, because the flow of gross benefits can, as a first approximation, be considered to be independent of the

Table 19

Comparison of the Commitment of State Funds Required for Private Nonprofit Hatchery (Under Existing and Proposed Financing Programs) And for State Hatchery (Millions of Dollars)

A. Cost to State for Private Nonprofit Hatchery: Existing State Financing Program: ($.000

Development costs	$ .200
Construction costs	1.800
Total	$2.000
Financed by:	
Assessments/grants	$ .500
State loan	1.500
Total	$2.000

Annual costs	Annual	Total Present Value
Loan repayment @ 8% (years 7-25)[1]	$.248	$1.500
Operating and maintenance (years 1-25)	.300	3.203
Total (years 7-25; $300,000 years 1-6)	$.548	$4.703

Financed by: Annual assessments and sales revenue. No cost to the state assuming earnings on other state investments ≤ 8%.

B. Cost to State for Private Nonprofit Hatchery: Proposed State Financing Program: ($.740)

Development costs	$ .200
Construction costs	1.800
Total	$2.000
Financed by:	
Assessments/grants	$ .000
State loan	2.000
Total	$2.000

Annual costs	Annual	Total Present Value
Loan repayment @ 8% (years 7-25)[2]	$.208	$1.260
Operating and maintenance (years 1-25)	.300	3.203
Total (years 7-25, $300,000 years 1-6)	$.508	$4.463

(Continued on next page)

Table 19 (cont'd.)

Financed by: Annual assessments and sales revenue. Cost to the state is the foregone interest income over the deferment period of \$.740 (= present value of amount of loan less present value of payments = \$2.000 - 1.260).

C. Cost to State for State Hatchery: (\$5.203)

Development costs \$	\$ .200
Construction costs	1.800
Total	\$2.000
Financed by state bond issue	2.000

Annual costs	Annual	Total Present Value
Bond issue repayment @ 8% (years 1-25)[3]	\$.187	\$2.000
Operating and maintenance (years 1-25)	.300	3.203
Total (years 1-25)	\$.487	\$5.203

Financed by: State's general fund (\$5.203 in present value, \$.487 annually).

D. Summary of Comparative Commitment of State Funds

	Private Nonprofit Hatchery		
	Existing Program	Proposed Program-	State Hatchery
Present value of capital cost	\$2.000	\$2.000	\$2.000
Present value of down payment	.500	.000	2.000
Present value of loan repayments	1.500	1.260	.000
Present value of interest forgiveness	.000	.740	.000
Present value of operating and maintenance costs	3.203	3.203	3.203
Total costs in present value	5.203	5.203	5.203
Paid by nonprofit corporation	5.203	4.463	.000
Paid by state	.000	.740[4]	5.203

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[1]Interest and principal payments deferred for six years with interest compounded over deferment period.

[2]Interest and principal payments deferred for six years, with interest forgiven over deferment period.

[3]Assumes bond issue is repaid over 25 years by equal annual payments into a sinking fund.

[4]Including the \$200,000 hatchery-firm development grant the total direct commitment of state funds under this program to a single-hatchery firm would be \$940,000.

institutional form of the hatchery unit.[8] Further, it is assumed in this analysis that level-two (and therefore level-three) feasibility have been established for the site in question. Consequently, the question of whether or not the hatchery should be built is answered affirmatively and it remains only to consider who (which sector) should build it.

In the example, it is assumed that construction costs for a remote 25 million egg hatchery are $1.8 million and that an additional $200,000 is required for site survey work, water-quality tests, preliminary engineering work, and the acquisition of necessary permits. Operating costs are assumed to be $300,000 per year. Further, since outlays occur at different points in time all values are discounted back to present value for ready comparability.

The present loan program involves no interest forgiveness and therefore the entire burden for repayment lies with the borrowing nonprofit firm; there is no explicit commitment of public funds. Private nonprofit firms would not be able to borrow below the market interest rate for relatively risky investments in the absence of the state loan program. The roughly two percent interest differential should not be counted as a cost to the state, however, unless it is established that the state could have earned commercial loan rates on alternative investments. What is involved here is the acceptance by the state of greater default risk than is normally assumed on state investments but the increased risk is at least partially offset by the ability of the state to develop mandatory assessment programs on existing salmon runs to ensure repay-

[8]This abstracts from a potentially serious disadvantage of state hatcheries discussed above, namely, the potential marketing conflicts that result when returns to the state hatchery exceed brood-stock requirements. This exercise also abstracts from the values created in fishing communities of allowing highly independent and self-reliant people provide their own enhancement program under their own control and direction, and on the cost side from the potential cost savings and technical advance associated with enhancement units having appropriate economic incentives.

ment.[9] It could be argued therefore that under this program the ultimate risk is borne by common-property fishing units.

The proposed revisions in the existing loan program are based on a recognition that the free-rider problems and extreme uncertainty forcing the regional nonprofit firms are likely to retard their development; that is, it is generally recognized that greater incentives are needed than provided by the existing loan program. There are two areas where revisions have been proposed: One is a development grant of $100,000 with an additional $100,000 on a 50 percent cash-matching basis. This grant would be designed to facilitate the formation of regional nonprofit associations; the additional matching portion is designed to encourage region-wide support for either a voluntary or mandatory (requiring a majority vote) self-assessment. The second revision that has been proposed is to forgive interest over the six-year deferment period. This is designed as an added incentive for regional nonprofit firms to assume the risks associated with salmon enhancement projects and, in particular, to allow these firms to resolve the cash-flow problems associated with hatchery investments. In particular, the sharing of risks implicit in this proposal, by sharing the initial financial burden, allows the regional nonprofit firm to propose assessment programs to the fishermen within a region that are less weighted toward front-end commitments. This proposal is consistent with its counterpart in attempting to overcome the economic disincentives associated with the free-rider and uncertainty characteristics of the present economic environment facing salmon enhancement investments. The total present value of costs to the state for a $2 million hatchery is $940,000, $750,000 in interest forgiveness and $200,000 development grant. The latter is available only

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[9] Alaska Statutes, Sec. 16.10.530 (a) - (d).

once for each regional nonprofit association so that subsequent hatcheries built by an association would cost the state $740,000 in direct subsidy.

An alternative to a private nonprofit hatchery is a hatchery constructed and operated by the state. Table 19 lays out the costs assumed by the state for this alternative ($5.203 million in present value). A politically probable result of adopting this alternative is the imposition of fish taxes to pay these costs. It might be argued therefore that the presentation in Table 19 is misleading in that it implies that these costs will be covered from existing revenue sources. Such would be the case, however, without an explicit change in fish-tax laws.

The reader will recognize that what is involved here is the basic and by now familiar question of whether, if fish-tax laws are changed to cover the cost of state enhancement projects, fishermen and fishing communities might not be better served by enhancement projects which they finance, control, and operate themselves, and whether or not the other citizens of Alaska are not better served by entrusting state investments in salmon enhancement production units to institutions that have the necessary economic incentives to be cost efficient and to be scientifically and technologically progressive. These are questions on which every serious policy maker must reflect as additional public investments in salmon enhancement production units are considered.

CHAPTER IV

SUMMARY AND CONCLUSIONS

The primary purpose of this report is to identify and evaluate public-policy issues relating to Alaska's salmon enhancement program while focusing on the role of private nonprofit hatchery firms. This was accomplished by means of a pilot economic feasibility analysis of the Port San Juan Hatchery owned by the Prince William Sound Aquaculture Corporation.

This report includes a discussion of economic incentives implicit in the present economic environment facing nonprofit hatchery firms (Chapter I); a formal economic feasibility analysis using the net present value format (Chapter II); and an analysis of present public policy toward salmon enhancement in Alaska (Chapter III). The findings with respect to each of these topics are summarized briefly below.

The success, and degree of success, of salmon enhancement investments by nonprofit firms depends importantly on the ability of these firms to effectively harness the latent and widely dispersed economic incentives that exist among potentially benefiting fishermen. Working against their accomplishing this are vaguely defined property rights and the associated "free-rider" problem, and extreme uncertainty about future benefits (see pp. 6-11). Countervailing influences in their favor are financial incentives provided by the state and the Alaska limited-entry program for salmon.

The feasibility analysis reveals that, with presently available information about costs, prices, and biological survival rates, hatchery investments by nonprofit firms are economically feasible, assuming that a continuous assessment program is supported by benefiting fishermen. Assessments are required because hatchery revenues from the sale of returning surplus salmon will not be sufficient to cover costs at their present levels. Assessments are economically justified because the fishermen will receive positive net benefits (after allowing for assessments paid) as a result of the productive activity of the hatchery (see pp.48-57). The feasibility analysis also demonstrates that the amount of the required assessments and the resultant net benefits received by fishermen are going to be determined by, and highly sensitive to, innovations which increase ocean survival and those which reduce investment and operating costs (see sensitivity analysis contained in Figures 6-8, pp.49-51; Table 15, pp.53-55; Table 16, p.58; and Table 17, pp.59-61). It is apparent that such innovations can convert what appear at present to be marginally profitable investments into highly profitable ones. It is also apparent that the *social* function of the nonprofit hatchery firm will be to provide the institutional framework for focusing otherwise highly dispersed economic self-interest incentives into an economic production unit that has the incentive to produce cost-decreasing and productivity-increasing innovations. It is this incentive structure which constitutes the primary characteristic, in addition to the important question of who is going to pay for salmon enhancement production units, distinguishing the private sector and the public sector enhancement approaches.

The third chapter presents a review and analysis of Alaska public policy toward private nonprofit salmon hatcheries. Because of the obvious interdependencies, this discussion includes the dual-hatchery-program concept and other private-sector institutional forms presently excluded by statute. With respect to the latter, two alternatives to the nonprofit approach are apparent. One is to allow profit-seeking firms to enter the hatchery business. Because of a pervasive political constraint, however (see p. 67), entry of such firms would probably necessarily be restricted to areas not presently supporting a common-property fishery, but which have biological potential (p. 74 and 75). The other alternative would be to encourage the restricted-stock, or cooperative, type profit-seeking firm. The advantages of this approach are impressive (see p. 75).

The most fundamental policy question facing the State of Alaska with respect to its salmon-enhancement program pertains to the allocation of public funds between state hatcheries and private-nonprofit hatcheries. One approach worthy of consideration is to require functional specialization based on a composite of biological and economic considerations (see pp. 70-74). The ultimate financing of the salmon enhancement efforts is a question that is closely related to the issue of allocating public funds (see pp. 76-81, especially Table 19, pp. 77 and 78). As a generalization, the cost of state constructed and operated hatcheries are borne by the general Alaska public and the primary beneficiaries are fishermen, processors and consumers of salmon products. Virtually all of the last group are nonresidents. An explicit revision in fish-tax laws would be required to modify these distributional consequences. A companion generalization is that the cost of private nonprofit hatcheries are borne exclusively or primarily by the benefiting fishermen (see Table 19, pp. 77 and 78) and that these costs will enter the price structure and be passed on in part to buyers.

APPENDIX

Table A-1

Construction Cost Categories

<u>Water System</u>

Water control dams
  reconstruction, repair, grouting, flashboards, gate control structures

Construction of:
- Lake-intake pipe system
  - 400 feet of 12-inch polyproplyn pipe
  - Lake-intake strainer
- Valve house
  - 10 foot by 10 foot two-story associated valve control structure
- Main pipeline
  - 2,500 feet of 12-inch insulated heat-traced aluminum-clad water pipe
  - 74 separate pipe-support trestles
  - Cabling and chocking
  - Six thrust-blocks leading to the tankhouse
- Tankhouse--three-story wood frame structure
  - One 12-foot diameter and two 10-foot diameter redwood tanks
  - 160,000 BTU forced-air firnace
  - Electric lighting
  - Associated pipeline valves, outlets, overflows, tank aerator, and terminal control
  - Instrumentation indicating water flow and temperature
  - Low-water alarm

<u>Incubation/Production System</u>

Freshwater system in the incubation building including:
- Strainer
- Orifice plate
- Incubator supply drop-control valves
- 7 recirculation pumps
- Piping system
- Incubator supply drops, control valves, and biological filters
- Saltwater treatment system
  - Saltwater pump
  - Over 400 feet of pipe
  - Intake strainer
  - Distribution system
- 72 incubator boxes fitted with astroturf to serve as substrate collection troughs
- Holding and recirculation tanks

(Continued on next page)

Table A-1 (cont'd.)

Incubation Building

Foundation, areawalks, and additional pilings to support increased floor load of building

Tank room--houses the recirculation system
- Concrete troughs, grating, and electric wiring
- Oil-fired boiler
- Water circulation pumps
- Domestic water take-off system

Main floor--incubation room
- Laboratory and lab equipment
- Materials of sheetrock wainscoating, windows, doors and necessary columns

Second floor
- Biologist quarters
- Transient quarters
  - Two bathrooms, seven double bedrooms, and cooking facilities
- Materials needed for second floor:
  - Partitioning lumber, sheetrock, textured ceilings, rugs, furniture, linoleum, two complete kitchens, and three bathrooms
- Three stairwells constructed in accordance with State of Alaska Fire Marshall requirements

Utility System--Waste Treatment

Installation of two-tank multiflow sewer system to provide secondary treatment of waste water
- 400 feet of four-inch waste line and outfall line from sewer tanks to the outfall
- Domestic water and waste system in incubation building, tankhouse and biologist quarters
- Heating system
- Separate fire protection water system

Electric Power Generation/Distribution

Construction and installation of:
- Pelton wheel hydroelectric power installation (provides for electric power by using the water from the main water pipeline)
  - Peltons, valves, terminal control, and related plumbing materials
- Standby generators (one 50 KW and one 30 KW)
- Generator house--15 feet by 20 feet
- Power distribution and wiring
  - Electric panels with gear, hatchery wiring and outside lighting
- Wiring of 2,500-foot heat-trace wire on pipeline to keep pipes from freezing

(Continued on next page)

Table A-1 (cont'd.)

Miscellaneous

Components and systems necessary for hatchery operation

7,000 gallon fuel tank storage capacity

Maintenance shop
- Welds, table saws and aircraft float to allow for the arrival and departure of aircraft

Improvements for watchman's quarters--a two-bedroom single-family dwelling

Construction of egg-take floats and other egg-take equipment for conducting an egg take to receive necessary brood stock

Demolition and removal to provide for fuel used on site, including diesel, lube oil for generators, stove oil, and gasoline

Small tools
- Hand tools for construction
- Power equipment for construction

Estimated market value of donated services and materials (See Appendix Table A-2 for detail)

Camp Cost

Installation of cookhouse

Groceries to feed the crew
- 27 people, on the average, to be fed for the construction period from May 15 to November 1, 1976

Cleaning supplies

Radio equipment for two-way communication between Cordova office and Port San Juan

Engineering

Preliminary engineering

Basic design engineering

Resident inspection

Engineering permit assistance

Associated direct costs of engineering

(Continued on next page)

Table A-1 (cont'd.)

Project Administration

Salary of project coordinator

Salaries of office staff associated with:
- Construction
- Administration at the site
- Insurance
- Workmen's compensation

Associated project costs of audit as required by Economic Development Administration and the State of Alaska, Department of Commerce

Telephone charges associated with construction and procurement of materials

Work permits for various regulatory agencies

Acquisition, Shipment and Distribution

Freight by air, sea, land, boat charter, and associated boat charter expenses

Transportation of construction crew

Loading, unloading and moving materials in Cordova and on job site

Procurement of materials
- Expediting in Seattle
- Assistance from engineers
- Movement of materials in Cordova

Interest

Interim financing

Vendor's interest

Bank service charges

Estimated implicit interest on contributed capital (See Appendix Tables A-3 and A-4 for detail)

Undistributed Construction Costs

Costs of construction materials that have been received before the costs can be distributed to the proper construction account
(Example: An invoice might show 400 sacks of cement. This invoice would be put in the undistributed costs until it is determined where the cement was used.)

Table A-2

Statement of Donated Construction Services and Materials

Year	Description of Donation	Estimated Value	
1975	Boat Charter	$60,912	
1975	Materials	1,187	
1975	Labor (1759.5 hrs. @ $6.50)	11,437	
1975	Helicopter	10,000	
1975	Total		83,536
1976	Boat Charter	58,400	
1976	Labor	3,000	
1976	Helicopter	6,000	
1976	Total		67,400
	Total		$150,936

Table A-3

Schedule of Implicit Interest on Contributed Capital @ 8%

Date Rec'd.	Single Payment Compound Amount Factor[1]	Fishermen Assessment	Interest on Fishermen Assessment	Processors Assessment	Interest on Processors Assessment	Tendermen Assessment	Interest on Tendermen Assessment
1975							
Jan	.16640	$	$	$	$	$	$
Feb	.15894						
Mar	.15153						
Apr	.14417						
May	.13686						
Jun	.12959	663.08	85.93				
Jul	.12237	19,140.84	2,342.26	18,267.98	2,235.45		
Aug	.11519	85,457.13	9,843.81	63,011.30	7,258.27		
Sep	.10806	8,579.90	927.14	8,252.78	891.80	410.68	44.38
Oct	.10098					745.50	75.28
Nov	.09394					500.00	46.97
Dec	.08695						
1976							
Jan	.08000	13.42	1.07	8,479.13	678.33		
Feb	.07310			16,000.00	1,169.60		
Mar	.06624						
Apr	.05942						
May	.05265						
Jun	.04592	2,764.20	126.93	2,764.20	126.93		
Jul	.03923	27,274.60	1,069.98	20,587.60	807.65		
Aug	.03259	406.82	13.26	968.05	31.55		
Sep	.02599	31,633.73	822.16	36,163.20	939.88		
Oct	.01943	25,659.25	498.56	24,232.32	470.83	554.00	10.76
Nov	.01291	13,427.80	173.35	476.42	6.15		
Dec	.00643			8,652.92	55.64		
Totals		$215,020.77	$15,904.45	$207,855.90	$14,672.08	$ 2,210.18	$ 177.39

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Table A-3 (cont'd.)

Date Rec'd.	Misc. Grants[2]	Interest on Misc. Grants	EDA Grant	Interest on EDA Grant	CETA Funds[3]	Interest on CETA Funds	Total Contributed Capital	Total Interest on Contributed Capital
1975								
Jan	$	$	$	$	$	$	$	$
Feb					532,83	84.69	532.83	84.69
Mar	5,000.00	757.65			912.63	138.29	5,912.63	895.94
Apr	5,000.00	720.85			912.63	131.57	5,912.63	852.42
May								
Jun	1,629.88	211.22			912.63	118.27	3,205.59	415.42
Jul	423.11	51.78			912.63	111.68	38,744.56	4,741.17
Aug	5,841.08	672.83			912.63	105.13	155,222,14	17,880.04
Sep	1,600.00	172.90			912.63	98.62	19,755.99	2,134.84
Oct	168.99	17.06			912.63	92.16	1,827.12	184.50
Nov					912.63	85.73	1,412.63	132.70
Dec	986.14	85.74			912.63	79.35	1,898.77	165.09
1976								
Jan							8,492.55	679.40
Feb							16,000.00	1,169.60
Mar			396,720.00	26,278.73			396,720.00	26,278.73
Apr	150.00	8.91					150.00	8.91
May								
Jun	4.00	.18			1,500.00	68.88	7,032.40	322.92
Jul	550.00	21.58					48,412.20	1,899.21
Aug					9,203.39	299.94	10,578.26	344.75
Sep					7,991.24	207.69	75,788.17	1,969.73
Oct	186.63	3.63			12,678.27	246.23	63,310.47	1,230.12
Nov			44,000.00	568.04	2,209.00	28.52	60,133.22	776.06
Dec							8,652.92	55.64
Totals	$21,539.83	$ 2,724.33	$440,720.00	$26,846.77	$42,328.40	$ 1,896.86	$929,675.08	$62,221.88

[1] Derived from $(1 + i)^t$, where i = interest rate and t = number of years (i.e., Dec. 1976 = 1/2, Jan. 1976 = 12/12, and Dec. 1975 = 13/12, etc.).

[2] Includes $10,540 of fishermen and other individual contributions, $10,000 from municipalities, and $1,000 from banks.

[3] Employee salary grants from State of Alaska.

Table A-4

Revenue and Cost Flows:
Moderate-Productivity Case and Mid Range O & M Cost

Year	Costs	Sales Revenue	Assessment Revenue	Total Revenue[1]	Cumulative Net Revenue	Interest Expense @ 10%
0	$2,066,061	$ 0	$ 0	$ 0	$ -2,066,061	$
1	370,000	0	0	0	-2,642,667	206,606
2	370,000	0	0	0	-3,276,934	264,267
3	370,000	306,518	436,679	743,197	-3,231,430	327,693
4	370,000	306,518	436,679	743,197	-3,181,376	323,143
5	370,000	306,518	436,679	743,197	-3,126,317	318,138
6	370,000	306,518	436,679	743,197	-3,065,752	312,632
7	370,000	306,518	436,679	743,197	-2,999,130	306,575
8	370,000	306,518	436,679	743,197	-2,925,846	299,913
9	370,000	306,518	436,679	743,197	-2,845,234	292,585
10	370,000	306,518	436,679	743,197	-2,756,560	284,523
11	370,000	306,518	436,679	743,197	-2,659,019	275,656
12	370,000	306,518	436,679	743,197	-2,551,724	265,902
13	370,000	306,518	436,679	743,197	-2,433,699	255,172
14	370,000	306,518	436,679	743,197	-2,303,873	243,370
15	370,000	306,518	436,679	743,197	-2,161,062	230,387
16	370,000	306,518	436,679	743,197	-2,003,971	216,106
17	370,000	306,518	436,679	743,197	-1,831,171	200,397
18	370,000	306,518	436,679	743,197	-1,641,091	183,117
19	370,000	306,518	436,679	743,197	-1,432,003	164,109
20	370,000	306,518	436,679	743,197	-1,202,006	143,200
21	50,000	306,518	436,679	743,197	- 629,010	120,201
22	50,000	306,518	436,679	743,197	1,286	62,901
Present Value	**5,229,136**	2,156,661	3,072,475	5,229,136	-	-

[1]Total revenue includes sum of assessment revenue and sales revenue. Assessment revenue has been calculated at the minimum annual payment in years 3-22 necessary to make NPV = 0 (see Table 15). Total revenue, therefore, is calculated to yield sufficient revenue to cover all costs. Costs include $2,066,061 initial investment cost, $370,000 operating costs in years 1-20, $50,000 operating costs in years 21 and 22, and working-capital cost at 10 percent.

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