FRED Reports

HATCHERY BROODSTOCK DEVELOPMENT
AND FACILITY BENEFIT-COST MODELS
FOR PUBLIC FISHERIES ENHANCEMENT

BY

Jeff Hartman
and
Kit Rawson

Number 25

ALASKA
DEPARTMENT OF FISH AND GAME

Alaska Department of Fish & Game
Division of Fisheries Rehabilitation,
Enhancement and Development

HATCHERY BROODSTOCK DEVELOPMENT AND FACILITY BENEFIT-COST MODELS FOR PUBLIC FISHERIES ENHANCEMENT

By
Jeff Hartman
and
Kit Rawson

Number 25

Alaska Department of Fish and Game
Division of Fisheries Rehabilitation,
Enhancement & Development

Don W. Collinsworth
Commissioner

Stanley A. Moberly
Director

P.O. Box 3-2000
Juneau, Alaska 99802

January, 1984

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont.)

LIST OF TABLES

LIST OF FIGURES

PREFACE

In September 1981 the Division of Fisheries Rehabilitation, Enhancement, and Development (FRED) initiated the development of models for predicting the benefits and costs of the Division's investments in fisheries enhancement. This work a rose out of a need for a formal method to measure the economic value of some components of the FRED program. Previous economic analyses of fisheries enhancement projects in Alaska have employed a variety of approaches. Their results have often been difficult to compare between projects or with other public investments. The methods presented in this document provide one type of economic yardstick by which the value of fisheries enhancement programs can be measured.

The primary purpose of this report is to review the Hatchery Broodstock Development (HBD) and Facility Benefit-Cost (FBC) Models. The document is written for an audience familiar with fisheries enhancement in Alaska. Some knowledge of economic theory is required for an understanding of the entire report. However, each major section begins with a non-technical overview for non-economists. Underlined words are defined in the glossary.

INTRODUCTION

The goals and purposes of this effort were outlined in a proposal (Hartman and Rawson 1982) where the three principal uses of economic models were stated as follows:

1. The model can be used for identifying the value of existing FRED projects and the economic consequences of proposed investments in fisheries enhancement. The results can be expressed in terms such that the present value of FRED projects can be compared with other forms of public investment in Alaska.

2. The model can be used to produce internal comparisons of alternatives to aid in the optimization of physical plants and the identification of the best capacity, facility location, and incubation and rearing schemes.

3. The model can be used to identify (with multipliers from other models) the distribution of benefits in the primary fishing industry and other sectors of the Alaskan economy as well as impacts on wages (see qualifiers in the text).

The purpose of this report is to describe the computer modeling work that has been completed as a result of the proposal. We report here only on the approach we have taken to economic modelling and the rationale behind that approach. Each application of the approach requires a concise statement of the policy question being addressed and its own explanation of assumptions and results. Lindauer and Hartman (1983) have completed an analysis whose purpose was to consider the impact of a proposed $5 million capital investment into Alaska fisheries enhancement. Their report should be consulted for one example of an application of our models.

Since the HBD and FBC computer models are essentially a means of summarizing numerous assumptions to achieve a concise statement of the expected value of a fisheries enhancement project, the results of any given analysis will depend mainly on the assumptions used. Therefore, along with a presentation of the structure of these models and assumptions used in developing that structure we will touch on some of the variable assumptions used for evaluation of a specific policy question. Finally a discussion of some of the limitations of the approach will be presented.

General Structure of the Models

Currently, our approach to economic modeling is built out of two separate computer program systems which operate on a Vector Graphics Microcomputer. The Hatchery Broodstock Development (HBD) system projects future salmon production from a facility based on its current level of production, plans for expansion, and life-stage survival assumptions. The Facility Benefit-Cost (FBC) system is the economic simulation model which uses harvest predictions from a given HBD simulation and combines these with economic assumptions to generate predictions of the benefits and costs for salmon or trout production from a specific enhancement facility.

Benefit-Cost Analysis

Applications of economic theory and economic models themselves may take many forms. Furthermore, these methodologies have been applied to a variety of regional, state, and national policy questions. In this document we will concentrate on only a portion of the models and policy questions relevant to fisheries enhancement. Evaluation of public investment policy such as investment in fisheries development may include treatment of both efficiency and equity issues. In social terms efficiency is "maximum production from some given level of inputs or cost minimization for a given level of output" (Randall 1981). It is often referred to as Pareto-efficiency or Pareto-optimality.

In the HBD and FBC models all effects related to efficiency have been quantified in dollar terms. Furthermore, the specific models presented are designed to account for measures of efficiency in terms of national income. Evaluation of projects using other accounting definitions (such as a state income accounts) may also be possible.

Equity issues, in contrast to efficiency issues, concern themselves with the distribution of impacts between groups. Examples of policy questions which involve equity issues are as follows: "Who or what individuals in a particular geographic area or sector of the economy will benefit from a project or government action?" or " How much will various groups benefit and over a given period of time?" We do not address equity issues in our models.

The positive analysis method presented in this manuscript relies on benefit-cost analysis, a widely used analytical tool which may yield useful information on public investment alternatives. Benefit-cost analysis is based on a modified definition of efficiency. It is somewhat different from Pareto-efficiency in that it only accounts for social benefits and costs. It does not formally deal with the mechanisms or costs of returning the losers in a transaction to their former level of welfare prior to the transaction.

The use of benefit-cost analysis in evaluating government policy has arisen out of a goal to expend public funds to further a nation's or state's social and economic objectives by efficient allocation of resources among competing groups. The method differs from traditional forms of government budgeting in that it concentrates on the results or consequences of government activity rather than simply on the monetary resources required.

The application of benefit-cost analysis presented in this document consists of a simple model to project future fish harvest from an enhancement facility and an accounting of the value of the fish output based on private benefits and costs and public (government) costs. The valuation process for a salmon hatchery involves accounting of increased salmon harvests over a very long time horizon. It is therefore necessary for the economic portion of the model to use a discount rate, which accounts for the real change in the value of goods with time.

Benefit-cost analysis may be strictly future oriented (*ex ante*) or it may evaluate events which have already occurred (*ex post*). Our approach may deal with policy questions involving either *ex post* or *ex ante* analysis. Furthermore, the approach used here is similar to that of other applications of benefit-cost analyses, such as the Susitna Hydro Feasibility Study (Yould 1982).

The Proper Use of Models

Since we are using mathematical models to analyze the net benefits of F.R.E.D. projects, there are several concepts of modeling relevant to fisheries enhancement applications which should be stated. Any model or part of a model which involves a projection of the future may be open to criticism at the time the projection is made. If the projection can be tested, its precision can be evaluated once the projected events have either occurred or not occurred. To accurately evaluate the precision of the projection in the future it is necessary to state why the projection is being made, as well as any limitations in the use of the results.

Numerous definitions of models are available. Hall and Day (1977) state that "a model is any abstraction or simplification of a system." For example, if we want to make predictions about a real system, such as a fishery, all of the details of the system may be too complex to grasp in a useful manner. But if we abstract a few essential features of the real system, the relationships may be examined in detail. Finally, the model is manipulated according to defined rules and the results are reexpressed in terms that allow us to describe future states of the real system (Figure 1). As Main and Baird (1981) emphasize, it is critical that all of the essential features of the real system be accounted for when a model is constructed. For example, a two foot long wooden model of an airplane

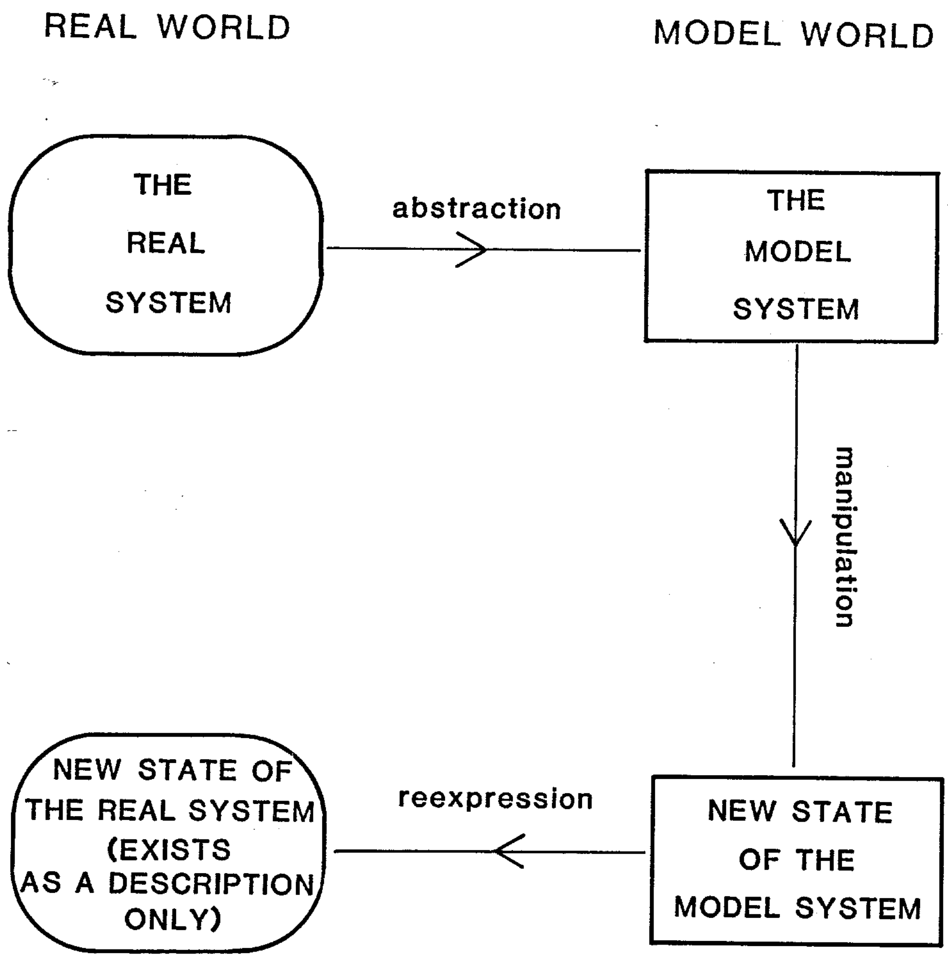

Figure 1. Diagram of the processes which occur in modeling.

might be tested in a wind tunnel to determine how the real machine will fly, while chairs might be set up between white lines in a room to model pedestrian traffic patterns within the same airplane. In either case the particular features abstracted from the system depend upon the goals of the modeling study and by how well they predict future states of the real system.

The abstractions themselves do not necessarily have to closely resemble components of the real system to produce precise predictions of the future. The ultimate test of any model is in its ability to explain an event which has already occurred or predict the outcome of an event in the future for which it has been specifically designed. For example, from our wind tunnel test analogy, the components of our model airplane may be wood or plastic - nothing like the metal structural alloys used in the real aircraft. However, the abstracted wood and plastic components may actually produce a more precise prediction of how the full scale plane will fly than if identical alloys and scaled down structural members from the real system had been used. In short, realistic assumptions and components do not always yield the most precise predictions of reality in a model. Many examples of this principle are found in mathematical modeling.

We are using a particular class of models, called mathematical models, to assist our understanding of some of the economic effects of fisheries enhancement in Alaska. Walters (1980) states that "a model is a precise set of statements about how the components of a system affect one another." This definition implies that the system under study, its essential components, a mathematical representation for each component, and mathematical rules for the relationships among the components must all be defined. A similar process has been used for developing the two main models discussed in this report.

In our hatchery broodstock development (HBD) model the system is a stock of fish produced by an enhancement project, such as a hatchery. The system components are the fish at various lifestages - eggs, fry, and adults. Each component is represented by a number of individuals in a given lifestage in a given year, and assumptions about survival rates and age distributions are applied (Appendix A) to model the expected growth of the broodstock over time. Certain features of a real hatchery broodstock were abstracted in the HBD model. They were chosen with the knowledge that the results from the simulations would then be used in economic analyses. The HBD model allows a user to postulate different ocean survival rates for fish released at different stages of development. For example, feeding hatchery produced fish to reach an advanced life stage or size involves greater program costs than releasing fish at an unfed or less advanced life stage. In order to determine whether the additional feeding and rearing costs are an efficient investment, the model must allow for explicitly examining the benefits of fish rearing in terms of expected gains in survival rates and harvest opportunity. This example illustrates a way in which the specific features of the HBD model can be chosen for a particular intended use.

In our facility benefit-cost (FBC) model, the system is the net benefits accruing to the economy as a result of fish produced by a FRED project. The components of the system are: the adult fish produced by the enhancement effort and the public (from the state treasury), costs of producing the fish, and the benefits and costs to different sectors of the industry of catching and processing the fish (including recreational fisheries) - all expressed in dollars. The components are related to each other (Appendix B) based upon assumptions about hatchery operational and capital costs, by the salmon processing and harvesting economy, by consumer behavior in the market place, and by the social opportunity costs of using these various resources in this particular manner as opposed to investing elsewhere for an identical amount of time.

Two precautions should be mentioned: First, like all mathematical models, ours rely upon numerous assumptions, each of which must usually be estimated with some imperfectly known error. Since the results depend upon the assumptions, it is tempting to say "no results of this model are valid, since the assumptions are not precisely known." Of course, since a model is an abstraction of reality, and cannot be expected to exactly reflect reality, the results derived from any model must be interpreted knowing that they apply only within the bounds determined by those features of the real system used to create the model. Continuing our example, a successful wind tunnel experiment gives no information about whether an airplane will carry passengers comfortably.

Secondly, the precision of the results depends upon the reliability and precision of the assumptions used. It is possible to produce a simple form of sensitivity analysis with our models to examine the degree to which changes in key assumptions affect the results. We encourage users (for many policy questions) to utilize this feature. If the results obtained from the HBD and FBC models are interpreted in light of these two cautions then they can indeed by valuable tools for studying the economic consequences of fisheries enhancement in Alaska.

THE HATCHERY BROODSTOCK DEVELOPMENT MODEL

Overview

The Hatchery Broodstock Development (HBD) model projects the future production of fish from a facility and the harvests resulting from that production. The current version of the model is tailored for a hatchery, although simulations of other kinds of enhancement facilities, such as fishpasses, are possible. The HBD model is an extension of FACSIM developed by Reed (1980) for the purpose of generating brood-stock development tables for FRED facilities. The model may be used alone to generate brood-stock development tables, or it may be used in conjunction with the Facility Benefit-Cost (FBC) model in an economic simulation. In the latter case, the HBD model is run first to generate the projected production of fish for a series of years. Then the output from the HBD simulation forms part of the input for an FBC simulation to generate a projection of the economic value of the enhancement effort.

Computation of Output Variables

The equations used in the HBD model are summarized in Appendix A, and the HBD computer programs are explained in a separate user's guide (Rawson, Hartman, and Tavzel 1983a). The purpose of this section is to review the structure of the HBD model and how its output variables are computed from its input variables. Figure 2 illustrates the relationships among the components of the HBD model.

The input variables for the HBD model are the following: the capacity of the facility to produce fish at different lifestages, the survival rates between lifestages in the hatchery, ocean survival rates, the age distribution of returning adults, the fecundity of adult females, the required stream escapement (either a percent or an absolute number), and the commercial and sport fishery interception rates. In addition, remote egg takes may be input into the model as well as any returning brood-stock from releases before the initial date of the simulation. The output variables are, for each year of the projection, the number of returning adults by age, the number of these intercepted by the commercial and sport fisheries, the stream escapement, the hatchery escapement (fish used for brood-stock), and the excess escapement (returning fish not needed for brood-stock which are available for a terminal fishery).

In the following subsections the computation of each of the output variables is discussed. Figure 2 illustrates the relationships of the model's components. The exact formulas for the computations are in Appendix A.

Adult Returns:

The projected number of adults returning from a given release group is computed by multiplying the number of fish released times their assumed ocean survival rate. The returning adults from a given release are allocated to several return years according to the age distribution input variables for the stock being simulated. For example, one might assume that a stock will be 20% age 2.0 and 80% age 3.0. Then if 1,000,000 fry are released in 1985 and their ocean survival is 1%, the total adult return will be 10,000. Of this total 2,000 will return in 1987 and 8,000 in 1988.

It is possible to input different ocean survival rates for fish released at different stages of development (e.g. emergent fry, fed fry, etc.). The survival rates and age distributions are assumed to be constant for the duration of the simulation, and there is no provision for them to vary stochastically.

Escapement, Fishery Interception, and Egg Take:

The HBD model separates the total adult return into components of stream escapement, commercial and sport fishery interception, hatchery escapement, and excess escapement.

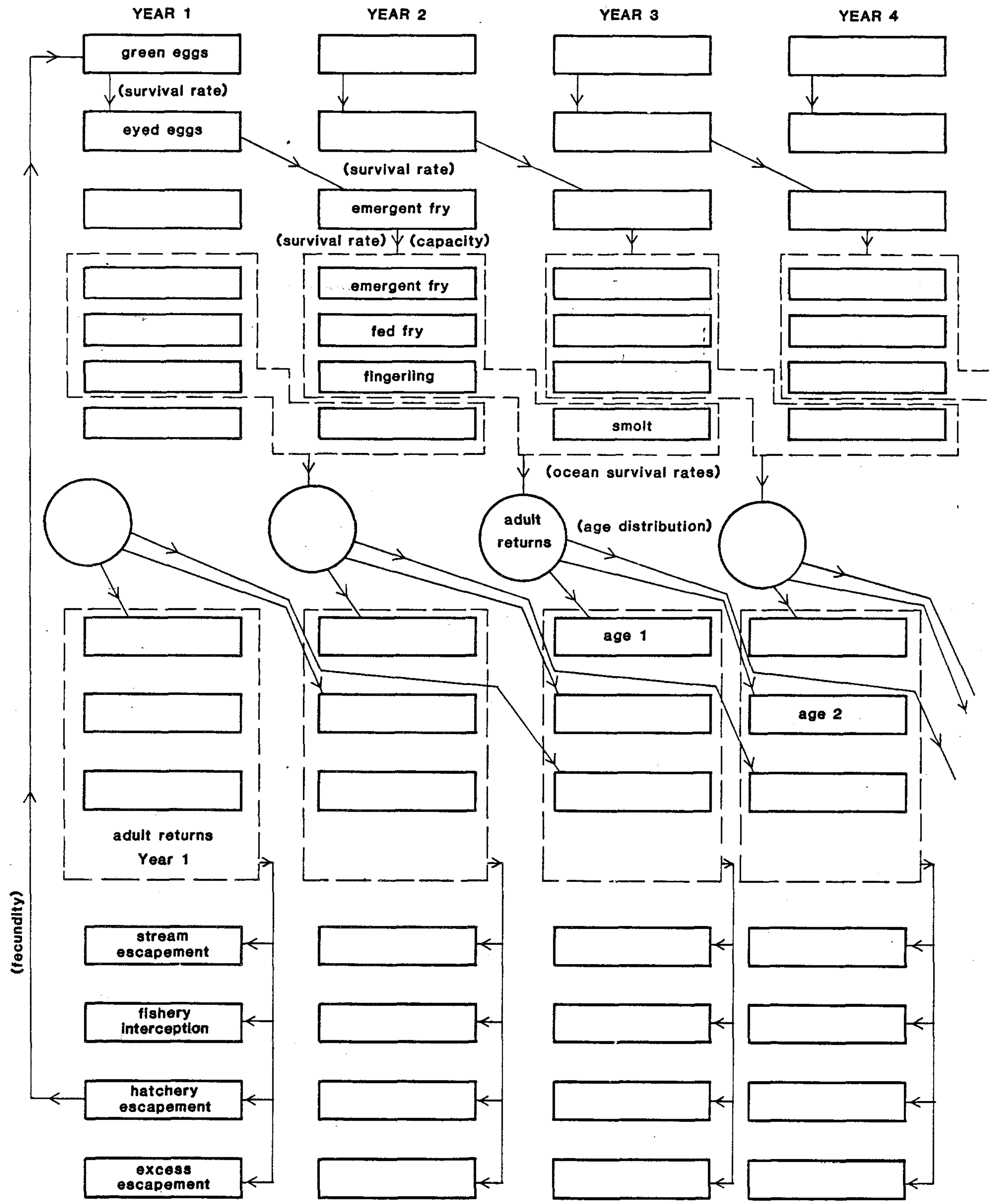

Figure 2. Diagram of the HBD model. The output variables computed by the model are inside the boxes outlined by solid lines. The arrows indicate which output variables are computed from which other output variables. Some of the input variables used in the computations are indicated in parentheses along the arrows.

Stream Escapement. The stream escapement represents the adult fish that will be allowed to migrate to natural spawning grounds. It is modeled as either a minimum absolute number of fish or as a multiplicative factor times the total number of returning adults. The stream escapement goal may be different for each year of the simulation. For example, it may be anticipated that some number of spawners below the optimum number will be allowed into the natural spawning grounds until such time that the enhanced stock is built up to a level sufficient to allow the optimum stream escapement, at which time the stream escapement goal would be increased.

In the HBD model stream escapement takes precedence over all other categories to which returning adults can be assigned. In other words, if only enough adults return to meet the stream escapement goal, there will be no fish left over for fisheries or hatchery brood-stock.

Fishery Interception. The interception of fish by commercial and sport fisheries is modeled as a percent of the returning adults remaining after stream escapement goals have been accounted for. The fishery interception rates may be different for each year of the simulation in order to represent possible future changes in management strategy or efficiency of the fleet. For example, it may be anticipated that a particular hatchery stock will be fished at a 20% rate in its initial development stages, while it will ultimately be fished at a 90% rate.

Hatchery Escapement. The hatchery escapement represents the fish used for egg take by facility. All of the fish remaining after stream escapement and fishery interception have been accounted for are available for hatchery escapement. The maximum number of females in the hatchery escapement is determined by dividing the facility's capacity for green eggs by the assumed fecundity for the stock under consideration. This number is multiplied by two to allow for an equal number of males and females for spawning, and the result is the maximum hatchery escapement. (The model provides for situations where certain age classes may not be 50% female; see Appendix A). If the maximum hatchery escapement exceeds the fish available for hatchery escapement, then all fish available are assigned to hatchery escapement. If the number of fish available exceeds the maximum hatchery escapement, then the difference between the two quantities is assigned to excess escapement.

Excess Escapement. The excess escapement represents the returning adults, if any, left over after all the above categories have been accounted for. These are merely reported as excess escapement in the output of the HBD model. When the results of an HBD simulation are used as input to the Facility Benefit-Cost (FBC) model, the fish in the excess escapement are assigned to either the commercial or sport fisheries (see the FBC section below). In some situations it could be assumed that fish in the excess escapement are not of sufficient quality for a fishery. Such an assumption would require that the economic model ignore this category and not assign these fish to any fishery. At present our FBC model does not allow for this situation, although such a modification would not be difficult. One way to deal with this problem with the current models would be to run the HBD model a second time with the stream escapement increased enough so that the excess escapement will be zero.

Emergent Fry, and Releases:

Emergent Fry. The number of green eggs loaded is computed by multiplying the number of females in the hatchery escapement by the assumed average effective fecundity of a female. The number of eyed eggs seeded is computed by multiplying the number of green eggs by the assumed green egg to eyed egg survival rate. The number of emergent fry in the year following the year of the egg take is computed by multiplying the number of eyed eggs times the assumed eyed egg to emergent fry survival rate.

Releases. Fish may be released as emergent fry, fed fry, fingerlings, or smolt. the maximum number of fed fry, fingerlings, and smolt that the facility can release are entered as input variables, Any excess fish that are not released under one of those three categories are assumed to be released as emergent fry. (Therefore, if all fish are to be released as emergent fry then the facility's capacities for fed fry, fingerlings, and smolt are entered as zero).

In case fewer fish are available for release than the facility has the capacity to rear, more developed age classes will take precedence over less developed ones. In other words, the facility's capacity for smolt releases will be satisfied first, then its capacity for fingerling releases, then its capacity for fed fry releases, and any fish left over will be released as emergent fry. The maximum number of smolt available for release is computed by multiplying the number of emergent fry times the assumed survival rate from emergent fry to smolt. If the number of smolt available for release exceeds the facility's capacity to rear smolt then the maximum number of fingerlings available for release is computed by multiplying the number of remaining emergent fry times the assumed emergent fry to fingerling survival rate. A similar calculation is done to determine the number of fed fry to be released, and any remaining fish are released as emergent fry.

Emergent fry, fed fry, and fingerling releases take place in the year following the year of egg take. Smolt releases take place 0, 1, or 2 years after the year of fry emergence, depending upon the number of winters that smolt are assumed to remain in the facility before release.

Data Sources for Input Variables

Facility Capacities and Survival Rates:

The FRED Division uses a series of respiratory rate and growth models for developing facility and brood source specific carrying capacities from available water quality and quantity information and physical plant resources. The values computed from these models are used to estimate the facility capacities for eggs and rearing to different lifestages throughout the period of an HBD simulation. Different facility capacities for emergent fry, fed fry, fingerlings, and smolt may be entered for each year of the simulation to allow for anticipated changes in program. For example, a particular simulation may be run to examine the impact of an planned capital investment in a facility, in which case any increases in capacity due to the investment would be input starting in the year the investment is planned to be made.

A species-specific set of parameters is required for determining the capacity of a facility for rainbow trout, since a rainbow program involves developing a brood-stock within a hatchery. Several complicated calculations are required for taking the differential fecundity and survival of the different age classes into account. Rainbow trout programs can be successfully modeled with the HBD model as long as the inputs to the model are computed with the special features of a rainbow program in mind.

The HBD model uses survival rates between lifestages within the facility. Depending upon the policy question being addressed, these may often be estimated from past performance at a given facility. In the case of a new stock they may be estimated from past experience with a similar stock.

Ocean Survival Rates:

Ocean survival rates can be estimated from the past performance of the stock being modeled or from information based on the performance of similar stocks. The values of the output variables computed by HBD model are very sensitive to differences in the ocean survival rate, especially if the results are used as input to the FBC model for an economic simulation. Additionally, ocean survival rates of salmon are known to fluctuate widely from year to year, but the HBD model assumes a constant rate. Also, past ocean survival rates often have not been estimated to high degree of precision. To account for this variability and uncertainty a simulation could be run once using a low estimate of ocean survival and once again using high estimate so that results can be bracketed pending further resolution of input data.

In the HBD model it is possible to enter different ocean survival rates for different lifestages of release. For example, if only part of a group is reared, one may assume that the fish released as fingerlings will survive at a 2% rate, while those released as emergent fry will only survive at a 1% rate. For some FRED Division programs such differences in ocean survival rates are well documented, for others they are only guesses. Depending upon the policy question being asked it may or may not be important to assume different ocean survival rates for different lifestages of release.

Harvest Rates:

The HBD model allows for harvest to take place at two stages: interception before the fish return to the egg-take site, and terminal harvest of excess escapement. As stated above, the HBD model merely reports the excess escapement as such, and our FBC model assumes that all of this excess escapement is harvested. Commercial and sport fishery interception rates are projected based upon knowledge of the particular fisheries to which the stock is exposed and future management plans. These are allowed to vary annually to reflect planned changes in management strategy.

THE FACILITY BENEFIT-COST (FBC) MODEL

Overview

The FBC model estimates present values for a number of benefit and cost alternatives for commercially caught and sport caught salmon directly attributable to a given salmon enhancement project. All future benefits and costs are adjusted to the base economic year dollars with a discount rate. The discount rate used in this model is intended to be estimated from the expected real rate of interest. The real interest rate equals the nominal rate less the rate of inflation.

As the Net Present Value of a projection may be sensitive to the discount rate used in the analysis it will often be helpful for some policy questions to test the range of possible outcomes by varying this input. It is also possible to deal with *ex post* policy questions by discounting a stream of costs or benefits which have already occurred.

Ex post applications require the use of a separate price index computer simulation model which we have implemented on a spreadsheet program. This routine allows for convenient adjustment of the value of past nominal benefits and costs to base year dollars. A thorough explanation for operating the price index model and the FBC model may be found in a separate user's guide (Rawson, Hartman, and Tavzel 1983b). Appendix D contains an example of the output from the FBC Model.

General Economic Equations:

The general structure for the present value of the enhanced salmon production takes the following form for recreationally and commercially harvested fish (see Appendix B for details).

Given the following definitions:

B_{pri} = Marginal benefits from the private sector attributable to the enhancement produced fish,

C_{pri} = Marginal costs from the private sector attributable to the enhancement produced fish (e.g. cost of harvesting, processing, etc.), and

C_{pub} = Marginal public costs from producing and managing enhancement produced fish (e.g. operational cost, capital cost and planning costs of hatchery, administrative costs and costs of program evaluation), The following quantities are computed:

NPV = Net present value

$= B_{pri} - C_{pri} - C_{pub}$, and

B/C = Benefit cost ratio

$= [B_{pri} - C_{pri}]/C_{pub}$

The B/C ratio should never be reported without the NPV.

Evaluation of the efficiency of an investment for a specific project requires the analyst to estimate the gross benefits and gross costs of increasing the available salmon resource.

The equations in the FBC routine focus on three sectors of the commercial salmon industry: the commercial fishery, the salmon packing industry, and the recreational or sport fishery. The benefits to the private sector from the increment in the fish stock can be estimated as either the marginal value (marginal profit) to the commercial fishery or as the marginal value to both the processing industry and the commercial fishery. In the first case the gross benefit to the commercial fishery from the incremental fish production is measured as the exvessel value of the product. The gross cost is measured as the resources foregone from the fleet to catch the incremental production. In the second case the gross benefit to the processing industry is the market value that they receive from the increased catch or first wholesale value. The processing costs are taken to be the value of the foregone resources required to both process and harvest the enhancement produced catch.

The user's choice of valuation methods depends on whether a state of perfect competition is expected to exist in the processing sector. According to classical and neoclassical economic theory this condition would result in zero economic profit being earned. The alternate condition assumes some level of oligopsony power from individual processors which would result in the capture of some economic profits. An expanded discussion of assumptions on the harvesting section and processing industry can be found in Hartman (1983).

The marginal value from sac roe sales is included in the estimate where applicable. It is also expressed as price per pound of market quality eggs.

Detailed Discussion of the FBC Model Components

The discussion in the following sections is an expanded explanation of how private and public marginal benefits and marginal costs are calculated in the FBC model.

Private Sector Benefits:

Market Demand and Price inputs (Commercial Fishery and processing sectors). Since the incremental revenue for processors or commercial fishermen is directly dependent on the consumer's final demand for the product, inputs for these variables are taken to follow the trend predicted by international market demand models made for Alaska.

Long term price changes for the FBC system may be entered by yearly adjustments of real prices for either landed values or wholesale values. The State of Alaska, Department of Commerce and Economic Development, has developed a salmon market demand model (DPRA 1982) with variables specifically designed for Alaska supply and international market conditions. If properly modified this system may be capable of producing long term price estimates of the wholesale marginal revenue for aquaculturally produced salmon (B. Aberle, pers comm). The inputs for this part of the program accept the price per pound of landed weight which is assumed to be approximately equal to the marginal revenue per pound.

Sport Fish Value Inputs. Many of the projects and facilities in FRED Division are scheduled to, or currently, produce salmon and trout highly valued by sport fishermen. In fact, some facilities are targeted almost entirely at sport fishermen. This section explains the economic benefits of sport fishery enhancement. The analysis method is intended only for the enhancement program.

Most economists who are studying the valuation of recreational fishing point out that it is inappropriate to use economic activity as the sole measure of the value of a nonmarket good such as sport fishing. McConnell (1979) states, "in the absence of good information about net social benefits for open access activities, decision makers tend to respond to measures which reflect the total level of economic activity. Decisions based on the level of economic activity can have rather severe consequences for nonmarket activities such as recreation". He continues, "No economist would argue seriously that fisheries management requires simply the computation of user cost and the imposition of a fee per pound of fish landed equal to the user cost". Even so, some decision makers use fishing expenses to determine recreational values. Responding to this, economists have proposed the use of direct and indirect methods of measuring changes in welfare, in order to achieve an optimum mix of commercial or recreational use, or to determine the efficient level of public investment for publicly provided recreation. Larson (1982) provides a thorough treatment of these valuation techniques.

Recreational evaluation procedures can identify benefits other than those directly received by Alaskan fishermen (such as existence valuation and option valuation techniques). However, the primary purpose of our valuation process is to identify the change in consumer surplus from the actual recreational fishing experience. The consumer surplus is a measure of the satisfaction people obtain from consumption of a commodity, based upon what they would be willing to pay for it. In the case of our enhancement investments it is what they would be willing to pay for the opportunity to fish for the incremental increase in the available stock. The theoretical basis of the recreational fishing surplus model assumes that small increases in the harvestable stock of recreational salmon will yield a disproportionately large growth in total value (consumer surplus) of the fishery. This will occur because of increased catch expectations. Thus, the demand curve will shift outward as information reaches the consumer that the probability of catching salmon or trout during a fishing trip has increased.

A sportfish valuation study based on estimates of consumer surplus is being conducted by ADF&G (M. Mills, pers comm). This study may provide some useful data or generalizations for appropriate sportfish valuation inputs. Beyond this work, however, there is no functional model which successfully incorporates information on the quanity of sport fish made available for harvest from fisheries enhancement into usable demande curves for estimating marginal values. In the absence of such data in Alaska, economists have taken an alternative approach of using average consumer surplus values for a recreational day for estimating the benefits of incremental changes in stock sizes available for sport harvest (Crutchfield et al. 1982). These are available from numerous studies in the Pacific Northwest and this approach has been applied to the FBC model.

Caution should be exercised when comparing the marginal values of sportfish, versus marginal values of commercial fish for potential allocation comparisons for a given enhancement valuation alternative. Nevertheless, in the absence of precise valuation methods it is our opinion that a conservative use of this approach is useful for estimating sport fishing value streams at this time. The 1982/1983 economic assumptions (Hartman 1983) include an expanded discussion of consumer surplus daily use values for one proposed enhancement scheme.

Harvest Efficiency Inputs (private costs for the FBC Model):

No formal computer models are currently being used in the ADF&G for predicting the relative changes in harvest costs for various commercial gear types given a change in an enhancement-produced salmon supply. Some principles of fleet dynamics models are surveyed by Clark (1976). A considerable amount of financial and economic data has been collected by the Limited Entry Commission on some specific Alaskan fisheries. This work and developing models may have considerable utility in projecting fleet harvest costs for enhancement produced increments. The survey results may be found in Muse and Schelle (1983).

There are two primary inputs for harvest efficiency performance of the commercial fishery in the HBD and FBC models: the quantity of enhancement produced fish harvested annually, and the incremental cost of the harvest effort. They allow the fishery costs by gear type to be entered for any given harvest for each year over the life of the hatchery harvests and are expressed as a cost per pound of harvested fish. It is assumed that the increment in these costs will be representative of the marginal increases in both the variable and fixed inputs to the fishery attributed to the hatchery produced harvest. Harvest efficiency for a given gear type in a fishery varies with such factors as number of entrants in a fishery, abundance of fish in harvest areas, expectations of success, and management actions.

Public Sector costs:

A few computer programs exist for predicting hatchery capital and operational costs for various operational schemes. Examples of programs containing routines for developing future or analyzing past operational and capital costs are: portions of the HATCH Model (Johnson 1974), the NMFS's CRFDP Operators Manual (McKuskick et al. 1981), and a Life Cycle Cost model developed by the Alaska Department of Public Works in 1977 (Anonymous, 1977). Though each of these models contains some useful combinations of calculations, it must be noted that they are not being used for day-to-day operational cost planning or construction cost budgeting in the state fisheries programs of Washington, Oregon, or Alaska. The HATCH Model is, however, used by the State of Washington for broad long-term policy decision making.

Without revision for Alaskan conditions, these models would yield cost estimates with less precision than an operational cost projection from an experienced hatchery manager, or an estimate of capital costs by hand from an experienced aquacultural engineer. The FRED Division currently uses an exhaustive in-house review method for refining budgets. The FBC model is designed to accept direct calculated estimates of real capital and operational costs by year. These costs include the annual fishery evaluation and administrative costs attributable to the salmon hatchery.

SPECIAL CONSIDERATIONS OF THE FBC MODEL

The following sections describe some separate features and related components to the FBC Model.

Price Indexes for the FBC Program

The specific price level index model (operating on a software package which is separate from the FBC model) allows for adjustments in the purchasing power of the dollar spent for a narrow range of goods. The FBC model uses real prices and costs which are computed using price indexes for the facility operations and capital costs; exvessel prices and cost; and processing prices and costs. Each past nominal price or cost is adjusted to a real value in base year dollars by means of an appropriate consumer or producer price index. The price index calculations for adjustment of past year nominal prices are of the following form since the "base year" is taken to be the first year for the simulation of future events:

$$R^t = N^t \quad \frac{P^0}{P^t} .$$

Where R^t is the real price of the good(s) in the past year t, N^t is the nominal price of the ith good(s) for past year t, p^o is the price index for the good in the base year, and p^t is the price index for the good in past year t. Price index categories are listed below:

1. Wholesale price index for adjustment of fresh/frozen or canned product. This index represents a market basket of meat goods from the U.S. national consumer price index.

2. Price index for canned and fresh/frozen production costs. This combination of goods represents cost inputs of the processors attributable incremental cost of the hatchery produced fish.

3. Ex-vessel price index. To be taken from some consumer price index as in #1. This routine is structured to produce real prices for up to four specific gear types per fishery.

4. Price index for costs to commercial fisherman of fishing.

5. Construction price index for the Alaskan salmon hatchery program. This is projected from the Handscomb Construction Escalating Index (Handscomb 1981).

Alaskan Impact Analysis

If a decision maker were only interested in a single objective, namely the maximization of fishing income (or value), then the economic evaluation would not need to go beyond benefit-cost analysis. However, if the decision-maker is also interested in formally dealing with distributional effects of proposed investments, then it is necessary to expand the scope of the work to that of impact assessment, which must be dealt with in a modeling framework which is separate from efficiency considerations. Impact studies may address any number of policy questions. Impact analysis may be quite different from benefit-cost analysis. But, there are many policy questions dealing primarily with efficiency which still have equity implications. In this context equity and efficiency considerations may be closely meshed.

Impact studies may measure changes in local or regional employment, labor force participation, real income distribution, and business and industrial activity by a series of sectors. While measurement of impacts from a project can take place even at the national level, we will extend our analysis only to assessments relevant to Alaska. Though not the primary function of the model, the FBC routine can account for these interactions within the Alaskan economy indirectly. This is done by incorporating values from external impact models capable of generating multipliers relevant to the salmon fishing and processing industry. Since the model receives inputs on processing revenue, processing cost, exvessel revenue, and exvessel costs, any of these may be used as a base for the multiplier.

One type of impact modelling is input-output analysis. A discussion of the mechanics of input-output models is provided by Miernky (1965). In general, the approach is based on a detailed accounting of goods and services at a given point in time. A series of industry coefficients are constants and are arranged in the form of a matrix (Randall 1981). They may be used to predict changes in employment and income from a change in economic activity from a primary sector. In our case, the primary activity would come from the harvesting and processing of salmon.

Impact models may vary in the degree of built-in regionalism. One approach may characterize activity in a single state as a whole. Another may focus on the distribution of activity between several sub-regions in a state (Youmans, Rempa, and Ives 1977).

One operating econometric model used by the Division of Budget of the Alaska Department of Revenue was used to produce a data set for the salmon industry based on a hypothetical increase in the salmon harvest of 10 percent over the naturally produced base level (Kreinheder and Teal, 1982). This incremental increase resulted in an income multiplier for the seafood industry of approximately 1.84. The estimate indicates that for each one dollar of processing income produced an additional increment of 84 cents is produced in the form of induced wages to Alaskans.

A regionally based impact analysis model tailored for the Alaskan fishing industry would be a valuable tool for enhancement output decisions. While benefit-cost analysis normally only deals with questions of optimality, the impact multiplier features of this model are considered to be a temporary but useful feature until further development of a regionally based input-output model and analysis is available.

DISCUSSION

The Problem of Interactions Between Stocks

In any quantitative analysis of costs and benefits, all relevant factors affecting the net change in the value of a resource must be identified and quantified over time. In addition, any significant externalities must be included in the valuation process. However, in practice it may be possible to quantify all factors. Among other things, any analysis of the economics of fisheries enhancement must include a consideration of the possible impacts of the enhanced stock on other, unaided, stocks. In their present form the HBD and FBC models do not explicitly deal with more than one stock. Given the present state of knowledge about interactions between stocks it may be possible to make simple modifications to our models to satisfy this need. Meanwhile, users of our models should be cognizant of the effects of stock interactions and account for these interactions to the extent possible.

Salmon fisheries enhancement, as well as many other profitable animal husbandry investments, involves uncertainty. Many biologists in the Pacific Northwest believe that they are beginning to understand the major factors which affect interactions of salmon in the spawning grounds, streams, lakes, and estuaries, thus potentially reducing some of the uncertainty in our projections. While precise models quantifying the effects of these interactions are still not available, they are theoretically possible.

Interactions of salmon in the ocean environment present a similar, but more extreme, challenge since our knowledge in this area is even more limited. However, some fisheries models formally explore the potential effects of enhancement-related ocean interactions via computer simulation. One approach (Walker, Rettig, and Hilborn 1983) uses formal decision analysis for the modelling of Oregon coho salmon enhancement policy. These tools demonstrate that even in the absence of precise biological information, a simple approach to quantifying biological interactions can assist in the process of identifying efficient choices for developing management policy in migratory fishes.

In the September 1981 Workshop on the Evaluation of Salmonid Enhancement (University of British Columbia, Vancouver, B. C.) a framework for the study of stock interactions was developed. It was divided into 4 principal areas: genetics, population dynamics, exploitation, and economics. The following outline summarizes some of the interactions discussed at the workshop.

A. Genetics

1. Straying of enhanced stocks might result in net gains or losses in genetic variability to unaided stocks of fish.

B. Population Dynamics

1. Predation

-Aided stocks may feed on unaided stocks of salmon.

-Aided stocks may feed on other aided stocks.

-Aided stocks may feed on other species of high value harvested by Alaskans.

-Other fish may feed on aided stocks of salmon, which would not occur without enhancement.

2. Losses may occur to unaided salmon stocks due to remote egg takes.

3. Competition

-Aided fish may affect aided or unaided stocks as a result of competition for habitat or food items.

-Population stability levels may change as a result of the increased population size of the aided stock.

-The harvest weight of fish may change as a result of competition with aided stocks.

4. Fecundity may be altered due to interactions of aided and unaided stocks.

5. Stocks may be lost or reduced due to disease introductions from stocking.

C. Exploitation

1. Altered manageability and/or harvestability

-The timing of the harvest of unaided stocks may change due to overharvest during periods of unaided and aided stock overlap.

-The efficiency of harvest may be reduced or increased as a result of interaction between aided and unaided stocks.

D. Economics

1. Market demand curves may move as a result of increased numbers and distribution of enhancement produced fish. Recreational demand curves may shift as a result of more optimistic catch expectations.

Modeling Biological Interactions

All of the concerns and hypothetical interactions discussed in this section fall into one of two structural types from the standpoint of modeling their effects on the net value of an enhancement project.

Type A

The first type is a one-way interaction of the form (A→B). In this case an independent factor such as the stocking of juveniles (stock A) affects a separate stock (stock B). The result is a change only in the population and economic value of B. Potential examples of this kind of interaction could include introductions of fish disease to stocks from enhancement produced fish or increased fishing effort directed at an enhanced stock resulting in an overexploitation of other stocks. One-way interactions which result in changes in population can be modelled indirectly using our programs by subtracting or adding the annual economic gain or loss of the external stock from the annual facility costs.

Type B

> The second type of interaction is reciprocal or (A↔B). In this case introduction of enhanced stock A results in effects on both populations of stocks A and B. A common example of this type of interaction would be competition between stocks for common habitat or food organisms where one of the two stocks is enhanced or rehabilitated. These two way interactions, unlike those of type A, would require estimates of gains and losses from both aided and unaided stocks. The value of the annual net loss could be added to the operational cost of the hatchery but this approach would be somewhat cumbersome if several facility simulations were to be adjusted. At this writing we are aware of no documented evidence of gains or losses in unaided stock populations from salmon enhancement interactions of the hypothetical types discussed in the 1981 Enhancement Evaluation workshop.

The HBD or the FBC models are not designed to formally deal with interactions between species. As the science of salmon fishery biology is in its infancy with respect to quantitative analysis of these types of interactions, it is unlikely that realistic predictive models for biological interaction will be available for some time. Yet the simplest of models may do much to illuminate the economic consequences of hypothetical gains and losses from enhancement when tempered with intuitive common sense of fisheries managers and enhancement planners. We have indicated some of the ways that interactions between stocks can be addressed with our models. There is much which can be done with the tools we have today.

Handling Uncertainty

The most perplexing problems in fishery resource economics are those concerned with risk, uncertainty, and irreversibility. In many cases the preferred approach for dealing with the uncertainty in a given input variable will be to run several simulations which represent reasonable ranges for expectations of performance. For example, the HBD model could be run once with the ocean survival for pink salmon fry set at 1% and again with ocean survival at 7%. The output from the two runs could then be fed into the FBC model, and the resulting computations could be considered to be the bounds of an interval of net present value for the facility being modeled.

Unfortunately, informal sensitivity analysis is not as simple in practice as the above example would indicate. As the number of input variables to be varied increases beyond one, the number of separate simulations to be done increases exponentially (if n input variables are to be varied, each with a high and low value, then the number of simulations is 2^n). Therefore users of our models must understand the biology and economics of fisheries enhancement enough to be able to evaluate the input variables as well as the output from the model. We recommend that users do run simulations several times with different values of key input variables. However, these key variables will have to be chosen carefully as the ones most likely to shed light on the policy question being addressed by the simulation.

GLOSSARY

1. Aided stock or unaided stock.

An unaided stock of salmon exists in concert with human induced environmental pressure such as fishing. An aided stock of salmon has been produced or made larger through enhancement or rehabilitation efforts. The term includes stocks which have been increased by enhancement in the past through transplants or other means. Aided stocks may or may not be self reproducing.

2. Classical economic theory.

The theory of market behavior under perfectly competitive conditions without government intervention. Usually associated with Adam Smith's Inquiry into the Nature and Causes of the Wealth of Nations (1776 cited in Sloan and Zurcher 1958). See also Neo-Classical economic theory.

3. Consumer Surplus.

The difference between the maximum total amount a consumer would be willing to pay to have a quantity of a given good (rather than do without it entirely), and the actual total amount he pays for that quantity of good. Also it is the triangular shaped piece above the price line on the demand curve. (See also demand curve).

4. Demand Curve.

The mathematical function or graphic curve which illustrates the relationship between the price and quantity of a good. Quantity is normally on the "x" axis and price is on the "y" axis.

5. Discount Rate.

The interest rate (r) used in calculating present value. In the case of a single future amount coming in t years the discount factor is: $(1+r)^{-t}$.

6. Efficiency.

Maximum production from some given level of inputs or cost minimization for a given level of output. See also pareto-efficiency.

7. Equity.

Distribution of wealth geographically or in different sectors of the economy. It may refer to direct or induced impacts.

8. Exploitation.

The process of reducing the population of fish through fishing. It can include either commercial fishing or sport or subsistence fishing.

9. Economic Profit or Economic Rent.

The difference between the total benefits and total cost at one quantity of production over a defined time horizon.

10. Good.

Anything (either material or immaterial) that satisfies a human desire. A good is something that an individual wants some of, rather than do without.

11. Marginal Analysis.

A method of analysis used by economists to evaluate additional (or incremental) benefits and/or costs associated with doing one more or one less unit of an activity. Marginal analysis is useful in determining if it is efficient to undertake, expand, or continue a project.

12. Marginal cost.

The change in total cost required to produce one additional unit (f) of a good.

13. Marginal Revenue (Marginal Benefit).

Change in total revenue which takes place from a one unit change in output.

14. Marginal Value (Marginal Profit).

Marginal benefit or revenue minus marginal cost.

15. Model.

A simplified representation of some real world process. It is simplified because it is put together by ignoring some features of the process and concentrating on a few of the most relevant assumptions and factors.

16. Neo-classical Economic Theory.

The theory of market behavior under conditions of both perfect and imperfect competition. Conditions of imperfect competition include the case of market failures from externalities (third party effects), government intervention, price fixing, or quotas.

17. Net Benefits (Net Revenue).

Total benefits (revenue) less total costs. In the social context it is equivalent to economic rent.

18. Normative and Positive Statements and Analysis.

A normative statement is one which is based at least in part on opinion of what ought to be or what ought to have been. A normative statement cannot be shown to be true or false, for example: "the price of sockeye salmon fell by too much in the 1982-1983 season." This statement cannot be tested for accuracy since it is opinion. A positive statement can be tested and is based on what has been or what will be. For example, "from year 1973 to year 1974 pink salmon prices rose in PWS."

In general, our method of economic analysis is an exercise, in positive analysis. However, the very nature of the method of analysis used in this report implies some value judgments of what is useful and important. So our positive method of analysis includes some normative elements.

19. Oligopsony Power (Monopoly Power).

The ability of a firm (in a market where sellers are few) to control price through adjustments of the firm's production. The price searching firm may use price control as a weapon in discouraging entry of other firms into the market place. The salmon processing industry is frequently referred to as a market where some oligopsony power is exercised.

22. Opportunity Cost.

The most highly valued opportunity forgone when an investment action is taken. The investment may involve any use time or resources of value.

23. Pareto-optimization (Pareto-efficiency) .

Efficiency related to a society. It includes the cost of returning losers to their former level of welfare by forcing winners to pay for the redistribution. Applications can be global, national, or regional.

24. Present Value.

The amount which a person would be willing to pay today to obtain the right to a certain amount or series of amounts in the future as estimated through use of a discount rate.

25. Stream (income, benefits or cost).

a. Time series of benefits or costs. Reoccurring benefits or costs which take place over a long time horizon.

b. A series of dollar amounts such as an income or cost stream extending into the past or future for a specific number of years.

26. Unaided Stock.

See aided stock.

27. User Costs.

Accounting costs incurred by a consumer in the process of obtaining a good. In the case of a sport fisherman they would be the total out of pocket expenses used for during unit of time in the process of sport fishing opportunities. It does not include opportunity cost.

28. Variable Assumptions.

An assumption used in the HBD or FBC models which be varied by the user when the simulation computer programs are operated.

29. Wild Stock.

A stock of fish which has never been impacted by human activity such as fishing pressure or changes in environmental conditions.

ACKNOWLEDGMENTS

We would like to thank the following reviewers for comments and recommendations made on earlier drafts of the documentation. They are Dr. David Reaume, Economist; Dr. John Karpoff, Economist, University of Alaska; Dr. Doug Larson, Economist, North Pacific Management Council; Dr. Jim Crutchfield, Economist, University of Washington; and Dr. Fred Johnson, Mathematician, Resource Consultants Associates. We also would like to acknowledge additional members of the economic working group including Brynn Keith, Jeff Hansen, Susan Lindauer and Hal Tavzel and the F.R.E.D. Report System regional editor Mike Kaill.

REFERENCES

Anonymous. 1977. Life Cycle Cost Analysis done for Department of Public Works (now Department of Transportation and Public Facilities) by Hanscomb Associates, Inc. File copy at FRED Div. Alaska Department of Fish and Game, Anchorage.

Brown, William C., Douglas Larson, Richard Johnson, and Roy Wahle. 1976. Improved Evaluation of Commercially and Sport-Caught Salmon and Steelhead of the Columbia River. Corvallis. Oregon State University Agricultural Experiment Station Special Report 463.

Clark, Colin W. 1976. Mathematical Bioeconomics: The Optimal Management of Renewable Resources. John Wiley & Sons, Inc. 337pp.

Crutchfield, J. A., S. Laugdon, O. A. Mathisen, and P. H. Poe. 1982. The biological, economic, and social valves of a sockeye salmon stream in Briston Bay, Alaska: a case study of Tazimna River. Fisheries Res. Inst. University of Washington. Circular No. 82-2.

Development Planning and Research Associates, Inc. (DPRA) 1982. Alaska salmon projected 1982 market conditions. Manhattan, Kansas.

Hall, C.A.S. and J.W. Day, Jr. 1977. Systems and Models: Terms and basic principles, pp. 5-36. In C.A.S. Hall and J.W. Day, Jr., Ecosystem modeling in theory and practice. John Wiley and Sons, New York.

Hartman, Jeff and Kit Rawson. 1982. F.R.E.D Division Enhancement Benefit-Cost Model. Alaska Department of Fish and Game, Anchorage. Unpublished.

Hartman, Jeff. 1983. Fishery and Economic Assumptions for 1982/1983 FRED Enhancement and Rehabilitation Simulations. Alaska Department of Fish and Game, Anchorage. Unpublished.

Johnson, Fredrick C. 1974. Hatch, a Model for Fish Hatchery Analysis. National Bureau of Standards Report #74521.

Kreinheder, Jack and David Teal. 1982. The Alaska Fishing Industry. Alaska House Research Agency Report 81-4, Alaska State Legislature, Juneau.

Larson, D. 1982. Recent advances in recreation valuation: a literature search. Alaska Sea Grant College Program. Unpublished report.

Lindauer, S. and J. Hartman. 1983. An analysis of net benefits from proposed capital improvement investments state salmon hatcheries. Alaska Department of Fish and Game, Anchorage. Unpublished.

Main, R.S. and C.W. Baird. 1981. Elements of microeconomics. West Publishing Co., St. Paul.

McConnell, K. E. 1979. Values of marine recreational fishing: measurement and inpact of measurement. Am. Jour. Agricultural Econ. 61(5): 921-925.

McKusick, Robert B., Glenn Keto, Diane Dempster, Susan Bochsler and Hans Radtke. 1981. CRFDP Operators Manual. Production and Economic Data Collection and Reporting for the Columbia River Fisheries Development Program. Northwest Economic Associates, Vancouver. Unpublished.

Miernky, William H. 1965. The Elements of Input-Output Analysis. Random House, New York.

Muse and Schelle, K. 1983. A fiscal model for the Southeast Alaska salmon drift gill net fishery - 1981. Alaska Commercial Fisheries Entry Commission Draft Report.

Randall, Alan. 1981. Resource Economics. Grid Publishing Inc., Columbus, Ohio.

Rawson, Kit, Jeff Hartman, and Hal Tavzel. 1983a. Users' Guide: The Alaska Hatchery Broodstock Development System. Alaska Department of Fish and Game, Anchorage. Unpublished.

Rawson, Kit, Jeff Hartman, and Hal Tavzel. 1983b. Users' Guide: The Alaska Rehabilitation and Enhancement Facility Cost-Benefit Simulation System. Alaska Department of Fish and Game, Anchorage.

Reaume, David M. 1977. Studying the Impact of Potential Development. The Alaska Policy Planning Model (Preliminary Report). Paper presented at the meetings of the Western Economics Association, Juneau, Alaska.

Reed, D. 1980. FACSIM, A Computer Program to Aid in Hatchery Facility Planning. Alaska Department of Fish and Game, Division of FRED, Juneau. Unpublished.

Sloan, H. S. and A. J. Zurcher. 1958. A dictionary of economics. Barnes and Noble, Inc., New York.

Walker, K. D., R. R. Rettig, and H. Hilborn. 1983. Analysis of Multiple Objectives in Oregon Coho Salmon Policy. Can. J. Fish. Aquat. Sci. 40:580-587.

Walters, C. J. 1980. Systems principles in fishery management. pp. 167-184. In R. T. Lackey and L. A. Neilsen, fisheries management. John Wiley and Sons, New York.

Yould, Eric P. 1982. The Susitna Hydro Studies. Alaska Power Authority, Anchorage.

Youmans, Russell, William Rempa, and Edward Ives. 1977. The Tillamook County Economy: A Working Model for Evaluating Economic Change. Corvallis. Oregon State University Extension Service Special Report 478.

PERSONAL COMMUNICATIONS

Aberle, Bill, Economist, Alaska Department of Commerce and Economic Development, Commerical Fisheries Development Division, Anchorage, Alaska 99501

Mills, Mike, Biometrician, Alaska Department of Fish and Game, Sport Fish Division, Anchorage, Alaska 99502

APPENDIX A

EQUATIONS FOR THE HATCHERY BROODSTOCK DEVELOPMENT MODEL

APPENDIX A

EQUATIONS FOR THE HATCHERY BROODSTOCK DEVELOPMENT MODEL

The HBD model is a discrete event simulation model which projects the development of a hatchery broodstock over a longtime horizon based upon preliminary data, survival assumptions, assumptions about commercial and sport fishery interception rates, assumptions about the fecundity of female fish, and assumptions about the required natural stream escapement for fishery management. The model was expanded from an earlier broodstock development model developed by Reed (1980).

The notation used in this appendix is contained in Table 1.

Fishery Interception, Escapement, and Hatchery Broodstock

First of all, the total number of returning adults in a year, j, is the sum of the total number of returning adults in up to 6 age classes.

$$R_j = \sum_{i=1}^{6} R_{ij} \qquad [A1]$$

The total returning adults are then divided into components of stream escapement, commercial fishery interception, sport fishery interception, hatchery escapement (that is, the fish that are used by the hatchery for egg-take), and excess escapement.

$$R_j = E_j + (C_j + S_j) + H_j + X_j \qquad [A2]$$

The excess escapement might represent fish available to a terminal commercial fishery or possibly fish available for sale by a hatchery. In our Facility Benefit-Cost model this excess escapement is divided into components of sport and commercial catch and combined with the commercial and sport interceptions.

The stream escapement is calculated as the maximum of i) a multiplicative factor times the total number of returning adults, or ii) the minimum absolute stream escapement required. If the total return is less than the minimum required stream escapement then all of the fish in the return are assumed to go to stream escapement.

$$E_j = \max [mR_j, \min (a_j, R_j)] \qquad [A3]$$

The commercial and sport interceptions are then calculated from the fish remaining after the stream escapement has been accounted for.

$$C_j = r_{cj} (R_j - E_j) \qquad [A4]$$

$$S_j = r_{sj} (R_j - E_j) \qquad [A5]$$

Table 1: Notation for the hatchery broodstock development model. Lower case symbols are quantities for which values must be assumed. Upper case symbols are quantities calculated from the assumptions according to the equations in this Appendix.

Symbol	Meaning
R_j	Total returning adults in year j
R_{ij}	Total returning adults of age i in year j
E_j	Stream escapement in year j
C_j	Commercial fishery interception in year j
S_j	Sport fishery interception in year j
H_j	Hatchery escapement in year j
X_j	Excess escapement in year j
m	Multiplicative factor for required stream escapement
a_j	Minimum required stream escapement in year j
r_{cj}	Commercial fishery interception rate in year j
r_{sj}	Sport fishery interception rate in year j
p_i	Proportion of the return at age i that is female
q_i	The proportion of the fish that return at age i
f	Mean fecundity (eggs/female)
F_j	Proportion of the total return for year j that is females
$c_{ef,j}$	Hatchery capacity for emergent production fry in year j
$c_{ff,j}$	Hatchery capacity for fed fry releases in year j
$c_{f,j}$	Hatchery capacity for fingerling releases in year j
$c_{s,j}$	Hatchery capacity for smolt releases in year j
$s_{ge,ee}$	Survival proportion from green egg to eyed egg
$s_{ee,ef}$	Survival proportion from eyed egg to emergent fry
$s_{ef,ff}$	Survival proportion from emergent fry to fed fry
$s_{ff,f}$	Survival proportion from fed fry to fingerling
$s_{f,s}$	Survival proportion from fingerling to smolt
$N_{ge,j}$	Number of green eggs in year j
$N_{ee,j}$	Number of eyed eggs in year j
$N_{ef,j}$	Number of emergent fry in year j
$L_{ef,j}$	Releases of emergent fry in year j
$L_{ff,j}$	Releases of fed fry in year j
$L_{f,j}$	Releases of fingerlings in year j
$L_{s,j}$	Releases of smolt in year j
k	Age of migration for smolt (usually 1)
o_{ef}	Ocean survival proportion from release as emergent fry
o_{ff}	Ocean survival proportion from release as fed fry
o_f	Ocean survival proportion from release as fingerling
o_s	Ocean survival proportion from release as smolt

In order to calculate the hatchery escapement, the proportion of the return for the year that is females must be first computed by multiplying the percent of females at each age class by the number of fish returning for that age class and dividing by the total return for the year.

$$F_j = \left(\sum_{i=1}^{6} p_{iq} R_{ij}\right)/R_j \qquad [A6]$$

The hatchery escapement is calculated by determining how many females are needed for the eggtake and then including an equal number of males in the hatchery escapement. If there are not enough fish left over after the stream escapement and the commercial and sport harvests have been subtracted to fill the hatchery with eggs, then all of the remaining fish in the return become the hatchery escapement, and the hatchery will get however many eggs are available from those fish.

$$H_j=\min[(R_j-E_j-C_j-S_j),\ F_j(R_j-E_j-C_j-S_j)\ C_{ef,j+1}/(fs_{fe,ee}s_{ee,ef})] \qquad [A7]$$

The excess escapement includes any fish that remain after the other components have been taken out of the return.

$$X_j = R_j - E_j - C_j - S_j - H_j \qquad [A8]$$

Eggs, Fry, and Releases

The number of green eggs loaded into the hatchery in year j are calculated by multiplying the fecundity assumption times the number of females in the hatchery escapement that year.

$$N_{ge,j} = f_q(H_j/2) \qquad [A9]$$

The number of eyed eggs in year j are calculated by multiplying the assumed green egg to eyed egg survival times the number of green eggs loaded.

$$N_{ee,j} = s_{ge,ee}N_{ge,j} \qquad [A10]$$

The number of emergent fry in the following year, j + 1, are calculated by multiplying the assumed eyed egg to emergent fry survival times the number of eyed eggs in year j.

$$N_{ef,j+1} = s_{ee,ef}N_{ee,j} \qquad [A11]$$

Releases of fish are projected from the computed number of emergent fry, the within hatchery survival assumptions, and the assumptions about the capacity of the hatchery to release fish at different life stages. The pool of emergent fry in year j + 1 is considered to be available to provide fish for release at the fingerling, fed fry, and emergent fry stages in year j + 1 and at the smolt stage in year j + 1 + k, where k is the number of winters that smolt (if any) are kept in the facility before release. In case the facility is able to release fish at more than one life stage, the more advanced life stages will take precedence over the others. Therefore, the number of smolt released in year j + 1 + k is calculated first.

$$L_{s,j+1+k} = \min [s_{f,s}\ s_{ff,f}\ s_{ef,ff} + N_{ef,j+1};\ c_{s,\ j+k}] \qquad [A12]$$

Then the number of fingerlings released in year j + 1 is calculated from the pool of emergent fry remaining after those necessary to produce the smolt release have been subtracted out.

$$L_{f,\ j+1} = \min [(s_{ff,f} s_{ef,ff} N_{ef,j+1}) - (Ls,j+1+k / s_{fq,s});\ c_{fq,j+1}] \qquad [A13]$$

Then the fed fry releases are calculated from the pool of emergent fry remaining after the smolt and fingerling releases have been accounted for.

$$L_{ff,j+1} = \min [s_{ef,ff} N_{ef,j+1} - (L_{f,j+1} /, s_{ff}) - (L_{s,j+1+k} / s_{ff,f}, s_{f,s}) c_{ff,j+1}] \qquad [A14]$$

Finally, the emergent fry releases are those emergent fry left over, if any, after the emergent fry necessary to produce the releases at the other life stages have been accounted for.

$$L_{ef,j+1} = N_{ef,j+1} - (L_{ff,j+1} / s_{ef,ff}) - (L_{f,j+1} / s_{ef,ff} s_{ff,f}) - (L_{s,j+1+k} / s_{ef,ff} s_{ff,f} s_{f,j}),j+1+k \qquad [A15]$$

Returning Adults

The number of returning adults is calculated from the release numbers, the assumed ocean survival rates, and the assumed age distribution for the species. A separate computation is made for each age class in the return.

$$R_{i,j+1+i} = q_i [o_{ef} L_{ef,j+1} + o_{ff} L_{ff,j+1} + o_f L_{f,j+1} + o_j L_{s,j+1}] \qquad [A16]$$

All of the adult returns in a single year are combined to give total adult return, and the cycle begins again with equation [A1].

APPENDIX B

EQUATIONS FOR THE FACILITY BENEFIT-COST MODEL

APPENDIX B

EQUATIONS FOR THE FACILITY BENEFIT-COST MODEL

Table 2 contains the definitions of all variables used in calculations for the FBC model. There are two levels of equations described here. The first are the foundation equations, that is, those equations which take information directly from the results of an HBD simulation and additional economic assumptions. The second level includes those equations used for producing the overall economic projections, such as the incremental value or impact value of an enhanced stock. These computations use the results calculated from the foundation equations.

Foundation Equations

The foundation equations are structured to enable the model to deal with a wide variety of policy questions. Some of these will involve ex-post and/or ex-ante analysis. Therefore the need for discounting of past benefits and costs results in the ability to shift back to the first year of the ex-post analysis or shifting to the base year for future oriented simulations. While the foundation equations leave the impression of only being able to solve combined ex-post ex-ante questions, analysis may be restricted to one or the other or both. In fact most policy questions only require ex-ante analysis.

The input variable for the base economic year determines when the discounting starts.

The gross incremental revenue (as a present value) of the commercial harvest for a series of past and future years from hatchery or enhancement produced fish is computed as follows:

$$HR = \sum_{j=1}^{S} \sum_{k=1}^{G_j} \left[\sum_{i=F}^{B-1} W_j (CH)_{ij} (FG)_{kj} (AP)_{ijke} + D_i \sum_{i=B}^{L} W_j (CH)_{ij} (FG)_{kj} (PR)_{jkl} D_i \right]. \qquad [B1]$$

The marginal cost of the commercial fishery harvest in base year dollars for members of the fishing fleet who participated in the harvest of enhancement produced fish is computed as follows:

$$HC = \sum_{j=1}^{S} \sum_{k=1}^{G_j} \left[\sum_{i=F}^{B-1} W_j (CH)_{ij} (FG)_{kj} (AP)_{ijke} D_i + \sum_{i=B}^{L} W_j (CH)_{ij} (FG)_{kj} (CR)_{jkl} D_i \right]. \qquad [B2]$$

Table 2. Definitions of variables used in the FBC Model.

F	=	First Year of Hatchery Operation
E	=	Economic Base Year
B	=	First year of Broodstock Simulation
L	=	Final year of economic simulation
AP_{ie}	=	Adjusted demand price per pound of previously caught fish from price index e in year i
CP	=	Cost per pound of previously caught fish from price index e
r	=	Interest rate
D_i	=	Discount Factor: $D_i = \dfrac{1}{[1 + r]^{(i - E)}}$
PO_i	=	Past Operational Cost in year i
FO_i	=	Future Operational Cost in year i
PC_i	=	Past Capital cost in year i
FC_i	=	Future Capital cost in year i
S	=	Number of species
CH_{ij}	=	Number of fish harvested by commercial fishery for given species j in year i
G_j	=	Number of Gear Types for species j
F_j	=	Percent Fresh Frozen for species j
MF_j	=	$F_j/100$ - a multiplicative factor for portion Fresh Frozen for species j
C_j	=	Percent Canned for species j
MC_j	=	$C_j/100$ - a multiplicative factor for portion canned for species j
RF_j	=	Recovery Factor of Fresh Frozen Fish for species j
RC_j	=	Recovery Factor of Canned Fish for species j
WC_{ji}	=	Wholesale price/lb. of Canned Fish for species j for i years
WF_{ji}	=	Wholesale price/lb. of Fresh Frozen for species j for i years
CC_{ji}	=	Cost per processed lb. of Canned for species j for i years

-Continued-

Table 2. Continued.

CF_{ji}	=	Cost per processed lb. of Fresh Frozen for species j for i years
PC_{kj}	=	Percent of commercial harvest attributed to gear type k, species j
FG_{kj}	=	Factor $PC_{kj}/100$ - a multiplicative factor of commercial harvest attributable to gear type k, species j.
PR_{kji}	=	Price per lb. in round for each gear type k, species j, year i
CR_{kji}	=	Cost per lb. in round for fisherman gear type k, species j, year i
CA_j	=	catch/angler day for species j
VA_j	=	value/angler day for species j
PE_j	=	Percent of female biomass which is eggs, species j
FE_j	=	Factor of female biomass which is eggs for species j ($PE_j/100$)
PA_j	=	Percent of females which are attributed to egg harvest for species j
FA_j	=	Factor of females which are attributed to egg harvest species j ($PA_j/100$)
WE_j	=	Price per lb. for eggs for species j
W_j	=	Weight/fish for species j
SH_{ij}	=	number of fish harvested by the sport fishery year i, species j
j	=	subscript for a given species j
k	=	subscript for a given gear type k
i	=	subscript for a given year i
e	=	subscript for specific adjustment of a given price or cost
WR	=	wholesale revenue from canned or fresh frozen salmon (Present value)
WC	=	Wholesale processing costs of fresh frozen and canned product (Present value)
HR	=	Harvest Revenue from all species (Present value)
HC	=	Harvest Cost (present value)
ER	=	Egg Sale Revenue or Profit (present value)
SV	=	Value from sport fishing effort present value
f_{HP}	=	Factor of economic impact of harvest profit
f_{HC}	=	Factor of impact to commercial harvest cost
f_{FI}	=	Factor of impact of facility capital investment
f_{FO}	=	Factor of impact of facility operational cost

-Continued-

Table 2. Continued.

f_{WP}	=	Factor of impact of processors profit
f_{WC}	=	Factor of impact of processors cost
f_{ER}	=	Factor of impact of egg sale value
1a MR	=	Marginal revenue of commercial fishing and sport fishing effort.
$2a_1$ DV	=	Direct value of commercial fishing and sportfishing effort.
$2a_2$ DV	=	Period or year of payback for 2a.
2_b I	=	Impact income from DV
2c	=	Ratio of impact income over costs
$3a_1$ DP	=	Profitability of processors and fisherman and value of sport fishing effort less hatchery costs.
$3b_1$ I	=	Impact income form sport fishing effort, commercial fishery, processing industry and hatchery capital and operational investment
4_{a1} DP	=	Profitability of processors and fisherman including egg sale values less hatchery costs.
$4b_1$ I	=	Impact income from sportfishing effort commercial fishery, processing industry and egg sale value over total processing cost, harvest cost and facility costs.

The wholesale revenue (usually marginal revenue) in base year dollars of fresh frozen and canned fish sold by a processors is computed as follows:

$$WR = \sum_{j=1}^{S} \left[\sum_{i=F}^{B-1} W_j (CH)_{ij} [(MC)_j (RC)_j (AP)_{ije} D_i + (MF)_j (RF)_j (AP)_{ije}] \right.$$

$$\left. + \sum_{i=B}^{L} W_j (CH)_{ij} [(MC)_j (RC)_j (WC)_{ji} \; D_i + (MF)_j (RF)_j (WF)_{ji} \; D_i] \right].$$

[B3]

The cost to the processor in base year dollars attributed to the incremental cost of producing canned and fresh-frozen product from enhancement produced fish over a stream of past and future years is computed as follows (The wholesale cost includes the purchase price of the landed fish):

$$WC = \sum_{j=1}^{S} \left[\sum_{i=F}^{B-1} W_j \; (CH)_{ij} \; [(MC)_j (RC)_j (AP)_{ije} \; D_i + (MF)_j (RF)_j (AP)_{ije} \; D_i] \right.$$

$$\left. + \sum_{i=B}^{L} W_j (CH)_{ij} [(MC)_j (RC)_j (CC)_{ji} \; D_i + (MF)_j (RF)_j (CF)_{ji} \; D_i] \right]. \quad [B4]$$

The gross or net revenues from the sale of eggs from past and future stream of enhancement-produced salmon is computed as follows:

$$ER = \sum_{j=1}^{S} \sum_{i=F}^{L} [W_j \; (CH)_{ij} \; (FE)_i \; (FA)_j \; (WE)_j \; D_i]. \qquad [B5]$$

The present value (usually marginal) of sport fishing effort spent on harvesting enhancement produced fish from past and future years is computed as follows:

$$SR = \sum_{j=1}^{S} \sum_{i=F}^{L} \lceil (SH)_{ji} / (CA)_{j} \rceil \, (VA)_{j} \, D_{i}. \qquad \lceil B6 \rceil$$

The equation for past and future facility operational costs are computed as follows:

$$OC = \sum_{i=F}^{B-1} \lceil (PO)_{i} (AP)_{ie} D_{i} + \sum_{i=B}^{L} (FO)_{j} \, D_{i} \rceil. \qquad \lceil B7 \rceil$$

The past and future facility capital costs are computed as follows:

$$FI = \sum_{i=F}^{B-1} \lceil (PC)_{i} \, (AP)_{ie} D_{i} + \sum_{i=B}^{L} (FI)_{j} \, D_{i} \rceil. \qquad \lceil B8 \rceil$$

<u>Overall Calculations</u>

Model 1:

Model 1 uses the estimated gross revenue or marginal revenue of the commercially landed fish (HR) and the marginal value of the sport fishery (SR)less the life cycle costs of the hatchery or project investment (FI) and operation, administration, evaluation, and maintenance (FO).

1a. $MV = HR + SV - (FI + FO)$ ⌈B9⌉

$1a_{2.}$ year where $MV \geq 0$ (where the year is a positive integer) ⌈B10⌉

1c. $B:C = (HR + SV) / (FI + FO)$ ⌈B11⌉

Model 2:

Model 2 is the same as Model 1, with the addition of the incremental cost of the enhancement generated commercial fishery effort. Also, in 2b (equations ⌈B14⌉ and ⌈B15⌉) the impact income of the incremental harvest value, incremental harvest cost and marginal facility cost is estimated by applying the appropriate regional or state income multiplier. 2c (equation ⌈B16⌉) uses the same terms as 2b, but expresses the present value of impact income in the state or region as a ratio.

$2a_1$. $DV = SV + HR - HC - (FI + FO)$ [B12]

$2a_2$. year when $DV \geq 0$ [B13]

$2b_1$. $I = SV + f_{HP} (HR - HC) + f_{HC} HC + f_{FI} FI + f_{FO} FO$ [B14]

$2b_2$. year when $I \geq 0$ [B15]

2c. $B:C = (SV + f_{HP} (HR - HC) + f_{HC} HC + f_{FI} FI + f_{FO} FO) / (FI + FO)$ [B16]

Model 3:

Model 3 considers the processing sector in addition to those factors in Model 2. In 3a (equation [B17]) the profitability of the commercial sector is estimated as in 2a. Similarly, the profit or value of the processing sector is taken to be revenue less incremental cost. The sport fishing value is treated as in 1 a,c and 2 a,b,c.

In 3b (equation [B19]) externally generated multiplicative factors to the profitability and costs of the commercial fishing and processing sector as well as the capital and operational costs of the enhancement or rehabilitation project.

The benefit-cost ratio for model 3c (equation [B21]) is simply the impact income from 3b (equation [B19]) divided by the standard capital and operational costs of the facility.

$3a_1$. $DP = SV + (WR - WC) + (HR - HC) - (FI + FO)$ [B17]

$3a_2$. year when $DP \geq 0$ [B18]

$3b_1$. $I = SV + (WR - WC) + (WC - HR) + (HR - HC) + f_{HC} HC + f_{FI} FI + f_{FO} FO$ [B19]

$3b_2$. year when $I \geq 0$ [B20]

3c. $B:C \left[SV + f_{WP}(WR - WC) + f_{WC}(WC - HR) + f_{HP}(HR - HC) + f_{HC} HC + f_{FI} FI + f_{FO} FO \right] (FI + FO)$ [B21]

Model 4:

Model 4 is an exact duplicate of Model 3, with the additional marginal or incremental value of the sac roe sales.

$4a_1$. $DP = SV + (WR - WC) + (HR - HC) + ER - (FI + FO)$ [B22]

4a$_2$. year when $DP \geq 0$ [B23]

4b$_1$. $$I = SV + f_{WP}(WR - WC) + f_{WC}(WC - HR) + f_{HP}(HR - HC) + f_{HC}\, HC + f_{ER}\, ER + f_{FI}\, FI + f_{FO}\, FO \qquad [B24]$$

4b$_2$. year when $I \geq 0$ [B25]

4c. $$B:C = \left[SV + f_{WP}(WR - WC) + f_{WC}(WC - HR) + f_{HP}(HR - HC) + f_{HC}\, HC\, f_{ER}\, ER + f_{FI}\, FI + f_{FO}\, FO\right] (FI + FO) \qquad [B26]$$

APPENDIX C

EXAMPLE OF HBD OUTPUT

This appendix contains an example of the computer output from the HBD Model. The first three pages list the input variables for the model (referred to as "assumptions" on the printout). The remaining pages contain the output variables by year.

ASSUMPTIONS FOR BROODSTOCK DEVELOPMENT PROGRAM

HATCHERY: KITOI HATCHERY SPECIES: PINK

FIRST YEAR	DURATION	EUROPEAN RELEASE AGE
1983	22 YRS.	0.0

SURVIVALS IN THE HATCHERY (PERCENT):

FROM:	GREEN EGGS	EYED EGGS	EMERGENT FRY	FED FRY	FINGERLINGS
TO:	EYED EGGS	EMERGENT FRY	FED FRY	FINGERLINGS	SMOLT
	90.00%	95.00%	95.00%	95.00%	000.00%

SURVIVALS (PERCENT) TO ADULT STAGE FROM RELEASE AS:

EMERGENT FRY	FED FRY	FINGERLINGS	SMOLT
1.70%	000.00%	3.20%	000.00%

PERCENT OF RETURN BY EUROPEAN AGE:

0.0	.1	.2	.3	.4	.5	.6
000.00%	100.00%	000.00%	000.00%	000.00%	000.00%	000.00%

FEMALE PERCENT OF RETURN BY EUROPEAN AGE:

0.0	.1	.2	.3	.4	.5	.6
000.00%	50.00%	000.00%	000.00%	000.00%	000.00%	000.00%

FECUNDITY (EGGS PER FEMALE)	PERCENT ADULT HOLDING MORTALITY
1600.	1.00%

MINIMUM PERCENT STREAM ESCAPEMENT: 000.00%

MINIMUM ANNUAL STREAM ESCAPEMENT BY YEAR:

	1983	1984	1985	1986	1987	1988	1989
MIN. ANN. ESCAPE	6000.	6000.	6000.	6000.	6000.	6000.	6000.

	1990	1991	1992	1993	1994	1995	1996
MIN. ANN. ESCAPE	6000.	6000.	6000.	6000.	6000.	6000.	6000.

	1997	1998	1999	2000	2001	2002	2003
MIN. ANN. ESCAPE	6000.	6000.	6000.	6000.	6000.	6000.	6000.

	2004
MIN. ANN. ESCAPE	0.

HATCHERY: KITOI HATCHERY SPECIES: PINK

FISHERY INTERCEPTION RATES (PERCENT) BY YEAR:

	1983	1984	1985	1986	1987	1988	1989
COMMERCIAL	85.00%	85.00%	85.00%	85.00%	85.00%	85.00%	85.00%
SPORT	000.00%	000.00%	000.00%	000.00%	000.00%	000.00%	000.00%

	1990	1991	1992	1993	1994	1995	1996
COMMERCIAL	85.00%	85.00%	85.00%	85.00%	85.00%	85.00%	85.00%
SPORT	000.00%	000.00%	000.00%	000.00%	000.00%	000.00%	000.00%

	1997	1998	1999	2000	2001	2002	2003
COMMERCIAL	85.00%	85.00%	85.00%	85.00%	85.00%	85.00%	85.00%
SPORT	000.00%	000.00%	000.00%	000.00%	000.00%	000.00%	000.00%

	2004
COMMERCIAL	85.00%
SPORT	000.00%

HATCHERY CAPACITIES (MILLIONS) BY YEAR:

	1983	1984	1985	1986	1987	1988	1989
EMERGENT FRY	73.500	73.500	73.500	73.500	73.500	73.500	73.500
FED FRY	8.000	8.000	8.000	8.000	8.000	8.000	8.000
FINGERLINGS	7.220	7.220	7.220	7.220	7.220	7.220	7.220
SMOLT	.000	.000	.000	.000	.000	.000	.000

	1990	1991	1992	1993	1994	1995	1996
EMERGENT FRY	73.500	73.500	73.500	73.500	73.500	73.500	73.500
FED FRY	8.000	8.000	8.000	8.000	8.000	8.000	8.000
FINGERLINGS	7.220	7.220	7.220	7.220	7.220	7.220	7.220
SMOLT	.000	.000	.000	.000	.000	.000	.000

	1997	1998	1999	2000	2001	2002	2003
EMERGENT FRY	73.500	73.500	73.500	73.500	73.500	73.500	73.500
FED FRY	8.000	8.000	8.000	8.000	8.000	8.000	8.000
FINGERLINGS	7.220	7.220	7.220	7.220	7.220	7.220	7.220
SMOLT	.000	.000	.000	.000	.000	.000	.000

	2004
EMERGENT FRY	.000
FED FRY	.000
FINGERLINGS	.000
SMOLT	.000

HATCHERY: KITOI HATCHERY SPECIES: PINK

PRELIMINARY DATA FOR BROODSTOCK DEVELOPMENT PROGRAM

NUMBER OF ADULTS RETURNING FROM PREVIOUS RELEASES
BY YEAR, BY EUROPEAN AGE:

AGE	1983
.1	851445.

REMOTE EGG TAKES (MILLIONS) BY YEAR:

1983	.000	1984	.000	1985	.000	1986	.000	1987	.000
1988	.000	1989	.000	1990	.000	1991	.000	1992	.000
1993	.000	1994	.000	1995	.000	1996	.000	1997	.000
1998	.000	1999	.000	2000	.000	2001	.000	2002	.000
2003	.000	2004	.000						

1983 EMERGENT FRY (MILLIONS): 73.530

HATCHERY: KITOI HATCHERY SPECIES: PINK

YEAR	1983	1984	1985	1986	1987	1988	1989
HATCHERY ADULTS/AGE							
.1	851445.	1201892.	1201382.	1201382.	1201382.	1201382.	1201382.
TOTAL	851445.	1201892.	1201382.	1201382.	1201382.	1201382.	1201382.
STREAM ESCAPEMENT	6000.	6000.	6000.	6000.	6000.	6000.	6000.
COMMERCIAL INTERCEPT.	718628.	1016508.	1016075.	1016075.	1016075.	1016075.	1016075.
SPORT INTERCEPT.	0.	0.	0.	0.	0.	0.	0.
HATCHERY ESCAPEMENT	108542.	108542.	108542.	108542.	108542.	108542.	108542.
EXCESS ESCAPEMENT	18275.	70842.	70766.	70766.	70766.	70766.	70766.
HATCHERY INVENTORIES (MILLIONS)							
GREEN EGGS	85.965	85.965	85.965	85.965	85.965	85.965	85.965
EYED EGGS	77.368	77.368	77.368	77.368	77.368	77.368	77.368
EMERGENT FRY	73.530	73.500	73.500	73.500	73.500	73.500	73.500
RELEASES (MILLIONS)							
EMERGENT FRY	57.109	57.079	57.079	57.079	57.079	57.079	57.079
FED FRY	8.000	8.000	8.000	8.000	8.000	8.000	8.000
FINGERLINGS	7.220	7.220	7.220	7.220	7.220	7.220	7.220
SMOLT	.000	.000	.000	.000	.000	.000	.000

HATCHERY: KITOI HATCHERY SPECIES: PINK

YEAR	1990	1991	1992	1993	1994	1995	1996
HATCHERY ADULTS/AGE							
.1	1201382.	1201382.	1201382.	1201382.	1201382.	1201382.	1201382.
TOTAL	1201382.	1201382.	1201382.	1201382.	1201382.	1201382.	1201382.
STREAM ESCAPEMENT	6000.	6000.	6000.	6000.	6000.	6000.	6000.
COMMERCIAL INTERCEPT.	1016075.	1016075.	1016075.	1016075.	1016075.	1016075.	1016075.
SPORT INTERCEPT.	0.	0.	0.	0.	0.	0.	0.
HATCHERY ESCAPEMENT	108542.	108542.	108542.	108542.	108542.	108542.	108542.
EXCESS ESCAPEMENT	70766.	70766.	70766.	70766.	70766.	70766.	70766.

HATCHERY INVENTORIES (MILLIONS)

GREEN EGGS	85.965	85.965	85.965	85.965	85.965	85.965	85.965
EYED EGGS	77.368	77.368	77.368	77.368	77.368	77.368	77.368
EMERGENT FRY	73.500	73.500	73.500	73.500	73.500	73.500	73.500

RELEASES (MILLIONS)

EMERGENT FRY	57.079	57.079	57.079	57.079	57.079	57.079	57.079
FED FRY	8.000	8.000	8.000	8.000	8.000	8.000	8.000
FINGERLINGS	7.220	7.220	7.220	7.220	7.220	7.220	7.220
SMOLT	.000	.000	.000	.000	.000	.000	.000

RESULTS OF BROODSTOCK DEVELOPMENT SIMULATION PAGE 3

HATCHERY: KITOI HATCHERY SPECIES: PINK

YEAR	1997	1998	1999	2000	2001	2002	2003
HATCHERY ADULTS/AGE							
.1	1201382.	1201382.	1201382.	1201382.	1201382.	1201382.	1201382.
TOTAL	1201382.	1201382.	1201382.	1201382.	1201382.	1201382.	1201382.
STREAM ESCAPEMENT	6000.	6000.	6000.	6000.	6000.	6000.	6000.
COMMERCIAL INTERCEPT.	1016075.	1016075.	1016075.	1016075.	1016075.	1016075.	1016075.
SPORT INTERCEPT.	0.	0.	0.	0.	0.	0.	0.
HATCHERY ESCAPEMENT	108542.	108542.	108542.	108542.	108542.	108542.	108542.
EXCESS ESCAPEMENT	70766.	70766.	70766.	70766.	70766.	70766.	70766.
HATCHERY INVENTORIES (MILLIONS)							
GREEN EGGS	85.965	85.965	85.965	85.965	85.965	85.965	85.965
EYED EGGS	77.368	77.368	77.368	77.368	77.368	77.368	77.368
EMERGENT FRY	73.500	73.500	73.500	73.500	73.500	73.500	73.500
RELEASES (MILLIONS)							
EMERGENT FRY	57.079	57.079	57.079	57.079	57.079	57.079	57.079
FED FRY	8.000	8.000	8.000	8.000	8.000	8.000	8.000
FINGERLINGS	7.220	7.220	7.220	7.220	7.220	7.220	7.220
SMOLT	.000	.000	.000	.000	.000	.000	.000

HATCHERY: KITOI HATCHERY SPECIES: PINK

YEAR	2004
HATCHERY ADULTS/AGE	
.1	1201382.
TOTAL	1201382.
STREAM ESCAPEMENT	0.
COMMERCIAL INTERCEPT.	1021175.
SPORT INTERCEPT.	0.
HATCHERY ESCAPEMENT	0.
EXCESS ESCAPEMENT	180207.

HATCHERY INVENTORIES (MILLIONS)

GREEN EGGS	.000
EYED EGGS	.000
EMERGENT FRY	73.500

RELEASES (MILLIONS)

EMERGENT FRY	73.500
FED FRY	.000
FINGERLINGS	.000
SMOLT	.000

APPENDIX D

EXAMPLE OF FBC OUTPUT

This appendix contains an example of the computer output from the FBC model. The first four pages list the input variables (called "assumptions" on the printout). The remaining pages are the output variables. This is an example of an *ex ante* analysis, so even though the hatchery began operation in 1975, costs and benefits before 1982 are not considered.

FACILITY: KITOI HATCHERY

FACILITY-WIDE ECONOMIC ASSUMPTIONS

FIRST YEAR OF FACILITY OPERATIONS - 1975
FIRST YEAR OF BROODSTOCK SIMULATION - 1983
FINAL YEAR OF ECONOMIC SIMULATION - 2006
ECONOMIC BASE YEAR - 1982

INTEREST RATE - 3.00%

FACILITY ANNUAL CAPITAL AND OPERATIONAL COSTS (IN 1000'S OF $)

	1975	1976	1977	1978	1979	1980	1981
CAPITAL COST:	.0	.0	.0	.0	.0	.0	.0
OPERATIONAL COST:	.0	.0	.0	.0	.0	.0	.0

	1982	1983	1984	1985	1986	1987	1988
CAPITAL COST:	.0	.0	.0	.0	.0	.0	.0
OPERATIONAL COST:	522.0	472.5	472.5	472.5	472.5	472.5	472.5

	1989	1990	1991	1992	1993	1994	1995
CAPITAL COST:	.0	.0	.0	.0	.0	.0	.0
OPERATIONAL COST:	472.5	472.5	472.5	472.5	472.5	472.5	472.5

	1996	1997	1998	1999	2000	2001	2002
CAPITAL COST:	.0	.0	.0	.0	.0	.0	.0
OPERATIONAL COST:	472.5	472.5	472.5	472.5	472.5	472.5	472.5

	2003	2004	2005	2006
CAPITAL COST:	.0	.0	.0	.0
OPERATIONAL COST:	472.5	.0	.0	.0

IMPACT MULTIPLIER FOR CAPITAL COST - 000.00%
IMPACT MULTIPLIER FOR OPERATIONAL COST - 000.00%

FACILITY: KITOI HATCHERY SPECIES: PINKS

SPECIES ECONOMIC ASSUMPTIONS

MEAN WEIGHT IN POUNDS: MALES - 3.50 FEMALES - 3.50

COMMERCIAL FISHERY : NUMBER OF GEAR TYPES - 2
IMPACT MULTIPLIER FOR INCREMENTAL REVENUE - 000.00%
INPACT MULTIPLIER FOR INCREMENTAL COSTS - 000.00%

PROCESSING : PCT. FRESH/FROZEN - 000.00% PCT. OF FISH USED - 000.00%
PCT. CANNED - 100.00% PCT. OF FISH USED - 63.00%
IMPACT MULTIPLIER FOR INCREMENTAL REVENUE - 000.00%
IMPACT MULTIPLIER FOR INCREMENTAL COST - 150.00%

EGG SALES : PCT. OF FEMALE WT. THAT IS EGGS - 7.00%
PCT. OF HARVESTED FEMALES USED FOR EGGS - 50.00%
WHOLESALE PRICE/LB - $ 4.00
IMPACT MULTIPLIER FOR INCREMENTAL REVENUE - 150.00%

SPORT FISHERY : CATCH/ANGLER/DAY - 0.00 VALUE/ANGLER/DAY - $ 0.00
IMPACT MULTIPLIER FOR INCREMENTAL VALUE - 000.00%

PRELIMINARY COMMERCIAL HARVESTS:

1982	1981	1980	1979	1978	1977	1976
0.	0.	0.	0.	0.	0.	0.

1975
0.

PRELIMINARY SPORT HARVESTS:

1982	1981	1980	1979	1978	1977	1976
0.	0.	0.	0.	0.	0.	0.

1975
0.

FACILITY: KITOI HATCHERY SPECIES: PINKS

COMMERCIAL HARVEST PROCESSING INFOMATION

CANNING ANNUAL WHOLESALE PRICE AND PROCESSING COSTS

	1975	1976	1977	1978	1979	1980	1981
WHOLESALE PRICE/LB:	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 1.27	$ 1.62	$ 1.63
PROCESSING COST/LB:	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 1.01	$ 1.30	$ 1.30

	1982	1983	1984	1985	1986	1987	1988
WHOLESALE PRICE/LB:	$ 1.44	$ 1.51	$ 1.51	$ 1.51	$ 1.51	$ 1.51	$ 1.51
PROCESSING COST/LB:	$ 1.15	$ 1.21	$ 1.21	$ 1.21	$ 1.21	$ 1.21	$ 1.21

	1989	1990	1991	1992	1993	1994	1995
WHOLESALE PRICE/LB:	$ 1.51	$ 1.51	$ 1.51	$ 1.51	$ 1.51	$ 1.51	$ 1.51
PROCESSING COST/LB:	$ 1.21	$ 1.21	$ 1.21	$ 1.21	$ 1.21	$ 1.21	$ 1.21

	1996	1997	1998	1999	2000	2001	2002
WHOLESALE PRICE/LB:	$ 1.51	$ 1.51	$ 1.51	$ 1.51	$ 1.51	$ 1.51	$ 1.51
PROCESSING COST/LB:	$ 1.21	$ 1.21	$ 1.21	$ 1.21	$ 1.21	$ 1.21	$ 1.21

	2003	2004	2005	2006	
WHOLESALE PRICE/LB:	$ 1.51	$ 1.51	$ 1.51	$ 1.51	$
PROCESSING COST/LB:	$ 1.21	$ 1.21	$ 1.21	$ 1.21	$

FACILITY: KITOI HATCHERY SPECIES: PINKS

COMMERCIAL HARVEST GEAR TYPE INFORMATION

GEAR TYPE NAME: PURSE SEINE PERCENT OF COMM. HARVEST: 93.00%

ANNUAL FISHERMEN'S PRICE AND COST

	1975	1976	1977	1978	1979	1980	1981
PRICE/LB TO FISHERMEN:	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ .47	$ .48	$ .46
FISHERMEN'S COST/LB:	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ .07	$ .07	$ .07

	1982	1983	1984	1985	1986	1987	1988
PRICE/LB TO FISHERMEN:	$ .24	$ .47	$ .47	$ .47	$ .47	$ .47	$ .47
FISHERMEN'S COST/LB:	$ .04	$ .07	$ .07	$ .07	$ .07	$ .07	$ .07

	1989	1990	1991	1992	1993	1994	1995
PRICE/LB TO FISHERMEN:	$ .47	$ .47	$ .47	$ .47	$ .47	$ .47	$ .47
FISHERMEN'S COST/LB:	$ .07	$ .07	$ .07	$ .07	$ .07	$ .07	$ .07

	1996	1997	1998	1999	2000	2001	2002
PRICE/LB TO FISHERMEN:	$ .47	$ .47	$ .47	$ .47	$ .47	$ .47	$ .47
FISHERMEN'S COST/LB:	$ .07	$ .07	$ .07	$ .07	$ .07	$ .07	$ .07

	2003	2004	2005	2006
PRICE/LB TO FISHERMEN:	$ .47	$ .47	$ .47	$ .47 $
FISHERMEN'S COST/LB:	$ .07	$ .07	$ .07	$ .07 $

GEAR TYPE NAME: BEACH SEINE PERCENT OF COMM. HARVEST: 7.00%

ANNUAL FISHERMEN'S PRICE AND COST

	1975	1976	1977	1978	1979	1980	1981
PRICE/LB TO FISHERMEN:	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ .47	$ .48	$ .46
FISHERMEN'S COST/LB:	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ .07	$ .07	$ .07

	1982	1983	1984	1985	1986	1987	1988
PRICE/LB TO FISHERMEN:	$ .24	$ .47	$ .47	$ .47	$ .47	$ .47	$ .47
FISHERMEN'S COST/LB:	$ .04	$ .07	$ .07	$ .07	$ .07	$ .07	$ .07

	1989	1990	1991	1992	1993	1994	1995
PRICE/LB TO FISHERMEN:	$ .47	$ .47	$ .47	$ .47	$ .47	$ .47	$ .47
FISHERMEN'S COST/LB:	$ .07	$ .07	$ .07	$ .07	$ .07	$ .07	$ .07

	1996	1997	1998	1999	2000	2001	2002
PRICE/LB TO FISHERMEN:	$ .47	$ .47	$ .47	$ .47	$ .47	$ .47	$ .47
FISHERMEN'S COST/LB:	$ .07	$ .07	$ .07	$ .07	$ .07	$ .07	$ .07

	2003	2004	2005	2006
PRICE/LB TO FISHERMEN:	$ .47	$ .47	$ .47	$ .47 $
FISHERMEN'S COST/LB:	$ .07	$ .07	$ .07	$ .07 $

RESULTS OF ECONOMIC SIMULATION BASE YEAR : 1982

FACILITY: KITOI HATCHERY INTEREST RATE : 3.00%

PRESENT VALUES OF FACILITY COSTS (IN $1000'S)

	1975	1976	1977	1978	1979	1980	1981
CAPITAL	.0	.0	.0	.0	.0	.0	.0
OPERATIONAL	.0	.0	.0	.0	.0	.0	.0
TOTAL	.0	.0	.0	.0	.0	.0	.0
TOTAL (IMP)	.0	.0	.0	.0	.0	.0	.0
CUM. TOTAL	.0	.0	.0	.0	.0	.0	.0

	1982	1983	1984	1985	1986	1987	1988
CAPITAL	.0	.0	.0	.0	.0	.0	.0
OPERATIONAL	522.0	458.7	445.4	432.4	419.8	407.6	395.7
TOTAL	522.0	458.7	445.4	432.4	419.8	407.6	395.7
TOTAL (IMP)	.0	.0	.0	.0	.0	.0	.0
CUM. TOTAL	522.0	980.7	1426.1	1858.5	2278.3	2685.9	3081.6

	1989	1990	1991	1992	1993	1994	1995
CAPITAL	.0	.0	.0	.0	.0	.0	.0
OPERATIONAL	384.2	373.0	362.1	351.6	341.3	331.4	321.7
TOTAL	384.2	373.0	362.1	351.6	341.3	331.4	321.7
TOTAL (IMP)	.0	.0	.0	.0	.0	.0	.0
CUM. TOTAL	3465.8	3838.8	4200.9	4552.5	4893.9	5225.3	5547.0

	1996	1997	1998	1999	2000	2001	2002
CAPITAL	.0	.0	.0	.0	.0	.0	.0
OPERATIONAL	312.4	303.3	294.4	285.9	277.5	269.5	261.6
TOTAL	312.4	303.3	294.4	285.9	277.5	269.5	261.6
TOTAL (IMP)	.0	.0	.0	.0	.0	.0	.0
CUM. TOTAL	5859.4	6162.7	6457.1	6743.0	7020.5	7290.0	7551.6

	2003	2004	2005	2006
CAPITAL	.0	.0	.0	.0
OPERATIONAL	254.0	.0	.0	.0
TOTAL	254.0	.0	.0	.0
TOTAL (IMP)	.0	.0	.0	.0
CUM. TOTAL	7805.6	7805.6	7805.6	7805.6

TOTALS: FIRST YEAR : 1975 FINAL YEAR : 2006 NO. OF YEARS : 32

TOTAL PRESENT VALUES OF FACILITY COSTS (IN $ 1000'S)

	CAPITAL	OPERATIONAL	ALL FAC. COSTS
TOTAL	.0	7805.6	7805.6
TOTAL (IMP)	.0	.0	.0

FACILITY: KITOI HATCHERY SPECIES: PINKS

PRESENT VALUES OF COSTS AND BENEFITS BY YEAR (IN $1000'S)

YEAR	1975	1976	1977	1978	1979	1980	1981
CANNERY PROCESSING							
REVENUE	.0	.0	.0	.0	.0	.0	.0
COST	.0	.0	.0	.0	.0	.0	.0
INC. V.	.0	.0	.0	.0	.0	.0	.0
FRESH/FROZEN PROCESSING							
REVENUE	.0	.0	.0	.0	.0	.0	.0
COST	.0	.0	.0	.0	.0	.0	.0
INC. V.	.0	.0	.0	.0	.0	.0	.0
TOTAL PROCESSING							
REVENUE	.0	.0	.0	.0	.0	.0	.0
COST	.0	.0	.0	.0	.0	.0	.0
INC. V.	.0	.0	.0	.0	.0	.0	.0
(IMP)	.0	.0	.0	.0	.0	.0	.0
P. COST	.0	.0	.0	.0	.0	.0	.0
(IMP)	.0	.0	.0	.0	.0	.0	.0
COMM. FISH.: PURSE SEINE							
REVENUE	.0	.0	.0	.0	.0	.0	.0
COST	.0	.0	.0	.0	.0	.0	.0
INC. V.	.0	.0	.0	.0	.0	.0	.0
COMM. FISH.: BEACH SEINE							
REVENUE	.0	.0	.0	.0	.0	.0	.0
COST	.0	.0	.0	.0	.0	.0	.0
INC. V.	.0	.0	.0	.0	.0	.0	.0
COMM. FISH. TOTAL							
REVENUE	.0	.0	.0	.0	.0	.0	.0
COST	.0	.0	.0	.0	.0	.0	.0
(IMP)	.0	.0	.0	.0	.0	.0	.0
INC. V.	.0	.0	.0	.0	.0	.0	.0
(IMP)	.0	.0	.0	.0	.0	.0	.0
EGG SALES	.0	.0	.0	.0	.0	.0	.0
(IMP)	.0	.0	.0	.0	.0	.0	.0
SPORT FISH	.0	.0	.0	.0	.0	.0	.0
(IMP)	.0	.0	.0	.0	.0	.0	.0

FACILITY: KITOI HATCHERY SPECIES: PINKS

PRESENT VALUES OF COSTS AND BENEFITS BY YEAR (IN $1000'S)

YEAR	1982	1983	1984	1985	1986	1987	1988
CANNERY PROCESSING							
REVENUE	.0	1880.4	2693.9	2614.2	2538.1	2464.2	2392.4
COST	.0	1506.8	2158.7	2094.8	2033.8	1974.6	1917.1
INC. V.	.0	373.6	535.2	519.4	504.3	489.6	475.3
FRESH/FROZEN PROCESSING							
REVENUE	.0	.0	.0	.0	.0	.0	.0
COST	.0	.0	.0	.0	.0	.0	.0
INC. V.	.0	.0	.0	.0	.0	.0	.0
TOTAL PROCESSING							
REVENUE	.0	1880.4	2693.9	2614.2	2538.1	2464.2	2392.4
COST	.0	1506.8	2158.7	2094.8	2033.8	1974.6	1917.1
INC. V.	.0	373.6	535.2	519.4	504.3	489.6	475.3
(IMP)	.0	.0	.0	.0	.0	.0	.0
P. COST	.0	577.8	827.7	803.3	779.9	757.1	735.1
(IMP)	.0	866.7	1241.6	1204.9	1169.8	1135.7	1102.6
COMM. FISH.: PURSE SEINE							
REVENUE	.0	864.0	1237.8	1201.2	1166.2	1132.2	1099.2
COST	.0	128.7	184.4	178.9	173.7	168.6	163.7
INC. V.	.0	735.3	1053.4	1022.3	992.5	963.6	935.5
COMM. FISH.: BEACH SEINE							
REVENUE	.0	65.0	93.2	90.4	87.8	85.2	82.7
COST	.0	9.7	13.9	13.5	13.1	12.7	12.3
INC. V.	.0	55.3	79.3	76.9	74.7	72.5	70.4
COMM. FISH. TOTAL							
REVENUE	.0	929.1	1331.0	1291.6	1254.0	1217.4	1182.0
COST	.0	138.4	198.2	192.4	186.8	181.3	176.0
(IMP)	.0	.0	.0	.0	.0	.0	.0
INC. V.	.0	790.7	1132.7	1099.2	1067.2	1036.1	1005.9
(IMP)	.0	.0	.0	.0	.0	.0	.0
EGG SALES	.0	138.4	198.2	192.4	186.8	181.3	176.0
(IMP)	.0	207.6	297.3	288.5	280.1	272.0	264.1
SPORT FISH	.0	.0	.0	.0	.0	.0	.0
(IMP)	.0	.0	.0	.0	.0	.0	.0

FACILITY: KITOI HATCHERY SPECIES: PINKS

PRESENT VALUES OF COSTS AND BENEFITS BY YEAR (IN $1000'S)

YEAR	1989	1990	1991	1992	1993	1994	1995
CANNERY PROCESSING							
REVENUE	2322.7	2255.0	2189.4	2125.6	2063.7	2003.6	1945.2
COST	1861.2	1807.0	1754.4	1703.3	1653.7	1605.5	1558.8
INC. V.	461.5	448.0	435.0	422.3	410.0	398.1	386.5
FRESH/FROZEN PROCESSING							
REVENUE	.0	.0	.0	.0	.0	.0	.0
COST	.0	.0	.0	.0	.0	.0	.0
INC. V.	.0	.0	.0	.0	.0	.0	.0
TOTAL PROCESSING							
REVENUE	2322.7	2255.0	2189.4	2125.6	2063.7	2003.6	1945.2
COST	1861.2	1807.0	1754.4	1703.3	1653.7	1605.5	1558.8
INC. V.	461.5	448.0	435.0	422.3	410.0	398.1	386.5
(IMP)	.0	.0	.0	.0	.0	.0	.0
P. COST	713.7	692.9	672.7	653.1	634.1	615.6	597.7
(IMP)	1070.5	1039.3	1009.1	979.7	951.1	923.4	896.5
COMM. FISH.: PURSE SEINE							
REVENUE	1067.2	1036.1	1006.0	976.7	948.2	920.6	893.8
COST	158.9	154.3	149.8	145.5	141.2	137.1	133.1
INC. V.	908.3	881.8	856.1	831.2	807.0	783.5	760.7
COMM. FISH.: BEACH SEINE							
REVENUE	80.3	78.0	75.7	73.5	71.4	69.3	67.3
COST	12.0	11.6	11.3	10.9	10.6	10.3	10.0
INC. V.	68.4	66.4	64.4	62.6	60.7	59.0	57.3
COMM. FISH. TOTAL							
REVENUE	1147.6	1114.1	1081.7	1050.2	1019.6	989.9	961.1
COST	170.9	165.9	161.1	156.4	151.9	147.4	143.1
(IMP)	.0	.0	.0	.0	.0	.0	.0
INC. V.	976.6	948.2	920.6	893.8	867.7	842.5	817.9
(IMP)	.0	.0	.0	.0	.0	.0	.0
EGG SALES	170.9	165.9	161.1	156.4	151.9	147.4	143.1
(IMP)	256.4	248.9	241.7	234.6	227.8	221.1	214.7
SPORT FISH	.0	.0	.0	.0	.0	.0	.0
(IMP)	.0	.0	.0	.0	.0	.0	.0

FACILITY: KITOI HATCHERY SPECIES: PINKS

PRESENT VALUES OF COSTS AND BENEFITS BY YEAR (IN $1000'S)

YEAR	1996	1997	1998	1999	2000	2001	2002
CANNERY PROCESSING							
REVENUE	1888.6	1833.6	1780.2	1728.3	1678.0	1629.1	1581.6
COST	1513.4	1469.3	1426.5	1384.9	1344.6	1305.4	1267.4
INC. V.	375.2	364.3	353.7	343.4	333.4	323.7	314.2
FRESH/FROZEN PROCESSING							
REVENUE	.0	.0	.0	.0	.0	.0	.0
COST	.0	.0	.0	.0	.0	.0	.0
INC. V.	.0	.0	.0	.0	.0	.0	.0
TOTAL PROCESSING							
REVENUE	1888.6	1833.6	1780.2	1728.3	1678.0	1629.1	1581.6
COST	1513.4	1469.3	1426.5	1384.9	1344.6	1305.4	1267.4
INC. V.	375.2	364.3	353.7	343.4	333.4	323.7	314.2
(IMP)	.0	.0	.0	.0	.0	.0	.0
P. COST	580.3	563.4	547.0	531.0	515.6	500.6	486.0
(IMP)	870.4	845.1	820.5	796.6	773.4	750.8	729.0
COMM. FISH.: PURSE SEINE							
REVENUE	867.8	842.5	817.9	794.1	771.0	748.5	726.7
COST	129.2	125.5	121.8	118.3	114.8	111.5	108.2
INC. V.	738.5	717.0	696.1	675.8	656.2	637.0	618.5
COMM. FISH.: BEACH SEINE							
REVENUE	65.3	63.4	61.6	59.8	58.0	56.3	54.7
COST	9.7	9.4	9.2	8.9	8.6	8.4	8.1
INC. V.	55.6	54.0	52.4	50.9	49.4	47.9	46.6
COMM. FISH. TOTAL							
REVENUE	933.1	905.9	879.5	853.9	829.0	804.9	781.4
COST	139.0	134.9	131.0	127.2	123.5	119.9	116.4
(IMP)	.0	.0	.0	.0	.0	.0	.0
INC. V.	794.1	771.0	748.5	726.7	705.5	685.0	665.0
(IMP)	.0	.0	.0	.0	.0	.0	.0
EGG SALES	139.0	134.9	131.0	127.2	123.5	119.9	116.4
(IMP)	208.5	202.4	196.5	190.8	185.2	179.8	174.6
SPORT FISH	.0	.0	.0	.0	.0	.0	.0
(IMP)	.0	.0	.0	.0	.0	.0	.0

FACILITY: KITOI HATCHERY SPECIES: PINKS

PRESENT VALUES OF COSTS AND BENEFITS BY YEAR (IN $1000'S)

YEAR	2003	2004	2005	2006
CANNERY PROCESSING				
REVENUE	1535.6	1648.0	.0	.0
COST	1230.5	1320.6	.0	.0
INC. V.	305.1	327.4	.0	.0
FRESH/FROZEN PROCESSING				
REVENUE	.0	.0	.0	.0
COST	.0	.0	.0	.0
INC. V.	.0	.0	.0	.0
TOTAL PROCESSING				
REVENUE	1535.6	1648.0	.0	.0
COST	1230.5	1320.6	.0	.0
INC. V.	305.1	327.4	.0	.0
(IMP)	.0	.0	.0	.0
P. COST	471.8	506.4	.0	.0
(IMP)	707.7	759.5	.0	.0
COMM. FISH.: PURSE SEINE				
REVENUE	705.6	757.2	.0	.0
COST	105.1	112.8	.0	.0
INC. V.	600.5	644.4	.0	.0
COMM. FISH.: BEACH SEINE				
REVENUE	53.1	57.0	.0	.0
COST	7.9	8.5	.0	.0
INC. V.	45.2	48.5	.0	.0
COMM. FISH. TOTAL				
REVENUE	758.7	814.2	.0	.0
COST	113.0	121.3	.0	.0
(IMP)	.0	.0	.0	.0
INC. V.	645.7	692.9	.0	.0
(IMP)	.0	.0	.0	.0
EGG SALES	113.0	121.3	.0	.0
(IMP)	169.5	181.9	.0	.0
SPORT FISH	.0	.0	.0	.0
(IMP)	.0	.0	.0	.0

FACILITY: KITOI HATCHERY SPECIES: PINKS

SUMMARY OF PRESENT VALUES OF COSTS AND BENEFITS (IN $1000'S)

	TOTAL REVENUE	TOTAL COSTS	TOTAL INC. VALUE
COMMERCIAL FISHERY :			
PURSE SEINE	20580.5	3065.2	17515.3
BEACH SEINE	1549.1	230.7	1318.4
OVERALL	22129.6	3295.9	18833.7
(IMP)		.0	.0
PROCESSING :			
CANNERY	44791.3	35892.3	8898.9
FRESH/FROZEN	.0	.0	.0
OVERALL	44791.3	35892.3	8898.9
(IMP)			.0
PRODUCTION		13762.7	
(IMP)		.0	
EGG SALES :			3295.9
(IMP)			4943.8
SPORT FISHERY :			.0
(IMP)			.0

NUMBER OF FISH HARVESTED

	1975	1976	1977	1978	1979	1980	1981
COMM.	0.	0.	0.	0.	0.	0.	0.
SPORT	0.	0.	0.	0.	0.	0.	0.
TOTAL	0.	0.	0.	0.	0.	0.	0.
	1982	1983	1984	1985	1986	1987	1988
COMM.	0.	736903.	1087350.	1086841.	1086841.	1086841.	1086841.
SPORT	0.	0.	0.	0.	0.	0.	0.
TOTAL	0.	736903.	1087350.	1086841.	1086841.	1086841.	1086841.
	1989	1990	1991	1992	1993	1994	1995
COMM.	1086841.	1086841.	1086841.	1086841.	1086841.	1086841.	1086841.
SPORT	0.	0.	0.	0.	0.	0.	0.
TOTAL	1086841.	1086841.	1086841.	1086841.	1086841.	1086841.	1086841.
	1996	1997	1998	1999	2000	2001	2002
COMM.	1086841.	1086841.	1086841.	1086841.	1086841.	1086841.	1086841.
SPORT	0.	0.	0.	0.	0.	0.	0.
TOTAL	1086841.	1086841.	1086841.	1086841.	1086841.	1086841.	1086841.
	2003	2004	2005	2006			
COMM.	1086841.	1201382.	0.	0.			
SPORT	0.	0.	0.	0.			
TOTAL	1086841.	1201382.	0.	0.			

TOTAL COMM. : 23675620. TOTAL SPORT : 0. GRAND TOTAL : 23675620.

FACILITY: KITOI HATCHERY

ALL SPECIES OVERALL ECONOMIC PROJECTIONS

YEAR	1975	1976	1977	1978	1979	1980	1981
INCREMENTAL VALUE - PUBLIC COST ($1000'S)							
MD. 1 ANN.	.0	.0	.0	.0	.0	.0	.0
MD. 1 CUM.	.0	.0	.0	.0	.0	.0	.0
MD. 2 ANN.	.0	.0	.0	.0	.0	.0	.0
MD. 2 CUM.	.0	.0	.0	.0	.0	.0	.0
MD. 3 ANN.	.0	.0	.0	.0	.0	.0	.0
MD. 3 CUM.	.0	.0	.0	.0	.0	.0	.0
MD. 4 ANN.	.0	.0	.0	.0	.0	.0	.0
MD. 4 CUM.	.0	.0	.0	.0	.0	.0	.0
INCREMENTAL VALUE / PUBLIC COST RATIO							
MD. 1 CUM.	-99.90	-99.90	-99.90	-99.90	-99.90	-99.90	-99.90
MD. 2 CUM.	-99.90	-99.90	-99.90	-99.90	-99.90	-99.90	-99.90
MD. 3 CUM.	-99.90	-99.90	-99.90	-99.90	-99.90	-99.90	-99.90
MD. 4 CUM.	-99.90	-99.90	-99.90	-99.90	-99.90	-99.90	-99.90
IMPACT INCOME ($1000'S)							
MD. 2 ANN.	.0	.0	.0	.0	.0	.0	.0
MD. 2 CUM.	.0	.0	.0	.0	.0	.0	.0
MD. 3 ANN.	.0	.0	.0	.0	.0	.0	.0
MD. 3 CUM.	.0	.0	.0	.0	.0	.0	.0
MD. 4 ANN.	.0	.0	.0	.0	.0	.0	.0
MD. 4 CUM.	.0	.0	.0	.0	.0	.0	.0
IMPACT INCOME / PUBLIC COST RATIO							
MD. 2 CUM.	-99.90	-99.90	-99.90	-99.90	-99.90	-99.90	-99.90
MD. 3 CUM.	-99.90	-99.90	-99.90	-99.90	-99.90	-99.90	-99.90
MD. 4 CUM.	-99.90	-99.90	-99.90	-99.90	-99.90	-99.90	-99.90

FACILITY: KITOI HATCHERY

ALL SPECIES OVERALL ECONOMIC PROJECTIONS

YEAR	1982	1983	1984	1985	1986	1987	1988
INCREMENTAL VALUE - PUBLIC COST ($1000'S)							
MD. 1 ANN.	-522.0	470.3	885.6	859.2	834.2	809.9	786.3
MD. 1 CUM.	-522.0	-51.7	833.9	1693.1	2527.2	3337.1	4123.4
MD. 2 ANN.	-522.0	331.9	687.4	666.8	647.4	628.5	610.2
MD. 2 CUM.	-522.0	-190.1	497.3	1164.1	1811.5	2440.0	3050.3
MD. 3 ANN.	-522.0	705.5	1222.6	1186.2	1151.6	1118.1	1085.5
MD. 3 CUM.	-522.0	183.5	1406.1	2592.3	3744.0	4862.1	5947.6
MD. 4 ANN.	-522.0	843.9	1420.8	1378.6	1338.4	1299.4	1261.6
MD. 4 CUM.	-522.0	321.9	1742.7	3121.3	4459.7	5759.1	7020.7
INCREMENTAL VALUE / PUBLIC COST RATIO							
MD. 1 CUM.	0.00	.95	1.58	1.91	2.11	2.24	2.34
MD. 2 CUM.	0.00	.81	1.35	1.63	1.80	1.91	1.99
MD. 3 CUM.	0.00	1.19	1.99	2.39	2.64	2.81	2.93
MD. 4 CUM.	0.00	1.33	2.22	2.68	2.96	3.14	3.28
IMPACT INCOME ($1000'S)							
MD. 2 ANN.	.0	.0	.0	.0	.0	.0	.0
MD. 2 CUM.	.0	.0	.0	.0	.0	.0	.0
MD. 3 ANN.	.0	866.7	1241.6	1204.9	1169.8	1135.7	1102.6
MD. 3 CUM.	.0	866.7	2108.3	3313.2	4483.0	5618.7	6721.3
MD. 4 ANN.	.0	1074.2	1539.0	1493.4	1449.9	1407.7	1366.7
MD. 4 CUM.	.0	1074.2	2613.2	4106.6	5556.6	6964.3	8331.0
IMPACT INCOME / PUBLIC COST RATIO							
MD. 2 CUM.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MD. 3 CUM.	0.00	.88	1.48	1.78	1.97	2.09	2.18
MD. 4 CUM.	0.00	1.10	1.83	2.21	2.44	2.59	2.70

FACILITY: KITOI HATCHERY

ALL SPECIES OVERALL ECONOMIC PROJECTIONS

YEAR	1989	1990	1991	1992	1993	1994	1995
INCREMENTAL VALUE - PUBLIC COST ($1000'S)							
MD. 1 ANN.	763.4	741.1	719.5	698.6	678.2	658.5	639.3
MD. 1 CUM.	4886.7	5627.9	6347.4	7046.0	7724.2	8382.7	9022.0
MD. 2 ANN.	592.5	575.2	558.4	542.2	526.4	511.1	496.2
MD. 2 CUM.	3642.7	4217.9	4776.4	5318.6	5845.0	6356.0	6852.2
MD. 3 ANN.	1053.9	1023.2	993.4	964.5	936.4	909.1	882.6
MD. 3 CUM.	7001.5	8024.7	9018.2	9982.6	10919.0	11828.2	12710.8
MD. 4 ANN.	1224.8	1189.2	1154.5	1120.9	1088.2	1056.6	1025.8
MD. 4 CUM.	8245.5	9434.7	10589.2	11710.1	12798.3	13854.9	14880.7
INCREMENTAL VALUE / PUBLIC COST RATIO							
MD. 1 CUM.	2.41	2.47	2.51	2.55	2.58	2.60	2.63
MD. 2 CUM.	2.05	2.10	2.14	2.17	2.19	2.22	2.24
MD. 3 CUM.	3.02	3.09	3.15	3.19	3.23	3.26	3.29
MD. 4 CUM.	3.38	3.46	3.52	3.57	3.62	3.65	3.68
IMPACT INCOME ($1000'S)							
MD. 2 ANN.	.0	.0	.0	.0	.0	.0	.0
MD. 2 CUM.	.0	.0	.0	.0	.0	.0	.0
MD. 3 ANN.	1070.5	1039.3	1009.1	979.7	951.1	923.4	896.5
MD. 3 CUM.	7791.9	8831.2	9840.3	10819.9	11771.1	12694.5	13591.1
MD. 4 ANN.	1326.9	1288.2	1250.7	1214.3	1178.9	1144.6	1111.3
MD. 4 CUM.	9657.8	10946.1	12196.8	13411.1	14590.0	15734.6	16845.9
IMPACT INCOME / PUBLIC COST RATIO							
MD. 2 CUM.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MD. 3 CUM.	2.25	2.30	2.34	2.38	2.41	2.43	2.45
MD. 4 CUM.	2.79	2.85	2.90	2.95	2.98	3.01	3.04

FACILITY: KITOI HATCHERY

ALL SPECIES OVERALL ECONOMIC PROJECTIONS

YEAR	1996	1997	1998	1999	2000	2001	2002
INCREMENTAL VALUE - PUBLIC COST ($1000'S)							
MD. 1 ANN.	620.7	602.6	585.1	568.0	551.5	535.4	519.8
MD. 1 CUM.	9642.7	10245.3	10830.4	11398.4	11949.9	12485.3	13005.1
MD. 2 ANN.	481.7	467.7	454.1	440.8	428.0	415.5	403.4
MD. 2 CUM.	7333.9	7801.6	8255.7	8696.5	9124.5	9540.1	9943.5
MD. 3 ANN.	856.9	832.0	807.7	784.2	761.4	739.2	717.7
MD. 3 CUM.	13567.7	14399.7	15207.5	15991.7	16753.1	17492.2	18209.9
MD. 4 ANN.	995.9	966.9	938.7	911.4	884.8	859.1	834.1
MD. 4 CUM.	15876.6	16843.5	17782.2	18693.6	19578.4	20437.5	21271.6
INCREMENTAL VALUE / PUBLIC COST RATIO							
MD. 1 CUM.	2.65	2.66	2.68	2.69	2.70	2.71	2.72
MD. 2 CUM.	2.25	2.27	2.28	2.29	2.30	2.31	2.32
MD. 3 CUM.	3.32	3.34	3.36	3.37	3.39	3.40	3.41
MD. 4 CUM.	3.71	3.73	3.75	3.77	3.79	3.80	3.82
IMPACT INCOME ($1000'S)							
MD. 2 ANN.	.0	.0	.0	.0	.0	.0	.0
MD. 2 CUM.	.0	.0	.0	.0	.0	.0	.0
MD. 3 ANN.	870.4	845.1	820.5	796.6	773.4	750.8	729.0
MD. 3 CUM.	14461.5	15306.6	16127.1	16923.6	17697.0	18447.8	19176.8
MD. 4 ANN.	1078.9	1047.5	1017.0	987.3	958.6	930.7	903.5
MD. 4 CUM.	17924.8	18972.2	19989.2	20976.5	21935.1	22865.7	23769.3
IMPACT INCOME / PUBLIC COST RATIO							
MD. 2 CUM.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MD. 3 CUM.	2.47	2.48	2.50	2.51	2.52	2.53	2.54
MD. 4 CUM.	3.06	3.08	3.10	3.11	3.12	3.14	3.15

FACILITY: KITOI HATCHERY

ALL SPECIES OVERALL ECONOMIC PROJECTIONS

YEAR	2003	2004	2005	2006
INCREMENTAL VALUE - PUBLIC COST ($1000'S)				
MD. 1 ANN.	504.7	814.2	.0	.0
MD. 1 CUM.	13509.8	14324.0	14324.0	14324.0
MD. 2 ANN.	391.7	692.9	.0	.0
MD. 2 CUM.	10335.2	11028.1	11028.1	11028.1
MD. 3 ANN.	696.8	1020.3	.0	.0
MD. 3 CUM.	18906.7	19927.0	19927.0	19927.0
MD. 4 ANN.	809.8	1141.6	.0	.0
MD. 4 CUM.	22081.3	23222.9	23222.9	23222.9
INCREMENTAL VALUE / PUBLIC COST RATIO				
MD. 1 CUM.	2.73	2.84	2.84	2.84
MD. 2 CUM.	2.32	2.41	2.41	2.41
MD. 3 CUM.	3.42	3.55	3.55	3.55
MD. 4 CUM.	3.83	3.98	3.98	3.98
IMPACT INCOME ($1000'S)				
MD. 2 ANN.	.0	.0	.0	.0
MD. 2 CUM.	.0	.0	.0	.0
MD. 3 ANN.	707.7	759.5	.0	.0
MD. 3 CUM.	19884.6	20644.1	20644.1	20644.1
MD. 4 ANN.	877.2	941.4	.0	.0
MD. 4 CUM.	24646.5	25587.9	25587.9	25587.9
IMPACT INCOME / PUBLIC COST RATIO				
MD. 2 CUM.	0.00	0.00	0.00	0.00
MD. 3 CUM.	2.55	2.64	2.64	2.64
MD. 4 CUM.	3.16	3.28	3.28	3.28

FACILITY: KITOI HATCHERY SPECIES: PINKS

ALL SPECIES OVERALL ECONOMIC PROJECTIONS
SUMMARY OF RESULTS

FIRST YEAR OF FACILITY OPERATION - 1975 ECONOMIC BASE YEAR - 1982
FINAL YEAR OF ECONOMIC PROJECTION- 2006 INTEREST RATE - 3.00%

	INC. VALUE - PUBLIC COST ($1000'S)	PAYBACK	IMPACT INCOME ($1000'S)	PAYBACK	PUBLIC COSTS ($1000'S)	FINAL INC. VAL. PUB. COST RATIO	FINAL IMPACT PUB. COST RATIO
MODEL 1 :	14324.0	1984			7805.6	2.84	
MODEL 2 :	11028.1	1984	.0	0	7805.6	2.41	0.00
MODEL 3 :	19927.0	1983	20644.1	1983	7805.6	3.55	2.64
MODEL 4 :	23222.9	1983	25587.9	1983	7805.6	3.98	3.28

EXECUTIVE SUMMARY FOR THE ENHANCEMENT BENEFIT-COST MODEL

Jeff Hartman and Kit Rawson
9-1-83

In September 1981 the Division of Fisheries Rehabilitation, Enhancement, and Development (FRED) initiated the development of models for predicting the benefits and costs of the Division's investments in fisheries enhancement. This work rose out of a need for a formal method to measure the economic value of some components of the FRED program. Previous economic analyses of fisheries enhancement projects in Alaska have employed a variety of approaches. Their results have often been difficult to compare between projects or with other public investments. The methods presented in this document provide one type of economic yardstick by which the value of fisheries enhancement programs can be measured.

Most public investment planning, including fisheries development investment includes treatment of both efficiency and equity issues. Efficiency issues in this manuscript are defined as those which are quantifiable in dollars through an accounting of national income. In social terms it is "maximum production from some given level of inputs or cost minimization for a given level of output", Randall (1981)[1]. Equity issues, on the other hand, concern themselves primarily with distribution of impacts between group. While many policy questions involve issues of fairness, the science of economics has no quantitative methods for evaluating normative judgements. It does however employ a number of methods, theories and models to measure the changes in efficiency and the impacts of specific resource investments and policies using positive analysis methods.

One widely used analytical tool which yields useful information on public investment alternatives based on a modified measure of efficiency is benefit-cost analysis. By modified, we mean that B/C analysis (unlike a true Pareto-efficient action) usually does not formally account for the mechanisms or costs of returning losses in a transaction to there former level of welfare prior to the transaction. Also, an accounting of <u>all</u> social benefits and costs in the analysis framework is usually impossible. In fishery resource applications benefit-costs analysis has arisen out of a goal to expend public funds to further a nation's or state's social and economic objectives in an effective manner with an efficient allocation of resources among competing groups. The analysis method differs from traditional forms of government budgeting in that it concentrates on the results or consequences of government activity rather than simply on the monetary resources required. Benefit-cost analysis is the emphasis of FRED Division's current and developing economic methods. In 1981 to 1982 an in-house computer simulation model

---

[1] This definition of efficiency is often referred to as Pareto-efficiency or Pareto-optimality.

designed to evaluate public salmon and trout enhancement alternatives. The methodology of this form of incremental analysis is similar to that of many of the more familiar applications of benefit-cost analysis, such as the Susitna Hydro Feasibility Study, Yould (1982).

Applications of Enhancement Benefit-Cost Analysis

Though it is impossible to anticipate all potential uses of enhancement and rehabilitation economic model, since it is in the relatively early stages of development, the principal capabilities of the present model are as follows:

1) The economic model can be used for identifying the worth of an existing program and the value of a proposed investment such as a capital or operational budget request.

2) The model can be used to produce internal comparisons of alternatives to aid in optimizing the design and operation of physical plants and in identifying the most efficient capacity, size, facility locations, incubation and rearing schemes.

3) The routine, with input from other economic studies may be useful in identifying the distribution of user benefits to specific sectors of the industry as well as impacts on wages and employment from direct and induced sources (see text for qualifiers).

General Structure of Models

Currently, the enhancement economic feasibility model is built out of two separate systems of computer programs which involve input of between 200 to 300 variables for a given simulation. The hatchery broodstock development (HBD) system projects future salmon production from a facility based on its current level of production, plans for expansion, life-stage survival assumptions, and fishery exploitation expectations.

The facility benefit cost (FBC) system is the economic simulation program which uses harvest predictions from a given (HBD) simulation and combines these with economic assumptions to generate predictions for benefit and cost stream[2] resulting from salmon and/or trout enhancement.

The (FBC) routine has also evolved into two separate components. The first, is a price index model which adjusts past nominal costs and benefits to base year dollars for ex-post analysis. The second, an ex-ante or future oriented program, estimates present values for a number of benefit and cost stream alternatives for commercially and recreationally harvested salmon or trout which are directly attributable to a given enhancement project.

---

[2] In this case a "stream" refers to a series of dollar amounts such as an income or cost stream extending into the past or future for a specific number of years.

The general structure for the present value of the enhanced salmon production takes the following form for both recreationally and commercially harvested fish.

Economic Equations

B_{pri} = Incremental benefits (revenue) from the private sector attributable to the enhancement produced fish.

C_{pri} = Incremental costs from the private sector attributable to the enhancement produced fish (e.g. cost of harvesting and/or processing etc.).

C_{pub} = Incremental public costs from producing and managing enhancement produced fish e.g. operational cost, capital cost and planning costs of hatchery; administration and evaluation.

B/C = Benefit cost as expressed by a ratio

$$[B_{pri} - C_{pri}]/C_{pub} = B/C.$$

NB = Net benefits as expressed as a difference

$$B_{pri} - C_{pri} - C_{pub} = NB$$

Salmon Fishery Benefits and Associated Costs

Evaluation of the efficiency of an investment for a specific project requires the analyst to estimate the gross benefits and gross costs of increasing the available salmon resource. In the (FBC) model the benefits to the private sector can be estimated as either the incremental value to the commercial fishery or as the incremental value to both the processing industry and the commercial fishery. In the first case the gross benefit to the commercial fishery from the incremental fish production is measured as the ex-vessel value of the product. The gross cost is measured as the resources foregone from the fleet to catch the incremental production. In the second case the gross benefit to the processing industry is the market value of the increased catch or first wholesale value. The processing costs are taken to be the value of the foregone resources required to both process and harvest the enhancement produced catch.

Sport Fish Valuation

Many of the projects and facilities in FRED Division are scheduled to or currently produce salmon and trout highly valued by sport fishermen. In fact, some facilities are targeted almost entirely at sport fishermen. Just what these recreation benefits are and will be is a subject discussed in the Documentation for the Enhancement Benefit Cost Model Hartman and Rawson 1983. The analysis method presented in the text is intended to only serve the purpose of the enhancement program evaluation.

Although recreational evaluation procedures can encompass benefits of a program other than those directly received by Alaskan fishermen (such as existence valuation and option valuation techniques), the primary purpose of our evaluation process is to identify the change in consumer surplus from the actual recreational fishing experience. The consumer surplus is a measure of the satisfaction people enjoy from their consumption of a commodity and is based upon what they would be willing to pay for it. In the case of our enhancement investments, it is what they would be willing to pay for the opportunity to fish for the incremental increase in the available stock.

Alaskan Impact Analysis

If a decision-maker were only interested in a single objective, namely the maximization of fishing income, then the economic evaluation would not need to grow beyond benefit cost analysis. However, if the decision-maker is also interested in formally dealing with distributional effects, then it is necessary to expand the scope of the work to impact assessment, which must be dealt with separately from efficiency considerations. The purpose of impact analysis is to measure changes and the magnitude of changes in local or regional employment, labor force participation, real income distribution and business and industrial activity by the series of sectors. Though measurements of impacts from a project can take place even at the national level, we will extend any analysis only to assessments relevant to Alaska. Though not the primary function of the model, the facility benefit cost (FBC) routine can account for these interactions within the Alaskan economy indirectly by incorporating values from external impact models capable of generating multipliers relevant to the salmon fishing and processing industry.

One type of impact assessment is input-output analysis. In general, the approach is based on a detailed accounting of goods and services at a given point in time. A series of industry coefficients are the constants and are arranged in the form of a matrix (Randall, 1981). They may be capable of predicting changes in employment and income from a change in economic activity from a primary sector. In our case the primary activity would come from the fish processing sector and to a lesser extent the fish harvesting sector.

One operating econometric model used by the Division of Budget for the Department of Revenue was used to produce a data set for the salmon industry based on a hypothetical increase in the salmon harvest of 10 percent over the naturally produced base level. This incremental increase resulted in an income multiplier for the seafood industry of approximately 1.84. The estimate indicates that for each one dollar of processing income produced an additional increment of 84 cents is produced in the form of induced wages to Alaskans.

What Constitutes an Efficient Return on Investments for an Enhancement Project?

Because resources are limited, the undertaking of any public investment, be it transportation, hydro-electric power generation, permanent fund, or a salmon enhancement facility will divert resources from an alternative use. The benefit cost concept essentially compares the gross benefits of the proposed project or resource allocation with all of the gross benefits forgone by its existence. Clearly, if the value of the benefits of the proposed project exceed the value of the benefits lost by the project's existence, then the project is in society's best interest, based on a measure of efficiency.

As a result, a single or series of benefit cost ratios or estimates of return on investment (NPV) for Alaskan public hatcheries may not provide as much familiar information to the decision-maker as a broader formalized comparison of the rate of return from public hatcheries versus rate of return from some selected Alaskan investment alternatives. While State policy to date does not require a formal benefit cost analysis for all public expenditures, possibly since the value of some public goods are technically difficult to express in benefit-cost analysis, comparison with anticipated returns for a few notable public investments will help shed light on the efficiency of a typical enhancement investment. Possible candidates for comparison would be the present permanent fund investments or proposed investments such as large public hydroelectric projects in Alaska.

Preliminary estimates from enhancement economic analysis suggest a typical hatchery investment benefit cost ratio would fall between a range of 2:1 and 3:1 with a typical return on investment (B-C) of approximately 20 million dollars over the anticipated economic life. While an explicit comparison of site specific cases with and without the proposed investment would be required to identify the alternative investment opportunities forgone from other public projects, it can be demonstrated that most existing enhancement projects compare favorably with some existing and proposed public projects.

References

Hartman, Jeff and Kit Rawson. 1983. F.R.E.D. Division Enhancement Benefit-cost Model. Alaska Department of Fish and Game, Anchorage. Unpublished.

Hartman, Jeff. 1983. Fishery and Economic Assumptions for 1982/1983 Enhancement and Rehabilitation Simulations. Alaska Department of Fish and Game, Anchorage. Unpublished.

Kreinheder, Jack and David Teal. 1982. The Alaska Fishing Industry House Research Agency Report 81-4, Alaska State Legislature, Juneau, Alaska.

Randall, Alan. 1981. Resource Economics. Grid Publishing Inc., Ohio.

Yould, Eric P. 1982. The Susitna Hydro Studies. Alaska Power Authority, Anchorage.