# Salmon Enhancement

## An Assessment of the Salmon Stock Development Program on Canada's Pacific Coast

by

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**FINAL REPORT**

of the

Program Review of the Salmonid Enhancement Program
Internal Audit and Evaluation Branch
Department of Fisheries and Oceans



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# EXECUTIVE SUMMARY

THE Salmonid Enhancement Program was launched in 1977 with the objective of doubling salmon catches on the Pacific coast. An ambitious program involving construction of hatcheries, artificial spawning channels and other enhancement works was expected to generate significant economic benefits and the cost was to be recovered from those who catch the fish.

Over the last 17 years some $526 million has been spent. A substantial enhancement capability, consisting of more than 300 facilities, is now in place. They contribute about 14,000 metric tonnes, or roughly 13 percent, of the annual catch of salmon. In addition, the Salmonid Enhancement Program has established significant programs in education, public information, native development and research related to enhancement.

Enhanced production has fallen significantly short of original expectations, mainly for two reasons. One is funding at lower levels than expected. The other is the shift in priorities, in the 1980s, from cost-efficient production in large-scale spawning channels for sockeye and hatcheries for chum salmon to costly attempts to restore depressed wild stocks, especially coho and chinook.

The economic achievements have been disappointing as well. The estimated lifetime cost of constructing and operating the enhancement facilities built under the Salmonid Enhancement Program exceeds the estimated benefits by $592 million, indicating a benefit-cost ratio of .6 for the program as a whole. The unquantified benefits of education, research and other non-production activities are not likely to be sufficient to offset the negative net benefits in fish production.

Some of the basic premises on which the Salmonid Enhancement Program was based have proven to be faulty. One was that salmon production could not be restored through better management of wild stocks; improvements in managing fishing have since increased catches of wild salmon by more than the increase in enhanced production. Another was that the technology of enhancement was proven; it has since been revealed as uncertain and risky. A third was an assumption that government would take steps to prevent further unnecessary investment in commercial fishing capacity, but no new measures were taken. A fourth was an assumption that the costs would be recovered from those who catch the fish, but only token efforts were made to do so.

The analysis indicates that the economic outlook for future enhancement is, potentially, much brighter. With the facilities in place, and their capital costs already expended, the prospective benefits exceed the prospective costs over the facilities' remaining life. Moreover, the economic performance of facilities varies widely, and termination of those that fail to meet minimal standards of cost-efficiency would significantly improve the overall results. There appears to be promising opportunities in additional salmon enhancement and habitat development projects also.

To take advantage of these opportunities, major changes are needed. Enhancement must be reconciled with the conservation of wild salmon; in particular, wild stocks must be protected from potential damage from enhanced stocks. A much stronger base of scientific support and project assessment must be provided. The planning and operation of enhancement works must be subjected to more rigorous economic tests. And the beneficiaries must take more responsibility for organizing and financing the enhancement effort.

These requirements call for a thorough overhaul of the enhancement program. A suggested new approach involves a gradual transfer of responsibilities for enhancement from the Department to an independent, non-profit corporation, controlled and financed primarily by the beneficiaries in the fishing community. The proposed corporation would raise its revenues from those who catch the fish and manage existing and new enhancement facilities with a view to generating maximum benefits for the fishing interests it represents. It would also be empowered to enter into agreements with local fishing and other organizations to take over enhancement facilities and develop new ones. These general proposals are intended to focus discussion between government and private interest groups, with a view toward identifying the most promising and acceptable approach for a renewed enhancement program.

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# PREFACE

IN May 1977, the federal Minister of Fisheries announced an ambitious new program to double the production of Pacific salmon. With the cooperation of the Province of British Columbia, the plan was to build hatcheries, fishways, artificial spawning channels and other works to boost salmon stocks back up to their original abundance.

Over the seventeen years since then, the Salmonid Enhancement Program has grown into one of the biggest of its kind in North America. Much has been accomplished; some $526 million has been spent, hundreds of millions of salmon and trout have been raised and released into the ocean, and many have returned to be caught by commercial, sports and native fishers.

But the Salmonid Enhancement Program has always been controversial. As the program developed its objectives and funding arrangements were changed, anxieties grew about the effect it was having on natural stocks, and the economics of producing fish artificially were questioned. Several evaluations of the program were commissioned, but they did not reach consistent conclusions about its success or its best future direction.

Several months ago the Department of Fisheries and Oceans asked me to review the Salmonid Enhancement Program. This followed a lengthy evaluation process within the Department itself. A framework for evaluating the program was prepared in 1988, outlining how it should be done and the data needed. A preliminary assessment in 1992 confirmed the need for a thorough review. The following year a detailed description and management review was prepared. The Department also commissioned a study by ARA Consulting Group Inc. of Halifax, who conducted interviews with representatives of fishing interests and others, examined the program's economic performance, and published a report in 1993. The Department asked me to review all these previous studies, undertake any further analyses I considered necessary, and provide an independent assessment with advice about the program's future.

Since most of the available data had already been compiled by previous investigators, I have focused my effort on its interpretation, the methods used to assess benefits, costs and risks, and the conclusions that should be drawn for the guidance of policy-makers. I have supplemented earlier studies with new assessments of the economic performance of enhancement projects and of their future outlook. And I have reviewed biological and economic problems, and my conclusions, with experts within and outside the Department.

This document summarizes my findings and conclusions. I have deliberately left out much of the complicated detail about the program's history, the technologies of rearing fish and problems of fisheries biology and management, because these are well documented in previous studies (listed in *References* at the end of this document). My aim is to present as clear and concise a picture as possible of the program's achievements, what we have learned from experience, what remains uncertain and risky, and the extent to which we can proceed with reasonable confidence.

My investigation, and this report, benefited considerably from comments and suggestions

from a group of experts including Drs. Anthony Scott, Peter Larkin and Carl Walters of the University of British Columbia, Dr. Gary Morishima, advisor to the Quinault Nation in Washington, Mr. Mike Nicell, Director of the Salmonid Enhancement Program Task Group, Dr. Marvin Shaffer, Assistant Deputy Minister in British Columbia's Ministry of Employment and Investment, Dr. Brian Riddell of the Pacific Biological Station in Nanaimo, Dr. Jeffrey Hard of the Northwest Fisheries Science Center in Seattle, Mr. David Griggs, Director of the Salmonid Enhancement Program, and Messrs. Allen Wood and Ted Perry, of the Department of Fisheries and Oceans in Vancouver. These experts joined me in a one-day workshop at the Fisheries Centre at the University of British Columbia where we reviewed an early draft of this report. They also provided written commentary and advice.

I am particularly grateful to Mr. Russell Mylchreest, of the Department of Fisheries and Oceans in Vancouver, who made an extraordinary effort to assist with the economic analysis. Mr. Douglas MacDonald, an economist with GTA Consultants Inc. in Antigonish, Nova Scotia, also helped with the economic evaluation and prepared the Appendix. Ms. Karen Traversey of the Department of Fisheries and Oceans and Mr. Jason Won, of the Treasury Board in Ottawa, provided helpful information and advice.

Senior officials in the Department of Fisheries and Oceans, including Mr. Pat Chamut, Director-General for the Pacific Region and Mr. Robert Bergeron of the Internal Audit and Evaluation Branch in Ottawa, gave me continuing support in carrying out my investigations.

My deepest indebtedness is to Mr. Peter Toews, who worked with me closely and continuously throughout this project. His knowledge and experience in program evaluation proved invaluable, and I benefited greatly from his help in analysing complicated issues and from his patience in helping me prepare this report.

I want to acknowledge, also, the contribution of Mrs. Patsy Quay, who brought her exceptional skills to the production of this document.

While this report has benefited from the contributions of many others, not all will agree with my conclusions, and I accept full responsibility for any errors or deficiencies.

Vancouver
May 31, 1994

Peter H. Pearse

# 1

# ENHANCEMENT OF SALMON PRODUCTION

MANY of the salmon now caught on Canada's Pacific coast are produced with human assistance in hatcheries and artificial spawning channels. Other stocks of salmon benefit from fishways built around barriers to their up-stream migration, improvements to spawning beds, and fertilization of the lakes where they spend the first few months of their lives. These are our *enhanced* stocks. They now account for about one in every eight salmon caught.

## The Salmonid Enhancement Program

Salmon enhancement received a major boost in 1977 when the federal government announced an exciting new *Salmonid Enhancement Program* with the objective of doubling salmon production within 30 years. This would restore catches to the historic highs reached late in the last century (see Figure 1). With a modest contribution from the government of British Columbia, $157.5 million was allocated for the first five years, and more in the years following. Today, after seventeen years and more than half a billion dollars expended, the program is now credited with about 13 percent of the total salmon catch.

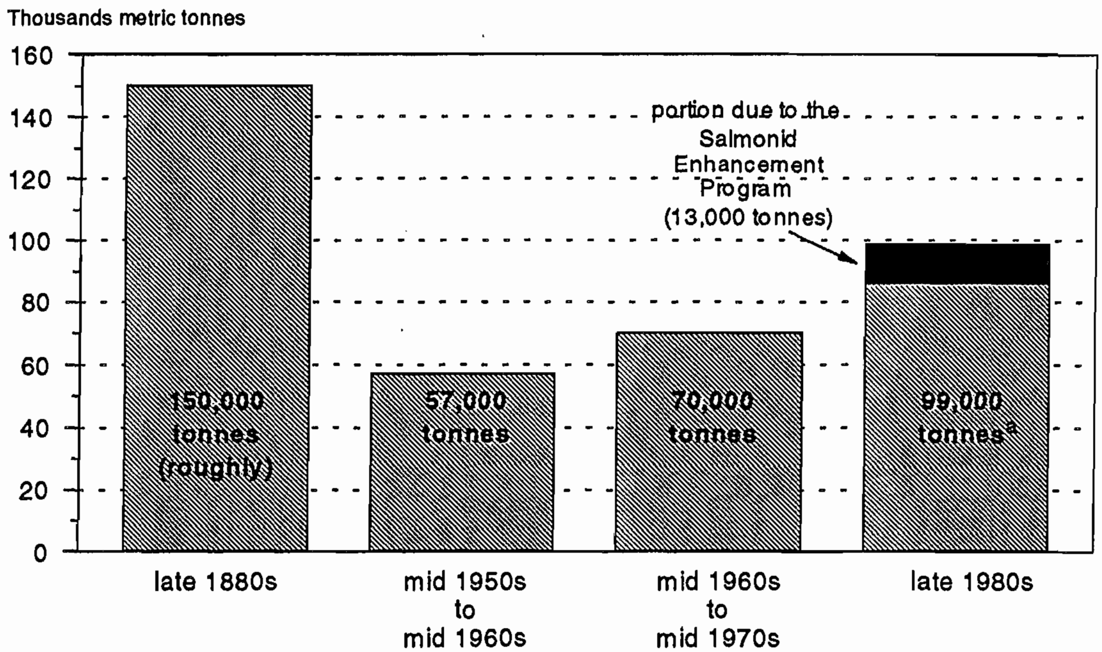
The Department of Fisheries and Oceans must now decide the future of the enhancement program. To prepare for the decision, the Department's senior management instructed the Internal Audit and Evaluation Branch to assess the contribution of the enhancement program to salmon production and sustainable fisheries, evaluate the economic and social benefits it has generated, and identify opportunities for increasing cost effectiveness.

This report is the end product of the evaluation process. It synthesizes previous evaluation studies, summarizes the additional analyses I have undertaken, and presents my conclusions about the best way to proceed with enhancement in the future.

## Previous Assessments

The present evaluation follows several earlier assessments of the enhancement program which documented its accomplishments and identified emerging concerns. The most important of these assessments are the following (the numbers in parentheses refer to the list of "References" at the end of this report):

- The 1982 Royal Commission on Pacific Fisheries Policy devoted a lengthy chapter to the program, less than five years after it began. It drew attention to growing concerns about stock interactions (that is, the adverse impact of enhanced stocks on wild stocks when they are fished together), the emphasis on large-scale facilities and the danger of viewing stock enhancement as




[a]Includes catches in the recreational and Indian "food" fisheries, which are excluded in earlier years.

**Figure 1. Average annual catches of salmon over the past century**

a solution to the over-expansion of the commercial fishing fleet. Recommendations included a renewed program guided by a rigorous evaluation system and conditional upon effective cost recovery. It suggested a more cautious approach, with attention to the possibilities of achieving the desired results by better management of wild stocks, through less intrusive forms of enhancement, and through adaptive response to experience (16).

- A 1985 Ministerial Task Force on Program Review (the Neilsen Task Force) expressed concern about the adverse effects of enhanced fish on wild stocks, the apparent decline in survival rates from enhancement facilities, the danger of considering stock enhancement as an alternative to reducing fishing capacity, and the absence of adequate cost-recovery (13).

- The 1985 preliminary evaluation by the Department's Internal Audit and Evaluation Branch examined the biological and economic impacts of the program. It concluded that, while impressive numbers of young fish had been reared and released, there was insufficient data on returns of adult fish to enable an evaluation of performance and value for money invested. It expressed concern about potential adverse effects on wild stocks, genetic changes, declining productivity of enhancement and inadequate integration of enhancement with fisheries management. It recommended that the Department undertake the research needed to address these concerns, and suggested a shift toward more natural, less risky types of enhancement. The study recommended that an evaluation framework be designed and steps taken to collect the data needed for a comprehensive evaluation of the program (3). The evaluation framework was completed in 1988.

- The 1986 Report of the Auditor-General recognized the same biological and operational problems, but stressed the inadequacy of procedures for evaluating projects in terms of their benefits and costs, and the failure to collect the needed data. The Auditor-General also criticized the modest effort at cost recovery (1).

- A 1992 evaluation assessment by the Department's Internal Audit and Evaluation Branch reiterated the key biological issues of declining productivity of enhanced stocks, declining size of adults, stock interactions, problems of managing mixed fisheries, and the overall cost-effectiveness of the program. It recommended that an evaluation of the program be completed in the following fiscal year (5).

- A 1993 Program Profile, prepared by the Internal Audit and Evaluation Branch, gathered together the available data on the evolution of the program, the financial and human resources expended on it, and its products and achievements (6).

- A 1993 Report by ARA Consultants Inc. of Halifax, commissioned by the Department, documented results of interviews with stakeholders and regional officials and of benefit-cost analyses provided by the Region's Program Planning and Economics Branch (21).

## Major Concerns

These previous reviews provide a rich source of information, analysis and expert opinion, which I have drawn upon in preparing this report. Although their conclusions and recommendations differ, they reveal remarkable consistency in concerns about salmon enhancement generally and the current program in particular. It is worth noting the most important of these issues at the outset, because they explain the context and emphasis in the following chapters. They fall into three general categories:

*Program management issues:*

- Program funding and enhancement strategies have not followed original plans.

- The cost of some projects appear to exceed the benefits.

- Some enhanced species and forms of enhancement generate much higher benefits per dollar spent than others, but spending has not been focused on those that generate the highest return.

- A large and increasing proportion of annual funds are absorbed in maintaining and operating facilities built in earlier years, leaving little for new projects.

- Many facilities are ageing, and decisions must be made about replacing and upgrading them, often at considerable cost.

- The program, intended originally to be funded through cost recovery from those who catch the fish, continues to be funded largely by the federal treasury.

*Biological and technical questions:*

- Some wild stocks have declined as enhanced stocks have been built up, a possible cause being biological interactions and adverse effects of enhancement.

- For some stocks, the productivity of enhancement — that is, the returning adult fish as a proportion of the young released from hatcheries and other facilities — appears to be declining as enhanced production increases.

- The success of various facilities, measured by the number of fish released that return as adults, varies widely, for reasons that are not well understood.

*Fisheries management problems:*

- Fishing enhanced stocks while they mingle with wild stocks may deplete the wild stocks. A much smaller percentage of enhanced stocks must be left to spawn than is necessary for wild stocks. So when wild and enhanced stocks swim together, and the fishing fleet strives to harvest the full surplus of the enhanced stocks, the wild stocks are harvested in the same proportion and are overfished.

- Enhancement has complicated management of the salmon fisheries.

These are not the only concerns that must be investigated, but they are the dominant ones, and their importance has influenced the organization and content of this report.

While my investigation raised many of the same concerns as previous studies, my conclusions differ in important respects. This is especially so of my economic analysis of the Salmonid Enhancement Program, partly because I had access to more information but more importantly because I found that some of the assumptions on which earlier predictions and evaluations were based have turned out, in light of the history of the program, to be invalid. I have attempted to analyse the program as rigorously as the data permit, and to draw conclusions from the analysis as objectively as possible.

The following chapter traces the development of salmon enhancement on the Pacific coast, emphasizing the objectives of the Salmonid Enhancement Program which provide the basis for evaluating it. Chapter 3 assesses the achievements of this effort in increasing salmon production. This is followed, in Chapter 4, by an economic evaluation of these accomplishments. In Chapter 5, the benefits of enhancement other than fish production are examined, and the economic outlook for the program is assessed. Chapter 6 sets out certain essential conditions which must be met to justify future enhancement expenditures. The final chapter proposes a new approach to salmon enhancement.

A governmental program such as the Salmonid Enhancement Program must be considered, from a policy viewpoint, within the context of other policy issues that currently bear on federal fisheries management. One of these is the heavy pressure on federal spending, and the effort to reduce it. Another related issue is the general drive toward greater efficiency in government, participation of interest groups in government programs, user-pay and cost-recovery.

A third consideration is the government's new commitment to sustainable development, and the need to take explicit account of ecological, economic and social sustainability in public decision-making. Thus the Salmonid Enhancement Program, and related programs of fisheries and habitat management — all of which are important to the restoration of salmon stocks — must be examined collectively as means of ensuring sustainable fish production.

# 2

# DEVELOPMENT OF THE ENHANCEMENT PROGRAM

BEFORE we begin to evaluate the enhancement program, we need to identify the objectives it was intended to serve, trace its development, put it into its present context, and sketch the scale and form of the enhancement effort.

## Forms of Enhancement

Enhancement covers a wide range of activities, all involving some human intervention to boost fish production. Some involve much more artificial methods than others. Among the least intrusive techniques are habitat improvements such as augmentation of pools and eddies in streams to make them more favourable to salmon production. This is often done by manipulating debris in waterways. Fishways are constructed to help migrating salmon overcome barriers, such as the Hell's Gate rapids in the Fraser canyon. Artificial spawning channels are built to create more (and more productive) spawning beds. And lakes are fertilized with nutrients to provide more productive freshwater habitat for young salmon.

Some techniques are designed to restore or supplement depressed stocks. Incubation boxes are mini hatcheries, used to augment natural production of salmon in small streams. And juvenile fish from hatcheries are out-planted into streams where stocks are depressed (referred to as "satelliting").

The method of enhancement involving the most intensive technology is ocean ranching. Hatcheries, often on a large scale, produce salmon fry or smolts from eggs in controlled conditions. They are then released to rear in the sea, and to be harvested when they return as adults.

The more artificial techniques give managers more control over the fish production process. Hatcheries, for example, give managers much more control over the highly sensitive freshwater phase of the salmon life cycle than do spawning channels, and spawning channels are more controlled environments than natural spawning beds. Greater control also enables more reliable assessments of performance. Usually, some of the fish released from hatcheries are marked to distinguish them from wild fish, which allows biologists to calculate adult survival rates when the fish return. Marking is costlier and more difficult with spawning channels and improved habitat.

## Steps in Production

Salmon pass through the four stages illustrated in Figure 2, and the survival rate between each is crucial. Enhancement is concerned with increasing the survival rate in the freshwater phase, where mortality is high under natural conditions.

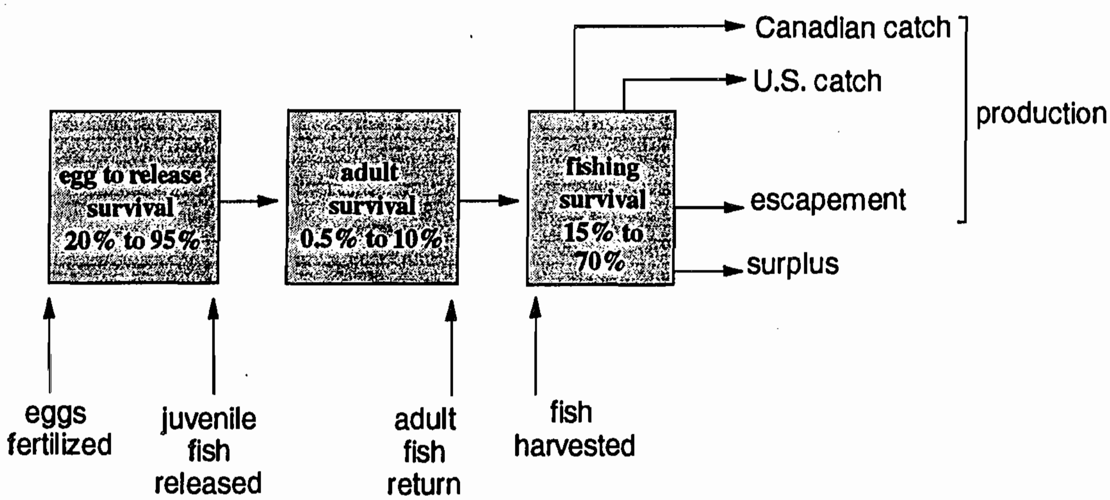



**Figure 2. Steps in production of enhanced salmon**

***Egg to release survival.*** The egg to release phase is the period from the time eggs are deposited and fertilized to the time the juvenile fish are released from hatcheries and other facilities, and begin to go to sea. Managers of enhancement facilities strive to increase the survival during this period by maintaining favourable temperatures and other environmental conditions for eggs and young fish, regulating their nutrition, protecting them from diseases and predators, and releasing them at the most favourable time. In the controlled environment of a hatchery the survival rate ranges between 70 and 95 percent, and in the somewhat more natural conditions of artificial spawning channels between 20 and 80 percent — both much higher than in natural spawning beds.

Enhancement facilities control the fish only until they are released as juveniles — fry or smolts. Because juvenile fish are the immediate product of the enhancement effort, the numbers released indicate the growth in enhancement capacity. Table 1 and Figure 3 show that total releases doubled since 1977 from 327 million juveniles to 680 million in 1990. Releases of chinook, coho and chum have increased four to five times, while pinks have increased threefold and sockeye only marginally.

***Adult survival.*** The most critical link in the production chain from a biological standpoint is adult survival. This is also the phase over which man has least control. From hatcheries, young fish move from a highly protected, artificial environment into a natural one, with all the perils of predators and diseases and the abrupt necessity to forage for food. They pass through freshwater, and typically spend some time in estuaries, before going to sea where a wide range of oceanographic and biological risks affect their survival.

**Table 1. Juvenile releases from enhancement facilities in 1977 and 1990**

| | 1977 | 1990 |
|---|---|---|
| | (millions) | |
| sockeye | 223 | 286 |
| pink | 31 | 92 |
| chum | 54 | 215 |
| coho | 5 | 21 |
| chinook | 14 | 66 |
| **Total** | **327** | **680[a]** |

[a]Total includes about 2 million steelhead and cutthroat trout.

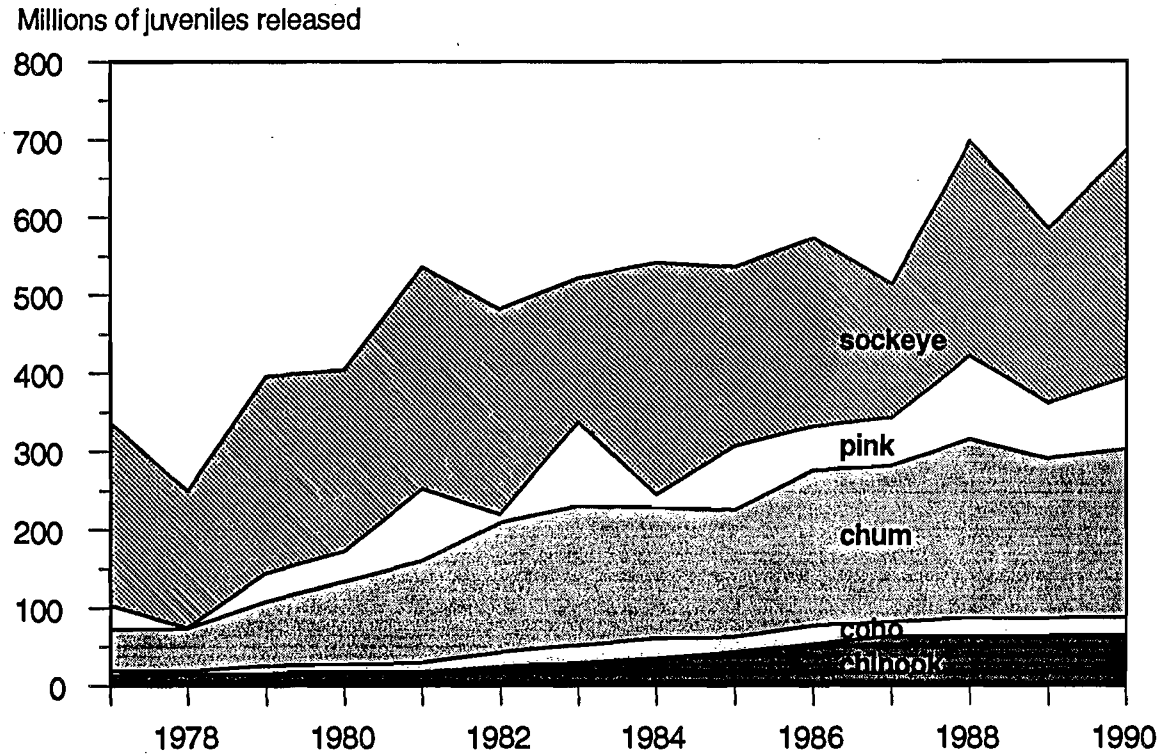


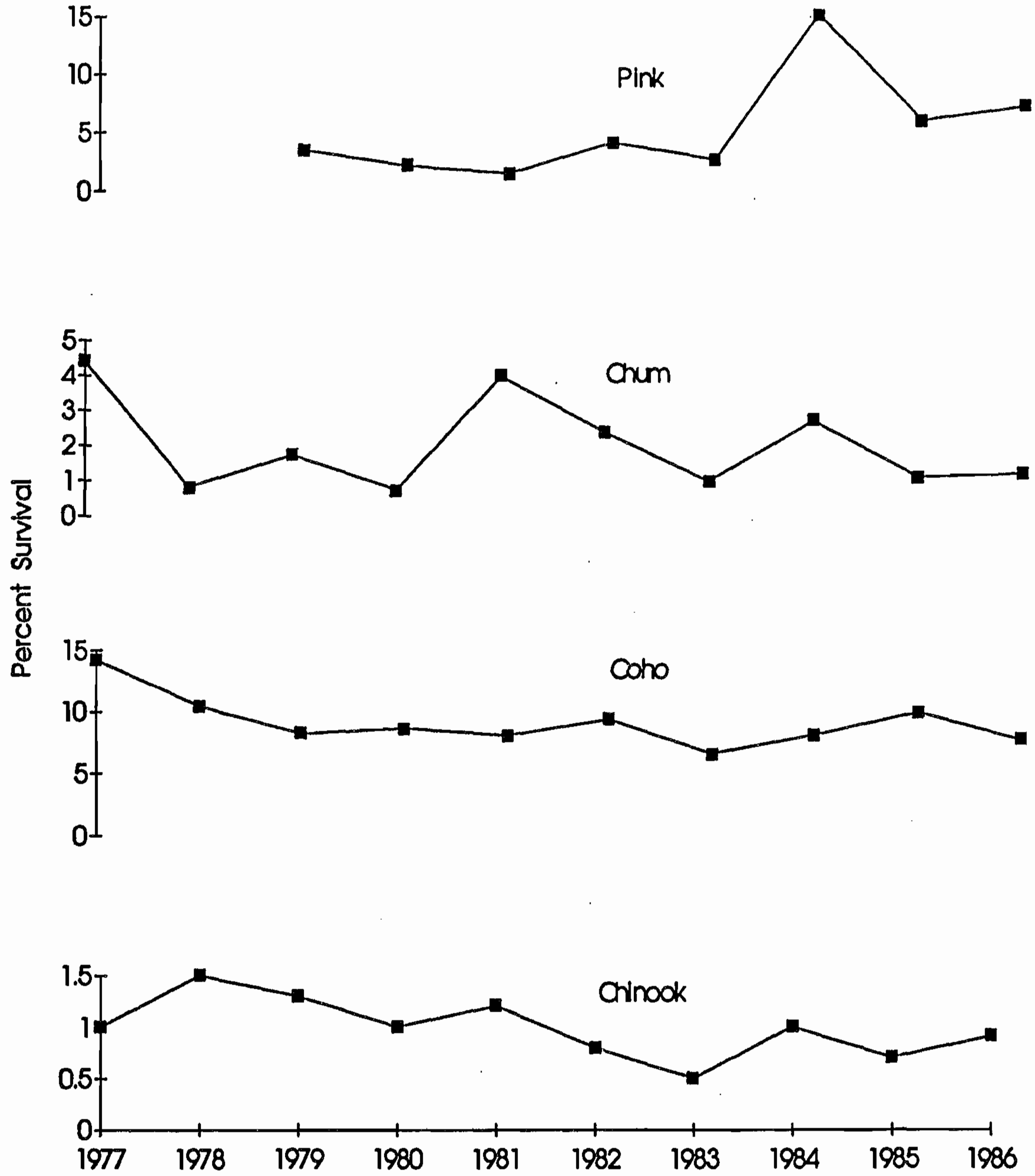

**Figure 3. Juvenile releases from enhancement facilities since 1977**

Adult survival rates are low and vary widely. Figure 4 shows that the adult survival of chinook and coho has declined and remains low. (Note that the years refer to brood years — the year the eggs were incubated; in each case the adults returned several years later.) In contrast, the survival of pink appears to be increasing and the same is true for sockeye (for which no graph is available). Chum show high variation but no clear trend. Returning adults of enhanced sockeye still represent less than one percent of releases, but they are produced in such enormous numbers in spawning channels that this rate is often considered satisfactory.

As we see in the next chapter, differences in the adult survival rate lead to wide differences in the cost of production among species.

*Fishing survival.* Fishing survival depends on the harvest rate, which fisheries managers try to restrict to ensure that sufficient spawners escape to maintain the stocks. Target exploitation rates vary between 30 and 85 percent, depending on species and the productivity of the particular stock. Enhanced stocks can be exploited at much higher rates than wild stocks, because few spawners are needed to satisfy the brood stock requirements of highly efficient hatcheries.

The portion of stocks that survive fishing — the "escapement" — returns to the hatcheries or streams where they originated. Often the escapement of a particular stock exceeds the requirements for brood stock, sometimes in substantial numbers. Occasionally fish from this surplus escapement spawn elsewhere in a natural environment, and sometimes surpluses at enhancement facilities are allocated to native groups, but many are not utilized in any way.




**Survival of released smolts in the case of coho; of fed fry of other species.**

**Figure 4. Trends in adult survival of enhanced salmon since 1977**

## Early Attempts at Salmon Enhancement

The most intrusive of the enhancement technologies, *hatcheries*, have the longest history in British Columbia. More than a century ago, in 1882, a hatchery was built on Bon Accord Creek, near Port Mann on the lower Fraser. Other, largely experimental, hatcheries followed. Most attempted to produce sockeye, and were unsuccessful. All were closed by 1937.

During the two decades following World War II, major *fishways* were constructed on the Fraser, Bulkley, Nass, Cowichan, Somass, Sproat, Indian and Naden Rivers. The most ambitious fishway project, at Hell's Gate in the Fraser canyon, was jointly financed by Canada and the United States through the International Pacific Salmon Fisheries Commission (hereafter "the Commission") established in 1937 to rehabilitate and share Fraser sockeye and pink stocks.

The first of a series of large *spawning channels* was built by the Department at Jones Creek near Chilliwack in 1953, and in the following decades others were developed at Robertson Creek, Big Qualicum River, and Babine Lake. The Babine Lake Development Project on the Fulton and Pinkut Rivers, built at a cost of some $10 million in the mid 1960s, involved constructing flow controls and some five kilometres of spawning channels, making it the largest spawning channel complex in the world.

Interest in hatcheries was renewed in the early 1970s with construction of a pilot facility at Big Qualicum. By the time the Salmonid Enhancement Program was launched in 1977, the Department had built hatcheries on the Capilano, Quinsam, Puntledge and Big Qualicum Rivers and on Robertson Creek.

Meanwhile, the Commission developed enhancement facilities on the Fraser. Fishways were constructed at Bridge River Rapids, Farwell Canyon, Hell's Gate and Yale Rapids, and spawning channels were built at Gates Creek, Nadina River, Weaver Creek, Seton Creek and Upper Pitt River.

The Department's facilities were transferred to the Salmonid Enhancement Program when it was launched in 1977. In 1985, when Canada and the United States signed the Pacific Salmon Treaty, the Commission's facilities were transferred to the program as well. Altogether, these "pre-SEP" facilities constituted a significant enhancement capability even before the Salmonid Enhancement Program got underway.

## Conception of the Salmonid Enhancement Program

In 1962, an eminent fisheries scientist at the Pacific Biological Station in Nanaimo, Dr. W.E. Ricker, published a paper in which he argued that salmon production on Canada's west coast was considerably below its potential and that, with careful management, catches could be roughly doubled from the then annual average of about 27 million fish (17). This could be achieved mainly through rebuilding depressed natural stocks, by allowing greater spawning escapements. Artificial enhancement played a minor role in Ricker's projections.

This came at a time when catches had been declining, and further declines were expected unless a major effort was made to rebuild the stocks. In 1974 the Department organized a policy seminar in Vancouver to explore the prospects and possibilities for the salmon fishery among federal and provincial officials, industry representatives and scientists. The attendants concluded that a major enhancement program should be launched immediately, with the cost to be recovered from those who catch the fish.

During the following two years the Department prepared a comprehensive enhancement plan. Its assessment of the problem, and of the opportunities, were reflected in a 1978 public discussion paper.

> Canada's Pacific salmon resource is now precariously balanced between extinction and survival. Without positive action there is good reason to believe that the balance will tip towards extinction. The fish culture technology that Canada has now developed and financed over the past few decades is now proved and ready for full-scale application. These enhancement techniques are available to increase salmon stocks to their historic levels of abundance ... (9).

In retrospect, the official view was flawed in two respects important to this review of the program. One is about the decline in salmon stocks. In fact, catches had already begun to increase during the 1960s and, apart from an unusually low catch in 1975, improvement continued into the 1970s. The other is about the proven technology of enhancement. As we shall see, many uncertainties and scientific unknowns persist even today.

Other considerations added support for an enhancement effort. The commercial salmon fishing fleet had been allowed to expand well beyond the capacity required to efficiently harvest the available catch. There were "too many boats chasing too few fish." Some people saw producing more fish as an alternative to the politically intractable task of reducing an overexpanded fleet. Moreover, while it was too soon for the Department to assess many of its own pre-SEP facilities, U.S. hatcheries on the Columbia River were showing good results for coho and chinook, and experiments at the Qualicum hatchery suggested that the U.S. experience could be matched here. Some spawning channels, notably at Weaver Creek, also showed promising early results (through the huge Babine complex was a disappointment for the first decade).

There had been warnings about risks associated with large-scale enhancement, but these were largely ignored. Scientists had cautioned enhancement enthusiasts about interactions between wild and enhanced stocks, mixed fishing, and the limits of ocean rearing capacity (11) (23). In view of this, the Department's proposals to Ministers and to the public were astonishingly ambitious and optimistic. The market outlook for salmon was portrayed as promising, with falling supply and strong demand; the technology needed was known and tested; salmon production and revenues to the fishing industry would rise sharply, providing plenty of scope for cost recovery; the industry's costs would not increase much because excess capacity was already in place. The likelihood that higher revenues would lead to more investment in surplus capacity was brushed aside on the assumption that government would take any steps needed to prevent unneeded investment (9).

This was coupled with warning that if nothing was done the present levels of production could, at best, barely be maintained, and any reduction would "...call for a massive inflow of government subsidies." The alternative to enhancement — of rebuilding natural stocks through better management of fishing and fish habitat (which later played a major role) — was seen as already exhausted. In this rather contrived context, a bold enhancement program was proposed as an urgent measure to save the declining stocks of salmon with well-understood technology, and with the cost to be borne by the direct beneficiaries.

The government was receptive. Other countries had enhancement programs. Public financing was available. The federal government knew British Columbia wanted the program. And it might alleviate the pressure to reduce the overexpanded fishing fleet.

Early in 1977 the Department presented the Minister with three options for an enhancement program. One was an aggressive, intensive technology plan, involving large hatcheries and other facilities, capable of achieving the doubling objective in 10 years. Another, at the opposite extreme, would not increase production at all, but would provide enough enhancement to offset projected declines in catches. The third, which was ultimately adopted, was a staged, multi-objective plan involving a mixture of facilities that could double production over 30 years. None took account of the pre-SEP facilities in predicting increases in production. And, in contrast to Dr. Ricker's proposal, none gave much consideration to increasing production by improving the management of wild salmon.

## Objectives and the Original Plan

In May 1977, the federal Minister of Fisheries and Oceans announced the Salmonid Enhancement Program, with the primary goal of doubling salmon production. There were other objectives as well, specifically:

- To augment national and provincial income.
- To generate employment.
- To improve economic opportunities for native people.
- To foster development of economically disadvantaged communities and regions.
- To increase recreational opportunities.

The program was to consist of two phases, the second contingent on the success of the first. For Phase I, 1977 to 1982, $150 million in federal funding and $7.5 million in provincial funds were allocated. This was to increase annual production by 22.7 thousand tonnes, about one-third of the ultimate goal. Economic benefits, in excess of costs, were predicted to be $325 million in 1980 dollars, or 1.5 dollars for every dollar spent. Enhancement facilities were expected to employ 458 person years of which 64 would be natives. In short, the main objective of the program was to generate economic benefits through cost-effective fish production, with costs and benefits equitably shared among beneficiaries.

The program includes relatively small provisions for steelhead and cutthroat trout, to mitigate losses in wild production. This accounts for such a small share of production — about .3 percent — it is not specifically dealt with in this report, though it is included in the total benefits and costs in Chapter 4.

The program has now passed through three phases, summarized in Table 2. The first, beginning in 1977 and originally intended to be a 5-year development phase, was stretched over two additional years because of growing federal

**Table 2. Phases of the Salmonid Enhancement Program**

| program phase | period | main developments | expenditures ($ millions) |
|---|---|---|---|
| Phase I | 1977–84 | • much hatchery construction<br>• Department facilities taken over<br>• Department facilities upgraded | 177 |
| Transition | 1984–87 | • little new construction<br>• Commission facilities taken over | 112 |
| Phase II | 1987–93 | • shift to less artificial technologies<br>• ongoing operations, repair and maintenance of facilities | 237 |
| | | | **526** |

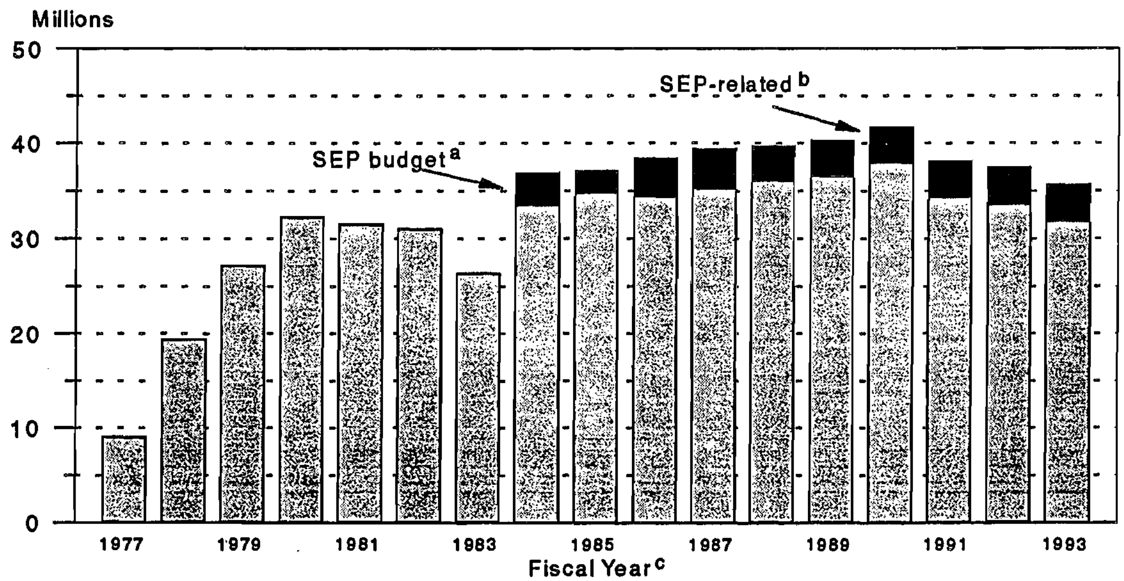
fiscal stringency. Heavy capital expenditures were made, and most of today's hatcheries were built during this period. The Department's pre-SEP facilities were transferred to the program and many were upgraded.

The original intention was to assess the program at the end of the first phase, before proceeding further. During the three-year transition phase that followed, there was little new construction, but the substantial Commission facilities on the Fraser were transferred to the enhancement program.

In 1987, Phase II of the program was approved with funding of $42.5 million per year for five years. Funding never reached this level, however, and allocations have declined since 1990. Additions to enhancement capacity were made, but this time they took the form of habitat improvements, spawning bed development and other less artificial technologies. No production target was specified for Phase II.

Annual expenditures over the 16-year life of the program to 1993 are shown in Figure 5. Altogether, $526 million have been spent. Of this, about $115 million or 22 percent has been capital expenditures, and, of that, $13 million was spent in upgrading pre-SEP facilities.

Generally, expenditures increased until 1990, then declined. Financial flexibility has been diminishing, because a growing portion of the available funds are required to operate the expanding array of facilities, leaving less available for new projects. Currently about 85 percent of spending is in the form of operating expenditures and only 11 percent capital expenditures. Moreover, many facilities are ageing and in need of repairs and upgrading. Recently, about $600 thousand has been spent annually on repairs and improvements to facilities, but engineering staff now estimate that $4 to $6 million is needed to upgrade facilities over the next three to four years.




[a]Expenditures from 1988 to 1992 include Western Diversification Funding. Provincial funds, and an extraordinary expenditure of $2.5M in 1990, are excluded.

[b]Expenditures by other Branches, over which SEP program managers have little control.

[c]Data shown refer to the fiscal year beginning in the year indicated.

**Figure 5. Annual expenditures under the Salmonid Enhancement Program**

Furthermore, capital requirements for this purpose are expected to increase by 5 to 10 percent annually. In addition, an increasing portion of the budget — the "SEP-related" funds in Figure 5 — is allocated to Science and other Branches of the Department and is not controlled by managers of the enhancement program. All these factors, and the recent budget reductions, have constrained new activities.

## Organization

The Salmonid Enhancement Program is a separately-administered program of the Pacific Region of the Department of Fisheries and Oceans. It is headed by an Executive Director who is responsible for six Divisions and a lake enrichment group. These are indicated in Figure 6, which also shows the complement of staff and budget allocation of each in the fiscal year ending in 1993. In total, the program was staffed with 205 person-years and funded with $37.8 million.

Two of the Divisions are regional operations — the *Coastal Operations* and the *Fraser and Northern B.C. Divisions*. These operate most of the major spawning channels and hatcheries. Of their 21 facilities, seven are operated under contract by native bands and other third parties. Operations have accounted for about 33 percent of the total resources of the enhancement program over its 17-year life, and produced about 86 percent of the output of juvenile salmon (including the output of pre-SEP facilities).

The *Resource Restoration Division* is responsible for habitat improvement projects. It also provides technical support to community groups and others engaged in about 60 projects of this kind. This Division has accounted for about five percent of the program's resources and three percent of juvenile fish production.

The *Community Involvement Division* administers two high-profile public participation programs. The Community Development Program now supports 25 community-based enhancement projects, and the Public Involvement Program some 226. Sixteen community advisors support thousands of volunteers involved in these projects. This Division has accounted for about 16 percent of total resources, and about four percent of juvenile fish output.

The *Development Division* is responsible for planning and construction of new facilities and upgrading old ones. It also operates 11 fishways and spawning channels. At the peak of construction in Phase I of the program, this Division employed over 40 engineers and technicians, now reduced to 18. The Development Division has accounted for 27 percent of total program resources and 6 percent of juvenile fish production.

The P*rogram Coordination and Assessment Division* is responsible for production planning and project assessment, and advises fisheries managers on the harvesting of enhanced stocks. It has accounted for three percent of program spending.

The *Lake Enrichment Program*, responsible for lake fertilization projects, is not a separate division, but it is delivered by a program coordinator and scientific staff attached to the Biological Sciences Branch. Lake enrichment has accounted for $25 million, or six percent of total resources, and two percent of juvenile salmon production.

A variety of other activities have shared the program's resources. About 10 percent of the funds have been used in other Branches of the Department, such as the Science Sector to support research, planning and economic analysis (the "SEP-related" funds in Figure 5). Another one percent was allocated to fisheries manageability studies in cooperation with the

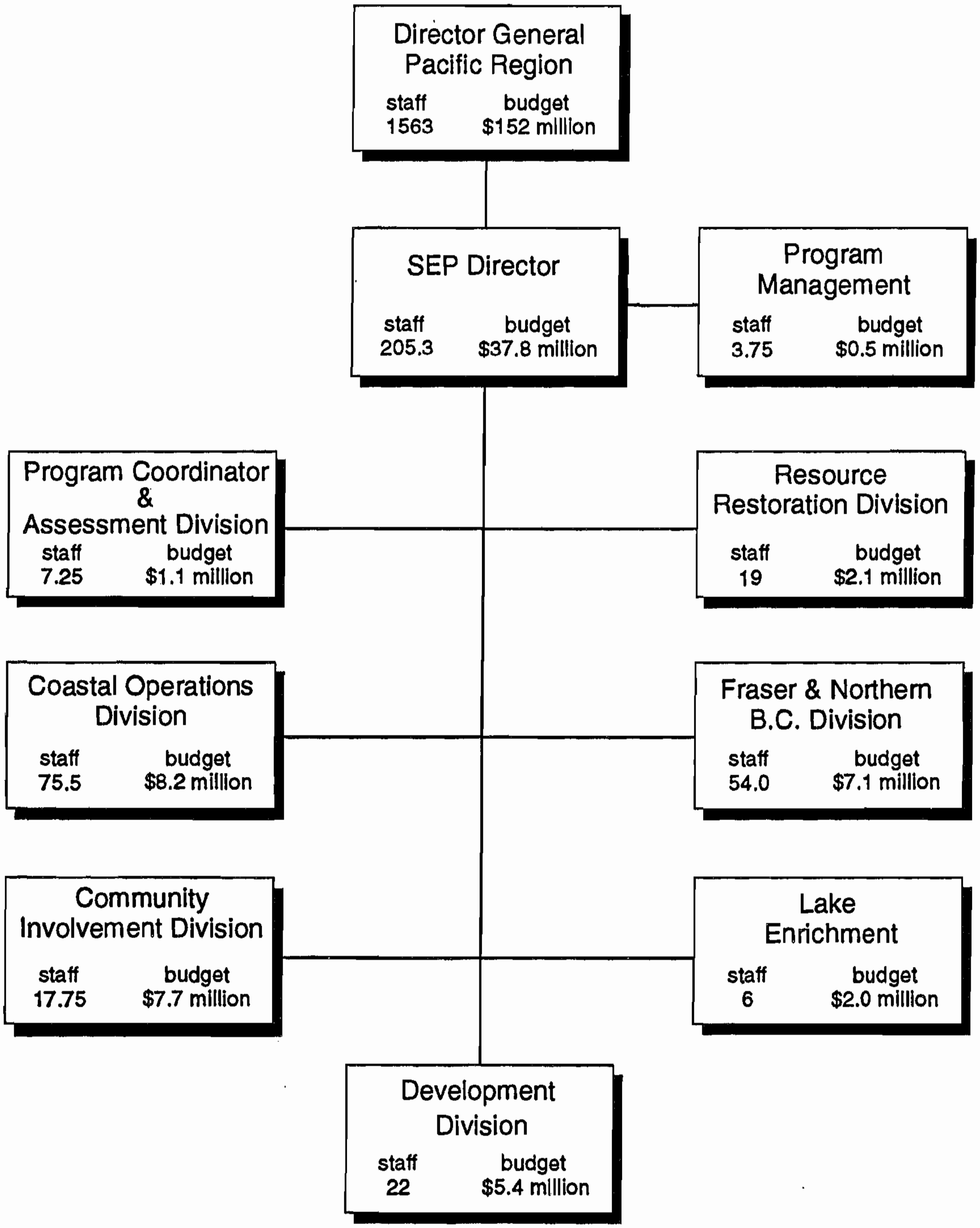



**Figure 6. Organization of the enhancement program and budget allocations**

Note: "staff" refers to person-years.
"budget" refers to allocations in the 1992-93 fiscal year.

government of British Columbia. The Director's office accounted for another one percent.

## Current Operations

There are now some 300 enhancement sites — an impressive increase from the few pre-SEP sites noted earlier. They are listed, by type of facility, in the Appendix. In this report, enhancement facilities are grouped into the categories listed in Table 3. In this table, and in the remainder of this report, "spawning channels" refers to large-scale artificial spawning beds, mainly for sockeye production. "Spawning bed restoration" refers mainly to rehabilitation of natural spawning habitats in river channels cut off by stream action. Community Development Projects are hatcheries operated mainly by native groups, and Public Involvement Projects are mostly small hatcheries and incubation boxes operated by local organizations of various kinds.

The capacity of the enhancement facilities now in place is reflected in the numbers of juvenile fish they rear and release to the sea (as we emphasize later, this is not a satisfactory measure of *production*, because that is reflected in the number of adults that ultimately return to be caught or to spawn). Table 3 indicates the number of juvenile fish released by the major types of enhancement facility. Spawning channels and hatcheries account for 85 percent of total releases.

Table 3 also shows separately the capacity of facilities built under the Salmonid Enhancement Program and the capacity of pre-SEP facilities. This reveals the dominance of spawning channels among pre-SEP facilities, and the heavy emphasis on hatcheries during the early years of the enhancement program.

**Table 3. Numbers of juvenile salmon released annually from enhancement facilities**

| | |
|---|---|
| PRE-SEP FACILITIES[a] | |
| Hatcheries | 69 |
| Spawning channels | 256 |
| Other[c] | 2 |
| Total pre-SEP facilities | 327 |
| SEP FACILITIES[b] | |
| Hatcheries | 196 |
| Spawning channels | 67 |
| Spawning bed restoration | 46 |
| Lake fertilization | 11 |
| Community and public involvement projects | 27 |
| Other[c] | 6 |
| Total SEP facilities | 353 |
| ALL FACILITIES | 680 |

[a]Releases in 1977 from all Department and Commission facilities.

[b]Releases in 1990 from facilities constructed under the Salmonid Enhancement Program, and additions to pre-SEP facilities constructed under the program.

[c]Miscellaneous fish production facilities including ponds, sea-pens, stream reconstruction works etc.

## Divergence from Original Plans

The present distribution of the program's resources, described above, differs significantly from original plans. While the early planning documents give only a sketchy indication of planned allocations, the plans for Phase I reveal that most of the funds were meant to be devoted primarily to fish production — the construction and operation of facilities. Only about three percent were to be spent on non-production activities such as community involvement and economic research. However, 20 to 25 percent of the funds have been devoted to non-production activities.

A related divergence from original plans was in the species of salmon produced. The original plan projected most of the enhanced production — 20 million of the 27 million fish — in sockeye, chum and pink salmon. However, since the program began in 1977, very little production capacity has been added for sockeye and pink, and chum production, while substantial, is less than projected.

Instead, much emphasis has been directed to enhancing chinook and coho; roughly two-thirds of program resources have been expended on these species. These are the two species most in demand by growing numbers of recreational fishers. They are also the least abundant species, and their stocks are the most severely depressed and in need of rebuilding. But as we show in the next chapter, the strong effort to rebuild stocks of chinook and coho has been unsuccessful, and they have continued to decline.

## Shifting Objectives

Much of the divergence from original plans can be explained by changes in the objectives of program managers. The original objective of the Salmonid Enhancement Program was to double salmon production — a goal expressed repeatedly in early planning documents and public announcements. However, this objective gradually waned; during the late 1970s and early 1980s priorities shifted toward restoration of depressed stocks, especially coho and chinook.

Soon after the program started in 1977, fisheries managers began to press for enhancement to restore depressed natural stocks rather than focusing on the most efficient fish production opportunities. The Salmonid Enhancement Board (which had a significant influence on enhancement policy until it was dissolved in 1984) recommended more remedial effort to rebuild depleted stocks, increased fish marking for stock assessment purposes, and expanded activities in education and public involvement. The 1982 Commission on Pacific Fisheries Policy proposed that new large facilities be postponed until the performance of those already in place was demonstrated, and that opportunities to rebuild natural stocks through better management of fishing should take priority over artificial enhancement (16).

In 1983 a submission to Ministers for funding the program's transition phase portrayed enhancement as one management tool among others (including management of fishing to rebuild natural stocks) available to achieve the Department's production objectives. This was a significant departure from the original rationale of the Salmonid Enhancement Program, which saw enhancement as the only means of increasing production. The doubling objective was no longer a program objective but a Departmental objective, to which enhancement was to contribute an undefined share.

The 1985 preliminary evaluation also recommended a shift of enhancement effort toward more natural methods in view of the risks to wild stocks (3). The 1985 Pacific Salmon Treaty with the United States opened up new opportunities, especially on the Fraser River. The following year the Department began work on a Salmon Stock Management Plan, which was to integrate enhancement, fisheries management and habitat management as means of restoring salmon populations.

The more holistic, strategic approach to salmon management has never been realized, but the Salmon Stock Management Plan helped to set the stage for Phase II of the enhancement program. Submissions to Ministers for funding in 1986 and 1987 presented enhancement as an integral part of the management plan — creating new opportunities, mitigating losses from overfishing and habitat degradation, and stabilizing production in many areas. No production targets were specified, but funding was requested to maintain and improve existing operations, to avoid a 25 percent decline in production.

All of this is consistent with the program managers' firmly-held view that the primary objective of the program changed from doubling salmon production to rehabilitating depressed wild stocks. But it is nevertheless difficult to document an official change of this kind in the program's mandate.

Indeed, the final submission to Ministers for funding, in 1987, reiterates the original objective, stating that "the Salmonid Enhancement Program's long-term objective is to double Canada's Pacific Coast salmonid stocks and thereby provide economic and job creation benefits to all Canadians...".

I find it difficult to interpret this apparent confusion of objectives, and it presents a difficulty for this review because the enhancement program must be evaluated in terms of its mandate. The evidence seems to justify the following conclusions, at least:

1. The priorities of the program's managers and planners clearly shifted, in the early 1980s, from boosting salmon production by artificial means to rehabilitating depressed natural stocks, especially coho and chinook.

2. It is less clear that the Treasury Board and Ministers abandoned the original objectives. Certainly they encouraged the program to do new and different things, but there is little evidence that they consciously abolished the objective of cost-efficient salmon production or the target of doubling production.

3. From the viewpoint of fisheries management, the change in priorities was not necessarily a bad thing. The big hatchery projects, hastily undertaken when the program began, were raising legitimate concerns. Opportunities had changed as well. The indications of confusion within the government about the purpose of the program is nevertheless worrisome.

4. The depiction, to Ministers, of enhancement as an integrated part of resource management along with habitat and fisheries management is a misrepresentation. Virtually all knowledgeable people agree that such integration, though urgently needed, is lacking.

5. The effort to achieve the program's original production targets was constrained by two factors. One was the shift in priorities referred to above, which diverted effort from highly-efficient technologies for producing sockeye and chum to inefficient and costly facilities for coho and chinook. The other factor was the shortfall in funding from the levels initially envisaged. Phase I funding was diluted by nearly half the planned level through the combined effects of inflation and stretching the funds over two additional years.

In short, the Salmonid Enhancement Program has not had a well defined production target since at least 1983, when doubling was recast as a goal to which enhancement, along with other activities, could contribute. More important for present purposes, however, is the uncertainty surrounding the program's change in priorities. For a time, at least, it was aimed at increasing salmon production, but as a practical matter the focus shifted to restoration of depressed stocks of coho and chinook.

We are left with the question of which of these objectives to use as the basis for evaluating achievements. I therefore examine both. The next chapter assesses the increase in enhanced salmon production attributable to the Salmonid Enhancement Program. It also identifies changes in production from wild stocks of coho and chinook. Chapter 4 analyses the accomplishments in economic terms, weighing the benefits and costs.

## Observations

In retrospect, the planners of the Salmonid Enhancement Program failed to take sufficient account of several factors that should have influenced the enhancement strategy. One was that salmon stocks were not, overall, in decline; catches had increased since the late 1950s and 1960s. Another was that there was a great deal of scope for rebuilding salmon stocks through better management of fishing and escapements, as Dr. Ricker had suggested and as was later demonstrated. A third was that the technology of enhancement and the impacts of enhanced stocks on wild stocks were not well understood.

As the enhancement program progressed, these misconceptions became clear, and in the face of new demands and opportunities priority shifted from cost-efficient production of enhanced stocks to restoration of depressed wild stocks. This change in objectives was not well documented, however, and there remains some ambiguity about the program's mandate.

Nevertheless, a formidable addition to enhancement capability has been put in place, as I describe in the next chapter. The change in emphasis from high-production facilities for sockeye, pink and chum to hatcheries for chinook and coho, smaller scale community projects and non-production activities, inevitably lowered the economic performance of the program, which I examine in Chapter 4.

# 3

# GAINS IN SALMON PRODUCTION FROM ENHANCEMENT

THE central purpose of the Salmonid Enhancement Program is to boost fish production. This chapter draws on the latest statistics and scientific evidence available to reveal how much the enhancement effort has contributed to catches of salmon.

There has been much confusion about how to measure performance in enhancement, so it is worth emphasizing a couple of points about the estimates that follow. First, the product of enhancement must be measured in terms of the fish that originate in enhancement facilities, return as adults, *and contribute either to catches or to the next generation as spawners.* In particular, we cannot judge success on the basis of how many juvenile fish are released to sea, because only a small and varying fraction of them survive, and we cannot count returning adult fish that add neither to catches nor to the next generation through effective spawning. Our interest here is in how many enhanced fish have been added to catches and needed escapements; this is how we define *production.*

Second, in order to appraise the Salmonid Enhancement Program's contribution, we must subtract from the enhanced production the share attributable to facilities that were in place before the program began. We include production from these pre-SEP facilities only to the extent that it is attributable to expansion of their capacity under the program.

Third, we must make an important distinction between *catch* and *production*. Production includes escapements of adult salmon as well as the fish caught. Here, we are mainly concerned with catch, which is the portion of production that yields direct benefits. Unless indicated otherwise, the enhanced catch refers to salmon produced in Canadian facilities and harvested by Canadians in the commercial, recreational and Indian "food" fisheries, and by U.S. fishers. Production includes, in addition to these catches, escapement of enhanced fish.

The object of this exercise is to identify the net contribution of the enhancement program; that is, the extent to which catches with the program exceed the catches we would have had without it — the *incremental gain.* This chapter begins by tracing the increase in salmon catches since the Salmonid Enhancement Program was introduced in 1977. It then assesses the contribution of enhanced production to this increase. Finally, it identifies the share of the enhanced production and catches that can be attributed to the Salmonid Enhancement Program.

## Increased Production

Enhanced salmon production became significant after 1981 when adult returns to the Babine Lake spawning channels and new facilities built under the Salmonid Enhancement Program began to materialize. Since then, enhanced production of salmon has grown to a significant share of the total catch, as illustrated in Figure 7.

The increase in catches since the enhancement program began can be measured by comparing present catches with catches prior to the program in pre-enhancement years. To obtain a reasonable measure of present catches, free of the wide year to year variation due to salmon cycles, we take the average of the last six years for which we have complete data — 1985 to 1990. On this basis, the present annual Canadian catch amounts to about 99,000 metric tonnes. From this we subtract average catches in earlier years, 1967 to 1978. As shown in Table 4, this indicates an increase in the annual catch of salmon of 29,000 metric tonnes, or 41 percent. Of this increase, 55 percent is attributable to increased catches of wild stocks. The remaining 45 percent — the 12,939 metric tonnes shown in Table 4 — is enhanced. (The division between wild and enhanced catch is not precise because of small but unknown quantities of enhanced salmon in pre-SEP catches, and of U.S. wild and enhanced salmon in Canadian catches). To this Canadian catch a small portion of enhanced production caught by U.S. fishers must be added to yield our best estimate of the current *catch* of enhanced salmon, 13,879 metric tonnes.

The estimate of total enhanced *production*, of 22,866 metric tonnes, shown in Table 4, is obtained by adding escapements of nearly 9,000 metric tonnes to the enhanced catch.

Most of the 29,000 tonnes increase in the average annual catch since 1978 has been in sockeye and pink salmon. Catches of these species have increased by 76 and 68 percent respectively, mostly due to increases in Fraser River wild stocks. The enhanced portion of the catch is only 5 percent for pink and 8 percent for sockeye.

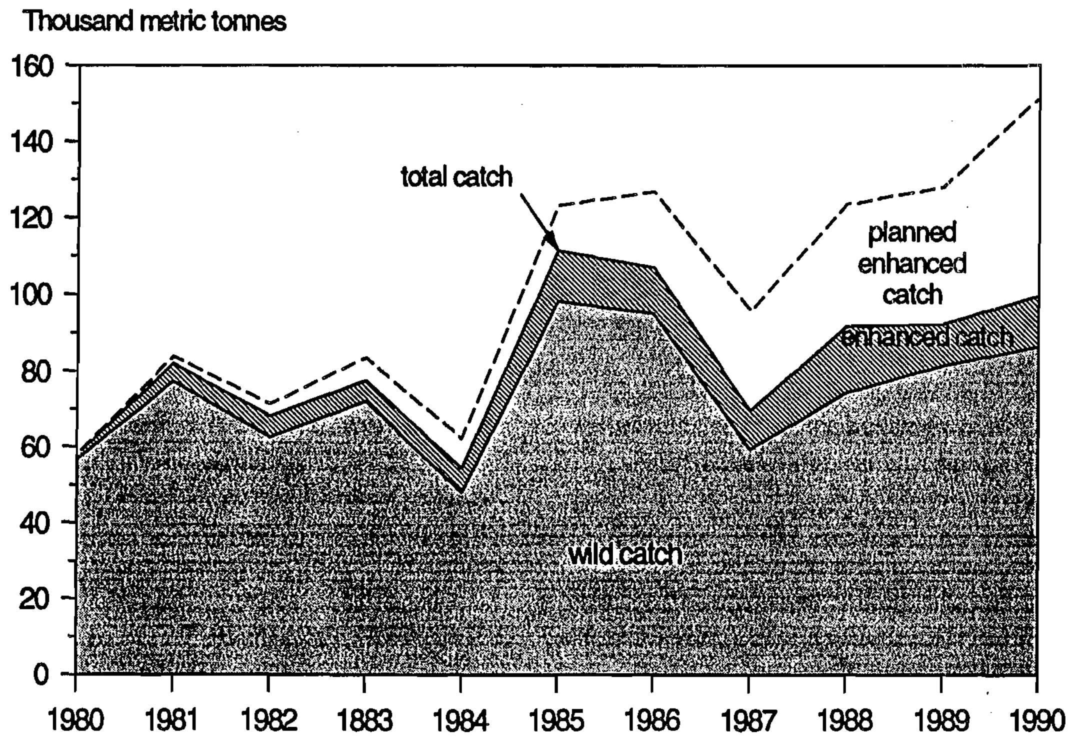



**Figure 7. Catches of wild and enhanced salmon since 1980**

**Table 4. Current annual production and catch of enhanced salmon[a]**

| | (metric tonnes) |
|---|---|
| Present Canadian catch | 99,000 |
| *less* pre-SEP catch | - 70,000 |
| Increase in annual catch since SEP began | 29,000 |
| *less* increase in catch of wild salmon[b] | - 16,061 |
| Canadian catch of enhanced salmon | 12,939 |
| *plus* U.S. catch of enhanced salmon | + 940 |
| Total catch of enhanced salmon | 13,879 |
| *plus* escapement of enhanced salmon[c] | + 8,987 |
| **Enhanced production** | **22,866** |

[a]Average for the years 1985 to 1990 inclusive.
[b]Includes some U.S. enhanced salmon.
[c]Includes surplus escapement.

Total catches of chum have also increased substantially — by some 42 percent. But in this case enhanced production has contributed significantly, and now comprises about 34 percent of the total average catch. Catches of wild chum have declined by 7 percent, but this may be due to changed fishing patterns. The condition of wild chum stocks is not well understood.

Catches of coho and chinook have declined by 4 percent and 15 percent respectively, and catches of wild fish have declined even more — by 19 percent for coho and 24 percent for chinook. Enhancement has compensated for the decline in wild stocks (and may have contributed to it, as discussed below). Changes in the management of chinook have probably played a role in the declining catches of this species also. Enhanced coho and chinook now account for 15 and 11 percent respectively of the total catches of these species.

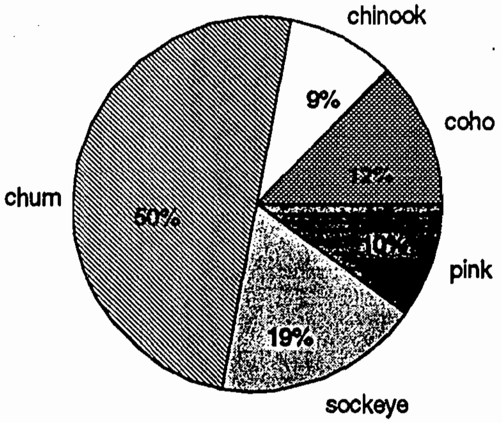
## Enhanced Production

Canadian enhanced salmon now account for 12,939 metric tonnes, or 13 percent of the total Canadian catch. As Figure 8 indicates, chum account for half of the enhanced catch, sockeye 19 percent, coho 12 percent, chinook 9 percent and pink 10 percent. These figures represent Canadian commercial catches plus sports catches of chinook and coho and catches in the Indian fishery. The proportions of wild and enhanced fish in the total catch are roughly illustrated in Figure 9.

To estimate the total enhanced production we must add to the Canadian catch the small amount of enhanced production caught by U.S. fishers, which is credited to Canada under the Pacific Salmon Treaty with the United States, and the escapement of enhanced fish. As Table 4 indicates, these adjustments bring the total enhanced production of salmon to 22,866 metric tonnes.

## Contribution of the Salmonid Enhancement Program

Not all enhanced production can be attributed to the Salmonid Enhancement Program, because some enhancement facilities were constructed before this program began. To assess the Salmonid Enhancement Program we must therefore subtract the enhanced production due to




| | metric tonnes[a] |
|---|---|
| includes: | |
| Canadian catch | 12,939 |
| U.S. catch | 940 |
| escapement | 8,987 |
| Total | 22,866 |

[a]Average annual production 1985 to 1990.

**Figure 8. Species composition of enhanced production**

pre-existing facilities inherited from the Department and the Commission, assuming that they would have continued to operate without the new program.

These adjustments, shown in Table 5, indicate that the enhanced production due to the Salmonid Enhancement Program is about 76 percent of the total enhanced production. The other 24 percent is attributable to facilities built outside the program.

About 80 percent of the production due to pre-program facilities consists of sockeye from the Babine Lake spawning channels, built in the late 1960s and early 1970s. The facilities on the Fraser River built by the Commission also consist mainly of sockeye spawning channels, which were transferred to the Salmonid Enhancement Program in 1985. Some of these facilities have been expanded and upgraded since they were inherited by the program; the increased production due to these improvements is attributed to the Salmonid Enhancement Program in Table 5.

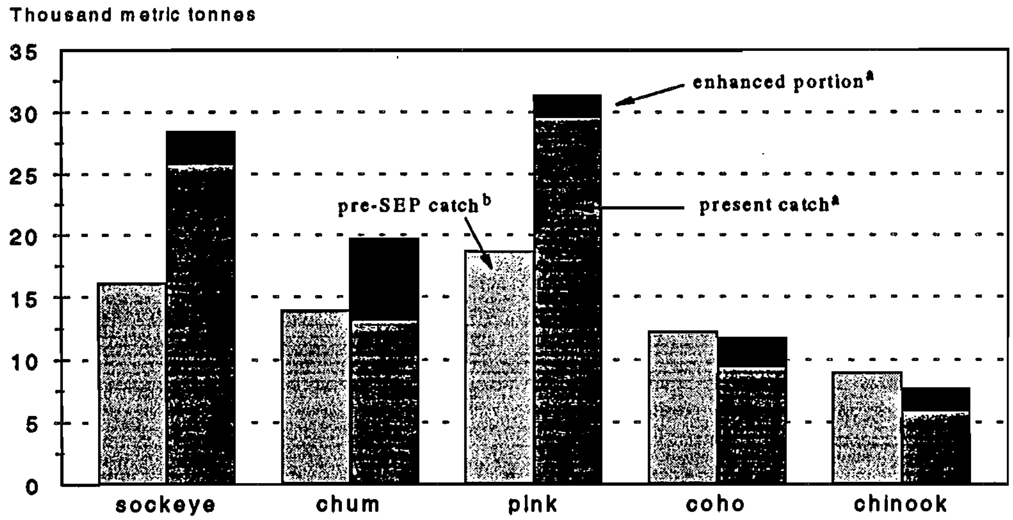
## Adverse Effects on Wild Salmon

A serious concern about large-scale enhancement is its adverse effects on stocks of wild salmon. While we have seen many stocks of wild salmon decline over the years, the causes are often overfishing, habitat deterioration or other factors that have nothing to do with enhancement. Nevertheless, large-scale enhancement is believed to cause wild stocks to decline in some circumstances, through predation, genetic changes, competition and other biological interactions. Fishing enhanced stocks can also cause decline in wild stocks;

**Table 5. The Salmonid Enhancement Program's contribution to salmon production**

| | present annual production[a] (metric tonnes) |
|---|---|
| Enhanced production | 22,866 |
| *less* production from pre-SEP facilities[b] | |
| The Department's pre-1977 facilities | - 4,396 |
| The Commission facilities | - 1,109 |
| **Production attributable to the Salmonid Enhancement Program** | **17,361** |

[a]Average for the years 1985 to 1990 inclusive.
[b]Excludes production due to expansion or improvement of facilities since they were transferred.




| | sockeye | chum | pink | coho | chinook |
|---|---|---|---|---|---|
| increase in total catch (%) | 76 | 42 | 68 | -4 | -15 |
| increase in wild catch (%) | 63 | -7 | 61 | -19 | -24 |
| enhanced portion of present catch (%) | 8 | 34 | 5 | 15 | 11 |

[a]Average for the years 1985 to 1990 inclusive.
[b]Average for the years 1967 to 1978 inclusive.

**Figure 9. Contribution of enhanced production to changes in salmon catches**

since wild stocks cannot sustain the high harvest rates of enhanced stocks, attempts to fully utilize enhanced stocks can deplete the wild stocks mingling with them. Later, in Chapter 5, I discuss examples of these biological interactions and fishing effects. Their impacts on production of wild salmon have not been clearly distinguished, and are difficult to estimate. They apparently vary greatly among areas, and with the circumstances of enhancement facilities — their scale, location, species produced and so on — so it is difficult to generalize about them or to estimate average effects.

The Department's Internal Audit and Evaluation Branch, in its 1988 Evaluation Framework for the Salmonid Enhancement Program (noted in Chapter 1), recognized that estimates of losses to wild salmon production due to enhancement were needed to measure the net contribution of the enhancement program (4). The "with and without enhancement" approach to assessing the net gain from the program requires subtracting from the production of enhanced fish any such losses in wild fish production. In view of the dearth of scientific information on this subject, the Evaluation Framework report proposed an international conference of experts and development of a simulation model, then considered to be the most promising way of estimating the effects of stock interactions. The conference was held in Nanaimo in 1991, and all the speakers who addressed the issue of managing mixed wild and enhanced stocks confirmed that enhancement has, in many instances, been prejudicial to the conservation of wild stocks. The Department began work on the simulation model, but the project was suspended when the funding was reallocated.

Since the requested information is still not available, I resorted to expert opinion for the purposes of this investigation. Research scientists within and outside the Department all reported a high level of concern about adverse impacts on wild stocks. However, my attempt to use expert opinion to assess the effects quantitatively revealed such uncertainty, and such divergence of opinion, that no defensible estimate could be made.

The assessment of the contribution of the Salmonid Enhancement Program in this chapter therefore takes no account of reduced production from wild stocks. This may exaggerate the benefits, but we have no way of estimating the degree.

## Concluding Comments

The analysis of enhanced production of salmon in this chapter leads to a number of conclusions about the Salmonid Enhancement Program which can be summarized as follows:

- Since the Salmonid Enhancement Program was introduced in 1977, the capacity to produce young fish for release to the sea has increased impressively, especially for chinook, coho and chum salmon. At present, some 700 million juvenile fish are released from enhancement facilities each year.

- The effectiveness of enhancement efforts must be measured in terms of adult fish that return to contribute to catches and to productive spawning. In recent years, adult production has averaged about 22,866 tonnes per year, of which 13,879 tonnes or 60 percent has been caught. The remainder has gone to escapement, of which a significant but unknown portion is surplus.

  Half the enhanced production consists of chum, which now comprise about a third of the total chum catch. Enhanced production of sockeye from spawning channels has also made a significant contribution to increased catches.

- Total salmon catches have increased significantly since the enhancement program began, but more of the increase is due to rebuilding of natural stocks than to artificial enhancement. Notably, catches of wild sockeye and pink salmon, mostly Fraser River stocks, have both increased by more than 60 percent through better control of fishing and high rates of ocean survival, and this has contributed significantly to the overall 16,600 tonnes annual increase in wild catch.

- The average annual catch of enhanced salmon between 1985 and 1990, of 13,879 tonnes, is well below the original target of about 50,000 tonnes that was to have been achieved by the end of this period. Further substantial increases in enhanced production appear unlikely.

- The main reasons for the modest achievement in total enhanced production are twofold. One is the shift in spending from cost-efficient production of sockeye and chum to costly attempts to restore depressed stocks of chinook and coho. The adult survival of chinook and coho is low, and lower than expected. About two-thirds of enhancement resources have been expended on these two species over the life of the program. The other reason is funding at lower levels than anticipated.

- There is little evidence that the enhancement program has succeeded in rebuilding wild stocks of chinook and coho. Catches and abundance of wild fish of both species have continued to decline, especially in Georgia Strait where they support much of the recreational fishing for salmon. Terminal fisheries on enhanced stocks on the west coast of Vancouver Island are credited with relieving fishing pressure on wild stocks in Georgia Strait, and enhancement may have facilitated regulatory arrangements to allow increased chinook escapements on the central coast and upper Fraser. But the effort to rebuild wild chinook stocks has produced, at best, limited and uncertain successes, and for coho has clearly failed.

- Declines in wild stocks of coho and chinook have been offset to some extent by enhanced production. Some scientists fear that diverse wild stocks are being displaced and replaced by enhanced stocks.

- Efforts to rebuild wild stocks of chum appear more successful. Shifting to terminal fisheries for enhanced stocks has enabled managers to divert fishing pressure away from wild stocks. However, the present condition of wild chum stocks is uncertain.

- There has been a significant loss in the abundance and diversity of many wild stocks of all species of salmon due to overfishing. This problem has been aggravated by the build-up of enhanced stocks which are exploited heavily while wild stocks mingle with them.

- The question of adverse effects of enhancement on wild stocks is serious but poorly understood. The required monitoring and research has not been carried out, despite repeated proposals to do so.

# 4

# BENEFITS AND COSTS OF ENHANCED PRODUCTION

WITH the estimates of production of enhanced salmon in the preceding chapter, I now turn to the value of that production and the costs of producing it. One of the primary goals of the Salmonid Enhancement Program was to increase national and provincial income, which means producing fish that are worth more than the costs of producing them. In this chapter I assess the costs of fish production in enhancement facilities, and compare these with the value of the fish produced.

The data needed for a precise evaluation of economic performance are not all available and, as is usually the case with benefit-cost analyses, various assumptions must be made. The following paragraphs summarize the results of calculations using the best data available and what I consider to be the most reasonable assumptions. The method of assessing costs and benefits, and some supplementary calculations, are described in detail in the Appendix to this document.

I should emphasize at the outset that although economic objectives of the Salmonid Enhancement Program are important, they are not the only objectives. The program includes activities that are not linked directly to catches of fish, such as education, training for natives and public information. We consider these later. I have also noted that the priorities of the program's managers shifted toward restoration of depressed stocks. But because the original purpose of the program was to take advantage of the economic potential of enhancement, I begin by examining the benefits and costs of salmon production.

### Costs of Production

With the aid of the Department's computer-based economic assessment model (which we modified in several ways, described in the Appendix) we determined the cost of production from each of the roughly 450 enhancement facilities constructed, of which more than 300 are now operating. This includes pre-SEP facilities as well as facilities built under the Salmonid Enhancement Program. For each facility, we added together the *capital* and *operating costs* in each year since it was built or transferred to the program. Costs in past years were adjusted for inflation, to express them all in dollars of constant value. The costs in each year since 1977 were then converted to their present worth in 1993 by applying a compound interest rate of 8 percent. This gave a single figure for the *past cost* of the facility in 1993 dollars, summarized for each type of facility in Table 6.

The Department's experts estimate that the enhancement facilities now in place will have a productive life extending, on average, another 24 years, to 2017. We therefore projected the cost, in constant dollars, of operating and

**Table 6. Total cost of enhancement to 1993 and projections to 2017 by type of facility**

| | past cost 1977 to 1993[a] | future cost 1994 to 2017[b] | total lifetime cost |
|---|---|---|---|
| | | (millions of 1993 dollars) | |
| PRE-SEP FACILITIES[c] | | | |
| Hatcheries | 130.8 | 29.7 | 160.5 |
| Spawning channels | 48.8 | 15.0 | 63.8 |
| Total pre-SEP facilities | 179.6 | 44.8 | 224.4 |
| SEP FACILITIES[d] | | | |
| Hatcheries | 896.3 | 135.7 | 1,032.0 |
| Spawning channels | 39.7 | 4.6 | 44.3 |
| Spawning bed restoration | 41.9 | 5.3 | 47.2 |
| Lake fertilization | 83.5 | 15.6 | 99.1 |
| Community Development Projects | 152.8 | 49.5 | 202.3 |
| Public Involvement Projects | 69.0 | 17.7 | 86.7 |
| Total SEP facilities | 1,283.2 | 228.5 | 1,511.6 |
| ALL FACILITIES | 1,462.8 | 273.2 | 1,736.0 |

[a]Capital and operating costs for each year since 1977, or since the facilities were constructed for facilities built since 1977, compounded at 8 percent to 1993.

[b]Projected capital and operating costs for each year from 1994 to 2017, discounted at 8 percent to 1993.

[c]Where pre-SEP facilities were expanded under the Salmonid Enhancement Program, the share of total costs attributable to the expansion was estimated and included in the "SEP Facilities" category.

[d]The cost of non-production activities which are part of the on-going operations of enhancement facilities, such as project assessment and fish marking, are included. Enhancement costs not directly associated with production, such as headquarters costs and other overhead costs, have been pro-rated across all projects in proportion to their other costs. Costs of other non-production activities under the Salmonid Enhancement Program, such as expenditures on research, education and public information, have been excluded.

maintaining each facility in each year from 1994 to 2017. These were discounted at 8 percent to give their equivalent value in 1993 dollars. This is the *future cost* of the facilities over their remaining life, summarized by category of facilities in Table 6. The past and future costs together give the *total cost* over the assumed life of the facilities. Table 6 indicates that the total lifetime costs of the enhancement facilities now operating is more than $1.7 billion.

The costs in Table 6 include overhead costs attributable to enhancement, such as the costs of the Director's office, project assessment and fish marking. But they exclude costs of non-production activities such as education, public information and research (discussed later). They also exclude the cost of fishways and some minor habitat restoration projects; although these are enhancement facilities, we have no data on their contribution to production and so are excluded from estimates of both costs and benefits here. In any event most of the fishways were built before the Salmonid Enhancement Program began.

## Value of Production

I now turn to the value of the fish produced. We calculated the value separately for the production taken in the commercial fishery, the Indian fishery and the recreational fishery.

### *Commercial fishery benefits*

About 92 percent of the total catch of salmon, wild and enhanced, are caught in the commercial fishery. Benefits of enhanced production accrue to vessel owners, crews, processors and plant workers. The method used to calculate the amount of these benefits is described in the Appendix, and is summarized only briefly here.

*Benefits to vessel owners.* Fishers sell their catches to buyers — mainly processing companies — who are fairly competitive, so the prices paid to fishers provide a reasonable measure of the value of the fish produced (though I qualify this later). We multiplied the average ex-vessel prices paid to fishers for each species, in each year from 1977 to 1993, by the estimated catches of enhanced production to obtain the *gross value* of the enhanced production taken in the commercial fishery (final prices for 1992 and 1993 were not available, so we estimated them).

From this gross value, the net benefit to vessel owners was estimated by deducting from each year's landed value of the enhanced catch:

(i) the estimated increase in vessel operating costs resulting from enhanced catches,

(ii) the share of revenue from enhanced catches that is paid to crews (the "crew share"), and

(iii) half the remainder, as the estimated portion of returns to vessels that is invested in vessel improvements ("fleet capitalization").

*Benefits to crews.* The net benefit to crews is the crew share generated by enhanced catches minus the income that crews would earn in the absence of enhanced catches. To provide for alternative employment income we applied the average wage in other resource industries to the portion of fishing time attributable to enhanced catches, and subtracted that from the crew share to obtain our estimate of the net benefits accruing to crews in each year.

*Benefits to processors.* The processing sector is sufficiently open and competitive that, in general, no net long-term gains, in excess of normal profits, are attributable to it. The exception is the canning sector, in which there is some evidence of barriers to entry, market power in purchasing fish and poor alternative employment opportunities for many of the plant workers. We therefore calculated net benefits in the processing sector as half the wholesale value of the canned portion of the enhanced catch minus the cost of the raw fish and the variable costs in canning.

These estimated net benefits to vessel owners, crews and processing added together give the total benefit of enhanced production in the commercial fishery in each year. For each year from 1977 to 1993 this benefit, again corrected for inflation, was compounded at an annual rate of 8 percent to provide the total value of these benefits in equivalent 1993 dollars. These are the *past benefits* that accrued to the commercial fishery in Table 7.

For each year, from 1994 to 2017, commercial catches of enhanced production were projected and valued using the Department's estimates of price trends. These future values were discounted at 8 percent to yield the *future benefits*, in 1993 dollars. The past and future benefits together give the *total lifetime benefits* of enhancement that accrue to the commercial fishery.

### *Indian fishery benefits*

The value of salmon caught in the Indian "food" fishery is difficult to quantify reliably, because most are not sold in markets. Moreover the fishing and processing, as well as consumption of the product, have special cultural significance to native people, which defies valuation in dollars. However, the desire of many native people to gain access to commercial markets for their fish suggests that market prices do not underestimate their value, to those native groups at least. Thus landed prices were used to estimate the value of enhanced fish taken in the

**Table 7. Total benefits of enhanced production by fishery and type of facilities**

| | past benefits[a] | | | | future | |
|---|---|---|---|---|---|---|
| | to the commercial fishery | to the Indian fishery | to the recreational fishery | all fisheries[b] | benefits all fisheries[c] | total lifetime benefits |
| | | | (millions of 1993 dollars) | | | |
| PRE-SEP FACILITIES | | | | | | |
| Hatcheries | 83.7 | 7.4 | 38.9 | 130.8 | 39.5 | 170.3 |
| Spawning channels | 122.8 | 15.3 | 0 | 138.1 | 100.5 | 238.6 |
| Total pre-SEP facilities | 206.5 | 22.6 | 38.9 | 269.0 | 140.0 | 408.9 |
| SEP FACILITIES | | | | | | |
| Hatcheries | 256.9 | 19.9 | 98.9 | 377.3 | 205.7 | 583.0 |
| Spawning channels | 46.2 | 4.9 | 0 | 51.2 | 44.2 | 95.3 |
| Spawning bed restoration | 7.7 | 0.5 | 2.1 | 10.3 | 9.6 | 19.9 |
| Lake fertilization | 91.8 | 6.7 | 1.1 | 99.7 | 29.0 | 128.6 |
| Community Development Projects | 18.9 | 1.6 | 12.2 | 32.8 | 29.8 | 62.5 |
| Public Involvement Projects | 7.0 | .6 | 6.5 | 14.0 | 16.4 | 30.5 |
| Total SEP facilities | 428.5 | 34.5 | 120.8 | 585.2 | 334.7 | 919.9 |
| ALL FACILITIES | 635.0 | 57.0 | 159.6 | 854.1 | 474.7 | 1,328.8 |

[a]Values for each year since 1977 compounded to 1993 at an annual rate of 8 percent.

[b]Includes a small amount (less than 0.4% of the total) in sales of eggs and surplus fish at hatcheries. Thus columns do not add exactly.

[c]Projected benefits in each year from 1994 to 2017, discounted to 1993 at an annual rate of 8 percent.

Indian fishery. But because of the traditional and cultural significance of this fishery, no fishing costs were deducted, so that the full landed prices were taken as net benefits accruing to the Indian fishery. Multiplied by catches of enhanced fish each year, and converted to 1993 equivalent value in the same way as for commercial benefits, produced the estimates of past and future benefits to the Indian fishery in Table 7.

### *Recreational fishery benefits*

The value of enhanced fish taken in the recreational fishery is even more difficult to assess. However, studies have estimated the recreational value per coho caught at about $14 and $54.00 per chinook (14). These values, in constant 1993 dollars, were applied to the catch of enhanced salmon taken in the recreational fishery each year since 1977, and projected catches to the year 2017. With these annual values, the past and future recreational benefits were calculated in the same manner as the commercial values, to yield the recreational benefits in 1993 dollars.

The estimates of future benefits to the commercial, Indian and recreational fisheries are added together to give the *Future benefits — all fisheries* in Table 7. The combined estimates of past and future benefits are the *total lifetime benefits* of the facilities.

## Comparison of Benefits and Costs

The total benefits of past and expected production of the enhancement facilities now operating, estimated in the manner described, amount to $1.3 billion in 1993 dollars. The costs, similarly expressed in 1993 dollars, are about $1.7 billion. The costs thus exceed the benefits by 407 million, and the ratio of benefits to costs is .8, implying that each dollar expended yields only about 80¢ in benefits. These results are summarized for each category of enhancement facility in Table 8.

Early in the enhancement program a benefit-cost ratio of 1.5 was proposed as a target for planning facilities. While it is questionable whether that target is still relevant, it is worth noting that only spawning channels achieve that level of economic efficiency. Among the facilities built under the Salmonid Enhancement Program, spawning channels and lake fertilization are the only categories that show benefits greater than costs.

## Evaluation of Salmonid Enhancement Program Facilities

A major purpose of this review is to assess the accomplishments of the Salmonid Enhancement Program, which requires evaluating the facilities built under the program independently of the pre-SEP facilities. The data in the preceding tables present the benefits and costs of "SEP facilities" separately for this purpose.

Table 10 indicates an overall benefit-cost ratio for "SEP facilities" of .6, reflecting costs that exceed the benefits over the life of these facilities by nearly $600 million. The performance of SEP facilities is depressed by the heavy weight of poorly-performing hatcheries producing coho and chinook. Community Development Projects also show

**Table 8. Comparison of benefits and costs of enhancement**

| | benefits[a] | costs[b] | net benefits | benefit/cost ratio |
|---|---|---|---|---|
| | | (millions of 1993 dollars) | | |
| PRE-SEP FACILITIES | | | | |
| Hatcheries | 170.3 | 160.5 | 9.7 | 1.1 |
| Spawning channels | 238.6 | 63.8 | 174.8 | 3.7 |
| Total pre-SEP facilities | 408.9 | 224.4 | 184.5 | 1.8 |
| SEP FACILITIES | | | | |
| Hatcheries | 583.0 | 1,032.0 | -448.9 | .6 |
| Spawning channels | 95.3 | 44.3 | 51.0 | 2.2 |
| Spawning bed restoration | 19.9 | 47.2 | -27.3 | .4 |
| Lake fertilization | 128.6 | 99.1 | 29.5 | 1.3 |
| Community Development Projects | 62.5 | 202.3 | -139.8 | .3 |
| Public Involvement Projects | 30.5 | 86.7 | -56.2 | .4 |
| Total SEP facilities | 919.9 | 1,511.6 | -591.8 | .6 |
| ALL FACILITIES | 1,328.8 | 1,736.0 | -407.2 | .8 |

[a]From Table 7. Total benefits over the lifetime of facilities, 1977 to 2017.

[b]From Table 6. Total costs over the lifetime of facilities, 1977 to 1017.

low returns on expenditures, as do side channels and Public Involvement Projects — again, especially those concentrating on coho and chinook.

## Differences Among Species

The value of the five species of salmon, and the cost of producing them, vary significantly. Differences in the cost of producing different species is important for purposes of assessing the cost-effectiveness of the enhancement effort. It is an important policy issue also, because each species is unique in terms of the condition of the stocks, the value of the fish produced, and the user-groups that benefit from the fish produced.

For facilities that produce only one species, the estimation of cost is relatively straightforward. For facilities that produce more than one species, we apportioned the total facility cost in proportion to the total weight, or "biomass," of the juveniles of each species released. (This is a more appropriate way of allocating costs than simply according to the *number* of juveniles of each species released, because some species such as coho and chinook are reared in facilities much longer, and released when they are much bigger, than other species. They are thus costlier to produce, because of their greater demands on facilities and on operating costs such as labour, feed and energy. The total *weight* of the juveniles released accounts, roughly, for these differences.) This indicates that, overall, pink salmon account for an almost insignificant portion — less than one percent — of program costs. Sockeye account for 5 percent, chum 19 percent, coho 28 percent and chinook 42 percent.

With the cost data for each type of facility, we used this method to calculate the recent average cost of each species of salmon produced in each category, including the pre-SEP facilities, for the 1984 to 1987 brood years. The results are summarized in Table 9. Noteworthy is the wide variation in average production cost among species — from 14¢ per fish for pink to $20.22 per chinook.

The primary causes of these wide differences among species are threefold. One is the differences in ocean survival, discussed in the last chapter. Another is the higher cost of capturing and holding adult brood stock of species such as coho and chinook. The third is variation in the cost of rearing the juveniles released. As noted earlier, coho and chinook are reared in hatcheries for longer periods than pink and chum, and so are more expensive.

For the purposes of the present review, it is important to note, also, the wide variation in production costs among the types of enhancement facilities, even for the same species. Indeed, the cost of production varies considerably even among facilities of the same type (this is not shown in Table 9, but can be seen in the Appendix). As a result, production costs vary over a remarkably wide range. The cost of producing chinook ranges from $3.58 to $255.26 per fish, sockeye range from 48¢ to $9.34, and even wider ranges are indicated for chum and coho. The cost per fish produced at the highest-cost facility is often thirty or forty times the cost at the least-cost facility.

If production costs were applied only to the fish that are caught (which would be more consistent with the calculation of benefits, but cannot be done meaningfully because of data limitations) the average costs per fish would be 30 to 40 percent higher than those shown in Table 9.

Some of the resulting differences in costs among species are noteworthy:

*Sockeye.* The average cost of producing sockeye, 87¢ per fish, is dominated by the cost of production from spawning channels. These facilities have low operating costs and produce huge numbers of fry which have relatively high rates of survival, and thus are relatively cost-effective.

**Table 9. Average cost of salmon produced by species and type of enhancement facility[a]**

| | sockeye | pink | chum | coho | chinook |
|---|---|---|---|---|---|
| | | | ($ per fish produced) | | |
| Hatcheries | 2.83 | .09 | 1.66 | 4.84 | 18.75 |
| Spawning channels | .77 | .14 | .57 | n.a. | n.a. |
| Spawning bed restoration | 1.48 | .83 | 1.59 | 3.73 | 35.22 |
| Lake fertilization | 2.15 | n.a. | n.a. | n.a. | n.a. |
| Community Development Projects | 4.76 | .58 | 5.51 | 18.99 | 42.68 |
| Public Involvement Projects | .58 | .33 | .94 | 2.61 | 4.30 |
| All facilities | .87 | .14 | 1.82 | 5.77 | 20.22 |
| Range: highest | 9.34 | 5.97 | 349.92 | 363.12 | 255.26 |
| lowest | .48 | .06 | .28 | .77 | 3.58 |

[a]Calculations based on 1984-1987 brood years. Includes both pre-SEP and SEP facilities.
n.a. means not applicable.

*Pink.* The average cost of pink produced is even lower, at 14¢ per fish, due to high rates of adult survival of juveniles released from hatcheries and spawning channels.

*Chum.* The production cost of chum benefits from a low cost of rearing juveniles in hatcheries (about 2¢ per fish), and relatively high rates of adult survival. However, the average cost per fish, of $1.82, is more than double that of sockeye.

*Coho.* The average cost per coho produced is considerably higher, at $5.77, but it varies widely among facilities. The small Community Development Program hatcheries are about three times costlier than the large hatcheries. The costliest facility — the Community Development Program hatchery at Kyuquot — shows a cost of $363.12 per fish. The Allouette River hatchery is the most efficient producer of coho due to exceptionally high adult survival rates, at 77¢ per fish.

*Chinook.* The production cost of chinook is by far the highest, averaging $20.22 per fish produced (or about $33.00 per fish caught). Again, the major hatcheries are about three times as cost effective in producing chinook as the small Community Development Projects. The largest chinook hatchery, at Robertson Creek, is the most efficient, at $3.58 per fish produced. The costliest is the Salmonid Enhancement Program's own hatchery at Birkenhead, where the cost is $255.26 per fish. (This facility has recently been converted to a public involvement project). Inland hatcheries on the upper Fraser are also expensive, because of low adult survival.

To calculate the net benefits of production of each species in each category of facility, we calculated the cost of producing each species over the lifetime of the facilities, (again using biomass to allocate costs) and compared these costs to the corresponding lifetime benefits expected. Table 10 displays the results, and repeats the ratio of benefits to costs for each category. These results reveal an extraordinarily wide range in the economic returns to enhanced production.

When enhancement facilities are grouped and evaluated by type, as in Table 10, significant positive net benefits are shown only for spawning channels and lake fertilization. Among species, almost all the net gains accrue through sockeye production. Positive net benefits from producing other species in pre-SEP facilities are more than offset by net losses in SEP facilities built under the Salmonid Enhancement Program.

## Sensitivity to Assumptions

I noted at the beginning of this chapter that it was necessary to make certain assumptions about data and relationships in order to proceed with the evaluation summarized above. Some of these assumptions are debatable, and some also differ from assumptions adopted by the Department and others in carrying out their evaluations (14) (21).

To show the effect of these assumptions on our results, and how our results would have differed if we had adopted other assumptions, we re-calculated the benefit-cost relationships using alternative assumptions, listed in Table 11. These assumptions, and the reasons why I consider them less appropriate than those I have adopted in the preceding pages, deserve brief comment.

1. *The base case*. The base case incorporates the assumptions described earlier in this chapter to assess the facilities built under the Salmonid Enhancement Program.

2. *Including pre-SEP facilities*. This shows the effect of including all the production and costs of the pre-SEP facilities in the assessment. Evaluation of the Salmonid Enhancement Program should, of course, exclude the benefits and costs of facilities built before the program began.

**Table 10. Net benefits of enhanced production by species and type of enhancement facilities[a]**

| | sockeye | pink | chum | coho | chinook | all species | *benefit/cost ratio* |
|---|---|---|---|---|---|---|---|
| | | | (millions of 1993 dollars) | | | | |
| PRE-SEP FACILITIES | | | | | | | |
| Hatcheries | -2.9 | 10.3 | 25.4 | -33.6 | 15.6 | 9.8 | *1.1* |
| Spawning channels | 166.7 | 7.4 | -.2 | -.1 | 0 | 174.8 | *3.7* |
| Total pre-SEP facilities | 163.8 | 17.7 | 25.6 | -33.7 | 15.5 | 184.5 | *1.8* |
| *Benefit/cost ratio* | *3.6* | *3.4* | 2.7 | *.6* | *1.3* | *1.8* | |
| SEP FACILITIES | | | | | | | |
| Hatcheries | 1.7 | 7.3 | -9.1 | -142.3 | -252.0 | -448.9 | *.6* |
| Spawning channels | 52.5 | .3 | -1.2 | 0 | 0 | 51.0 | *2.2* |
| Spawning bed restoration | -.2 | .6 | -23.1 | -3.8 | -.8 | -27.3 | *.4* |
| Lake fertilization | 29.5 | 0 | 0 | 0 | 0 | 29.5 | *1.3* |
| Community Development Projects | -3.4 | 1.4 | -26.7 | -58.3 | -44.9 | -139.8 | *.3* |
| Public Involvement Projects | 0 | -0.6 | -2.8 | -32.2 | -13.8 | -56.2 | *.4* |
| Total SEP facilities | 80.1 | 9.1 | 62.9 | -236.7 | -311.5 | -591.8 | *.6* |
| *Benefit/cost ratio* | *1.6* | *1.4* | *.8* | *.4* | *.5* | *.6* | |
| ALL FACILITIES | 243.9 | 26.8 | -37.3 | -270.4 | -296.2 | -407.2 | *.8* |
| *Benefit/cost ratio* | *2.2* | *1.9* | *.9* | *.4* | *.5* | *.8* | |

[a]Based on the total lifetime benefits and costs of enhancement facilities, calculated as in Tables 7 and 6 respectively.

3. *Net benefits to all processing.* This includes an extreme estimate of benefits accruing to the processing sector; that is, benefits equal to the wholesale value of all processed fish minus only variable costs and the cost of the raw fish, implying that additional production through enhancement will not induce investment in processing capacity. The early planners of the Salmonid Enhancement Project assumed this, on the grounds that surplus capacity already existed, and that government could be expected to take steps to prevent further investment (9). However, no controls were ever introduced, and investment in processing has continued.

4. *No processing benefits.* This provides for no benefits to processors, which would be an appropriate long-run assumption if there were no barriers to entry — conditions which are not fully met, in the canning sector at least. The only benefit included for the processing sector is the income of plant workers in excess of their potential earnings in alternative employment.

5. *Adverse impacts on wild stocks.* This incorporates a crude assumption to illustrate the possible adverse effect of enhancement on wild stocks, by deducting from enhanced production half the observed declines in catches of coho and chinook in Georgia Strait and half the declines in Skeena sockeye catches since 1977. There are no reliable data to support this illustrative impact, however.

6. *No alternative employment income for crews.* This assumes that none of the labour employed in catching enhanced salmon has alternative employment opportunities, so that all labour income is net gain. This almost certainly underestimates the mobility of fishers.

7. *Indian fishery catch valued at wholesale prices.* This ascribes a value to the enhanced catch in the Indian fishery at the wholesale value of processed fish in the commercial sector. These fish are not processed and marketed like commercial catches, however, and there is no basis for valuing them at processed prices.

8. *Doubled value of recreational catch.* Doubling the assumed value of fish caught by recreational fishers — to $28 per coho and $108 per chinook — shows the sensitivity of the results to recreational values. However, there is no basis for such an alternative assumption. Indeed, the base case estimates are average values, and may already exaggerate the marginal value of enhanced catches.

9. *Interest rate of 5 percent.* Assuming a lower interest rate, of five percent, raises the benefit-cost ratio because it reduces the present worth of the initial cost of facilities and raises the discounted value of future benefits. However, such a low interest rate is not consistent with the value of funds reflected in long-term borrowing rates.

10. *Interest rate of 10 percent.* A higher interest rate of ten percent finds support in a federal benefit-cost analysis manual (22). However, that suggestion, proposed eighteen years ago, is high in today's context.

While I consider all of these alternative assumptions less defensible than those we have adopted in our base case calculations, Table 11 indicates that none of them alone alters the overall economic assessment significantly.

The Department's own evaluation model for the Salmonid Enhancement Program incorporates several of these alternative assumptions which together produce much more favourable results (4). Most of them were adopted, as well, in the recent assessment by the ARA Consulting Group Inc. (21). Most importantly, that study provided for much greater benefits in processing, by excluding capital costs and assuming that all revenues in excess of variable costs and the cost of fish would accrue as profits. It also included the pre-SEP facilities, which show a

**Table 11. Effect of alternative assumptions on the estimated benefits and costs of the Salmonid Enhancement Program**

| change in assumptions from the base case | total benefits | total costs | net benefits | *benefit/cost ratio* |
|---|---|---|---|---|
| | | (millions of 1993 dollars) | | |
| 1. Base case[a] | 919.9 | 1,511.6 | -591.8 | .6 |
| 2. Including pre-SEP facilities | 1,328.8 | 1,736.0 | -407.2 | .8 |
| 3. Net benefits in all processing[b] | 1,248.1 | 1,511.6 | -263.5 | .8 |
| 4. No net benefits to processors[c] | 839.6 | 1,511.6 | -672.0 | .6 |
| 5. Adverse impacts on wild stocks[d] | 717.2 | 1,511.6 | -794.5 | .5 |
| 6. No alternative employment income for crews[e] | 961.7 | 1,511.6 | -550.0 | .6 |
| 7. Indian fishery catch valued at wholesale prices[f] | 965.8 | 1,511.6 | -545.9 | .6 |
| 8. Doubled value of recreational catch[g] | 1,075.0 | 1,511.6 | -436.7 | .7 |
| 9. Interest rate of 5 percent | 1,001.6 | 1,278.1 | -276.5 | .8 |
| 10. Interest rate of 10 percent | 907.4 | 1,740.4 | -833.0 | .5 |

[a]Based on assumptions described earlier in this chapter.

[b]Including net benefits to all forms of processing, calculated as the wholesale value of the processed fish minus only operating costs and the cost of fish.

[c]Net benefits in processing only to plant workers.

[d]Adverse impacts equal to one-half the observed declines in catches of wild coho and chinook in Georgia Strait and of wild Skeena sockeye.

[e]Net benefits to crews assumed to be the total crew share (i.e. no deduction for alternative earnings).

[f]Net benefits in Indian fishery assumed to be the processed value of the fish caught.

[g]Recreational benefits assumed to be double the values assumed in the base case, i.e. $28 per coho caught and $108 per chinook.

benefit-cost ratio three times higher than the facilities built under the program. In addition, it valued Indian "food" catches at wholesale prices of processed fish. These provisions, combined, roughly doubled the benefits shown for the base case in this chapter, and increased costs by only 13 percent.

In addition, the ARA study used much higher forecasts for fish prices (which the Department has since revised and reduced to reflect the lower prices paid in recent years) increasing net benefits by $260 million. The ARA study produced a considerably higher benefit-cost ratio for the program, of 1.14, mainly as a result of these few differences in assumptions and data.

## Concluding Observations

In strictly economic terms, the production-oriented projects of the Salmonid Enhancement Program show poor returns, overall, on the substantial funds expended on them. In today's dollars, the value of all past expenditures on the enhancement facilities now operating is nearly $1.5 billion, most of which was expended under the Salmonid Enhancement Program. If all these facilities were maintained and operated to the end of their useful life, the total past and future cost, valued today, would be more than $1.7 billion. The corresponding benefits, in the form of increased catches of salmon in the commercial, Indian and recreational fisheries, fall significantly short of these costs.

There is room for debate about some of the assumptions on which this evaluation is based. But within the range of reasonable alternative assumptions, the overall conclusions are not significantly different.

The economic performance of enhancement projects reveals extraordinarily wide variation, from high returns on expenditures on sockeye spawning channels to substantial losses on hatcheries producing mostly coho and chinook. The cost per fish produced varies from a few cents to hundreds of dollars.

This analysis suggests that the Salmonid Enhancement Program, as it developed, was not guided by a consistent effort to achieve a high level of economic performance, as originally intended. The shift in production from large-scale salmon production to stock restoration activities, noted in Chapter 2, had the effect of lowering economic returns. That shift involved redirecting attention from cost-effective sockeye production to coho and chinook, which are not only expensive to produce, but also show low survival.

As I noted at the beginning of this chapter, economic production of salmon was an important, but not the only objective of the Salmonid Enhancement Program. In the following chapter I examine these other benefits and costs, and attempt to evaluate the program in its broader context. I then return to the economic benefits and costs of enhancement facilities to assess the outlook for the future.

# 5

# EVALUATION AND OUTLOOK

THE Salmonid Enhancement Program involves activities that are not aimed primarily at the production of fish. These, and certain effects of enhancement, such as its impacts on wild stocks, are not measurable in commensurate terms and were therefore excluded from the previous chapter's examination of economic performance. In the present chapter I assess these other activities, though only subjectively. I attempt, also, to indicate how my assessment should affect the conclusions drawn from the earlier economic evaluation. The latter part of the chapter draws on all this information to assess possibilities for the future.

## Non-production Activities

I turn first to the non-production activities which are directed toward specific objectives of the Salmonid Enhancement Program. These are fourfold: education and public involvement, research and project assessment, stock assessment and native development.

### *Education and public involvement*

The Salmonid Enhancement Program has committed substantial resources to the related activities of education and public involvement. Early in the program, an educational package "Salmonids in the Classroom" was produced for primary and intermediate pupils in British Columbia schools. More than $1 million has been expended on the original design and subsequent improvements to this package. A supplementary package, "Gently Down the Stream" has been added to help prepare pupils for hatchery tours.

"Salmonids in the Classroom" now reaches some 100,000 pupils annually, 15,000 of whom are also involved in classroom fish incubation projects. The whole educational package is now produced by the B.C. Teachers' Federation and distributed at a price sufficient to cover costs.

This education material is highly regarded among educators, partly because of the support they receive. Three educational coordinators provide advice and support to teachers throughout the province. In addition, the 15 community advisors supported by the Salmonid Enhancement Program assist with classroom projects. And teachers are continuously consulted about ways to improve the material. The annual cost of these advisory and support services is about $625,000.

An innovative public involvement program, coordinated by the community advisors, has supported some 286 small enhancement projects — mostly incubation boxes for coho and chum, but also some stream rehabilitation, side channels and small hatcheries. An estimated 236,000 people (including school-children) have been involved in these activities since the program began.

Recently, pressure from the Salmonid Enhancement Program Task Group and the public has shifted activities toward stream rehabilitation projects. A "Streamkeepers" public involvement initiative has been launched and a manual on stream rehabilitation produced. About $780,000 is now expended annually on public involvement activities.

The benefits of these activities are difficult to assess, but several public opinion surveys indicate that public awareness of the program and its benefits are high, especially within fishing communities. The educational effort is well regarded by educators. And the Salmonid Enhancement Program has received several awards for its communications and public involvement. Apart from some criticism that the information given to the public exaggerates the successes of enhancement, both the educational and public involvement programs appear highly successful.

### *Research and assessment*

The Salmonid Enhancement Program has provided funds for applied research on lake fertilization, fish health, predation, gravel cleaning in spawning channels, interactions between wild and enhanced fish and other questions. The benefits of this work have extended beyond the enhancement program to fish culture generally, including the aquaculture industry in Canada and elsewhere. In recent years, some $700 thousand has been spent annually an enhancement-related research, about three-quarters on problems relating to lake fertilization. As I note in the next chapter, this work has had an important influence on the development of the lake fertilization program.

Project assessment, which I discuss in the following chapter as well, currently accounts for expenditures of about $1 million annually. This work is closely related to mark recovery.

### *Mark recovery program*

With the Salmonid Enhancement Program, a major, systematic tagging and recovery program became feasible, because juvenile fish could be tagged before being released from hatcheries. Previously, a modest number of coho were being marked in Canada and the United States to assist biologists in calculating adult survival rates, harvest rates and other information needed to manage the stocks.

The procedure involves inserting tiny coded wire tags into the snouts of juvenile coho and chinook. These fish then have their adipose fins clipped, so they can later be recognized in catches. Sockeye, pink and chum, which are hatched but not reared in facilities, and so are smaller when released, are usually marked only with a fin-clip.

The initial purpose in tagging enhanced fish was to determine their survival rates. But today this information, combined with new stock assessment techniques, provides the foundation for managing both wild and enhanced stocks of chinook and coho, in both Canada and the United States. Its usefulness extends to the other species of salmon as well. It enables estimates of exploitation rates, and U.S. interceptions of Canadian fish and *vice versa*. It also provides essential data for the wild coho stock rebuilding initiative in the Strait of Georgia, the joint Canada-U.S. Chinnook Rebuilding Plan, and the negotiations between Canada and the United States on interceptions of each others' stocks. The information about the contribution of enhanced production, in Chapter 3, could not have been compiled without this data.

In 1992, coded wire tags were used to mark 8.5 million juvenile fish, at a cost of about 12¢ per fish. Another 3.7 million salmon of all species were marked by removing their adipose fin, at a cost of about 4¢ each. Total marking expenditures under the Salmonid Enhancement Program that year amount to $1.15 million, but have since been reduced to less than half that level.

The present mark recovery program is regarded by experts as one of the world's best. It would be difficult and costly to maintain such a program in the absence of enhancement facilities.

*Native development*

From the beginning, an objective has been to develop economic opportunities for native people. This is achieved mainly through Community Economic Development Projects on reserves, employment of natives at hatcheries elsewhere, expanded catches in the traditional Indian fishery, and increased opportunities in commercial fishing and processing.

In 1992 the Community Economic Development Program funded 17 native-operated hatcheries, which supported an estimated 68 native employees and volunteer workers, some in communities having no other economic opportunity. These projects are supervised by the 15 community advisors located throughout the province, referred to earlier. Another 26 person-years of native employment was provided in other hatcheries.

The amount of training provided was recently estimated at 44 person-years annually, though the benefits are difficult to quantify. Although even more training of personnel is considered desirable, there are rarely opportunities to use the skills learned, other than at the facility where the training is received.

As noted in an earlier chapter, some enhancement facilities are realizing increasing surplus escapements, which are allocated to native communities. At Nitinat, Chilliwack and Chehalis, the Department has entered into agreements with native bands to harvest these surpluses for commercial sale.

Separate from the Salmonid Enhancement Program, as part of the Aboriginal Fisheries Strategy, the Department has committed $14 million over 7 years to give native communities a greater role in fisheries management, including enhancement. Managers believe the experience of having worked with native communities under the Salmonid Enhancement Program has facilitated successful working arrangements through the Aboriginal Fisheries Strategy.

These non-production activities under the Salmonid Enhancement Program are difficult to evaluate without detailed investigation of each. However, they are perceived to be successful by knowledgeable observers, and they seem to be achieving their objectives. But I have no basis for assessing efficiency in the use of funds, or the benefits generated in relation to the costs.

## Unquantified Biological Effects

The economic analysis in Chapter 4 also excluded certain impacts of enhancement on fish production for which data are lacking. By far the most important of these, judging from the scientific literature and opinions of fisheries biologists, is the adverse effect of enhancement on wild stocks. There is no doubt that many wild stocks have declined since the Salmonid Enhancement Program began, but how much is a result of enhancement is highly uncertain. Expert opinion ranges from an insignificant fraction to a major proportion, and the data needed to support conclusions are lacking.

Later in this report I note evidence of these adverse stock interactions resulting from enhanced coho and chinook in Georgia Strait, sockeye in the Skeena River and chum on the central coast. In the preceding chapter I noted that an arbitrary assumption about the impact on coho and chinook stocks alone had a measurable effect on the economic results. But the true magnitude of these effects remains highly uncertain.

It should be noted that stock interactions, particularly those that arise from mixed-stock fishing, are not exclusively associated with enhancement. Abundant wild stocks mixing with weak wild stocks while they are fished gives rise to the same problem. And sometimes the effect is a result of mixed species, such as sparse stocks of steelhead fished with prolific stocks of sockeye. Enhancement, by creating abundant stocks that can be heavily exploited, aggravates these effects.

On the other hand, enhancement can sometimes be credited with beneficial effects on wild stocks. For example, by creating new fishing opportunities, enhancement projects can draw fishing pressure away from wild stocks elsewhere. These are benefits of enhancement which are not captured in the economic evaluation in Chapter 4.

However, while we have no reliable data, the weight of expert opinion is that most escapements of enhanced salmon contribute little to wild stock rebuilding, especially for coho and chinook. Thus enhancement must be viewed mainly as a supplement to wild stock production, or as compensation for losses in wild production, rather than as a means of restoring it.

All these considerations complicate the question of how wild stocks would have fared if no enhancement had taken place. Clearly, there would have been no adverse effects from biological interactions and fishing of mixed enhanced and wild stocks, and to that extent pressures on wild stocks would have been less. Moreover, in the absence of enhanced stocks, the depletion of wild stocks such as coho and chinook in Georgia Strait would have been more apparent, which might have facilitated corrective action. But these effects are hypothetical. The assessments in the preceding chapter are based on the assumption of no net impact of enhancement on wild stocks.

I noted in Chapter 2 that the priorities of the Salmonid Enhancement Program managers shifted in the 1980s to restoration of depressed wild stocks of coho and chinook, and this new objective should be recognized in an evaluation of performance. However, there is little evidence of enhancement having contributed directly to the restoration of these wild stocks, which have continued to decline. The few examples of chinook rebuilding on the upper Fraser and central coast are apparently due to increased escapements of wild fish. So this consideration does not improve the measured performance of the program.

Finally, some enhancement works were excluded from the economic assessment of enhancement facilities because data needed to assess their contribution to production are unavailable. These include fishways, water storage and bank stabilization works as well as counting fences. They have accounted for only $5.8 million, or about one percent of expenditures under the Salmonid Enhancement Program.

## Offsetting Values

The benefits, or adverse effects, of all of these non-production activities and biological interactions were excluded from the economic analysis in Chapter 4. The costs were also excluded, except for project assessment, mark recovery and native training, which are incorporated into the operating costs of enhancement facilities. The non-production activities generate positive benefits, while some of the biological effects — notably the adverse impacts on wild stocks — are detrimental.Thus they offset each other to some extent in an overall appraisal of the Salmonid Enhancement Program. But because we cannot measure their positive and negative contributions we cannot quantify the net effect of all of them taken together, nor even conclude whether they improve or worsen the ratio of benefits to costs calculated in the preceding chapter.

For present purposes it is tempting to assume that the benefits of the non-production activities and detrimental effects on wild stocks cancel each other, but there is little justification for such an assumption. An assumption more favourable to the program is that the net benefits of the non-production activities — the benefits in excess of their costs — are sufficient to offset the losses from stock interactions. This would leave the overall benefit-cost ratios in

Chapter 4 undisturbed. This is also an arbitrary assumption, but it helps to indicate that in order to improve the value-for-money reflected in the benefit-cost ratios, the non-production benefits would have to exceed their costs by an amount greater than the losses resulting from adverse stock effects.

In the base case calculations in Table 8, past benefits of the Salmonid Enhancement Program fall short of past costs by some $592 million in 1993 dollars. The non-production activities account for less than one-quarter of the expenditures under the program, so to offset this shortfall they would have to yield extraordinarily high benefits relative to costs, even if the detrimental biological effects were small. Thus it appears safe to conclude that, even with the non-production benefits included, the overall benefits of the Salmonid Enhancement Program fall short of the costs.

For purposes of assessing future possibilities, this issue of unquantified benefits is more tractable, because non-production activities can be considered separately from enhancement facilities. They are linked to enhancement facilities, insofar as school programs benefit from visits to hatcheries, fish marking depends on hatchery facilities and native people find employment in enhancement facilities. But much of the education and public involvement, research and native programs are separable from enhancement facilities and, to the extent that they are not, the incremental benefits in these forms is likely to decline as more facilities are built.

## Outlook for Future Economic Performance

I now want to focus attention on the future outlook. Chapter 4 provided estimates of the economic performance of enhancement facilities over their whole life. But some of that is now past; the costs that have been sunk and the benefits realized cannot be changed, so neither bears on the best future course of action. Plans for the future should be guided only by the benefits and costs expected from now on.

The future costs and future benefits over the remaining life of the facilities, from the present to the year 2017, are presented in Tables 6 and 7. These provide the data for their prospective benefit-cost ratios in the right-hand column of Table 12.

The results show very high benefit-cost ratios for spawning channels because, once built, they entail low operating costs. The prospective benefit-cost ratios are also higher than the lifetime ratios in Table 8 for hatcheries, lake fertilization and Public Involvement Projects. Again, within the broad categories in these tables, there is wide variation among individual facilities.

Table 12 includes future benefit-cost ratios for each species of salmon. Because most sockeye and pink are produced in spawning channels, the ratios for these species are high also. The outlook for chinook is mixed, and for coho it is consistently poor.

## Alternative Futures

The figures in Table 12 imply continued production from existing facilities until 2017. This need not happen, of course; facilities can be closed or modified and new ones built. It is therefore instructive to consider how the economic outlook for the enhancement effort might be improved by eliminating the facilities showing poorest performance.

It must be emphasized that plans for any particular enhancement facility should be based on more detailed analysis of its technical and economic performance, and the scope for improving these, than is possible in this review of the program as a whole. The social and other factors unique to each facility, are relevant also. With this caution, the following paragraphs are intended to indicate the scope for improving economic performance.

**Table 12. Estimated net benefits of enhancement facilities over their remaining life[a]**

| | sockeye | pink | chum | coho | chinook | all species | *benefit/cost ratio* |
|---|---|---|---|---|---|---|---|
| | | | (millions of 1993 dollars) | | | | |
| Hatcheries | 0 | 4.8 | 50.9 | -7.5 | 7.5 | 47.1 | *1.3* |
| Spawning channels | 110.5 | 11.2 | .3 | n.a. | n.a. | 122.0 | *7.0* |
| Spawning bed restoration | .2 | 1.8 | 1.5 | 1.7 | .3 | 5.4 | *2.3* |
| Lake fertilization | 12.7 | n.a. | n.a. | n.a. | n.a. | 12.7 | *1.8* |
| Community Development Projects | n.a. | .6 | -2.6 | -15.7 | -1.1 | -21.1 | *.6* |
| Public Involvement Projects | n.a. | 0 | -.4 | -5.1 | 5.8 | -.9 | *.9* |
| All facilities | 123.4 | 18.3 | 49.6 | -26.7 | 12.4 | 165.3 | *1.6* |
| *Percent of total benefits (%)* | *75* | *11* | *30* | *-16* | *8* | *100* | |
| *Benefit-cost ratio* | *4.4* | *6.5* | *2.1* | *.7* | *1.1* | *1.6* | |

[a]Based on the future benefits and future costs, from 1994 to 2017, from Tables 6 and 7. Includes pre-SEP and SEP facilities. Values in 1993 dollars. Future values discounted to 1993 at 8 percent.

n.a. means no entry applicable.

A reasonable criterion for maintaining facilities is that their benefits exceed their costs. If this rule were adopted, and all facilities showing a prospective benefit-cost ratio less than 1.0 were closed, the benefit-cost ratio of the remaining facilities would rise to 2.9, as shown in Table 13. This would involve discontinuing 179 facilities that would otherwise be expected to generate losses, including nearly half of the hatcheries and spawning channels, most of the Community Development Projects and all of the Public Involvement Projects. The overall benefit-cost ratio would increase to 2.9.

A benefit-cost ratio of only 1.0 is a modest target, however, and a higher threshold might be sought. Certainly, planned projects, given the risks and uncertainties involved, should meet a significantly higher test unless there were compensating, non-economic considerations. But here we are considering projects already in place, and continued operation is justified as long as they continue to promise benefits moderately in excess of costs. As the threshold is raised the number of facilities that exceed it falls, and the overall benefit-cost ratio rises. A cut-off benefit-cost ratio of 1.2, for example, reduces the number of facilities to 81 and raises the overall benefit-cost ratio to 3.5. It must be emphasized, again, that none of these scenarios is recommended here, at least not without more thorough analysis. They are intended only to illustrate how economic tests can guide decision-making aimed at improving the economic performance of the enhancement effort.

Decisions about the future of any particular facilities will call for more detailed examination of them, taking account their unique circumstances, their local impacts, and the alternative means of achieving the same contribution to the enhancement effort. And we have not examined the important element of timing in any decisions about changing the present configuration of enhancement facilities.

**Table 13. Implications of maintaining only facilities showing prospective benefits greater than costs**

| | all existing facilities | | only those with expected benefits greater than costs | |
|---|---|---|---|---|
| | number | *benefit/cost ratio* | number | *benefit/cost ratio* |
| Hatcheries | 24 | *1.5* | 11 | *2.2* |
| Spawning channels | 15 | *7.4* | 9 | *7.6* |
| Spawning bed restoration | 58 | *1.8* | *56* | *2.5* |
| Lake fertilization | 5 | *1.9* | 5 | *1.9* |
| Community Development Projects | 29 | *.6* | *4* | *2.2* |
| Public Involvement Projects | 133 | *.9* | 0 | *n.a.* |
| **Total** | **264** | ***1.7*** | **85** | ***2.9*** |

n.a. means no entry applicable.

## Concluding Observations

The unquantified effects of the Salmonid Enhancement Program, excluded from the economic analysis in Chapter 4, weigh partly on the side of benefits and partly on the side of costs, and it is not possible to determine their net impact. However, their scale in the total program means that, at best, they can compensate for only a modest part of the net losses associated with enhanced salmon production.

However, with so much enhancement capacity already in place, the outlook for the future is better. Many more facilities are capable of producing benefits, from now on, satisfactorily in excess of the costs of producing them.

The economic performance of the enhancement effort can be improved substantially by eliminating facilities that have poor economic prospects. Improvements in these, or closure of them if improvements are not feasible would, by getting rid of heavy continuing losses, improve the outlook of the program and provide financial flexibility to undertake other more promising activities.

# 6

# CONDITIONS FOR FUTURE SUCCESS

THE success of an enhancement effort of the magnitude directed to Canada's Pacific salmon depends on a host of factors, ranging from biological conditions and scientific knowledge to economic circumstances and institutional organization. In this chapter I want to draw special attention to four prerequisites which this investigation has revealed as critical, and which call for change. These are:

- Enhancement must be reconciled with the management and conservation of wild stocks.
- The enhancement effort must be supported by a solid, on-going program of research and project assessment.
- Enhancement must generate benefits in excess of the costs.
- Private beneficiaries must take much of the responsibility for financing and organizing enhancement.

This chapter explains these fundamental requirements, and why adequate responses to them are essential to the success of a continued enhancement program.

## Reconciling Enhancement with Management of Wild Stocks

Development of enhanced stocks of salmon can potentially damage wild stocks. This is a longstanding concern of biologists not only here but also in other countries with large-scale salmon enhancement programs. Even the formal agreement between the federal and provincial governments establishing the Salmonid Enhancement Program in 1977 noted that "enhancement of one stock could result in a detrimental effect on other natural stocks..." (16, Ch. 4).

We noted in Chapter 3 that many stocks of wild salmon have declined. Not all can be blamed on enhancement; overfishing and habitat destruction have often been damaging as well. But it is likely that enhancement has contributed to the decline of some wild stocks.

To the extent that enhanced stocks simply displace wild stocks, enhancement is self-defeating. Indeed, we are left worse off, because artificial production is a costly business compared to natural production. It is also riskier, because production is concentrated in a few artificial facilities which are more vulnerable to natural or man-caused catastrophes than the thousands of natural spawning streams along the coast. And finally, as natural stocks decline, the genetic diversity of salmon stocks is narrowed. For all these reasons, wild stocks contribute importantly to the long-term sustainability of the resource.

Consequently, enhancement must be underpinned by a wild stock protection policy. Enhancement projects cannot be justified without reasonable assurance that they will not adversely affect wild stocks. This will require a much stronger effort to integrate the management of enhanced and wild stocks, from the planning of enhancement projects right through to the management of fishing.

This issue of adverse impacts of enhanced stocks on wild stocks has several dimensions which have implications for the needed changes in fisheries management.

### *Biological interactions*

When artificial stocks produced in enhancement facilities are introduced on a large scale into waters occupied by wild stocks, the wild stocks may decline as a result of competition, adverse genetic changes resulting from interbreeding, or displacement by the enhanced stocks. These effects are often poorly understood, but the results are evident in the decline of wild stocks where enhanced stocks have been increased.

A notable example is that of coho in Georgia Strait. Evidence presented in Chapter 3 illustrates the problem. The Salmonid Enhancement Program made a strong effort to rebuild the depressed stocks of coho in Georgia Strait, which are particularly important to the recreational fishery. Catches of enhanced coho have grown to some 600 thousand annually, and now account for about 40 percent of the total catch of coho in the Strait. However, as releases of juvenile fish have increased, their rate of survival has declined (Figure 4). While the total catch of coho has declined only slightly, catches of wild fish have declined significantly, having been replaced by catches of enhanced fish (Figure 9). In addition, spawning escapements of wild fish continue to decline. Thus, far from stock rebuilding, which was the objective of enhancement, the evidence suggests that wild stocks continue to decline.

Some of the decline in wild stocks is probably due to disturbance and pollution of spawning streams in the rapidly developing Georgia basin. Some is probably a result of overharvesting in mixed fisheries (see below) aggravated by the presence of enhanced stocks. But biologists have begun to conclude that the ocean's carrying capacity is limited, and that the more enhanced stocks are increased, the more they are likely to depress wild stocks. This, and other theories about the biological interactions between enhanced and wild stocks at sea have not been proven, however.

Nevertheless, the existence of the problem is clear, and the trends are worrisome. The annual catch of wild coho in Georgia Strait is now about half the number caught at the time the Salmonid Enhancement Program was introduced. Most of this loss is offset by catches of enhanced fish. In effect, we have substituted enhanced fish for wild fish.

The existing management regime for coho in Georgia Strait is obviously not sustainable. If it continues, the stocks may well follow the disturbing pattern experienced in the lower Columbia River. There, after many years of hatchery coho production, the National Fisheries Marine Service concluded, in 1991, that it was no longer possible to identify a distinct wild coho population. Adult returns have varied widely, but there has been no net increase in catches since hatchery production began (18).

An expert task force on the plight of wild stocks of coho in Georgia Strait has recommended tighter restrictions on catches to protect wild stocks from further decline and loss of diversity. But the expansion of enhanced stocks has masked the urgency, and no action has been taken.

### *Effect of mixed fishing*

Enhanced stocks can sustain a high rate of harvest. Usually more than 95 percent of the total number of mature fish can be taken because only a few are needed to provide the brood stock for enhancement facilities, where favourable conditions are maintained for egg fertilization, incubation and rearing. Wild stocks cannot sustain such heavy harvesting; a much larger proportion of the adult population must be left to escape to the spawning beds in order to maintain the stocks. As a result, if enhanced stocks mix with wild stocks while they are being fished (which is usually the case), full utilization of the enhanced fish can result in overfishing the wild stocks. Alternatively, leaving enough of the wild stocks to spawn often means that enhanced stocks are underutilized.

A prominent example of this problem is the controversial Skeena sockeye fishery, which has been generated by the huge Babine Lake spawning channels. Heavy exploitation of the enhanced sockeye off the mouth of the Skeena and off southeast Alaska has raised concerns about depletion of wild stocks of sockeye and early runs of coho and steelhead in the Skeena.

The Department has made a commitment to reduce the incidental harvest of steelhead by half, and is attempting to design a "sustainable fisheries" plan for the Skeena and Kitimat Rivers. This will likely call for reduced harvest rates in the commercial fishery to protect the wild stocks. But that will produce even larger surplus escapements of enhanced Babine Lake sockeye, already averaging 600,000 fish annually. Some of these surplus fish are utilized by local native bands, but most are not utilized at all.

The Babine enhancement facilities may be simply too big to permit full utilization of the fish without causing serious ecological disturbance. Certainly, the abundance of enhanced fish makes it exceedingly difficult for fisheries managers to restrict catches in the interest of protecting wild stocks.

Another example of this "mixed fishing" problem is the chum fishery of the central coast, which supports heavy commercial fishing. The Snootli Creek hatchery produces nearly half the chum caught by the seine and gillnet fleets in one area (area #8) and about 75 percent of the stocks are harvested. This is much too high an exploitation rate for the wild stocks in the area and they are being depleted. However, fishery managers find it difficult to reduce the harvest rate because of the abundance of enhanced fish (7). In effect, the enhanced stocks have been driving the management of the fishery to the detriment of wild stocks.

### *Other effects on fisheries management*

The build-up of abundant enhanced stocks can also create management difficulties because of its effect on the expectations of those who depend on the catch.

An example is the enhanced stocks of chinook produced at the Robertson Creek hatchery near Port Alberni, which is often cited as an example of highly successful enhancement. In recent years, average returns have exceeded 170,000 adult chinook, providing highly rewarding fishing for both commercial and recreational fishers in Barkley Sound and Alberni Inlet. Local native communities are also sharing in the enhanced production. Although some local stocks of chinook have been depleted, there are relatively few adverse impacts on wild stocks.

However, a serious problem is looming because the young year classes of enhanced chinook, expected to return in 1995 and 1996, appear to have virtually collapsed as a result of poor marine survival. The enormous expectations created by the enhanced stocks, and the reliance on them by all fishing groups, means that the shortfall, when it occurs, will be very dislocative to the local community. And the pressure on the remaining fish is likely to be difficult to manage.

Other problems of this kind have been mentioned earlier. It is difficult to convince sport fishing groups of the need to reduce harvests of coho in Georgia Strait to protect wild stocks when surplus enhanced stocks are available. The same is true of chinook in Georgia Strait (24). And commercial fishers resist additional restrictions on catches of Skeena sockeye and mid-coast chum when escapements are surplus to requirements.

The preceding examples illustrate only a few of many ways in which enhanced production of salmon, and harvesting of enhanced production, threatens wild stocks. This is not to say that the management of enhanced and wild stocks cannot be reconciled. On the contrary, the harvesting of enhanced stocks can be manipulated to minimize impacts on wild stocks by careful adjustment of the location and timing of fishing and of the gear used. And enhancement facilities themselves can be built in locations to minimize mixed fisheries, and on a scale that does not produce unmanageable impacts on wild stocks.

There are examples of well-conceived enhancement projects and operations. The Nitinat hatchery on the west coast of Vancouver Island produces enhanced stocks that return without mingling unmanageably with wild stocks. The enhanced chum are fished near shore by commercial vessels, then in an Indian fishery in Nitinat Lake, resulting in up to 95 percent utilization.

However, as the earlier examples indicate, attempts to integrate the management of enhanced stocks with wild stocks have frequently floundered. Enhancement planners have consulted fisheries managers about plans for specific projects, but their strategies are often forgotten in the pressure of the fishing season. The integrated management proposed in the 1986 Salmon Stock Management Plan, referred to in Chapter 2, has never been implemented. Since the Salmonid Enhancement Program began in 1977, many meetings have been held to discuss this issue, but there is little evidence of corrective action.

It is difficult to avoid the conclusion that the Salmonid Enhancement Program has developed with thoroughly inadequate attention to the way enhanced stocks will be fished, and how that will be reconciled with the management of wild stocks. This does not seem to be due to differences of opinion about the problem — fisheries managers agree it is important and warrants attention — but rather to the gulf between the branch of the Department concerned with enhancement and that concerned with fisheries management. Clearly, if enhancement is to continue, this problem must be resolved. In the following chapter I propose policies to deal with it.

## Providing for Research and Assessment

The need for research to support the enhancement program has emerged as an important issue. When the Salmonid Enhancement Program was conceived, the planners considered that the technologies involved were proven, and they did not provide for significant research support (an exception was lake fertilization; some early experiments had indicated sufficient promise to warrant continuing research in this technique). We noted in the preceding chapter that the program's spending on applied research and assessment has recently amounted to about $2.2 million annually. Of the $.7 million spent on applied research about three quarters is devoted to lake fertilization.

It is now acknowledged that enhancement technologies and the complexities of marine ecosystems are not well understood and that the whole program is experimental. The outcome of projects must be recognized as uncertain, with significant risk that expected biological and economic results will not be realized, and that fisheries management will be complicated. This calls for a more cautious approach, guided by a strong commitment to research, monitoring and adaptive response.

Today there is more interest than ever before in research to address the concerns about enhancement that biologists have been raising. The scope of research interest has also been widening beyond the early concentration on juvenile production to the determinants of adult survival and interactions with wild stocks. However, this increasing interest has coincided with declining funding in recent years.

The most intensive applied research effort has been on lake fertilization. Much has been learned about the conditions for success of this technique. As a result, the number of lakes treated has been reduced from fifteen to six as research has helped managers identify the most promising locations and scale of activities. In contrast, the early hatcheries and spawning channels were planned and built hastily, without this guidance, and it is now clear that they would have benefited from a more experimental and adaptive approach, buttressed by on-going scientific investigation and assessment. In this sense, we have only begun to do the research to determine why facilities fail in some situations, or beyond a certain scale, after many of them have already been built.

A related need is that of assessment of projects and programs, including examination of the performance of existing facilities as well as evaluations of proposed projects. Some assessment capability has been in place since the Salmonid Enhancement Program began, and annual expenditures for this purpose have gradually increased to about one million dollars. The Department now has a substantial capability in biological and economic assessment of enhancement projects, but it suffers two criticisms. One is that assessment information has not been made widely available to the public, especially information that might suggest weaknesses in the program (10). For example, annual reports indicated "expected" returns rather than actual production. But even the public annual reports have been discontinued.

The other criticism is that assessments have been ignored. For example, a 1989 analysis of enhancement facilities identified some thirty which had such a poor performance outlook that they should be closed or substantially changed (15). But response has been slow, due largely to local resistance to closures.

Continuing rigorous assessment of projects and programs is essential not only as a means of accumulating knowledge about what works and what doesn't, but also as a means of planning a program of enhancement that will maximize the chances of biological and economic success.

In the next chapter I recommend an expanded commitment to research and assessment to support the enhancement effort.

## Ensuring Economic Performance

The examination of benefits and costs in Chapter 4 reveals inadequate economic returns from the enhancement effort. Overall, the economic benefits fall short of the costs, and it is unlikely that benefits in forms other than fish production are sufficient to compensate for the shortfall. Future enhancement can be justified only if it generates higher returns on investment.

However, the evidence indicates that the economic performance of enhancement facilities varies widely, suggesting that careful selection of projects could significantly improve results for the program as a whole. The meager economic outcome appears, in retrospect, to be a result of economic objectives having faded as the Salmonid Enhancement Program developed. This is reflected in the shift from cost-efficient production facilities for sockeye and chum to the costly and relatively unproductive effort to restore depleted stocks of coho and chinook, and the expansion of community and public participation projects.

But even with a higher value placed on the rehabilitation of depressed stocks as the program evolved, new projects were not always selected with reference to their benefits and costs. Nor were poorly-performing projects closed; local pressure to maintain facilities was often sufficient to over-ride attempts to terminate them. The result is a much lower economic performance than could have been achieved.

Economic efficiency could almost certainly have been improved in other ways as well. Greater use of temporary or mobile facilities to restore stocks or remote streams would have reduced capital costs and increased flexibility. More careful selection of sites to avoid mixed-stock fishing and thereby enable fuller utilization of production would have increased returns. These possibilities must be regarded as lessons of past experience, to guide future planning.

In any event, the Salmonid Enhancement Program has not generated the economic returns originally expected of it, and continued expenditures can be justified only if the prospects are substantially improved.

Economic performance can undoubtedly be improved through more careful selection of projects, more efficient management of them, and termination of those that fail, as already mentioned. But it is equally important to ensure that the potential gains are not lost through further expansion of redundant capacity in the commercial fishery. This special problem of fishing industries — the tendency to respond to increased catches by investing in already excessive capacity — threatens, in the long run, to dissipate any net gains, and must be prevented or controlled to protect the potential benefits from enhanced production.

This problem was recognized 26 years ago when licences for commercial salmon fishing vessels were restricted as a first step to prevent further expansion of the over-expanded salmon fleet. But limits on the number and dimensions of vessels is not enough to stop expansion of the fishing capacity of the fleet or investments in gear and equipment. The catching power of the fleet and the capital embodied in vessels and gear have continued to grow, increasing the cost of fishing and eroding the net benefits that would otherwise accrue to vessel owners, crews or government from increased catches.

Governments of leading fishing nations have experimented with various techniques for preventing excessive investment in fishing capacity. The main alternatives are:

- Additional restrictions on vessels and gear.
- Capturing the increased revenues through royalties or landings charges on the catch.
- Purchasing licences or licensed vessels and retiring them from the fishing fleet.
- Eliminating incentives to expand fishing power by allocating catches among vessel owners as individual quotas.
- Eliminating incentives to expand fishing power by supporting fishing cooperatives or other means of self-regulation among fishers in particular fisheries.

The planners of the Salmonid Enhancement Program assumed, in their original economic projections, that the government would take any steps needed to prevent additional unnecessary investment (9). This assumption accounts, in large part, for the early projections of high economic returns. Despite the historical record since then, the assumption has been incorporated into recent benefit-cost analyses also (21). But the fact is that no new controls on investment have been introduced and investment has continued, which explains, in large degree, the lower returns found in the retrospective evaluation in Chapter 4. There, we nevertheless assumed that half of the net benefits accruing vessel owners from enhanced catches were not dissipated in further investment in fishing capacity but were realized as profits. That assumption may exaggerate the benefits over the long run, because both theory and observation indicate that increased profits will not be sustained in competitive common-property fisheries. Certainly, the assumption that enhanced production will raise the profits of vessel owners is more tenuous the more time the fleet has to respond with investment.

In short, future expenditures on enhancement must yield benefits that exceed the costs, and this calls for considerable improvement over past performance. Nevertheless, improved economic returns appear possible through more careful choice and design of projects, more efficient management and abandonment of facilities that fail to meet minimal standards of cost-effectiveness. Further, to ensure that the potential gains are realized and sustained, it is essential to prevent further unproductive investment in capacity, particularly in the commercial fishing fleet. In the following chapter I discuss means of responding to these needs.

## Involving Private Interest Groups

Hitherto, the Salmonid Enhancement Program has been mainly a governmental enterprise. Although its primary purpose has been to produce fish for well-identified private fishing groups, it has been planned, undertaken, managed and financed almost entirely within the Department of Fisheries and Oceans. With the accumulated experience of the last seventeen years, and with enhanced production now being realized, it is time for more active participation of private interest groups.

The separation, hitherto, of those who organize and pay for enhancement from those who benefit from it undoubtedly accounts for some of the problems noted in this report, such as the unpredictability of program funding and the inconsistent attention to cost-effectiveness. There is no apparent justification for continuing to postpone the recovery of costs from the beneficiaries, as originally intended, and in doing so close the circle between those who benefit and those who organize and pay for enhancement. This will involve private fishing interests participating as partners with government in financing and managing a more cost-effective enhancement program.

Involvement of non-governmental interests can occur in three forms — funding, participating in governmental program planning, and undertaking projects.

### *Cost recovery*

From the beginning, the cost of the Salmonid Enhancement Program was expected to be recovered from those who catch the enhanced production. This objective was reiterated in the 1986 report of the Auditor General and in the Treasury Board's approval of Phase II funding in 1987 (1). But, so far, only a modest fraction of the cost has been paid by the direct beneficiaries.

Measures to recover costs have been feeble. Commercial licence fees were doubled from token amounts in 1981 and again in 1987. Recreational fishing licences were introduced in 1981 and the fees were doubled in 1987 also. Since 1989, recreational anglers have also been required to purchase a $3.00 stamp to catch chinook, the proceeds of which are paid to the Pacific Salmon Foundation.

In a rather vague policy, all recreational licence fees and three-quarters of commercial licence fees collected since 1986 are considered enhancement cost recovery.

Since 1987, only about 15 percent of the annual cost of the enhancement program has been recovered from fishing groups, and about half that in earlier years. Over the whole period of the program, about 8 percent of total costs have been recovered. As indicated in Figure 10, recreational fishers have contributed about 60 percent and commercial fishers 40 percent of the total amount recovered.

Cost recovery has been resisted by the fishing community on grounds that fishers should not be required to pay until the catches of enhanced fish were realized. That is now the case.

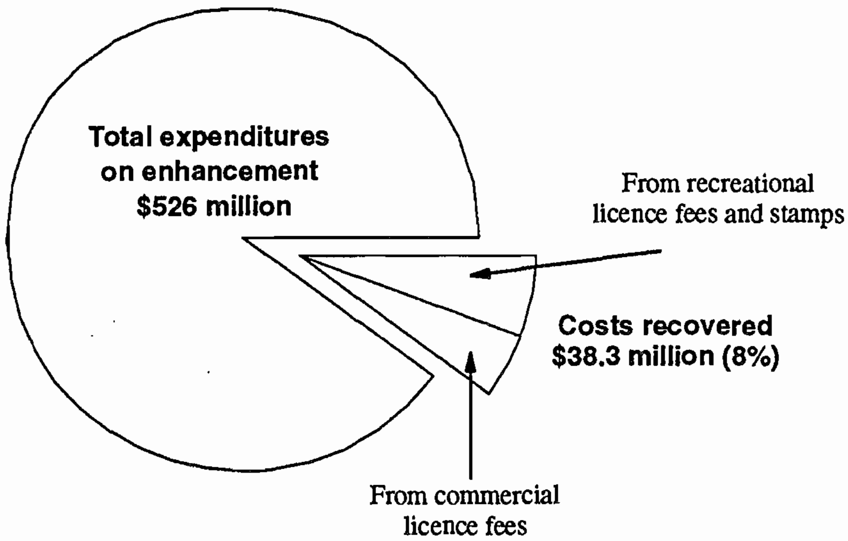



**Figure 10. Costs of enhancement and costs recovered from fishing groups**

There are several possible ways in which financing can be raised from those who catch the fish.

- Voluntary donations.
- Increased fees for commercial and recreational fishing licences and stamps.
- A royalty or landings charge on catches.
- Self-financing projects by fishing groups.

There may be a place for each of these financing alternatives. Voluntary contributions already play a part through the Pacific Salmon Foundation, a federally incorporated non-profit organization established in 1987 to promote conservation, restoration and enhancement of Pacific salmon. It funds enhancement activities, to the extent of $35 to $56 thousand annually in recent years. Its funding consists of the revenues from the chinook conservation stamps referred to above, profits from a gift shop at the Capilano hatchery and an annual contribution from the Treasury Board, as well as corporate donations. The Treasury Board has recently approved an extension of the conservation stamp to all salmon species, which will increase revenues substantially in future. It has also approved a significant increase in its annual contribution if it is matched by private contributions.

The Pacific Salmon Foundation serves a valuable purpose in providing a channel for public involvement in enhancement activities, and is well placed to support, especially, programs of education and public awareness about fish management and conservation. However, it does not offer sufficient revenue for core funding for a significant enhancement program.

Fees for fishing licences and stamps have been the main means of cost recovery so far, and the current modest charges probably leave scope for further increases. Their disadvantage, as a means of effecting the user-pay principle, is that they apply indiscriminately among fishers, regardless of wide differences in their catches of fish.

A royalty or landings charge, in contrast, ensures that fishers pay in proportion to their share of the catch. Levies of this type have been introduced in New Zealand and other countries in recent years, and in small fisheries on the Pacific coast, including the blackcod and halibut fisheries, to help cover costs of management programs. They have also been considered for commercial landings of salmon (16). They offer an attractive means of ensuring that fishers share costs equitably, and can be administered in conjunction with the existing compulsory reporting of landings in the commercial fishery. They are less attractive for the recreational fishery where landings are not systematically recorded, and so fees for tags, stamps or licences offer more expeditious alternatives.

In my opinion, the objective in the choice of financing method should not simply be to raise revenue, but rather to provide a fiscal arrangement that will encourage fishing groups to evaluate potential enhancement projects in light of the benefits and costs, identify promising opportunities, and cooperate with government in undertaking advantageous projects, discarding others, and organizing fishing to take best advantage of them. In short, the financing arrangements should provide a focus for greater involvement of fishing groups in all stages of fish production.

### *Participation in governmental planning*

The Salmonid Enhancement Program's activities in education, information and public participation are impressive. These are important activities, because restoration of salmon stocks depends on sympathetic understanding and support from the fishing community and the public. Moreover, enhancement lends itself well to public involvement.

For these reasons, it is important to provide orderly and effective means for channelling public input into the program's planning and operations, and for communicating the program's plans and problems to the interested public.

### *Undertaking projects*

At the present stage of enhancement policy, the possibility of enabling private fishing groups to organize and finance enhancement projects, in return for access to the fish produced, deserves attention. We already have some useful experience to draw upon. In 1987 a group of sport fishing operators on the remote central coast, collectively organized their own enhancement project, under the Rivers Inlet-Hakai Pass Sport Fishing Association. They set out to enhance early runs of chinook in three local rivers to extend their fishing season. The Department assisted with the design and construction of the facility and on-going technical support. The association pays the operating costs, including a full-time hatchery manager. The project appears promising.

Another example is the Tofino Enhancement Society, formed in the mid 1980s to finance and develop an enhancement facility on Vancouver Island's west coast with advice from Department engineers. A local board of directors now oversees the operation of a substantial facility on the Cypre River.

In Alaska, associations of commercial fishers who hold licences to fish in certain regional salmon fisheries levy fees on their members' landings to finance hatcheries and other enhancement works from which they benefit from increased production. In Washington state and elsewhere, native groups operate enhancement facilities which they have built and financed. Here, the Department has been studying opportunities for local salmon management to enable communities or groups of fishers to take responsibility for managing and harvesting local stocks, which could include undertaking enhancement activities.

In the following chapter, I suggest building on these opportunities at two levels. One is the overall enhancement program, the management of which might be gradually transferred to fishing interests as they assume greater financial responsibility. The other is at the level of individual projects, which might be undertaken and financed by local groups or other fishing interests in return for access to the enhanced production.

## Conclusion

The four conditions, described in this chapter as prerequisites for a successful enhancement program, are not new. Three of them — the need to reconcile enhancement with the management of wild stocks, the importance of generating economic benefits, and the necessity of cost recovery — were acknowledged at the outset of the Salmonid Enhancement Program seventeen years ago. The fourth — the need for scientific research and assessment — was recognized shortly after. Most have been asserted repeatedly in subsequent reviews of the enhancement program.

Other important lessons can be learned from our experience, among them the scope for increasing salmon production through better management of wild stocks. Enhancement planners in the 1970s expected only further declines in wild stocks, but they have since added more to production than have enhanced stocks. To this extent our experience supports Dr. Ricker's early assessment, and it suggests, as he did, that there may be even more potential in wild stocks. For all the reasons discussed earlier in this report, enhancement projects should always be weighed against means of obtaining equivalent production through improved management of wild stocks.

It is difficult to avoid the conclusion that the enhancement program, launched with strong support from government and the fishing community, achieved such momentum that it took on a life of its own and the conditions on which it was approved were forgotten. Managers of the program adapted to changing circumstances and priorities as best they could, but certain actions that had to be taken to ensure the program's success were beyond their control, and were not taken. These include the changes needed to provide for cost recovery, control of excess fishing capacity and coordination of the fisheries management and enhancement branches of the Department, which call for the attention of higher levels of authority.

It is now essential to put the program on a firmer footing. In future, enhancement must be viewed as one instrument in the management of salmon resources. It needs to be fully integrated with the management of wild fish production, fish habitat protection and fishing. It is one means, complementing others, of strengthening resource conservation and development. And it must be integrated not only with the management of fish resources but also within the economic and social system within which fisheries operate. In the following chapter, I suggest a new approach to enhancement to respond to these needs, and to give the fishing community, scientists, the federal treasury and the public greater confidence in its contribution to sustainable resource development.

# 7

# A RENEWED APPROACH TO ENHANCEMENT

MY review of the Salmonid Enhancement Program, summarized in preceding chapters, has revealed a substantial and well-established governmental program in an innovative field of fisheries resource management. It now has in place a large number and variety of enhancement facilities, which add a significant increment to salmon production. It is supported by a substantial complement of expert and experienced staff. And it plays an important role in education, information and public involvement.

At the same time, the program raises serious concerns about cost-effectiveness, possible damaging effects on wild fish, the relationship between those who benefit and those who pay the cost, and other important matters. The program is also losing flexibility and momentum, because of the weight of its on-going operations combined with declining financial resources. And its objectives have become somewhat blurred.

In important respects, the enhancement effort has fallen disappointingly short of expectations in both biological and economic terms. The original objective of doubling salmon production now seems unrealistic, and inappropriate as well. And the costs have exceeded the benefits. Having spent $526 million over 17 years, the Salmonid Enhancement Program can be viewed as a large-scale experiment, with successes and failures that provide valuable guidance for future action.

The most serious weaknesses of the enhancement program that have emerged in this investigation have been identified in earlier studies as well — notably the weak effort to reconcile enhancement with wild fish management, the lack of priority to economic criteria in program planning, the failure to control unnecessary investment in the fishing industry, and the failure to implement cost recovery. Corrective actions needed at a high level of fisheries policy-making have not been taken.

At the same time, this review reveals considerable opportunities in salmon enhancement if these shortcomings can be overcome. But that will require major changes. This suggests that enhancement should not be abandoned, but rather rejuvenated and given a new direction. In short, this investigation leads to the inexorable conclusion that the Salmonid Enhancement Program needs a thorough overhaul.

To take advantage of the opportunities, the essential conditions described in the preceding chapter must be met. In this chapter, I suggest new arrangements which are designed to meet those conditions and provide for a renewed enhancement effort that can proceed with more confidence in beneficial results.

At the outset I want to emphasize that the following suggestions are tentative, intended for discussion within the fishing community and government. My purpose is to sketch, in broad outline, a possible new approach, to be fleshed out in close consultation with fisheries interests.

The central idea of these proposals is to gradually transfer responsibilities for the enhancement effort from the Department to the beneficiaries in the fishing community. This would be done through an independent non-profit corporation, which I refer to as the Salmon Enhancement Corporation (or simply Corporation) controlled by fishing interests and governments in proportion to their financial contributions. It would be empowered to enter into agreements with local or other fishing groups to take over existing enhancement facilities and develop new ones. The federal government would maintain a position in this organization commensurate with its responsibilities for education, public involvement, native development and other non-production activities. Other policy changes would be required to implement financing and other arrangements.

I begin by describing the structure of the proposed Corporation and its role, which provides the framework for discussing how the financing, resource management and other essential conditions can be met.

## The Salmon Enhancement Corporation

Responsibility for the salmon enhancement program should be transferred to an independent, non-profit corporation, controlled largely by fishing interests. This Salmon Enhancement Corporation would be designed to involve beneficiaries directly in the enhancement program, and link its financing to the benefits received. It would enable those who catch the fish produced to control the financing and to focus enhancement planning on cost-efficient production and maximum returns for their expenditures.

The Corporation would be managed by a board of directors representative of fishing interests, governments and others in proportion to their financial contributions to the program. Directors would be appointed by the Minister of Fisheries and Oceans in consultation with interest groups. The number of governmental representatives would gradually be reduced as funding shifted to fishing interests (see below) until it reached the number proportionate to the continuing involvement of government in non-production activities.

The Corporation would take responsibility for all salmon enhancement and habitat improvement projects, and would administer the budget for these activities. It would decide whether to maintain, expand or close existing facilities and whether to develop new ones, and it would determine the scale and type of investments in habitat improvement. The corporate structure would free the enhancement program from the constraints and uncertainties of annual government budgeting, and enable orderly development planning and financing.

The current Salmonid Enhancement Program organization would be re-constituted as a special operating agency responsible to the Corporation, providing continuing expert guidance and managerial capabilities. The Department would be responsible for advising the Corporation about biological issues, production plans, research needs and other scientific and technical matters. The Corporation's activities would necessarily be subject to the Minister's overriding responsibility for fish conservation.

The Department would, of course, continue its efforts to restore and develop wild stocks of salmon, and it should ensure that artificial enhancement projects do not interfere with these efforts.

## Financing

Financing arrangements should be organized to ensure that the costs of enhancement are borne by those who benefit directly from the increased production. To gain the cooperation of fishing groups it is essential that their contributions are used exclusively to increase fish production, and that decisions about how the funds are spent are made by a body which represents their interests.

The Salmonid Enhancement Program is presently operating with a budget of about $29 million (excluding funds over which the program has no control). This is funded mainly by the federal treasury. A nominal contribution from the province of British Columbia of up to five percent of program costs is provided in kind, in the form of water licences, brood stock collection and other services. Licences for commercial and recreational fishers currently generate fees equal to about one-quarter of annual costs, but these are paid into the federal consolidated revenue.

To put these financing arrangements on the desired footing, several steps should be taken. First, the Department and Treasury Board should enter into a contribution agreement with the new Corporation to guarantee that the Corporation will receive an annual contribution equal to the assigned cost-recovery revenues from commercial and recreational fishing licences. At current rates, this will yield about $8 million.

Next, licence fees should be doubled as soon as practicable. This would raise sport-fishing licence fees from $10 to $20 — hardly an excessive charge for a year's salmon fishing, especially in view of the heavy dependence of recreational fishing on coho and chinook which are so costly to produce. Commercial salmon fishing licence fee would rise from $400 to $800 for small gillnet vessels and from $1,600 to $3,200 for seiners. This would bring the contribution of commercial and recreational fishers to about $16 million. At the present level of funding, this would leave a governmental contribution of $13 million. The federal government should seek some portion of this from the province of British Columbia.

Finally, to generate increased funds equitably for the long-term, provisions should be made to introduce a royalty, or landings charge, to be levied on commercial landings of salmon and collected in the simplest possible fashion from fish buyers. With the current landed value of salmon averaging about $200 million annually, each one percent in landings charge would generate $2 million in revenue.

A landings charge is impracticable for recreational catches, so increased revenues from this sector should be in the from of licence fees or tags. I make no suggestions for charges in the native food fishery because of the legal and practical complications and the relatively small catch in this sector.

The Salmon Enhancement Corporation should be responsible for advising the Minister about the desired level of licence fees and landings charges, which will determine its resources for enhancement purposes. The Corporation can be expected to seek funds with reference to its opportunities in enhancement projects that promise significant benefits to the fishing interests it represents.

These arrangements are intended to ensure that new enhancement projects will be undertaken with financing from those who catch the fish. They are not intended to recover the cost of the facilities already in place; these are sunk costs which, regardless of original plans, should be regarded the federal contribution to the continuing enhancement program. Nor is it intended to cover the cost of related programs of public information, research and other non-production activities.

## Decentralized Activities

The Salmon Enhancement Corporation should be empowered to enter into agreements with local fishing organizations to take over existing enhancement facilities and to build new ones. Except for facilities that generate widely dispersed benefits (such as a fishway on a major river) there is much to be gained by decentralizing enhancement operations, giving local organizations the opportunity to engage in fish production in return for higher catches.

Building on experience here, in Alaska and elsewhere, local fishing groups and enterprises should be encouraged to undertake and finance projects involving enhancement facilities and habitat improvements from which they can benefit. To allow the participating fishers to capture maximum benefits from their effort and expenditures, the government should provide for regional or local licensing arrangements, and organize fishing to minimize interception by others of the enhanced production.

Correspondingly, the Corporation should be encouraged to decentralize enhancement operations. In the long run, enhancement projects might be undertaken increasingly by local organizations of various kinds, augmenting wild stocks with enhanced production, and managing both under the Department's surveillance in more integrated, inshore fisheries. This would leave the Salmon Enhancement Corporation to manage facilities that generate widespread benefits, coordinate the overall enhancement program, and advise the Minister on financing, research, and all other matters relating to enhancement policy.

## Transitional Arrangements

The Salmon Enhancement Corporation should be established as soon as possible and assigned control of the enhancement budget. With directors broadly representative of the financial contributors, federal government representatives would initially dominate. If British Columbia contributes to the program it should be represented as well. Over time, with the increases in licence fees and other contributions suggested above, the proportion of directors representing fishing interests would be correspondingly increased and federal representatives reduced.

The federal government should reduce its financial commitment to the program only gradually to enable a smooth transition to new financing arrangements. The Corporation should be encouraged to increase its financial flexibility by closing facilities that cannot generate satisfactory returns.

The federal government's financial contribution should be maintained at a level sufficient to cover the costs of the Corporation's activities that are not aimed primarily at fish production, such as public information, training and research. Some of these non-production activities might be better accommodated under other auspices, such as the Department or the Pacific Salmon Foundation; such alternatives should be given careful consideration in transferring responsibilities to the new Corporation.

## Other Arrangements

To support these arrangements and ensure the success of a renewed enhancement effort, the government must make a number of other changes.

*Management coordination.* As I have emphasized in earlier chapters, a most urgent need is to achieve greater coordination among enhancement operations, habitat development, and the management of wild fish production and fishing. A major effort is needed to ensure that the planning of enhancement projects, and the management and utilization of enhanced stocks, provide adequately for the conservation of wild stocks.

The proposed Corporation, in planning enhancement projects and operations, and the Department, in designing fishing plans, will have a joint responsibility to develop this needed coordination. Priority to the protection and restoration of wild stocks should be specified in the Corporation's corporate objectives, and the Department should not approve enhancement projects without reasonable assurance that they will not threaten wild stocks either through biological interactions with enhanced stocks or through mixed-stock fishing. Moreover, the Department should exercise its responsibilities for fish conservation by curtailing or closing existing facilities that are found to be damaging to wild stocks.

The institutional separation of the enhancement Corporation from the Department, as suggested here, may help to sharpen the Department's commitment to conserving wild stocks in the face of enhancement plans and operations. Moreover, decentralized projects, supported by local licensing arrangements, are likely to stimulate local fishers' incentives to conserve and develop wild stocks as well as enhanced stocks.

The continuing decline of wild stocks of chinook and coho salmon in Georgia Strait demands special attention. Though the problem is masked by the increasing numbers of enhanced fish, these valuable wild stocks are clearly being overfished, and they can be saved only by reducing the fishing pressure on them. In this, as in other cases noted in this report, enhancement has complicated the management problem.

A solution may be found in diverting fishing pressure from wild stocks to enhanced stocks. This could be done by visibly marking all the enhanced coho and chinook released into the Strait, by clipping their adipose fins. Then, if commercial and recreational hook-and-line fishers were permitted to catch and retain only marked fish, pressure on wild stocks would be relieved. This approach is already being considered by a task force of the Pacific Salmon Commission. My intention here is to add urgency to the problem and the need for a solution.

*Research.* The commitments to research under the Salmonid Enhancement Program have been small in relation to the expenditures on enhancement facilities, and it has become increasingly clear that they have been small in relation to needs as well. The government must take primary responsibility for scientific research (as distinct from feasibility studies and project-oriented investigations that may be needed for private enhancement projects) and the enhancement effort clearly needs more scientific support. I have described the need to strengthen provisions for project assessment as well. Accordingly, the government should make a commitment to enhancement-related research and assessment equal to a fixed proportion — in the order of 15 percent — of expenditures on enhancement. The research and assessment need not be undertaken entirely internally, of course.

The most serious deficiency in current knowledge about enhancement concerns the interactions between enhanced and wild stocks, and I have noted widespread concern about adverse effects of enhancement on wild stocks. I have also emphasized the importance of protecting wild stocks, not only for economic reasons but also to maintain the vigour and biodiversity of salmon resources. This is probably the most critical issue in determining the future of enhancement in this region, but there has been little research on it so far. Until scientific understanding about the interactions of wild and enhanced stocks is improved, any evaluation of enhancement will be incomplete.

In Chapter 3, I noted that the Department began work on a simulation model to assess this problem, but abandoned it when funds were reallocated. That project should be reactivated as a high priority. Recently, a team of scientists from the Department and the University of British Columbia began a major study to determine the causes of low survival of enhanced chinook juveniles released into Georgia Strait. But a much more concerted research effort is needed, and it will call for greater involvement of the Department's Science Sector.

Other research priorities should be dictated by the problems enhancement presents, as perceived by detached experts as well as those directly involved in the program. Biologists within the enhancement program should be encouraged to identify research priorities in consultation with scientists in the department's Science Sector. There is much to be said for including, also, academic experts and others in these discussions.

In the course of this investigation it has become apparent that the evaluation model and methodology used for assessing the economic performance of enhancement projects needs thorough review. The magnitude of the investments involved call for rigorous assessments, yet they are now based on questionable assumptions and data that have major implications for the results. A careful review of the evaluation system, involving external experts and including identification of data requirements, should be given high priority.

*Economic performance.* In previous chapters I have pointed to the need for improved economic returns from expenditures on enhancement. One means of achieving this is through more rigorous selection of projects with reference to economic criteria, more attention to the economic efficiency of operations, and the closure of facilities that cannot meet minimum standards of cost-effectiveness. There is much scope for improvement in these ways. The directors of the Salmon Enhancement Corporation, as representatives of those who pay for enhancement and seek satisfactory returns, can be expected to have strong incentives to take advantage of opportunities to improve economic performance.

Thus the Corporation is likely to want to invest only in projects that will yield benefits substantially in excess of costs, and to close existing facilities that cannot generate a net gain. The government might want to maintain some inefficient facilities for social or other non-economic reasons; if so, the financial burden should not be borne by the Corporation. The government should either subsidize such operations to cover the financial shortfall or take over the operation of them. It will be important to allow the Corporation to consistently pursue an objective of maximum returns for its expenditures.

The continuing threat that the economic gains from enhanced production will be lost in further investment in excessive fishing capacity must be dealt with. This problem goes beyond enhancement policy, but enhancement cannot proceed with confidence in long-run economic returns as long as the incentives to expand excess capacity exist.

The proposals in this chapter may facilitate a solution to this longstanding problem. Restrictions on the number and dimensions of salmon vessels are already in place. Royalties on landings will dampen incentives to invest in unnecessary fishing capacity. And local organization of fisheries is likely to encourage cooperation among fishers and vessel owners to reduce excessive capacity and costs.

These measures are not likely to be sufficient to prevent further expansion of the salmon fleet, however, especially if catches and returns increase. It is beyond the scope of this review to propose the best means of ensuring efficient development of the fishing fleet, but it is important to emphasize that some means must be found. Otherwise the potential economic gains from enhancement can not be realized. In the broader context of sustainable development of fishing industries, which includes improvement of economic performance, this must be regarded as the greatest challenge in fisheries policy.

*Consultation.* I have noted the need for understanding and support for enhancement from the fishing community and the general public. This calls for arrangements for communicating enhancement policies and activities to the interested public, and channelling public input into policies and plans.

The established mechanism for this purpose is the Salmonid Enhancement Task Group, a widely representative body which offers commentary and advice to the Minister. This Task Group appears to be well structured to serve its purpose, but it needs to be revitalized. Appropriate measures should be taken in consultation with the Task Group to strengthen its mandate and activities.

The Task Group is not, of course, the only channel for public input. Studies and surveys can provide useful information about attitudes and perceived shortcomings of the enhancement program (21). The many organizations that represent commercial, aboriginal and recreational fishing interests can provide guidance as well, and should be encouraged to do so.

## Organizing Change

As I indicated at the beginning of this chapter, my purpose in suggesting these new arrangements is to propose a new approach to salmon enhancement that meets the essential conditions outlined in Chapter 6. It is not intended to offer a detailed blueprint but rather a broad outline for discussion, modification and refinement.

As a first priority the Department should engage fishing groups in a focused discussion about the future of salmon enhancement. These consultations should be organized through a special task force, including representatives of commercial, recreational and aboriginal fishing interests, among others, as well as the Salmonid Enhancement Task Group, the Pacific Salmon Foundation, and the Salmonid Enhancement Program itself. Participation of the government of British Columbia should be sought also. The federal government should define the range of possibilities it can consider, with reference to its legal obligations and the essential conditions described in Chapter 6. Within these parameters, the task force should be encouraged to consider, in addition to the proposals in this report, alternative approaches and possibilities, and experiences in Alaska, Washington and elsewhere.

With continuing support from the Salmonid Enhancement Program staff in examining options and their implications, these consultations should proceed as quickly as possible to identify the most promising and acceptable arrangements.

## Concluding Observations

The Salmonid Enhancement Program is quite different from the program envisaged when it was launched in 1977. Notwithstanding considerable achievements, its success in fish production is considerably less than expected, partly because of budget reductions and partly because priorities changed over the years. Its accomplishments in economic terms have also fallen short of expectations, and must be considered inadequate for a resource development program. It has proven to be much more costly to government than anticipated and, at the same time, less profitable to private fishing interests. Uncertainties have developed about the scientific foundation for the program and its basic objectives.

Yet this investigation reveals exciting opportunities in salmon enhancement. Some projects yield high returns in both biological and economic terms. Ways of avoiding adverse effects are now better understood. And programs of public education and public information appear highly successful. A substantial enhancement capacity is in place, supported by expert and experienced staff.

The problem we now face is how to take advantage of these opportunities. Clearly, we cannot continue the present course. To realize the potential benefits a number of fundamental changes must be made. Most importantly, enhancement must be more carefully integrated with overall salmon management, especially the management of wild stocks; a stronger base of scientific support and project assessment must be provided; the planning and operation of enhancement works must be subjected to more rigorous economic tests; and private beneficiaries must be given more responsibility for organizing and financing the enhancement effort.

These needed changes, documented in earlier chapters of this report, together imply a substantially new approach to enhancement. In this chapter I have suggested, in broad terms, the form this might take.

One of the prerequisites for a future enhancement program is that private fishing interests play a larger role. They can be expected to do so only if the program is designed to respond to their needs and concerns. This report will have served its purpose if it provides the basis for constructive consultations between government and fishing interests in designing and implementing a new salmon enhancement policy.

# REFERENCES

The documents listed below are referred to, in the text of this report, by their numbers.


(1) Auditor-General of Canada. *1986 Annual Report*. Chapter 10. Ottawa. 1986.

(2) Cross, C., Lapi, L. and Perry, E. "Production of Chinook and Coho Salmon from British Columbia Hatcheries – 1971 through 1989," Canadian Technical Report of Fisheries and Aquatic Sciences 1816(1991): 45 pp.

(3) Department of Fisheries and Oceans, "Evaluation Study of the Salmonid Enhancement Program," Volume I, Program Evaluation Branch, Ottawa, 1985.

(4) Department of Fisheries and Oceans, "Evaluation Framework of the Pacific Salmonid Enhancement Program, "Program Evaluation Branch, Ottawa, 1988.

(5) Department of Fisheries and Oceans, "Evaluation Assessment of the Pacific Salmonid Enhancement Program," Internal Audit and Evaluation, Ottawa, February 1992.

(6) Department of Fisheries and Oceans, *Pacific Salmonid Enhancement Program Review. Volume I: Program Profile.* Internal Audit and Evaluation. June, 1993. 58 pp. + appendices.

(7) Department of Fisheries and Oceans. "Report on the Central Coast Salmon Stock Management Plan Process," Program Planning and Economics Branch, Pacific Region, Vancouver, 1991.

(8) Department of Fisheries and Oceans. "Strait of Georgia Coho Salmon, South Coast Initiative Final Report." 1992, 53 pp.

(9) Fisheries and Environment Canada. *The Salmonid Enhancement Program.* A Public Discussion Paper. Information Branch, Fisheries and Marine Science, Vancouver, 1978.

(10) Hilborn, R. and Winton, J. "Learning to Enhance Salmon Production: Lessons from the Salmonid Enhancement Program." *Canadian Journal of Fisheries and Aquatic Science* 50. 1993.

(11) Larkin, P.A., "Play it Again, Sam — An Essay on Salmon Enhancement," *Journal of the Fisheries Research Board of Canada* 31(8):1434-56. 1994.

(12) Meffe, G.K. "Techno – Arrogance and Halfway Technologies: Salmon Hatcheries on the Pacific Coast of North America." C*onservation Biology* 6(1992):350-353.

(13) Ministerial Task Force on Program Review (the Neilsen Report). Natural Resources Program. Supply and Services Canada, September, 1985.

(14) Mylchreest, R. Salmonid Enhancement Program Evaluation Model — Guide to SEP Evaluation Methodology. Department of Fisheries and Oceans, Pacific Region. Vancouver, 1993.

(15) Mylchreest, R. and Greer, A. "SEP Project Review: An Economic Evaluation of Salmonid Enhancement Projects." Department of Fisheries and Oceans, Program Planning and Economics Branch. Vancouver, 1989.

(16) Pearse, Peter H., *Turning the Tide: A New Policy for Canada's Pacific Fisheries*. The Commission on Pacific Fisheries Policy, Vancouver, September 1982.

(17) Ricker, W.E., "*Productive Capacity of Canadian Fisheries*," Fisheries Research Board of Canada Circular 64, Nanaimo, June 1962.

(18) Riddle, B.E. "Salmonid Enhancement: Lessons from the Past and a Role for the Future." In Mills, D. (ed.) *Salmon in the Sea and New Enhancement Strategies*, Fishing News Books, Oxford, 1993.

(19) Shaffer, M. & Associates Ltd., "Economic Impact Analysis of the Salmonid Enhancement Program," Canada Fisheries and Oceans Economic and Commercial Analysis Report No. 44, December 1981.

(20) Shaffer, M. & Associates Ltd., "Potential Economic Benefits of Salmon Enhancement for Native Indians," Report prepared for Canada Department of Indian Affairs, Vancouver, March 1990.

(21) The ARA Consulting Group Inc. "Program Review: Salmonid Enhancement Program," An analysis prepared for the Internal Audit and Evaluation Branch, Department of Fisheries and Oceans, 1993, 56 pp. and appendices.

(22) Treasury Board Secretariat. *Benefit-cost Analysis Guide*. Planning Branch. Ottawa, Ontario. March, 1976.

(23) Walters, Carl J. *Design of Experimental Salmon Enhancement Policies*. Working Paper #5. 1975.

(24) Walters, C. and Riddell, B.E. "Multiple Objectives in Salmon Management: the Chinook Sport Fishery in the Strait of Georgia, British Columbia." *Northwest Environmental Journal* 2:1-15, 1986.

(25) West, C. and Mason, J. "Evaluation of Sockeye Salmon Production from the Babine Lake Development Project." Canadian Special Publication of Fisheries and Aquatic Science 96(1987):176-190.

# Economic Evaluation Methodology for the Salmonid Enhancement Program

# APPENDIX

to

## Salmon Enhancement: An Assessment of the Salmon Stock Development Program on Canada's Pacific Coast

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## 1. Introduction

This Appendix explains the method used to assess the economic performance of the Salmonid Enhancement Program in Chapter 4 of *Salmon Enhancement: An Assessment of the Salmon Stock Development Program on Canada's Pacific Coast*, by Peter H. Pearse (Vancouver, May 1994). The Appendix has three components:

- an overview of the estimation methodology and assumptions used in the current evaluation of the Salmonid Enhancement Program;
- tests of the sensitivity of the results to some of the key assumptions in the model;
- detailed estimates of benefits and costs, showing (1) production costs by species and facility from 1984 to 1987, (2) benefit-cost results by project for the period 1977 to 2107 and (3) benefit-cost results by project for the period 1994 to 2107.

Chapter 4 focuses exclusively on economic efficiency aspects of SEP. Distributional considerations are not dealt either in the Chapter or in this Appendix.

This Appendix was prepared by Mr. Douglas MacDonald of GTA Consultants Inc. of Antigonish, Nova Scotia, who assisted Dr. Pearse in carrying out his economic evaluations. Mr. MacDonald worked closely with Dr. Pearse, Mr. Peter Toews, special advisor to Dr. Pearse, and Mr. Russell Mylchreest, Senior Economist, Program Planning and Economics Branch of the Department of Fisheries and Oceans in Vancouver, to ensure that the assumptions used in the evaluations were consistent with current conditions in the fishing industry and the economy of British Columbia. Much of the following descriptive discussion is drawn from documents prepared by Mr. Mylchreest.[1]

## 2. Estimation Methodology And Key Assumptions

The analysis in Chapter 4 puts all benefits and costs attributable to SEP into monetary terms using the principles of benefit-cost analysis. The benefit-cost methodology follows Treasury Board *Benefit-Cost Guidelines*, except where noted.[2] Essentially, the method determines whether investment in enhancement generates a net economic benefit for Canada. The economic benefits are generated primarily through increased catches in the commercial, recreational and Native food fisheries. Estimating salmon catch benefits is based on many assumptions about biological and economic factors (discussed below).

### 2.1 Estimating Catches Attributable to SEP

***Estimating Incremental Catches***

The first critical task in conducting benefit/cost analysis of SEP is to estimate incremental catches attributable to the program. This is not a simple task and a variety of sampling techniques including mark recovery (mostly for chinook and coho), fin clip observation (mostly for chum and pink) or stock reconstruction techniques (mostly for sockeye) are used. Where this assessment information is unavailable, catches are based on actual and forecast release data plus release-to-adult survival, age distribution, exploitation, and user distribution biostandards for each species to estimate the catch. The biostandard estimates have been updated to reflect observed rates in recent years (up to 1991).

***Separating Pre-SEP and SEP Production***

When estimating the incremental contribution of SEP, it is necessary to exclude production at pre-SEP facilities that would have occurred if SEP had not been undertaken. This is necessary to measure incremental production due to the Salmonid Enhancement Program.

Allocating enhanced production to investments made by SEP versus those made prior to SEP is complicated by the fact that SEP incurred expenditures adapting and improving quite a number of the facilities constructed prior to the program. Some method of estimating the proportion of production from such facilities that results from SEP's investment, as opposed to production resulting from investments made prior to SEP, must be derived.

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[1]Mylchreest, Russell, July 1993. *Salmonid Enhancement Program Evaluation Model - Guide to SEP Evaluation Methodology*. Program Planning & Economics Branch, Fisheries & Oceans - Pacific Region. Vancouver, B.C.

[2]Treasury Board Secretariat. March, 1976. *Benefit-Cost Analysis Guide*. Planning Branch. Ottawa, Ontario.

The following formula was used to calculate SEP's share of production at pre-SEP facilities:

$$SSP = TP * CERF_q/CERF_s,$$

where:

| | | |
|---|---|---|
| SSP | = | SEP's share of production; |
| TP | = | Total production of the facility; |
| $CERF_q$ | = | The ratio of capital expenditures made by SEP at the facility in question to total expenditures (all capital and operating costs) at the facility from 1977 to the present; |
| $CERF_s$ | = | The ratio of capital expenditures to total expenditures at a similar (SEP) facility over the life of the facility; |

This admittedly crude method of allocating total production at a SEP funded pre-SEP facility attempts to relate the share of production claimed by SEP to the proportion of capital contributed by SEP. The ratio of capital to total expenditures at the pre-SEP facility in question is divided by the same ratio at a similar SEP facility. The resulting coefficient estimates the proportion of overall capital investment in pre-SEP facilities attributable to SEP.

An example may illustrate the formula. At the Fulton River spawning channel, capital expenditures from 1977 to 1992 were 11.5% of total expenditures. Capital expenditures at a similar spawning channel built entirely by SEP, however, were 64.4% of total expenditures over its lifetime. SEP's share of the production of the Fulton spawning channel is calculated as follows:

$$SSP = TP \text{ (at Fulton) } x\ .115/.644$$
$$= .18\ TP$$

Table 1 shows the effect of calculating SEP's share of catches attributable to pre-SEP facilities using the above formula compared to the total net benefits of enhancement. The Table shows that net benefits due only to SEP are -$592 million as opposed to -$407 for all enhancement projects.

**Table 1. Difference between SEP and all enhancement evaluations**
(1993 present worth of lifetime benefits and costs of facilities at 8%)

| | **Base Case** SEP only | Including all enhancement |
|---|---|---|
| | (millions of 1993 dollars) | |
| Benefits: | | |
| Processing | 103.9 | 164.0 |
| Harvesting | 537.2 | 795.2 |
| Native food | 74.8 | 114.8 |
| Recreational | 202.3 | 252.3 |
| Total | 919.9 | 1,328.8 |
| DFO costs | 1,511.6 | 1,736.0 |
| Net benefits | -591.8 | -407.2 |
| Benefit-cost ratio | 0.61 | 0.77 |

*U.S. Catches*

The model values the U.S. catch of Canadian enhanced salmon as if it had been caught by Canadians. This follows the equity principle of the Pacific Salmon Treaty, which assumes Canadian salmon caught by Americans are offset by Canadian catches of U.S. salmon.

## 2.2 Estimating SEP Benefits

The value of catches generated by SEP need to be estimated. This value includes estimates of the benefits to commercial, recreational, and Native food harvesters plus some other benefits accruing to the facility.

*Commercial Benefits*

In the commercial harvesting sector, the evaluation model begins with the wholesale value of SEP-produced salmon harvested in the commercial fishery (i.e., the price to processors) as the measure of gross commercial benefits. This value is based on actual wholesale price data for the 1977-1991 period and price forecasts for years after 1991, using a model developed for the Program Planning & Economics Branch.[3] The model forecasts the likely demand and prices for products in major markets, based on information such as personal incomes in that market and the availability and price of competing products (e.g., farmed salmon for fresh coho or Alaskan sockeye for fresh/frozen sockeye). The model predicts little increase in real prices for salmon after 1991.

The salmon acquisition costs to processors, and the price paid to salmon harvesters, is the ex-vessel price. Similar to wholesale prices, landed prices are based on actual price data for the 1977-1991 period and are forecast as a fixed proportion of wholesale prices for years after 1991. The proportion is based on the actual landed to wholesale price ratios observed for 1988 to 1991.

*Native Food Benefits*

Native Indians fish for food and ceremonial purposes without commercial or sport licences. Similar to the recreational catch, no market exists to value this right, so the value has to be estimated. It is assumed that the Native food value equals the landed value of salmon in the commercial fishery. No costs are assigned to harvesting the catch of enhanced salmon.

*Recreational Benefits*

As no market prices are available for recreational fishing values — that is, no market exists for salmon caught in the recreational fishery — it is difficult to estimate the value of the recreational catch of salmon. It is even more difficult to estimate the recreational value of incremental catches due to enhancement. But recreational fishing is obviously valuable to the roughly 400,000 people who buy recreational fishing licences.

[3]Fisheries & Oceans Canada. 1989. *Salmon Pricing Trends: A Simulation Model.* Economic and Commercial Analysis Report No. 53. Prepared by Marvin Shaffer and Associates.

Without a market valuation, estimating recreational values hinges on the ability to estimate and interpret the consumer surplus associated with recreational salmon fishing. Consumer surplus represents the value anglers place on an incremental salmon caught in the recreational fishery in excess of their actual costs of fishing.

Estimates of the recreational value of incremental salmon produced by SEP are presented in Table 2 for species with substantial recreational fisheries. The numbers are derived from a variety of studies completed for SEP.

**Table 2. Estimates of recreational benefits of incremental salmon catches**

| | sockeye | coho | chinook |
|---|---|---|---|
| | (1993 $ per salmon) | | |
| Recreational benefit | 25.75 | 14.00 | 54.00 |

### *Other Benefits*

Several additional benefits arise from SEP are included in Chapter 4. These are discussed briefly here.

*Employment.* Benefits occur if a portion of the employment at enhancement projects, or in the processing and harvesting industries, increases net employment in Canada (i.e., reduces unemployment). The persistently high unemployment rates in some B.C. regions imply that opportunity costs of some workers are probably less than market wages. In this situation, the calculation of the economic net benefits of a project should use opportunity costs rather than market wage rates. The opportunity cost (or shadow price of labour) is estimated by calculating the probability that the workers hired for construction and operations of project facilities and in harvesting enhanced salmon would be otherwise employed. This calculation follows a standard methodology.[4]

*Rack Sales.* Salmon that elude the various fisheries and return to the facility, and are surplus to the facility's broodstock requirements, can be sold. The federal government conducts a bidding process for this salmon and the value is included as a benefit for the facility. The model forecasts future sales and adds the results to total rack sales.

*Egg Sales.* Similar to rack sales, surplus eggs at a hatchery can be sold (often to private fish farms). Again, the value of actual sales is included in the evaluation model. No forecast of future sales is included as sales to fish farms stopped when the operators developed their own broodstock.

[4]Fisheries & Oceans - Pacific Region. May, 1986. *SEP Methodology: Shadow Price of Labour.* Regional Planning and Economics Branch. Vancouver, B.C.

*Training.* No economic benefits of training are included in the model other than the benefits from improved performance (i.e., salmon production). A study of possible other economic benefits from training at Community Economic Development Program facilities attempted to measure the benefits from improved skills, such as improved employment chances outside of SEP. The study found these additional benefits difficult to estimate but apparently small.[5]

### 2.3 Estimating SEP Costs

#### *Program Costs*

A database maintained by SEP provides information on the expenditures involved in planning, development, construction, operation and assessment of all projects. The SEP data base also contains some costs incurred by other federal government departments (e.g., Employment and Immigration, Indian Affairs, etc.). Because the collection of costs from other departments is inconsistent, and because the expenditures were often made for purposes other than salmon production, they are not included in the model.

SEP program costs include capital and operating costs for each facility since it was built or taken over by SEP. Costs for operating the facilities up to the end of their useful project life (assumed to be 2017) were projected on the basis of current expenditure levels at the project, i.e., the costs needed to maintain the facility at current levels of production. These costs are summarized in Chapter 4 and shown for each project in the tables attached to this Appendix.

Non-production costs of SEP are excluded from the evaluation model. These include costs of educational programs, applied research, public information and advisory costs. Also excluded are the development, construction and operating costs of fishways and several habitat restoration projects. These costs are excluded because the benefits of these projects are not measurable.

Benefit-cost results are reported by species in Chapter 4. In order to do this, it was necessary to estimate the current costs of producing each of the five major species of salmon. A major constraint was that no data were available on the division of project costs among the various species produced.

After consultations with program managers, costs were apportioned among the species produced on the basis of the biomass of the juveniles of each species released. Greater biomass per juvenile for species such as coho and chinook thus becomes a proxy for higher operating costs (including labour, feed and energy) necessary for achieving the greater biomass. Applicable capital costs were prorated and added in as well. In order to get as recent a picture as possible, juvenile production data from the 1984 to 1987 brood years were used and the adult survival rates for those years were applied to come up with average values of the cost per adult fish produced for those four brood years. The data on average cost by facility are presented in an attachment to this Appendix.

#### *Commercial Fishery Costs*

Commercial industry participants, (processors, vessel owners, and crews) incur a number of costs that must be deducted from gross benefits. These costs are shown in Table 3 and are described below.

[5]Peat Marwick. 1988. An Analysis of Training Benefits of the Community Economic Development Program.

Table 3. **Examples of net benefit calculations for enhanced salmon caught in the commercial fishery**

| Species:<br>Gear: | sockeye<br>net | chinook<br>troll |
|---|---|---|
| | (1993 $ per kg) | |
| Wholesale price | 8.56 | 6.29 |
| – Processing costs | 2.13 | 1.30 |
| – Fish cost | 5.62 | 4.90 |
| = **Processing benefits** | **.81** | **.09** |
| Landed price | 5.62 | 4.90 |
| – Harvesting costs | .30 | .55 |
| – Crew share | 2.30 | 2.01 |
| – Vessel capitalization | 1.51 | 1.17 |
| = **Vessel benefits** | **1.51** | **1.17** |
| Crew share | 2.30 | 2.01 |
| – Crew wages | .29 | .61 |
| = **Crew benefits** | **2.01** | **1.40** |
| = **Harvesting benefits** | **3.52** | **2.57** |
| = **Commercial benefits** | **4.33** | **2.66** |

*Processing Costs.* The following costs were subtracted from the revenues of salmon processors resulting from the sale of products produced from enhanced fish:

- costs of acquiring salmon (ex-vessel prices);
- variable processing costs (including processing workers' wages).

*Harvesting Costs.* Estimates of the non-labour harvesting costs (e.g., fuel, bait, food, etc.) to catch the additional production from SEP assumes that some additional effort is required. (That is, the fleet does not just catch the additional production in the same number of sets, just pulling up more fish in each set.) Estimates of these harvesting costs for each species and gear are based on cost and earnings survey data collected by the Program Planning & Economics Branch over the years.[6]

[6]The DPA Group Inc. December, 1988. *British Columbia Salmon Fleet Financial Performance, 1981-1985.* Fisheries & Oceans - Pacific Region. Vancouver, B.C. and, Fisheries & Oceans - Pacific Region. July 1992. *Financial Performance of the British Columbia Salmon Fleet, 1986-1990.* Program Planning & Economics Branch. Vancouver, B.C.

Economic theory of a common property fishery predicts — and practical experience in the B.C. salmon fishery supports — that vessel owners reinvest excess profits from the fishery in increased harvesting capacity. Estimates of this harvesting cost are based on a study of troll vessel incomes and investments over time carried out for the Program Planning & Economics Branch. The results suggests that nearly 50% of vessel returns are re-invested in the vessel. Although economic theory suggests that all vessel profits will be absorbed in increased capital and other costs in a common property fishery, this analysis adopts the 50% re-investment figure.

The last harvesting cost is the crew share paid to the skipper and crew on a salmon fishing vessel. It generally is a percentage of the landed value. For the evaluation model, it is assumed that 41% of the landed value goes to crew share. This estimate is based on the cost and earning surveys mentioned above.

However, the crew share overstates the opportunity cost of the crew involved in harvesting. Opportunity cost is the earnings crew members give up from alternative employment opportunities in order to fish. This labour cost is estimated by valuing the increased crew effort at the average weekly wage in B.C. If no alternative employment existed, the opportunity cost of the crew would be zero, increasing the benefits to harvesting.

### 2.4 Net Present Value and the Discount Rate

The net present value of annual benefits and costs puts the benefits and costs into comparable values, in the case of this evaluation: 1993 dollars. The discount rate is essential to the net present value calculation as it reflects the time preference for money. It is a critical assumption in the evaluation of long-term, capital intensive projects such as SEP. A rate of 8 percent is used as the Base Case in Chapter 4.

## 3. Sensitivity Analysis

Table 11 in Chapter 4 shows the effect on the benefit-cost results of changing some key assumptions underlying the analysis. This section elaborates on the brief discussion in Chapter 4 of some of the most important assumptions.

### 3.1 Processing Net Benefits

The current **Base Case** assumes that some monopsony power exists in the processing sector, notably in canning operations. In canning, processors have some control over prices paid to the seine fleet, and some barriers prevent entry of new competitors. Therefore, canneries may be able to earn some economic rent by maintaining ex-vessel prices below competitive levels.

In Chapter 4, economic rent earned by canneries is assumed to equal half the difference between the wholesale value of the canned production attributable to SEP and the variable costs incurred to purchase and process canned salmon. This assumption differs from earlier assessments which included all the difference between wholesale values and variable processing costs as economic rent to the processing sector.

The degree of competitiveness in the processing sector, and the ability of this industry to maintain ex-vessel prices below competitive levels in the long run, is debatable. Events, such as the removal of some export restrictions, have increased competitiveness in recent years. If the processing industry is competitive, no economic rents would accrue to this sector from processing SEP produced salmon in the long run.

The effect of different assumptions concerning processing benefits is shown in Table 4.

**Table 4. Effect of different assumptions about processing benefits**
(1993 present worth of lifetime benefits and costs at 8%)

| | **Base Case** one-half canning benefits | Benefits to all processing | No benefits to processors |
|---|---|---|---|
| | (millions of 1993 dollars) | | |
| Benefits: | | | |
| Processing | 103.9 | 432.2 | 23.6 |
| Harvesting | 537.2 | 537.2 | 537.2 |
| Native food | 74.8 | 74.8 | 74.8 |
| Recreational | 202.3 | 202.3 | 202.3 |
| Total | 919.9 | 1,248.1 | 839.6 |
| DFO costs | 1,511.6 | 1,511.6 | 1,511.6 |
| Net benefits | -591.8 | -263.5 | -672.0 |
| Benefit-cost ratio | 0.61 | 0.83 | 0.56 |

The **Base Case** depicted in Table 4 shows benefit-cost results if one-half of the difference between revenues and variable costs accruing to the canning sector are included as net benefits. Net benefits increase by more than $300 million compared to the **Base Case** if all the difference between variable processing costs and revenues are included as net benefits (although net benefits are still negative as shown in the second column of numbers in Table 4). If no processor benefits are assumed, the benefits to the processing sector fall to $-672 million, which is the estimated benefits due to increased employment only (see below).

## 3.2 Native Benefits

The **Base Case** in Chapter 4 applies ex-vessel prices to the Native food catch to calculate benefits. If the Native food catch was valued using wholesale prices, benefits would increase by $45 million or 5% as shown in Table 5.

**Table 5. Effect of different values for native food catch**
(1993 present worth of lifetime benefits and costs at 8%)

| | Base Case landed value | Wholesale value |
|---|---|---|
| | (millions of 1993 dollars) | |
| Benefits: | | |
| Processing | 103.9 | 103.9 |
| Harvesting | 537.2 | 537.2 |
| Native food | 74.8 | 120.7 |
| Recreational | 202.3 | 202.3 |
| Total | 919.9 | 965.8 |
| DFO costs | 1,511.6 | 1,511.6 |
| Net benefits | -591.8 | -545.9 |
| Benefit-cost ratio | 0.61 | 0.64 |

## 3.3 Recreational Benefits

The estimates of the recreational value of SEP catches contained in Table 2 above are highly uncertain. To show the sensitivity of the results to these values, Table 6 indicates the effect of doubling the recreational values used in Table 2.

**Table 6. Effect of doubling recreational salmon values**
(1993 present worth of lifetime benefits and costs at 8%)

| | Base Case assumption | Doubled recreational values |
|---|---|---|
| | (millions of 1993 dollars) | |
| Benefits: | | |
| Processing | 103.9 | 103.9 |
| Harvesting | 537.2 | 537.2 |
| Native food | 74.8 | 74.8 |
| Recreational | 202.3 | 404.6 |
| Total | 919.9 | 1,120.5 |
| DFO costs | 1,511.6 | 1,511.6 |
| Net benefits | -591.8 | -391.1 |
| Benefit-cost ratio | 0.61 | 0.74 |

Table 6 shows that net benefits would increase by $200 million if the recreational values of salmon produced by SEP were twice those assumed in the **Base Case**.

### 3.4 Opportunity Cost of Crews

Calculations in Chapter 4 are based on an assumption that some of the crew members would find alternative employment if they did not participate in the salmon fishery. Table 7 shows the impact of assuming that no alternative employment for crew members exists.

**Table 7. Effect of different assumptions about alternative employment for crews** (1993 present worth of lifetime benefits and costs at 8%)

| | **Base Case** some alternative | No alternative employment |
|---|---|---|
| | (millions of 1993 dollars) | |
| Benefits: | | |
| Processing | 103.9 | 103.9 |
| Harvesting | 537.2 | 579.0 |
| Native food | 74.8 | 74.8 |
| Recreational | 202.3 | 202.3 |
| Total | 919.9 | 961.7 |
| DFO costs | 1,511.6 | 1,511.6 |
| Net benefits | -591.8 | -550.0 |
| Benefit-cost ratio | 0.61 | 0.64 |

The lack of alternative employment would mean that there was no opportunity cost to employing crews in the salmon fishery. As is seen in the table, this would increase the net benefits of SEP by slightly over $40 million.

### 3.5 Effects on Wild Stocks

A critical issue in estimating the Salmonid Enhancement Program's contribution to catches is the effects of enhancement on wild stocks. Enhancement can affect wild stocks in several ways from changing salmon genetics to changing fisheries management practices. The most problematic change in fisheries management is that increased salmon abundance due to SEP production can increase exploitation rates on some wild stocks, leading to stock and catch declines over time.

Although both positive and negative effects can occur, no hard biological evidence exists on the magnitude of the change in wild salmon catches caused by enhancement. This is an important unanswered question associated with the Salmonid Enhancement Program.

Lacking hard biological evidence, expert opinion was used to try to estimate the overall extent of wild stock interactions. However, the estimated effects were not defendable; consequently, it was decided that they could not be included in the Base Case. Thus the program receives the benefit of the doubt on this issue, although any benefit-cost analysis which ignores these effects is incomplete.

Table 8 illustrates the effect on the results of making a crude assumption about adverse effects on wild stocks.

**Table 8. Effect of including wild stock interactions**
(1993 present worth of lifetime benefits and costs at 8%)

| | **Base Case** assumption | Adverse affect on wild stocks |
|---|---|---|
| | (millions of 1993 dollars) | |
| Benefits: | | |
| Processing | 103.9 | 92.6 |
| Harvesting | 537.2 | 461.8 |
| Native food | 74.8 | 57.2 |
| Recreational | 202.3 | 104.0 |
| Total | 919.9 | 717.2 |
| DFO costs | 1,511.6 | 1,511.6 |
| Net benefits | -591.8 | -794.4 |
| Benefit-cost ratio | 0.61 | 0.47 |

The estimate in Table 8 was made by deducting from the enhanced production half of the observed declines in wild Strait of Georgia coho and chinook catches since 1977, and half of the observed decline in catches of wild Skeena sockeye. If these effects were truly attributable to enhancement, they would have a significant effect on the benefit-cost analysis; the table shows that net benefits would decline by one-third or $200 million. However, there are no data to support such impacts, which lends urgency to undertaking the investigations needed to fully understand wild stock effects.

## 3.6 Discount Rates

The 8 percent discount rate used in the **Base Case** of Chapter 4 is lower than the 10 percent rate suggested by Treasury Board. However, experts consulted for this study felt that it better represents the preference between present and future values as reflected in long-term rates of return on private sector investments. On the other hand, some writers suggest a discount rate lower than 8 percent for long-term resource decision-making, or when investments should reflect a "social" discount rate.[7] The sensitivity of the results to different discount rates, 5 and 10 percent, is shown in Table 9.

[7]Heaps, T. and B. Pratt. February, 1989. The Social Discount Rate for Silviculture Investments. Simon Fraser University. Prepare for Industry Development and Marketing Branch, B.C. Ministry of Forests.

**Table 9. Effect of different discount rates**
(1993 present worth of lifetime benefits and costs at 8%)

| | Base Case 8 % | 5 % | 10 % |
|---|---|---|---|
| | (millions of 1993 dollars) | | |
| Benefits: | | | |
| Processing | 103.9 | 112.4 | 102.8 |
| Harvesting | 537.2 | 581.1 | 532.4 |
| Native food | 74.8 | 85.9 | 71.2 |
| Recreational | 202.3 | 220.9 | 199.1 |
| Total | 919.9 | 1,001.6 | 907.4 |
| DFO costs | 1,511.6 | 1,278.1 | 1,740.4 |
| Net benefits | -591.8 | -276.5 | -833.0 |
| Benefit-cost ratio | 0.61 | 0.78 | 0.52 |

Note that each 1% increase in the discount rate decreases net benefits by over $100 million.

## 3.7 Comparison to Results in the ARA Report

A previous benefit-cost analysis of SEP, undertaken earlier in this evaluation exercise, had considerably different results. An analysis completed by ARA Consulting Group Inc. used assumptions different than those adopted in the current evaluation.[8] The affect of these changes is summarized in Table 10.

**Table 10. Cumulative effect of changing assumptions from the ARA report**
(1993 present worth of lifetime benefits and costs at 8%)

| | ARA results | Lower wholesale price forecast | Reduced processing benefits | Native food at landed price | **Base Case** exclude pre-SEP |
|---|---|---|---|---|---|
| | | | (millions of 1993 dollars) | | |
| Benefits: | | | | | |
| Processing | 738.7 | 630.3 | 164.0 | 164.0 | 103.9 |
| Harvesting | 925.4 | 795.2 | 795.2 | 795.2 | 537.2 |
| Native food | 206.3 | 185.2 | 185.2 | 114.8 | 74.8 |
| Recreational | 252.3 | 252.3 | 252.3 | 252.3 | 202.3 |
| Total | 2,125.2 | 1,865.5 | 1,399.2 | 1,328.8 | 919.9 |
| DFO costs | 1,736.0 | 1,736.0 | 1,736.0 | 1,736.0 | 1,511.6 |
| Net benefits | 389.2 | 129.5 | -336.8 | -407.2 | -591.8 |
| Benefit-cost ratio | 1.22 | 1.07 | 0.81 | 0.77 | 0.61 |

[8]ARA Consulting Group Inc., April 1993. Program Review: Salmonid Enhancement Program, Halifax, N.S.

The ARA results shown in Table 10 are not exactly as shown in their report because, although they are based on the assumptions in that report, they incorporate updated enhancement catch and cost estimates prepared for the current evaluation. Further, since the ARA report, the forecast for wholesale and landed prices has been reduced significantly to reflect the lower prices paid in recent years. This change knocked $260 million from net benefits.

The remaining differences between the results in this report and the ARA report flow from different assumptions. The net benefits in this report's base case are $466 lower as a result of lower rents in processing; $70 million lower because of the change from wholesale to landed price to value Native food catches, and $185 million less as a result of excluding pre-SEP projects not due to SEP investments. These changes cut total net benefits by $981 million compared to those presented in the ARA report.

The adjustments to the ARA assumptions were considered necessary to ensure that the benefit-cost results were consistent with the best available information on factors such as fish prices, present circumstances of the fishing industry, and economic theory.

The projected benefit-cost results contained in this report, while lower than those in the ARA report, may still be optimistic. The main reasons why the estimates of economic performance in Chapter 4 may err on the high side are that they make no allowance for adverse effects of enhancement on wild stocks, and that the economic rents assumed to accrue to vessel owners and the processing sector of the commercial fishery are speculative and may be overstated.

The questions raised in the course of the present investigation about the basic assumptions in the Department's evaluation model, and their serious implications for estimates of economic performance, suggest that a thorough review of the Department's model and evaluation methodology is needed.

## 4. Detailed Runs

Attached are a series of tables that show results of the detailed economic analysis of each facility. There are three tables:

Table A1 • Enhancement costs per fish produced, by facility: 1984 to 1987 average.
This shows the estimated current cost of enhancement, per fish produced, by species, for each enhancement facility.

Table A2 • Lifetime benefits and costs, by facility.
This shows the 1993 present value of annual benefits and costs from 1977 to 2017, and benefit cost ratio, for each facility.

Table A3 • Future benefits and costs, by facility.
This shows the 1993 present value of all future benefits and costs, from 1994 to 2017, and benefit cost ratios, for each facility.

All these tables include the relevant information for all SEP facilities and the SEP (i.e., post-1977) portion of the pre-SEP facilities.

**Table A1. Enhancement costs per fish produced, by facility (1984 to 1987 average cost)**

| | Sockeye | Pink | Chum | Coho | Chinook |
|---|---|---|---|---|---|
| | | | (dollars per returning adult) | | |
| **1. Hatcheries** | | | | | |
| Big Qualicum River | | | 0.62 | 10.24 | 28.34 |
| Capilano River | | | | 3.29 | 47.29 |
| Robertson Creek | | | | 5.54 | 3.58 |
| Puntledge River | | 0.16 | 2.25 | 9.93 | 28.65 |
| Quinsam River | | 0.06 | | 3.31 | 11.79 |
| Pitt River (Upper) | 2.83 | | | | |
| Shuswap River | | | | | 46.03 |
| Little Qualicum River | | | 1.3 | | 20.81 |
| Chilliwack River | | | 1.08 | 1.82 | 6.21 |
| Nitinat River | | | 0.65 | 4.02 | 19.47 |
| Conuma River | | | 7.28 | 7.37 | 20.79 |
| Snootli Creek | | 1.42 | 1.57 | 14.82 | 146.68 |
| Kitimat River | | | 1.58 | 27.03 | 22.29 |
| Pallant Creek | | | 7.62 | 6.06 | 12.28 |
| Inch Creek | | | 2.24 | 8.32 | 26.31 |
| Chemainus River | | | | 25.85 | 12.24 |
| Birkenhead River | | | | 30.53 | 255.26 |
| Tenderfoot Creek | | | | 10.75 | 71.21 |
| Chehalis River | | | 1.63 | 2.92 | 7.7 |
| Quesnel River | | | | 88.4 | 72.14 |
| Eagle River | | | | 20.09 | 142.35 |
| Spius Creek | | | | 20.54 | 66.92 |
| Clearwater River | | | | 22.27 | 176.97 |
| Whitehorse | | | | | 353.31 |
| Devereux Creek | | | | 248.63 | 326.33 |
| Hatchery Average | 2.83 | 0.09 | 1.66 | 4.84 | 18.75 |
| Lowest | 2.83 | 0.06 | 0.62 | 1.82 | 3.58 |
| Highest | 2.83 | 1.42 | 7.62 | 248.63 | 353.31 |
| **2. Channels** | | | | | |
| Fulton River | 0.61 | | | | |
| Pinkut Creek | 1.03 | | | | |
| Jones Creek | | 0.4 | 1.7 | | |
| Weaver Creek | 0.48 | 0.13 | 0.36 | | |
| Seton River | | 0.13 | | | |
| Gates River | 1.73 | | | | |
| Nadina River | 1.11 | | | | |
| Channels Average | 0.77 | 0.14 | 0.57 | | |
| Lowest | 0.48 | 0.13 | 0.36 | | |
| Highest | 1.73 | 0.4 | 1.7 | | |

Table A1 (cont'd)

| | Sockeye | Pink | Chum | Coho | Chinook |
|---|---|---|---|---|---|
| | | | (dollars per returning adult) | | |
| **3. Spawning Bed Restoration** | 1.48 | 0.83 | 1.59 | 3.73 | 35.22 |
| **4. Community Development Projects** | | | | | |
| Vancouver Bay | | 0.52 | 2.15 | 6.35 | 9.3 |
| Kitsumkalum River | | | 11 | 38.89 | 159.57 |
| San Juan River | | | 1.13 | 5.02 | 11.68 |
| Seymour River | | 1.12 | 2.91 | 15.92 | 15.63 |
| Cowichan River | | | 5.4 | 36.06 | 37.38 |
| Kispiox River | | | | 17.33 | 53 |
| Kincolith | | | | 71.62 | 82.57 |
| Masset | 9.34 | | | 151.11 | 203.4 |
| Nimpkish | 4.75 | | 8.61 | 25.37 | 34.12 |
| Bella Bella | | | 3.9 | 23.38 | |
| Sliammon River | | 3.88 | 8.04 | 44.45 | |
| Sechelt | | 5.97 | 1.58 | 12.5 | 59.8 |
| Nanaimo River | | | 3.4 | 15.16 | 24.28 |
| Thornton Creek | | | 3.98 | 16.06 | 25.87 |
| Port Hardy | | 0.55 | 1.36 | 7.63 | 6.53 |
| Chehalis River | | | 7.15 | | 44.08 |
| Alouette River | | 0.1 | 0.28 | 0.77 | |
| Thompson R. North | | | | 50.19 | |
| Penny | | | | | 108.99 |
| Hartley Bay | | | | 68.68 | |
| Skidegate | | | 58.49 | 99.17 | |
| Terrace | | | | 11.93 | 86.01 |
| Klemtu | | 3.19 | 7.01 | 19.16 | |
| Fort St. James | | | | | 60.33 |
| Oweekeno | | | 7.5 | | 40.55 |
| Powell River | | 1.23 | 3.42 | 25.76 | 26.9 |
| Fort Babine | | | | 26.14 | 61.17 |
| Toboggan Creek | | | | 23.76 | 46.7 |
| Kyuquot | | | 349.92 | 363.12 | |
| Clayoquot | 6.88 | | | 20.09 | 168.87 |
| Community Development | | | | | |
| Average | 4.76 | 0.58 | 5.51 | 18.99 | 42.68 |
| Lowest | 4.75 | 0.1 | 0.28 | 0.77 | 6.53 |
| Highest | 9.34 | 5.97 | 349.92 | 363.12 | 203.4 |
| **5. Public Involvement Projects** | | | | | |
| Large PIP | 0.56 | 0.33 | 0.76 | 2.43 | 4.19 |
| Small PIP | | 0.66 | 1.4 | 3.06 | 8.1 |
| Public Involvement Average | 0.58 | 0.33 | 0.94 | 2.61 | 4.3 |
| **All Enhancement Average** | **0.87** | **0.14** | **1.82** | **5.77** | **19.96** |
| Lowest | 0.48 | 0.06 | 0.28 | 0.77 | 3.58 |
| Highest | 9.34 | 5.97 | 349.92 | 363.12 | 255.26 |

**Table A2. Lifetime benefits and costs, by facility (1993 present value of annual benefits and costs, 1977 to 2017 at 8%)**

| | Benefits | | | | Total | Net | B/C |
|---|---|---|---|---|---|---|---|
| | Commercial | Native | Sport | Total | Costs | Benefits | ratio |
| | (thousands of 1993 dollars) | | | | | | |
| **1. Hatcheries** | | | | | | | |
| Big Qualicum River | 16,711 | 2,803 | 11,501 | 31,271 | 28,051 | 3,220 | 1.11 |
| Capilano River | 1,297 | 122 | 2,331 | 3,761 | 5,298 | -1,537 | 0.71 |
| Robertson Creek | 47,647 | 8,356 | 12,208 | 69,444 | 57,010 | 12,434 | 1.22 |
| Puntledge River | 21,948 | 1,475 | 13,725 | 37,148 | 91,768 | -54,620 | 0.40 |
| Quinsam River | 7,465 | 170 | 2,985 | 10,628 | 10,302 | 326 | 1.03 |
| Pitt River Upper | 606 | 10 | 0 | 618 | 1,323 | -705 | 0.47 |
| Shuswap River | 872 | 156 | 519 | 1,547 | 16,452 | -14,905 | 0.09 |
| Little Qualicum River | 24,898 | 2,997 | 12,648 | 40,543 | 47,460 | -6,918 | 0.85 |
| Chilliwack River | 23,159 | 9,789 | 41,712 | 74,705 | 80,876 | -6,172 | 0.92 |
| Nitinat River | 122,534 | 11,304 | 3,018 | 136,856 | 98,351 | 38,504 | 1.39 |
| Conuma River | 10,100 | 3,003 | 2,028 | 15,131 | 66,179 | -51,048 | 0.23 |
| Snootli/Atnarko | 35,708 | 1,620 | 2,240 | 39,568 | 58,710 | -19,142 | 0.67 |
| Kitimat River | 14,630 | 888 | 9,471 | 25,019 | 91,022 | -66,003 | 0.27 |
| Pallant Creek | 10,401 | 283 | 934 | 11,618 | 72,647 | -61,029 | 0.16 |
| Inch Creek | 6,946 | 1,449 | 4,805 | 13,200 | 39,148 | -25,949 | 0.34 |
| Chemainus River | 2,130 | 367 | 4,819 | 7,316 | 6,933 | 383 | 1.06 |
| Birkenhead River | 55 | 13 | 46 | 114 | 8,130 | -8,016 | 0.01 |
| Tenderfoot Creek | 3,179 | 275 | 6,893 | 10,347 | 26,704 | -16,357 | 0.39 |
| Chehalis River | 16,829 | 5,259 | 20,611 | 42,699 | 68,863 | -26,164 | 0.62 |
| Quesnel River | 3,937 | 441 | 490 | 4,868 | 46,115 | -41,247 | 0.11 |
| Eagle River | 971 | 220 | 1,000 | 2,191 | 26,723 | -24,532 | 0.08 |
| Stuart River | 4 | 1 | 1 | 6 | 1,075 | -1,069 | 0.01 |
| Spius Creek | 980 | 215 | 1,098 | 2,293 | 20,627 | -18,334 | 0.11 |
| Clearwater R (Upper) | 364 | 65 | 238 | 667 | 17,414 | -16,747 | 0.04 |
| Whitehorse | 0 | 0 | 0 | 0 | 3,442 | -3,442 | 0.00 |
| Indian River | 21 | 2 | 47 | 70 | 0 | 70 | |
| Indian Arm | 106 | 11 | 232 | 349 | 0 | 349 | |
| Blaney Creek | 52 | 2 | 0 | 54 | 1,558 | -1,504 | 0.03 |
| Devereux Creek | 21 | 2 | 29 | 52 | 1,361 | -1,309 | 0.04 |
| Babine Fence | 0 | 0 | 0 | 0 | 4,810 | -4,810 | 0.00 |
| Atnarko River | 32 | 2 | 15 | 49 | 5,834 | -5,785 | 0.01 |
| Penny | 5 | 1 | 2 | 8 | 4,556 | -4,548 | 0.00 |
| Lillooet River Upper | 0 | 0 | 0 | 0 | 22 | -22 | 0.00 |
| Snettisham Can/Us | 0 | 0 | 0 | 0 | 3,752 | -3,752 | 0.00 |
| Thornton Creek | 886 | 13 | 0 | 899 | 3,487 | -2,588 | 0.26 |
| Kalum | 20 | 3 | 7 | 30 | 1,587 | -1,557 | 0.02 |
| Inches Hatchery | 0 | 0 | 0 | 0 | 6,596 | -6,596 | 0.00 |
| Kitimat | 0 | 0 | 0 | 0 | 5,878 | -5,878 | 0.00 |
| Mitchell River | 0 | 0 | 0 | 0 | 1,911 | -1,911 | 0.00 |
| Hatchery Total | 374,514 | 51,316 | 155,653 | 583,068 | 1,031,975 | -448,907 | 0.57 |

Table A2 (cont'd)

| | Benefits | | | | Total | Net | B/C |
|---|---|---|---|---|---|---|---|
| | Commercial | Native | Sport | Total | Costs | Benefits | ratio |
| | (thousands of 1993 dollars) | | | | | | |
| **2. Channels** | | | | | | | |
| Fulton River | 21,211 | 3,165 | 0 | 24,376 | 5,364 | 19,012 | 4.54 |
| Pinkut Creek | 24,996 | 3,741 | 0 | 28,737 | 9,946 | 18,791 | 2.89 |
| Jones Creek | 11 | 0 | 0 | 11 | 10 | 1 | 1.13 |
| Weaver Creek | 5,774 | 352 | 0 | 6,126 | 900 | 5,226 | 6.80 |
| Seton River Lower | 763 | 9 | 0 | 772 | 295 | 477 | 2.62 |
| Gates River | 602 | 55 | 0 | 657 | 410 | 247 | 1.60 |
| Nadina River | 2,328 | 212 | 0 | 2,540 | 600 | 1,940 | 4.23 |
| Horsefly Creek | 14,394 | 1,308 | 0 | 15,702 | 4,873 | 10,829 | 3.22 |
| Chilko River | 360 | 33 | 0 | 393 | 1,351 | -958 | 0.29 |
| Kakweiken River | 6,461 | 0 | 0 | 6,461 | 1,855 | 4,606 | 3.48 |
| Adams River Upper | 129 | 7 | 0 | 136 | 1,142 | -1,006 | 0.12 |
| Glendale Channel | 8,007 | 5 | 8 | 8,020 | 7,548 | 472 | 1.06 |
| Orford River | 377 | 23 | 0 | 400 | 3,372 | -2,972 | 0.12 |
| Washwash River | 0 | 0 | 0 | 0 | 174 | -174 | 0.00 |
| Nekite River | 275 | 4 | 2 | 281 | 2,687 | -2,406 | 0.10 |
| Phillips Channel | 696 | 2 | 5 | 703 | 3,820 | -3,117 | 0.18 |
| SEP Channel Total | 86,384 | 8,916 | 15 | 95,315 | 44,347 | 50,968 | 2.15 |
| **3. Spawning Bed Restoration** | | | | | | | |
| Craig Creek | 4 | 0 | 1 | 5 | 10 | -5 | 0.50 |
| Black Creek | 4 | 0 | 4 | 8 | 16 | -8 | 0.50 |
| Menzies Creek | 5 | 0 | 4 | 9 | 18 | -9 | 0.50 |
| Englishman River | 582 | 64 | 626 | 1,272 | 2,631 | -1,359 | 0.48 |
| Billy Harris Slough | 1,246 | 81 | 270 | 1,597 | 3,681 | -2,084 | 0.43 |
| Ed Leon Slough | 1,041 | 65 | 192 | 1,298 | 2,598 | -1,300 | 0.50 |
| Nanoose Creek | 1 | 0 | 2 | 3 | 6 | -3 | 0.50 |
| Trent River | 7 | 0 | 6 | 13 | 26 | -13 | 0.50 |
| Paradise Chan Upper | 221 | 17 | 90 | 328 | 722 | -394 | 0.45 |
| Rotary Park | 468 | 37 | 37 | 542 | 1,080 | -538 | 0.50 |
| Hopedale Slough | 185 | 17 | 96 | 298 | 797 | -499 | 0.37 |
| Peach Creek | 827 | 53 | 170 | 1,050 | 2,287 | -1,237 | 0.46 |
| Ryder Creek | 82 | 4 | 0 | 86 | 170 | -84 | 0.50 |
| Barrett Creek | 78 | 5 | 14 | 97 | 240 | -143 | 0.40 |
| Worth Creek | 195 | 17 | 84 | 296 | 651 | -355 | 0.45 |
| Chilqua Creek | 231 | 12 | 22 | 265 | 566 | -301 | 0.47 |
| Judd Slough | 545 | 43 | 153 | 741 | 1,764 | -1,023 | 0.42 |
| Mamquam River | 491 | 28 | 86 | 605 | 1,268 | -663 | 0.48 |
| Paradise Chan Lower | 157 | 12 | 45 | 214 | 588 | -374 | 0.36 |
| Westholme Channel | 1,107 | 85 | 57 | 1,249 | 3,129 | -1,880 | 0.40 |
| Kitsumkalum Lake | 243 | 37 | 0 | 280 | 659 | -379 | 0.43 |
| Railroad Creek | 210 | 11 | 17 | 238 | 578 | -340 | 0.41 |
| Kitty Coleman Creek | 2 | 0 | 2 | 4 | 17 | -13 | 0.24 |
| Baynes Sound Str. | 385 | 29 | 371 | 785 | 2,652 | -1,867 | 0.30 |
| Moodie's Channel | 131 | 11 | 117 | 259 | 677 | -418 | 0.38 |
| B.C. Rail. Channel | 107 | 9 | 43 | 159 | 372 | -213 | 0.43 |

Table 2A (cont'd)

| | Benefits | | | | Total | Net | B/C |
|---|---|---|---|---|---|---|---|
| | Commercial | Native | Sport | Total | Costs | Benefits | ratio |
| | (thousands of 1993 dollars) | | | | | | |
| Deadman Channel | 70 | 8 | 262 | 340 | 750 | -410 | 0.45 |
| Andeside Channel | 17 | 1 | 1 | 19 | 66 | -47 | 0.29 |
| Dudley Marsh | 4 | 0 | 3 | 7 | 14 | -7 | 0.50 |
| Grant Lake | 2 | 0 | 1 | 3 | 6 | -3 | 0.50 |
| Hicks Creek Pond | 31 | 5 | 34 | 70 | 192 | -122 | 0.37 |
| Kitwancool Channel | 39 | 1 | 2 | 42 | 169 | -127 | 0.25 |
| Oyster Channel | 1,202 | 1 | 18 | 1,221 | 2,515 | -1,294 | 0.49 |
| McNab Channel | 90 | 7 | 23 | 120 | 238 | -118 | 0.50 |
| Drainy Channel | 153 | 16 | 77 | 246 | 487 | -241 | 0.50 |
| Adams Channel | 334 | 57 | 236 | 627 | 1,363 | -736 | 0.46 |
| York Rd Channel | 1,167 | 0 | 0 | 1,167 | 2,312 | -1,145 | 0.50 |
| Stave R Channel | 322 | 16 | 11 | 349 | 743 | -394 | 0.47 |
| Kawkawa Channel | 114 | 4 | 10 | 128 | 264 | -136 | 0.49 |
| Englishman Channel | 93 | 7 | 21 | 121 | 258 | -137 | 0.47 |
| Brennan Park Channel | 93 | 7 | 22 | 122 | 271 | -149 | 0.45 |
| Tiampo Channel | 67 | 5 | 29 | 101 | 200 | -99 | 0.50 |
| Brandt Creek Channel | 124 | 10 | 29 | 163 | 421 | -258 | 0.39 |
| Brandt Creek Diversion | 61 | 5 | 15 | 81 | 209 | -128 | 0.39 |
| Hixon Channel | 13 | 1 | 12 | 26 | 52 | -26 | 0.50 |
| Tower Channel | 61 | 5 | 15 | 81 | 209 | -128 | 0.39 |
| Alouette Channel | 8 | 3 | 31 | 42 | 252 | -210 | 0.17 |
| Ianson Channel | 58 | 21 | 202 | 281 | 643 | -362 | 0.44 |
| Millstone River | 22 | 1 | 22 | 45 | 89 | -44 | 0.50 |
| Skwawka River | 0 | 0 | 0 | 0 | 61 | -61 | 0.00 |
| Coho Creek Channel | 17 | 1 | 4 | 22 | 75 | -53 | 0.29 |
| Taylors Channel | 33 | 1 | 7 | 41 | 81 | -40 | 0.50 |
| Deroche Channel | 0 | 0 | 0 | 0 | 40 | -40 | 0.00 |
| Highfalls Channel | 16 | 1 | 11 | 28 | 55 | -27 | 0.50 |
| Coal Creek Channel | 40 | 1 | 29 | 70 | 266 | -196 | 0.26 |
| Ushers Channel | 244 | 15 | 46 | 305 | 604 | -299 | 0.50 |
| Van. Bay Chan | 42 | 3 | 62 | 107 | 1,540 | -1,433 | 0.07 |
| Smokehouse Channel | 242 | 13 | 26 | 281 | 597 | -316 | 0.47 |
| Cottonwood Channel | 10 | 2 | 19 | 31 | 61 | -30 | 0.50 |
| Cedar R. Pond | 0 | 0 | 0 | 0 | 18 | -18 | 0.00 |
| Seabird Channel | 52 | 6 | 44 | 102 | 281 | -179 | 0.36 |
| Ruskin Channel | 162 | 10 | 33 | 205 | 406 | -201 | 0.50 |
| Hopedale Channel | 339 | 21 | 66 | 426 | 844 | -418 | 0.50 |
| Prettys Channel | 20 | 2 | 7 | 29 | 67 | -38 | 0.43 |
| Mashiter Channel | 93 | 7 | 41 | 141 | 279 | -138 | 0.50 |
| Jack Slough | 151 | 12 | 36 | 199 | 572 | -373 | 0.35 |
| Weldwood Channel | 72 | 6 | 18 | 96 | 190 | -94 | 0.50 |
| Fishweir Channel | 76 | 1 | 0 | 77 | 156 | -79 | 0.50 |
| Bonsall Slough | 511 | 40 | 46 | 597 | 1,230 | -633 | 0.49 |
| Campbell R Channel | 0 | 0 | 0 | 0 | 5 | -5 | 0.00 |
| Cowichan R Channel | 0 | 0 | 0 | 0 | 53 | -53 | 0.00 |

Table 2A (cont'd)

| | Benefits | | | | Total | Net | B/C |
|---|---|---|---|---|---|---|---|
| | Commercial | Native | Sport | Total | Costs | Benefits | ratio |
| | (thousands of 1993 dollars) | | | | | | |
| Sliammon R Channel | 0 | 0 | 0 | 0 | 9 | -9 | 0.00 |
| Coquitlam R Ponds | 0 | 0 | 0 | 0 | 740 | -740 | 0.00 |
| Sherman Channel | 0 | 0 | 0 | 0 | 29 | -29 | 0.00 |
| Spawning Bed Restoration Total | 14,820 | 960 | 4,080 | 19,860 | 47,183 | -27,323 | 0.42 |
| **4. Lake Enrichment** | | | | | | | |
| Great Central Lake | 49,598 | 3,302 | 2,491 | 55,391 | 27,079 | 28,312 | 2.05 |
| Long Lake | 25,393 | 800 | 0 | 26,193 | 14,344 | 11,849 | 1.83 |
| Chilko Lake | 11,190 | 1,406 | 0 | 12,596 | 5,826 | 6,770 | 2.16 |
| Nimpkish Lake | 9,860 | 1,080 | 0 | 10,940 | 6,382 | 4,558 | 1.71 |
| Henderson Lake | 7,337 | 759 | 86 | 8,182 | 8,565 | -383 | 0.96 |
| Sproat Lake | 4,280 | 367 | 0 | 4,647 | 4,054 | 593 | 1.15 |
| Kennedy Lake | 3,993 | 474 | 74 | 4,541 | 7,472 | -2,931 | 0.61 |
| Qci Lakes | 1,785 | 552 | 0 | 2,337 | 8,997 | -6,660 | 0.26 |
| Hobiton Lake | 1,594 | 165 | 19 | 1,778 | 5,329 | -3,551 | 0.33 |
| Woss Lake | 1,016 | 112 | 0 | 1,128 | 429 | 699 | 2.63 |
| Lowe Lake | 283 | 35 | 0 | 318 | 2,454 | -2,136 | 0.13 |
| Curtis Lake | 277 | 36 | 0 | 313 | 2,461 | -2,148 | 0.13 |
| Bonilla Lake | 205 | 27 | 0 | 232 | 2,417 | -2,185 | 0.10 |
| Devon Lake | 52 | 7 | 0 | 59 | 952 | -893 | 0.06 |
| Kitlope Lake | 40 | 6 | 0 | 46 | 2,028 | -1,982 | 0.02 |
| Muriel Lake | 33 | 2 | 3 | 38 | 323 | -285 | 0.12 |
| Lake Enrichment Total | 116,936 | 9,130 | 2,673 | 128,739 | 99,112 | 29,627 | 1.30 |
| **5. Community Development Projects** | | | | | | | |
| Vancouver Bay | 835 | 38 | 545 | 1,418 | 2,230 | -812 | 0.64 |
| Kitsumkalum River | 447 | 21 | 21 | 489 | 2,511 | -2,022 | 0.19 |
| San Juan River | 2,817 | 254 | 721 | 3,792 | 7,283 | -3,491 | 0.52 |
| Seymour River | 646 | 52 | 1,208 | 1,906 | 10,087 | -8,181 | 0.19 |
| Cowichan River | 6,350 | 857 | 10,234 | 17,441 | 18,747 | -1,306 | 0.93 |
| Kispiox River | 415 | 34 | 157 | 606 | 10,304 | -9,698 | 0.06 |
| Kincolith | 468 | 86 | 49 | 603 | 6,737 | -6,134 | 0.09 |
| Masset | 321 | 3 | 258 | 582 | 7,262 | -6,680 | 0.08 |
| Nimpkish | 3,054 | 204 | 653 | 3,911 | 17,945 | -14,034 | 0.22 |
| Bella Bella | 2,484 | 120 | 62 | 2,666 | 11,968 | -9,302 | 0.22 |
| Sliammon River | 973 | 73 | 732 | 1,778 | 9,377 | -7,599 | 0.19 |
| Sechelt | 963 | 78 | 1,861 | 2,902 | 6,282 | -3,380 | 0.46 |
| Nanaimo River | 3,128 | 379 | 3,844 | 7,351 | 20,798 | -13,447 | 0.35 |
| Thornton Creek | 2,083 | 170 | 473 | 2,726 | 7,044 | -4,318 | 0.39 |
| Port Hardy | 2,031 | 47 | 518 | 2,596 | 7,493 | -4,897 | 0.35 |
| Chehalis River | 804 | 84 | 239 | 1,127 | 5,960 | -4,833 | 0.19 |
| Alouette River | 1,077 | 112 | 884 | 2,073 | 2,991 | -918 | 0.69 |
| Thompson River | 201 | 53 | 262 | 516 | 3,481 | -2,965 | 0.15 |
| Deadman River | 74 | 18 | 87 | 179 | 4,035 | -3,856 | 0.04 |
| Penny | 66 | 15 | 55 | 136 | 1,979 | -1,843 | 0.07 |

**Table 2A** (cont'd)

| | Benefits | | | | Total | Net | B/C |
|---|---|---|---|---|---|---|---|
| | Commercial | Native | Sport | Total | Costs | Benefits | ratio |
| | (thousands of 1993 dollars) | | | | | | |
| Hartley Bay Creek | 434 | 35 | 111 | 580 | 2,685 | -2,105 | 0.22 |
| Skidegate | 230 | 6 | 52 | 288 | 2,862 | -2,574 | 0.10 |
| Terrace | 227 | 29 | 155 | 411 | 4,134 | -3,723 | 0.10 |
| False Creek Pens | 29 | 4 | 90 | 123 | 0 | 123 | |
| Klemtu | 932 | 51 | 66 | 1,049 | 3,482 | -2,433 | 0.30 |
| Fort St. James | 76 | 16 | 52 | 144 | 2,031 | -1,887 | 0.07 |
| Oweekeno | 422 | 18 | 0 | 440 | 4,488 | -4,048 | 0.10 |
| Powell River | 848 | 65 | 1,455 | 2,368 | 7,304 | -4,936 | 0.32 |
| Fort Babine | 472 | 33 | 130 | 635 | 3,140 | -2,505 | 0.20 |
| Toboggan Creek | 334 | 26 | 123 | 483 | 4,665 | -4,182 | 0.10 |
| Kyuquot | 1 | 0 | 0 | 1 | 151 | -150 | 0.01 |
| Clayoquot | 779 | 91 | 249 | 1,119 | 2,692 | -1,573 | 0.42 |
| Lang Channel | 92 | 5 | 5 | 102 | 144 | -42 | 0.71 |
| Community Development Total | 34,113 | 3,077 | 25,351 | 62,541 | 202,291 | -139,750 | 0.31 |
| **6. Public Involvement Projects** | | | | | | | |
| Memekay River | 373 | 10 | 236 | 619 | 1,736 | -1,117 | 0.36 |
| Mossom Creek | 55 | 4 | 39 | 98 | 303 | -205 | 0.32 |
| Alberni Enh Soc | 98 | 3 | 15 | 116 | 334 | -218 | 0.35 |
| Gold River | 1,643 | 229 | 1,077 | 2,949 | 8,058 | -5,109 | 0.37 |
| Sewell Inlet | 123 | 2 | 94 | 219 | 632 | -413 | 0.35 |
| Little Campbell River | 211 | 19 | 473 | 703 | 2,102 | -1,399 | 0.33 |
| Noons Creek | 74 | 6 | 152 | 232 | 635 | -403 | 0.37 |
| Courtenay | 154 | 10 | 140 | 304 | 875 | -571 | 0.35 |
| Oyster River | 1,758 | 193 | 2,513 | 4,464 | 12,129 | -7,665 | 0.37 |
| Kanaka Creek | 266 | 62 | 589 | 917 | 2,614 | -1,697 | 0.35 |
| Ouellette Creek | 44 | 3 | 30 | 77 | 244 | -167 | 0.31 |
| Anderson Creek | 109 | 10 | 205 | 324 | 906 | -582 | 0.36 |
| Kingfisher Creek | 63 | 12 | 51 | 126 | 419 | -293 | 0.30 |
| Kloiya Creek | 24 | 7 | 16 | 47 | 159 | -112 | 0.30 |
| Goldstream River | 324 | 40 | 607 | 971 | 2,709 | -1,738 | 0.36 |
| Eby Street | 341 | 14 | 38 | 393 | 1,107 | -714 | 0.35 |
| Brunette River | 133 | 15 | 451 | 599 | 1,638 | -1,039 | 0.37 |
| Marble River | 1,095 | 153 | 649 | 1,897 | 5,236 | -3,339 | 0.36 |
| Scott Cove Creek | 76 | 2 | 105 | 183 | 563 | -380 | 0.32 |
| Sooke River | 1,110 | 103 | 297 | 1,510 | 4,340 | -2,830 | 0.35 |
| Sachs Creek | 89 | 0 | 102 | 191 | 561 | -370 | 0.34 |
| Nadu Creek | 10 | 0 | 14 | 24 | 119 | -95 | 0.20 |
| Tahsis River | 396 | 59 | 273 | 728 | 1,984 | -1,256 | 0.37 |
| Holberg | 147 | 11 | 44 | 202 | 581 | -379 | 0.35 |
| Horseshoe Bay | 275 | 32 | 629 | 936 | 2,534 | -1,598 | 0.37 |
| Silvermere Lake | 98 | 19 | 168 | 285 | 788 | -503 | 0.36 |

**Table 2A** (cont'd)

| | Benefits | | | | Total | Net | B/C |
|---|---|---|---|---|---|---|---|
| | Commercial | Native | Sport | Total | Costs | Benefits | ratio |
| | (thousands of 1993 dollars) | | | | | | |
| Bella Coola | 76 | 4 | 7 | 87 | 250 | -163 | 0.35 |
| Oldfield Creek | 120 | 18 | 33 | 171 | 533 | -362 | 0.32 |
| Malaspina Coll. | 54 | 4 | 94 | 152 | 466 | -314 | 0.33 |
| Chapman Creek | 323 | 22 | 541 | 886 | 2,399 | -1,513 | 0.37 |
| Rivers In-Hakai Pass | 220 | 9 | 0 | 229 | 800 | -571 | 0.29 |
| Quadra I. Enh. Soc. | 274 | 7 | 102 | 383 | 1,148 | -765 | 0.33 |
| Spruce C. Wldlf A. | 25 | 6 | 19 | 50 | 353 | -303 | 0.14 |
| Serpentine Enh Soc | 125 | 11 | 241 | 377 | 1,055 | -678 | 0.36 |
| Thornton Vol | 123 | 4 | 18 | 145 | 406 | -261 | 0.36 |
| Little River/Gsvi | 83 | 7 | 158 | 248 | 684 | -436 | 0.36 |
| Small PIP (207 projects) | 3,882 | 327 | 4,429 | 8,638 | 25,326 | -16,688 | 0.34 |
| Public Involvement Total | 14,394 | 1,437 | 14,649 | 30,480 | 86,729 | -56,249 | 0.35 |
| **All Enhancement Projects** | **641,161** | **74,836** | **202,421** | **920,003** | **1,511,637** | **-591,634** | **0.61** |

**Table A3. Future benefits and costs, by facility (1993 preset value of annual benefits and costs, 1994 to 2017, discounted at 8%)**

| | Benefits | | | | Total | Net | B/C |
|---|---|---|---|---|---|---|---|
| | Commercial | Native | Sport | Total | Costs | Benefits | ratio |
| | (thousands of 1993 dollars) | | | | | | |
| **1. Hatcheries** | | | | | | | |
| Big Qualicum River | 11,986 | 5,320 | 5,108 | 22,414 | 12,197 | 10,218 | 1.84 |
| Capilano River | 1,242 | 376 | 3,065 | 4,683 | 9,102 | -4,419 | 0.51 |
| Robertson Creek | 12,449 | 5,318 | 3,885 | 21,652 | 10,002 | 11,650 | 2.16 |
| Puntledge River | 6,103 | 420 | 4,928 | 11,451 | 10,572 | 879 | 1.08 |
| Quinsam River | 8,965 | 589 | 5,293 | 14,847 | 11,155 | 3,692 | 1.33 |
| Pitt River Upper | 1,304 | 22 | 0 | 1,326 | 2,984 | -1,658 | 0.44 |
| Shuswap River | 339 | 57 | 210 | 606 | 3,857 | -3,251 | 0.16 |
| Little Qualicum River | 8,731 | 1,414 | 4,505 | 14,650 | 3,010 | 11,639 | 4.87 |
| Chilliwack River | 6,927 | 6,287 | 15,567 | 28,781 | 8,854 | 19,926 | 3.25 |
| Nitinat River | 47,232 | 9,642 | 1,104 | 57,978 | 10,209 | 47,769 | 5.68 |
| Conuma River | 3,386 | 3,063 | 912 | 7,361 | 9,247 | -1,886 | 0.80 |
| Snootli/Atnarko | 10,036 | 484 | 1,241 | 11,761 | 10,034 | 1,727 | 1.17 |
| Kitimat River | 6,618 | 404 | 4,476 | 11,498 | 11,428 | 70 | 1.01 |
| Pallant Creek | 2,903 | 84 | 223 | 3,210 | 9,479 | -6,269 | 0.34 |
| Inch Creek | 2,349 | 979 | 2,157 | 5,485 | 7,149 | -1,664 | 0.77 |
| Chemainus River | 786 | 114 | 1,513 | 2,413 | 1,819 | 594 | 1.33 |
| Tenderfoot Creek | 1,745 | 134 | 3,294 | 5,173 | 6,035 | -862 | 0.86 |
| Chehalis River | 5,889 | 3,534 | 9,528 | 18,951 | 7,919 | 11,032 | 2.39 |
| Quesnel River | 108 | 25 | 90 | 223 | 2,169 | -1,946 | 0.10 |
| Eagle River | 297 | 72 | 348 | 717 | 5,471 | -4,754 | 0.13 |
| Spius Creek | 398 | 94 | 449 | 941 | 6,722 | -5,781 | 0.14 |
| Whitehorse | 0 | 0 | 0 | 0 | 276 | -276 | 0.00 |
| Babine Fence | 0 | 0 | 0 | 0 | 2,948 | -2,948 | 0.00 |
| Mitchell River | 0 | 0 | 0 | 0 | 483 | -483 | 0.00 |
| Snettisham Can/Us | 0 | 0 | 0 | 0 | 2,292 | -2,292 | 0.00 |
| Hatchery Total | 139,793 | 38,431 | 67,896 | 246,120 | 165,412 | 80,708 | 1.49 |
| **2. Channels** | | | | | | | |
| Fulton River | 39,078 | 5,938 | 0 | 45,016 | 4,215 | 40,801 | 10.68 |
| Pinkut Creek | 25,554 | 3,883 | 0 | 29,437 | 4,218 | 25,219 | 6.98 |
| Jones Creek | 71 | 3 | 0 | 74 | 129 | -55 | 0.57 |
| Weaver Creek | 24,458 | 2,834 | 0 | 27,292 | 2,617 | 24,674 | 10.43 |
| Seton River Lower | 5,939 | 72 | 0 | 6,011 | 2,275 | 3,736 | 2.64 |
| Gates River | 6,487 | 589 | 0 | 7,076 | 3,161 | 3,915 | 2.24 |
| Nadina River | 9,454 | 859 | 0 | 10,313 | 1,609 | 8,704 | 6.41 |
| Horsefly Creek | 11,097 | 1,008 | 0 | 12,105 | 1,007 | 11,098 | 12.02 |
| Chilko River | 0 | 0 | 0 | 0 | 0 | 0 | |
| Kakweiken River | 3,987 | 0 | 0 | 3,987 | 0 | 3,987 | |
| Glendale Channel | 2,990 | 0 | 0 | 2,990 | 0 | 2,990 | |
| Orford River | 363 | 23 | 0 | 386 | 412 | -26 | 0.94 |
| Washwash River | 0 | 0 | 0 | 0 | 0 | 0 | |
| Nekite River | 0 | 0 | 0 | 0 | 0 | 0 | |
| Phillips Channel | 0 | 0 | 0 | 0 | 0 | 0 | |
| Channels Total | 129,478 | 15,209 | 0 | 144,687 | 19,644 | 125,043 | 7.37 |

Table 3A (cont'd)

| | Benefits | | | | Total | Net | B/C |
|---|---|---|---|---|---|---|---|
| | Commercial | Native | Sport | Total | Costs | Benefits | ratio |
| | (thousands of 1993 dollars) | | | | | | |
| **3. Spawning Bed Restoration** | | | | | | | |
| Englishman River | 297 | 31 | 268 | 596 | 239 | 357 | 2.50 |
| Billy Harris Slough | 302 | 20 | 75 | 397 | 159 | 238 | 2.50 |
| Ed Leon Slough | 288 | 18 | 58 | 364 | 146 | 218 | 2.50 |
| Paradise Chan (Upper) | 53 | 4 | 22 | 79 | 32 | 47 | 2.50 |
| Rotary Park | 315 | 25 | 20 | 360 | 144 | 216 | 2.50 |
| Hopedale Slough | 36 | 3 | 17 | 56 | 22 | 34 | 2.50 |
| Peach Creek | 322 | 21 | 65 | 408 | 164 | 244 | 2.50 |
| Ryder Creek | 21 | 1 | 0 | 22 | 9 | 13 | 2.50 |
| Barrett Creek | 49 | 3 | 10 | 62 | 25 | 37 | 2.50 |
| Worth Creek | 2 | 0 | 0 | 2 | 1 | 1 | 2.50 |
| Chilqua Creek | 93 | 5 | 10 | 108 | 43 | 65 | 2.50 |
| Judd Slough | 106 | 9 | 46 | 161 | 65 | 96 | 2.50 |
| Mamquam River | 110 | 9 | 26 | 145 | 58 | 87 | 2.50 |
| Paradise Chan Lower | 42 | 3 | 17 | 62 | 25 | 37 | 2.50 |
| Westholme Channel | 393 | 31 | 25 | 449 | 180 | 269 | 2.50 |
| Kitsumkalum Lake | 156 | 24 | 0 | 180 | 72 | 108 | 2.50 |
| Railroad Creek | 38 | 2 | 8 | 48 | 19 | 29 | 2.50 |
| Baynes Sound Str. | 246 | 20 | 260 | 526 | 1,040 | -514 | 0.51 |
| Moodie's Channel | 67 | 6 | 58 | 131 | 53 | 78 | 2.50 |
| B.C.Rail. Channel | 46 | 4 | 20 | 70 | 28 | 42 | 2.50 |
| Deadman Channel | 48 | 6 | 180 | 234 | 94 | 140 | 2.50 |
| Andeside Channel | 5 | 0 | 1 | 6 | 2 | 4 | 2.50 |
| Hicks Creek Pond | 10 | 1 | 9 | 20 | 8 | 12 | 2.50 |
| Kitwancool Channel | 8 | 0 | 1 | 9 | 4 | 5 | 2.50 |
| Oyster Channel | 907 | 0 | 0 | 907 | 364 | 543 | 2.50 |
| McNab Channel | 50 | 4 | 12 | 66 | 26 | 40 | 2.50 |
| Drainy Channel | 115 | 13 | 59 | 187 | 75 | 112 | 2.50 |
| Adams Channel | 117 | 34 | 165 | 316 | 127 | 189 | 2.50 |
| York Rd Channel | 906 | 0 | 0 | 906 | 363 | 543 | 2.50 |
| Stave R Channel | 227 | 11 | 8 | 246 | 99 | 147 | 2.50 |
| Kawkawa Channel | 66 | 2 | 6 | 74 | 30 | 44 | 2.50 |
| Englishman Channel | 66 | 5 | 16 | 87 | 35 | 52 | 2.50 |
| Brennan Park Channel | 54 | 4 | 13 | 71 | 28 | 43 | 2.50 |
| Tiampo Channel | 41 | 3 | 17 | 61 | 24 | 37 | 2.50 |
| Brandt Creek Channel | 73 | 6 | 17 | 96 | 38 | 58 | 2.50 |
| Brandt Creek Diversion | 38 | 3 | 9 | 50 | 20 | 30 | 2.50 |
| Hixon Channel | 7 | 1 | 7 | 15 | 6 | 9 | 2.50 |
| Tower Channel | 38 | 3 | 9 | 50 | 20 | 30 | 2.50 |
| Alouette Channel | 5 | 2 | 16 | 23 | 9 | 14 | 2.50 |
| Ianson Channel | 36 | 13 | 129 | 178 | 71 | 107 | 2.50 |
| Coho Creek Channel | 10 | 0 | 2 | 12 | 5 | 7 | 2.50 |
| Taylors Channel | 23 | 1 | 5 | 29 | 12 | 17 | 2.50 |
| Highfalls Channel | 11 | 1 | 3 | 15 | 6 | 9 | 2.50 |
| Coal Creek Channel | 11 | 1 | 21 | 33 | 13 | 20 | 2.50 |
| Ushers Channel | 173 | 11 | 35 | 219 | 88 | 131 | 2.50 |
| Van. Bay Channel | 29 | 2 | 45 | 76 | 30 | 46 | 2.50 |

Table 3A (cont'd)

| | Benefits | | | | Total | Net | B/C |
|---|---|---|---|---|---|---|---|
| | Commercial | Native | Sport | Total | Costs | Benefits | ratio |
| | (thousands of 1993 dollars) | | | | | | |
| Smokehouse Channel | 132 | 7 | 14 | 153 | 61 | 92 | 2.50 |
| Cottonwood Channel | 5 | 1 | 12 | 18 | 7 | 11 | 2.50 |
| Seabird Channel | 13 | 2 | 20 | 35 | 14 | 21 | 2.50 |
| Ruskin Channel | 124 | 8 | 25 | 157 | 63 | 94 | 2.50 |
| Hopedale Channel | 190 | 12 | 39 | 241 | 97 | 144 | 2.50 |
| Prettys Channel | 9 | 1 | 4 | 14 | 6 | 8 | 2.50 |
| Mashiter Channel | 52 | 4 | 22 | 78 | 31 | 47 | 2.50 |
| Jack Slough | 84 | 7 | 20 | 111 | 44 | 67 | 2.50 |
| Weldwood Channel | 40 | 3 | 10 | 53 | 21 | 32 | 2.50 |
| Fishweir Channel | 52 | 1 | 0 | 53 | 21 | 32 | 2.50 |
| Bonsall Slough | 388 | 31 | 25 | 444 | 178 | 266 | 2.50 |
| Coquitlam R Ponds | 0 | 0 | 0 | 0 | 647 | -647 | 0.00 |
| Resource Restoration Total | 7,145 | 443 | 1,981 | 9,569 | 5,311 | 4,258 | 1.80 |
| **4. Lake Enrichment** | | | | | | | |
| Great Central Lake | 12,495 | 880 | 1,455 | 14,830 | 7,961 | 6,869 | 1.86 |
| Chilko Lake | 6,360 | 798 | 0 | 7,158 | 3,842 | 3,316 | 1.86 |
| Henderson Lake | 2,673 | 328 | 46 | 3,047 | 1,636 | 1,411 | 1.86 |
| Hobiton Lake | 668 | 82 | 12 | 762 | 409 | 353 | 1.86 |
| Long Lake | 2,893 | 325 | 0 | 3,218 | 1,727 | 1,491 | 1.86 |
| Lake Enrichment Total | 25,089 | 2,413 | 1,513 | 29,015 | 15,575 | 13,440 | 1.86 |
| **5. Community Development Projects** | | | | | | | |
| Vancouver Bay | 302 | 14 | 129 | 445 | 213 | 232 | 2.09 |
| Kitsumkalum River | 323 | 15 | 13 | 351 | 568 | -217 | 0.62 |
| San Juan River | 1,322 | 137 | 388 | 1,847 | 2,003 | -156 | 0.92 |
| Seymour River | 263 | 20 | 477 | 760 | 2,179 | -1,419 | 0.35 |
| Cowichan River | 3,600 | 502 | 6,391 | 10,493 | 4,542 | 5,951 | 2.31 |
| Kispiox River | 194 | 15 | 66 | 275 | 2,008 | -1,733 | 0.14 |
| Kincolith | 253 | 46 | 22 | 321 | 1,723 | -1,402 | 0.19 |
| Masset | 141 | 0 | 128 | 269 | 1,712 | -1,443 | 0.16 |
| Nimpkish | 1,280 | 55 | 420 | 1,755 | 3,565 | -1,810 | 0.49 |
| Bella Bella | 1,011 | 52 | 38 | 1,101 | 1,712 | -611 | 0.64 |
| Sliammon River | 351 | 25 | 432 | 808 | 1,439 | -631 | 0.56 |
| Sechelt | 514 | 38 | 893 | 1,445 | 1,805 | -360 | 0.80 |
| Nanaimo River | 1,083 | 134 | 1,547 | 2,764 | 3,660 | -896 | 0.76 |
| Thornton Creek | 878 | 84 | 235 | 1,197 | 2,107 | -910 | 0.57 |
| Port Hardy | 554 | 10 | 221 | 785 | 2,802 | -2,017 | 0.28 |
| Alouette River | 394 | 39 | 333 | 766 | 708 | 58 | 1.08 |
| Thompson River | 82 | 24 | 115 | 221 | 1,360 | -1,139 | 0.16 |
| Deadman River | 54 | 14 | 66 | 134 | 643 | -509 | 0.21 |
| Penny | 33 | 8 | 28 | 69 | 617 | -548 | 0.11 |
| Hartley Bay Creek | 287 | 24 | 77 | 388 | 1,254 | -866 | 0.31 |
| Skidegate | 172 | 5 | 26 | 203 | 1,163 | -960 | 0.17 |
| Terrace | 62 | 10 | 54 | 126 | 142 | -16 | 0.89 |
| Klemtu | 398 | 24 | 38 | 460 | 1,491 | -1,031 | 0.31 |

Table 3A (cont'd)

| | Benefits | | | | Total | Net | B/C |
|---|---|---|---|---|---|---|---|
| | Commercial | Native | Sport | Total | Costs | Benefits | ratio |
| | (thousands of 1993 dollars) | | | | | | |
| Fort St. James | 25 | 6 | 20 | 51 | 834 | -783 | 0.06 |
| Oweekeno | 218 | 10 | 0 | 228 | 2,044 | -1,816 | 0.11 |
| Powell River | 452 | 32 | 716 | 1,200 | 2,490 | -1,290 | 0.48 |
| Fort Babine | 237 | 17 | 70 | 324 | 1,254 | -930 | 0.26 |
| Toboggan Creek | 148 | 12 | 52 | 212 | 2,145 | -1,933 | 0.10 |
| Clayoquot | 507 | 59 | 161 | 727 | 1,352 | -625 | 0.54 |
| Lang Channel | 51 | 3 | 0 | 54 | 0 | 54 | |
| Community Development Total | 15,189 | 1,434 | 13,156 | 29,779 | 49,537 | -19,758 | 0.60 |
| **6. Public Involvement Projects** | | | | | | | |
| Mossom Creek | 27 | 2 | 24 | 53 | 57 | -4 | 0.93 |
| Alberni Enh Soc | 20 | 1 | 4 | 25 | 27 | -2 | 0.93 |
| Gold River | 1,081 | 149 | 700 | 1,930 | 2,084 | -154 | 0.93 |
| Sewell Inlet | 41 | 0 | 55 | 96 | 104 | -8 | 0.93 |
| Little Campbell River | 96 | 9 | 234 | 339 | 366 | -27 | 0.93 |
| Noons Creek | 16 | 2 | 45 | 63 | 68 | -5 | 0.93 |
| Courtenay | 56 | 4 | 52 | 112 | 121 | -9 | 0.93 |
| Oyster River | 862 | 117 | 1,517 | 2,496 | 2,695 | -199 | 0.93 |
| Kanaka Creek | 116 | 31 | 303 | 450 | 486 | -36 | 0.93 |
| Anderson Creek | 51 | 5 | 103 | 159 | 172 | -13 | 0.93 |
| Kingfisher Creek | 19 | 4 | 17 | 40 | 43 | -3 | 0.93 |
| Kloiya Creek | 10 | 3 | 7 | 20 | 22 | -2 | 0.93 |
| Goldstream River | 147 | 19 | 283 | 449 | 485 | -36 | 0.93 |
| Eby Street | 74 | 4 | 11 | 89 | 96 | -7 | 0.93 |
| Brunette River | 46 | 5 | 184 | 235 | 254 | -19 | 0.93 |
| Marble River | 677 | 98 | 452 | 1,227 | 1,325 | -98 | 0.93 |
| Scott Cove Creek | 30 | 1 | 52 | 83 | 90 | -7 | 0.93 |
| Sooke River | 444 | 48 | 135 | 627 | 677 | -50 | 0.93 |
| Sachs Creek | 28 | 0 | 49 | 77 | 83 | -6 | 0.93 |
| Tahsis River | 232 | 34 | 157 | 423 | 457 | -34 | 0.93 |
| Holberg | 62 | 6 | 22 | 90 | 97 | -7 | 0.93 |
| Horseshoe Bay | 121 | 11 | 288 | 420 | 453 | -33 | 0.93 |
| Silvermere Lake | 43 | 11 | 101 | 155 | 167 | -12 | 0.93 |
| Bella Coola | 37 | 2 | 0 | 39 | 42 | -3 | 0.93 |
| Oldfield Creek | 76 | 14 | 21 | 111 | 120 | -9 | 0.93 |
| Malaspina Coll. | 24 | 2 | 48 | 74 | 80 | -6 | 0.93 |
| Chapman Creek | 214 | 13 | 332 | 559 | 604 | -45 | 0.93 |
| Rivers In-Hakai Pass | 179 | 8 | 0 | 187 | 202 | -15 | 0.93 |
| Quadra I. Enh. Soc. | 173 | 4 | 31 | 208 | 225 | -17 | 0.93 |
| Spruce C. Wldlf A. | 12 | 3 | 10 | 25 | 27 | -2 | 0.93 |
| Serpentine Enh Soc | 83 | 8 | 148 | 239 | 258 | -19 | 0.93 |
| Thornton Vol | 33 | 1 | 7 | 41 | 44 | -3 | 0.93 |
| Little River/Gsvi | 36 | 3 | 74 | 113 | 122 | -9 | 0.93 |
| 100 Small PIP Projects | 2,272 | 184 | 2,729 | 5,185 | 5,598 | -413 | 0.93 |
| Public Involvement Total | 7,438 | 806 | 8,195 | 16,439 | 17,748 | -1,309 | 0.93 |
| **All Enhancement Projects** | **324,132** | **58,735** | **92,741** | **475,608** | **273,227** | **202,381** | **1.74** |