An Ex-Post Benefit-Cost Analysis of the Meziadin Fishway

Kristopher Lam

Program Development Branch
Salmonid Enhancement Program
Department of Fisheries and Oceans
Vancouver, B.C. V6E 2P1

February 1982

Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 1643

Government of Canada
Fisheries and Oceans

Gouvernement du Canada
Pêches et Océans

Canadian Manuscript Report of Fisheries and Aquatic Sciences

These reports contain scientific and technical information that represents an important contribution to existing knowledge but which for some reason may not be appropriate for primary scientific (i.e. *Journal*) publication. They differ from Technical Reports in terms of subject scope and potential audience: Manuscript Reports deal primarily with national or regional problems and distribution is generally restricted to institutions or individuals located in particular regions of Canada. No restriction is placed on subject matter and the series reflects the broad interests and policies of the Department of Fisheries and Oceans, namely, fisheries management, technology and development, ocean sciences, and aquatic environments relevant to Canada.

Manuscript Reports may be cited as full publications. The correct citation appears above the abstract of each report. Each report will be abstracted by *Aquatic Sciences and Fisheries Abstracts* and will be indexed annually in the Department's index to scientific and technical publications.

Numbers 1-900 in this series were issued as Manuscript Reports (Biological Series) of the Biological Board of Canada, and subsequent to 1937 when the name of the Board was changed by Act of Parliament, as Manuscript Reports (Biological Series) of the Fisheries Research Board of Canada. Numbers 901-1425 were issued as Manuscript Reports of the Fisheries Research Board of Canada. Numbers 1426-1550 were issued as Department of Fisheries and the Environment, Fisheries and Marine Service Manuscript Reports. The current series name was changed with report number 1551.

Details on the availability of Manuscript Reports in hard copy may be obtained from the issuing establishment indicated on the front cover.

Rapport manuscrit canadien des sciences halieutiques et aquatiques

Ces rapports contiennent des renseignements scientifiques et techniques qui constituent une contribution importante aux connaissances actuelles mais qui, pour une raison ou pour une autre, ne semblent pas appropriés pour la publication dans un journal scientifique. Ils se distinguent des Rapports techniques par la portée du sujet et le lecteur visé; en effet, ils s'attachent principalement à des problèmes d'ordre national ou régional et la distribution en est généralement limitée aux organismes et aux personnes de régions particulières du Canada. Il n'y a aucune restriction quant au sujet; de fait, la série reflète la vaste gamme des intérêts et des politiques du Ministère des Pêches et des Océans, notamment gestion des pêches; techniques et développement, sciences océaniques et environnements aquatiques, au Canada.

Les Manuscrits peuvent être considérés comme des publications complètes. Le titre exact paraît au haut du résumé de chaque rapport, qui sera publié dans la revue *Aquatic Sciences and Fisheries Abstracts* et qui figuera dans l'index annuel des publications scientifiques et techniques du Ministère.

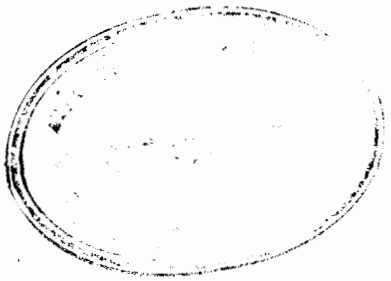
Les numéros de 1 à 900 de cette série ont été publiés à titre de manuscrits (Série biologique) de l'Office de biologie du Canada, et après le changement de la désignation de cet organisme par décret du Parlement, en 1937, ont été classés en tant que manuscrits (Série biologique) de l'Office des recherches sur les pêcheries du Canada. Les numéros allant de 901 à 1425 ont été publiés à titre de manuscrits de l'Office des recherches sur les pêcheries du Canada. Les numéros 1426 à 1550 ont été publiés à titre de Rapport manuscrits du Service des pêches et de la mer, Ministère des Pêches et de l'Environnement. Le nom de la série a été changé à partir du rapport numéro 1551.

La page couverture porte le nom de l'établissement auteur où l'on peut se procurer les rapports sous couverture cartonnée.

Canadian Manuscript Report of

Fisheries and Aquatic Sciences 1643

February 1982



AN EX-POST BENEFIT-COST ANALYSIS OF THE MEZIADIN FISHWAY

by

Kristopher Lam

Program Development Branch

Salmonid Enhancement Program

Department of Fisheries and Oceans

Vancouver, B.C. V6E 2P1

Cat. No. FS 97-4/1643 ISSN 0706-6473

Correct citation for this publication:

Lam, Kristopher, 1982. An Ex-Post Benefit-Cost Analysis of the Meziadin Fishway. Can. MS Rep. Fish. Aquat. Sci. 1643: iv + 40 p.

TABLE OF CONTENTS

Section	Title	Page
	Table of Contents	ii
	Abstract/Résumé	iv
I	The Five Account Methodology	1
II	Introduction	2
III	Meziadin Sockeye Production	6
IV	The National Income Account	9
	Benefits and Costs to the Commercial Fishery	9
	Construction and Operating Costs of the Facility .	11
	Summary of National Income Benefits & Costs	12
V	The Regional Development Account	16
VI	The Native People Account	20
	1. Impacts Near the Project Site	20
	2. Benefits to the Native Indian Commercial Fleet ...	20
	3. Increased Employment Opportunities in the Processing Sector	21

TABLE OF CONTENTS (Continued)

Section	Title	Page
	4. Improvements in the Food Fishery	21
VII	The Employment Account	22
VIII	The Resource and Environmental Preservation Account ...	24
	1. Change in Stock Characteristics	25
	2. Intra and Interspecies Interactions	26
	3. Stock Manageability	26
	4. Cultural and Educational Potential	27
	5. Aesthetic Values and Naturalness	28
	6. Terrestrial and Aquatic Ecology	29
	7. Recreational Opportunities	30
IX	Summary and Conclusions	32
	Appendix 1	37

ABSTRACT

Lam, Kristopher, 1982. An Ex-Post Benefit-Cost Analysis of the Meziadin Fishway. Can. MS Rep. Fish. Aquat. Sci. 1643: iv + 40 p.

Salmonid Enhancement Program facilities are currently being evaluated using a multiple objective planning framework referred to as the Five Account Methodology. The five accounts to be assessed include National Income, Regional Development, Native People, Employment, and Resource and Environmental Preservation. The Meziadin fishway, although constructed prior to the start of S.E.P., is evaluated using the same methodology. However, rather than relying totally on projected cost and production information, historical data is available for a number of years. By carrying out ex-post benefit-cost analyses on pre-S.E.P. facilities, their overall performance can be assessed and the information used to increase the net benefits of S.E.P. facilities.

RESUME

Lam, Kristopher, 1982. An Ex-Post Benefit-Cost Analysis of the Meziadin Fishway. Can. MS Rep. Fish. Aquat. Sci. 1643: iv + 40 p.

On évalue les installations mises en place dans le cadre du Programme de mise en valeur des salmonidés en utilisant un schéma de planification à objectifs multiples qu'on appelle la méthode des cinq postes. Le revenu national, le développement régional, les autochtones, l'emploi et la préservation des ressources et du milieu sont les cinq postes à évaluer. Bien qu'elle ait été construite avant le début du P.M.V.S., la passe à poissons Méziadin est évaluée selon la même méthode. Cependant, plutôt que de se fier entièrement aux informations concernant les coûts et la production prévus, on dispose de données remontant à un certain nombre d'années. En effectuant les analyses de rentabilité à postériori des installations antérieures au P.M.V.S., on peut en évaluer l'efficacité et utiliser les renseignements pour accroître les bénéfices nets engendrés par les nouvelles installations.

I. THE FIVE ACCOUNT METHODOLOGY

The Meziadin Fishway will be evaluated in terms of the Five Account Methodology currently being used to assess potential S.E.P. projects and programs. By applying this framework, developed by the Economics Working Group a thorough evaluation of the quantitative and qualitative impacts resulting from an enhancement project is possible. Impacts will be assessed in the following five accounts.

1. National Income
2. Regional Development
3. Native People
4. Employment
5. Resource and Environmental Preservation

Quantifiable benefits and costs are measured in the National Income Account. The Regional Development Account assesses the geographic distribution of income impacts from the project. The Native People Account measures the socio-economic impacts created by S.E.P. projects on Indian bands. Impacts near the project site, benefits to the Native commercial fleet, increased employment opportunities in the processing sector; and improvements in the food fishery are measured. The Employment Account ranks projects on the basis of primary employment generated and on the probability of hiring labour resources which would otherwise be unemployed. The Resource and Environmental Preservation Account measures the cultural and environmental impacts of an enhancement facility. For a detailed description of the Five Account Methodology refer to "The Salmonid Enhancement Program", Fisheries and Marine Service, an unpublished document containing the economic rational for salmonid enhancement.

II. INTRODUCTION

The Meziadin system is the major contributor in the important Nass River sockeye fishery. Located 125 miles north-east of Prince Rupert, it was estimated that Meziadin sockeye escapements represented 39 and 31 percent of the total Nass River sockeye escapement in 1957 and 1958 respectively.[1] Two falls, however, on the Meziadin River, immediately upstream from the Nass confluence, seriously impeded the sockeye migration. Even with an existing weir-type fishway constructed in 1913 at the upper falls, it was felt that significant losses of returning sockeye were still occurring. As a result, detailed biological and engineering surveys were undertaken to determine the spawning escapement to the Meziadin, and the extent of losses and duration of delays caused by the falls.

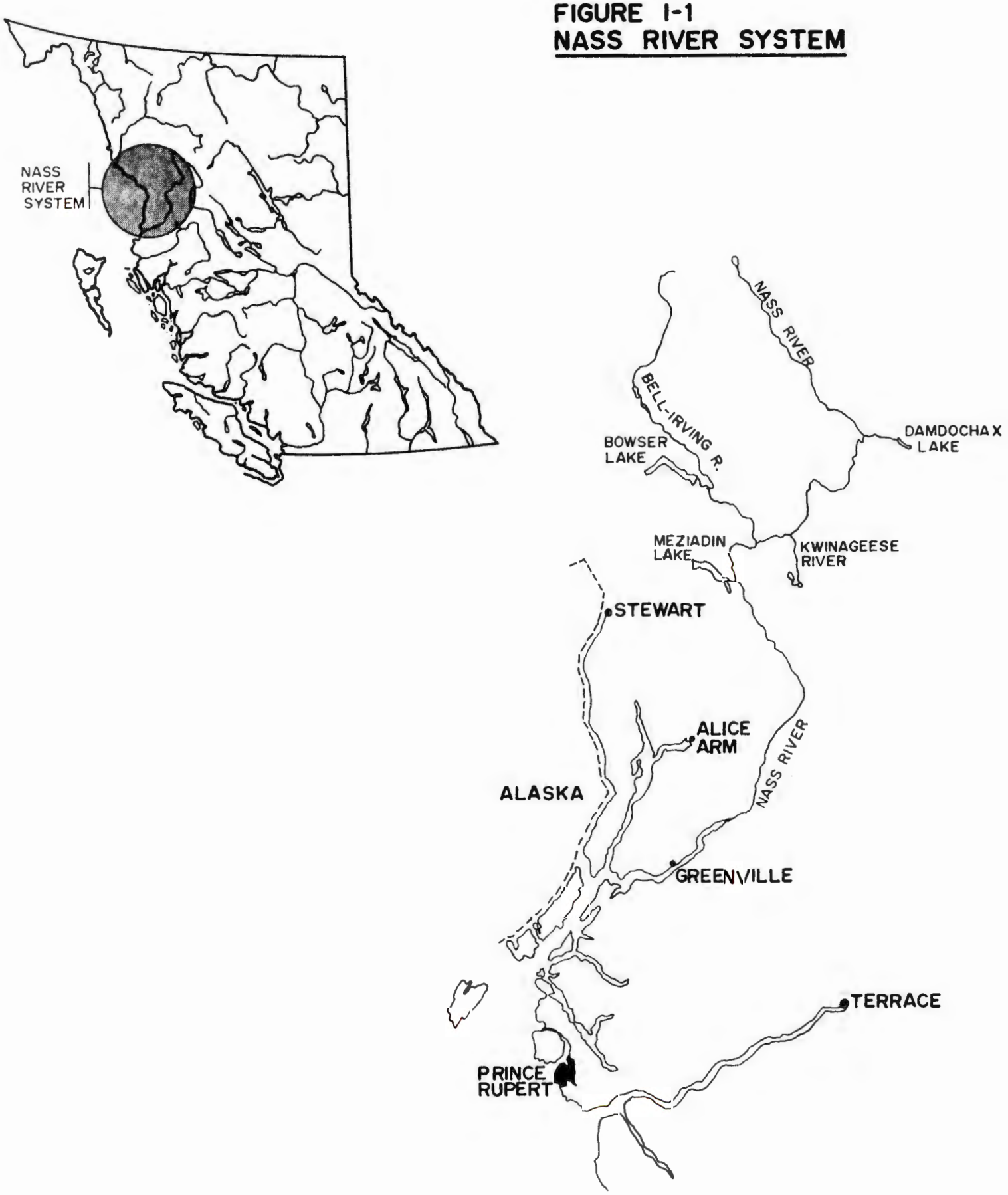
The biological survey consisted of a tagging and recovery operation taking place from 1956 to 1959.[2] Although the results for 1956 were incomplete, with the tagging operation taking place after the peak migration period, there were strong indications that serious losses and delays were occurring due to the falls. In 1957, it was estimated that 38 percent of the sockeye run of 185,500 to the Meziadin did not make it over the falls. In addition, of the fish that did manage to surmount the obstruction, 5 percent died unspawned due to an average delay of seven days. In 1958, only an estimated 4 percent of the 85,500 Meziadin escapement could not pass the falls. The average period of delay was only four days, with no evidence of prespawning mortality caused by the delay. The low mortality was believed to be caused by the relatively high water level in the river that year. In 1959, an estimated loss of 45 percent of the run occurred at the falls.

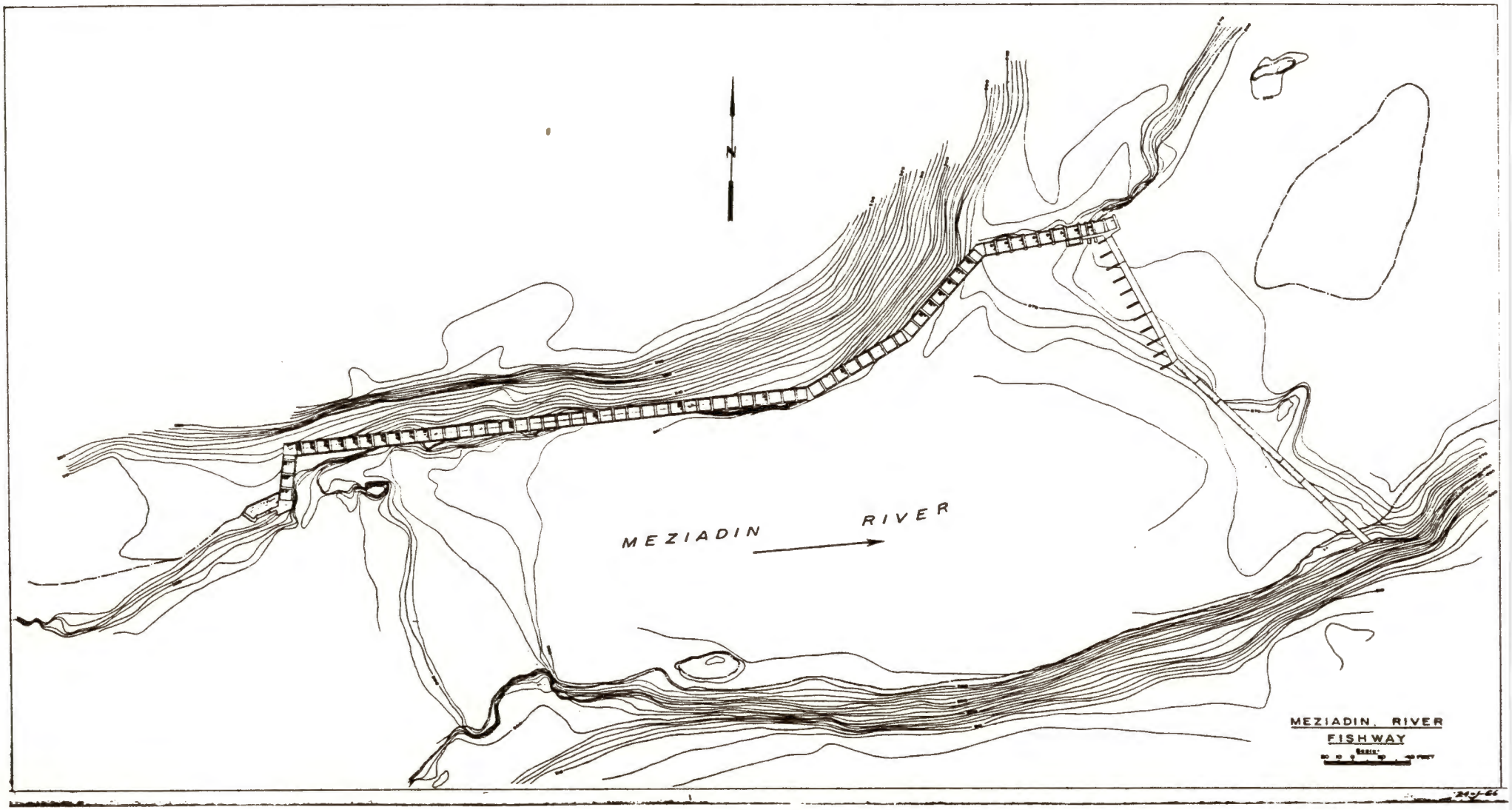
On the basis of the above results, a decision was reached to construct a new fishway at the site of the two falls to allow the salmon to bypass the obstructions. Engineering surveys were conducted from 1958 to 1961, and a design for the fishway was proposed.

In 1965, approximately 10 miles of access road was constructed and construction of the fishway commenced. The fishway was completed in 1966 in time to receive the sockeye run for that year. The facility consists of a vertical slot type fishway approximately 670 feet long. This is comprised of seventeen 8 by 10 foot pools at the lower falls, and 13 pools of the same dimension at the upper falls. The two sections are connected by 5 pools, 75 feet in length (see figure I-2). A barrier dam was also erected at the lower falls to direct fish to the entrance of the fishway at the left bank. Also included is an auxiliary water supply to improve the attraction qualities at the fishway entrance, counting facilities at the fishway exit and a camp and warehouse for the summer staff residing at the site carrying out fish counts. The total cost of the facilities, including the access road, in terms of 1965 dollars, amounted to approximately $850,000.[3]

The affects of the fishway on the returning spawners may be illustrated by the tagging and recovery operations conducted in 1966 during the first year of operation. Fish tagged immediately in front of the fishway entrance were on average recovered two days after tagging above the falls. Fish tagged at the barrier dam on the right bank were recovered above the falls 3.5 days after tagging on average. Compared with the average period of delays of up to 7.7 days previous to construction of the fishway, a significant reduction in delay caused by the falls was evident.

FIGURE 1-1
NASS RIVER SYSTEM




N
MEZIADIN
RIVER
MEZIADIN RIVER
FISHWAY

III. MEZIADIN SOCKEYE PRODUCTION

The estimation of sockeye production attributable to the fishway is based on a three-year (1957-1959) biological survey carried out by R. Palmer. The purpose of the survey was to determine the extent of losses to the run caused by the two falls on the Meziadin River. It was discovered in 1957 that of the total run of 185,5000 sockeye, only 15,000 were able to make it past the falls. In addition, of these 115,000 an estimated 5 percent died unspawned because of the delay caused by the falls. This resulted in a total loss of approximately 76,000 fish or 41 percent of the total run. In 1958, 82,000 sockeye out of a total run of 85,500 were able to surmount the falls with only an insignificant level of pre-spawning mortality caused by the delay at the falls. Only 3,500 sockeye or 4 percent of the run were unable to ascend the falls. The loss to the 1959 run was estimated to be 45 percent as only 17,500 fish out of a total run of 32,000 ascended the falls. There was no estimate of pre-spawning mortality caused by the delay for this year.

The mortality rates can then be used to estimate the production that is directly attributable to the fishway. For example, in 1957 the mortality rate was approximately 41 percent of the run. Had the fishway been in operation at that time, that 41 percent of the run would have survived to spawn and the benefits derived from their progeny could have been attributed to the fishway. The 59 percent of the run that were able to ascend the falls without the use of a fishway would not be included as a benefit of the fishway.

The results of Palmer's survey indicate a great variability in the mortality rates of the run and with only three years of data available it was impossible to determine an average of the number of fish that would be saved by the fishway each year. Also, it was mentioned previously that the mortality rate of the run may be dependent on water levels in the river at the time of migration, but, because of the lack

of historical water level information, a relationship could not be established making it impossible to predict expected water levels and resulting mortalities. The analysis was therefore undertaken using two different mortality rates - 4 percent, the proportion of the run that died unspawned in 1958, and 45 percent, the mortality rate of the run in 1959. These two rates represent the lowest and highest mortality rates of the three years of recorded data and will at least illustrate the range of benefits that could be expected from the fishway.

Table II-1 displays total escapement to the river beginning in 1966, the first year of operation.[4] Also displayed is the escapement attributable to the fishway assuming that 4 percent and 45 percent of the run is being saved by the fishway.

Table III-1 MEZIADIN SOCKEYE ESCAPEMENTS

Year	Total Escapement	4% of Escapement	45% of Escapement
1966	65,000	2,600	29,250
1967	42,000	1,680	18,900
1968	72,000	2,880	32,400
1969	136,000	5,440	61,200
1970	77,000	3,080	34,650
1971	192,000	7,680	86,400
1972	130,000	5,200	58,500
1973	235,000	9,400	105,750
1974	165,000	6,600	74,250
1975	54,000	2,160	24,300
1976	102,000	4,080	45,900
1977	242,000	9,680	108,900
1978	111,000	4,440	49,950
1979	193,000	7,720	86,850
1980	130,000*	5,200	58,500
.	.	.	.
.	.	.	.
.	.	.	.
2005	130,000*	5,200	58,500

* Target Escapement

IV. THE NATIONAL INCOME ACCOUNT

National income benefits from the Meziadin Fishway will accrue to commercial fishermen and processing companies through increased available catches. Based on historical distribution patterns and current management practices it is estimated that 66 percent of the total adult production of Meziadin sockeye will be caught by commercial fishermen. Of the fish that are caught 75 percent will go to the North Coast net fishery while 25 percent will be taken by American fishermen in Alaskan waters. No value is asigned to Canadian fish caught by American fishermen. It should be noted that sport fishermen will not receive any national income benefits as sockeye are not readily caught on sport gear. It should also be noted that national income benefits will not accrue to Native Indians as their food fish requirements in the Nass region were already being met prior to construction of the fishway. Table IV-1 displays actual catches of Meziadin sockeye as well as the possible range of catches attributable to the fishway from 1970 to 1979. From 1980 on, catch figures are projected with a 40 year operating life assumed.[5]

Benefits and Costs to the Commercial Fishery

The gross benefits of the commercial fishery are measured by the wholesale value of the processed fish products. There are two reasons why the wholesale value is used rather than the final retail value. First, much of B.C.'s salmon products are exported in which case the wholesale value would represent the final sale value to Canadians. Second, for products sold within Canada, it would be extremely impractical to aggregate all the final retail prices of these products and to net out their selling costs. Although resulting in a more conservative estimate of National Income benefits, wholesale value information is much more centralized and readily available.

To obtain the wholesale value per fish it was necessary to convert wholesale market prices per pound for processed sockeye products into wholesale values per landed pound. This value was then multiplied by the average weight per sockeye in the North Coast Region to obtain wholesale value per piece. The gross wholesale value per sockeye in 1970, the first year in which fish attributable to the fishway are caught was $9.16 in 1980 dollars.[6] From 1970 to 1980, the real price has increased at an average rate of 4.8 percent per year. Based on a demand study, however, the real price from 1980 on is projected to increase by only 0.35 percent each year. For a detailed illustration of the derivation of gross wholesale values, refer to, "The Estimation of Commercial Fisheries Benefits and Associated Costs for the National Income Account," by Jay C. Barclay and Robert W. Morley.

The gross commercial benefit, discounted to 1965 in 1980 dollars, at a rate of 10 percent, assuming 4 percent of the run is saved by the fishway amounts to $533,000. Assuming 45 percent of the run is saved, the present value of the gross commercial benefits amounts to $5,987,000.

Costs that can be measured in the commercial fish purpose are the associated costs of harvesting and processing. Only the incremental variable costs are considered, as it is assumed that the fishing fleet and the processing plants have sufficient capacity to handle the increase in salmon, and that no additional capital investment will be initiated due to the building of the Meziadin fishway.

The costs of harvesting salmon include the variable costs of fuel, food, boat and gear maintenance, ice and bait, marine insurance, and labour. The costs of processing salmon are composed of acquiring, in-plant processing, and marketing costs. Both harvesting and processing costs vary by species, gear type and catch area. These costs were derived for 1976 using information obtained from an Acres Consulting Report and a UMA/Edwin Reid Study. The catching costs for

Meziadin sockeye amount to $0.79 per piece, while the processing costs total $3.94 per piece in 1980 dollars.[8] These costs in real terms are assumed to have remained constant from 1970 to 1978. From 1978 on, they are expected to increase at a real rate of 0.5 percent per year. The present worth of the associated costs, discounted to 1965 in 1980 dollars at a rate of 10 percent ranges from $252,000 if 4 percent of the run can be attributed to the fishway to $2,841,000 assuming 45 percent of the run is attributable to the fishway.

Construction and Operating Costs of the Facility

Costs assignable to the fishway began in 1956/57 fiscal year with the biological surveys conducted to determine the loss of the run attributable to the falls. Although no complete records of the costs of the study are available, it is estimated that the total cost of the study, in 1980 dollars, was $150,000. This figure is based on the estimated cost of the study had it been carried out in 1980 under the conditions identical to those of the 1950's.

It was not until 1965 that construction of the facility began. The fishway, as well as 10 miles of access road, were completed within a year, in time for the 1966 sockeye run, at an estimated cost of $850,000 in 1965 dollars, or $2,222,000 in 1980 dollars.

Operating maintenance costs began in 1966, and have been fairly constant each year. Approximately $15,000 in 1980 dollars are used to hire two fish counters each year, for a duration of 10 weeks. The costs involved include salaries, food, lodging, and transportation. Approximately $1,000 in 1980 dollars are spent each year on maintenance costs. In 1980, $7,500 was spent under the Small Projects Program on repair and upkeep. The cost activities include the repairing of a fence and the removal of gravel from the fishway.

In order to make meaningful comparisons of costs in one year to those of another, they must be converted from current dollars into constant dollars to adjust for inflation. An average of the Consumer Price Index and the G.N.E. Implicit Price Index was used to make the conversions. Discounting over time, both the benefits and the costs by the social discount rate eliminates the effects of society's rate of time preference.[9]

The costs, present worthed to 1965, in 1980 dollars, at a discount rate of 10 percent, is estimated to be $2,434,000.

Summary of the National Income Account

Table IV-2 displays the present value of the benefits and costs for the two scenarios. For sensitivity purposes discount rates of 5 and 15 percent were also used. At the recommended discount rate of 10 percent, the net benefits range from -$2,446,000 assuming 4 percent of run is saved by the fishway to $419,000 in the scenario where 45 percent of the run is attributable to the fishway. This results in overall benefit-cost ratios of 0.18:1 and 1.08:1 respectively. It should be noted again that these figures represent only the low and high range of the benefit-cost ratios and will vary with the escapement of fish that is deemed attributable to the fishway.

Table IV-1. MEZIADIN SOCKEYE COMMERCIAL CATCH ATTRIBUTABLE TO THE FISHWAY

Year	Total Meziadin Catch	4% of Meziadin Catch	45% of Meziadin Catch
1970	51,300	2,100	23,100
1971	96,500	3,900	43,400
1972	104,500	4,200	47,000
1973	411,100	16,400	185,000
1974	277,200	11,100	124,700
1975	23,000	900	10,400
1976	117,500	4,700	52,800
1977	321,900	12,900	144,900
1978	170,100	6,800	76,500
1979	29,000	1,200	13,100
1980*	84,500	3,400	38,000
1981	258,600	10,300	116,400
1982	449,400	18,000	202,200
1983	278,300	71,100	125,200
1984	273,700	10,900	123,200
1985	260,000	10,400	117,000
1986	247,000	9,900	111,200
.	.	.	.
.	.	.	.
.	.	.	.
2009	247,000	9,900	111,200
2010	185,200	7,400	83,300
2111	17,000	700	7,700

* Projected Catch

Table IV-2 SUMMARY OF NATIONAL INCOME BENEFITS AND COSTS

(present worthed to 1965 in 1980 $'000)

(a) Assuming 4% of the total run is attributable to the fishway:-

Item		Discount Rate (%) 5	10	15
1.	Benefits			
	Commercial	1,294	533	268
	Total Benefits	1,294	533	268
2.	Costs			
	Biological Survey	212	293	402
	Capital	2,222	2,222	2,222
	Operating	365	212	154
	Associated Costs	599	252	131
	Total Costs	3,398	2,979	2,909
3.	Net Benefits	-2,104	-2,446	-2,641
4.	Benefit-Cost Ratio	0.38:1	0.18:1	0.09:1

Table IV-2 (continued)

(b) Assuming 45% of the total run is attributable to the fishway:-

Item		Discount Rate (%) 5	10	15
1.	Benefits			
	Commercial	14,562	5,987	2,541
	Total Benefits	14,562	5,987	2,541
2.	Costs			
	Biological Survey	212	293	402
	Capital	2,222	2,222	2,222
	Operating	365	212	154
	Associated Costs	6,738	2,841	1,471
	Total Costs	9,537	5,568	4,249
3.	Net Benefits	5,025	419	-1,708
4.	Benefit-Cost Ratio	1.53:1	1.08:1	0.60:1

V. THE REGIONAL DEVELOPMENT ACCOUNT

The regional development objective is to decentralize future economic growth within the province, and to increase the economic opportunities in the less developed areas.[10] In order to rate projects in this account, the geographic distribution of income impacts associated with a project is estimated. Then, the value of income realized by less developed regions of the province is given greater weight. The less developed areas (LDA) affected by the Meziadin Fishway include the North Coast, Central Coast, Johnstone Strait, and West Coast Vancouver Island. The more developed areas (MDA) include the Georgia Strait and Fraser River sub-regions.

The income impacts can be broken down into income realized by commercial fishermen, wages earned in the processing sector, net corporate income, and operations and maintenance income. Table V-1 shows the distribution of income impacts generated by the Meziadin Fishway for the 4 percent and 45 percent of the fish attributable to the fishway scenarios.

Of the total income impacts generated, 40 percent will accrue to the less developed areas. The other 60 percent in the form of net corporate income and fishing income will be realized by the more developed areas. When compared to other projects located in the South Coast, the 40 percent proportion of income giving to the less developed areas can be regarded as extremely high. Because of the geographical distribution of corporate headquarters and the base locations of fishermen, it is doubtful that any major project could direct more than 40 percent of the income impacts towards the less developed areas.

Of the less developed areas, it should be noted that the principal beneficiary of the project is the Skeena sub-region where most of the processing takes place and where most of the fishermen are based. The Nass sub-region, where the project site is located will receive all of

the operating and maintenance income while all sub-regions will receive fishing income. Operating and maintenance income is identical for both scenarios since it does not vary with the number of fish using the fishway.

Comparing the distributional impacts of the Meziadin fishway with those of other projects, the final Regional Development Account rating is very good. In terms of overall fishing income, operating and maintenance income, and processing wages, the project appears to have fulfilled the regional development goals of redirecting benefits away from the more developed areas. But, the distribution of impacts within the less developed areas cannot be considered optimal because only the Skeena sub-region will realize a substantial gain. The distributional impacts for both scenarios will be identical since the proportion of income impacts going to the less developed areas will not change with the number of fish produced by the fishway. The absolute impacts, however, will be greater for the scenario where 45 percent of the run is attributed to the fishway.

Table V-1. DISTRIBUTION OF INCOME IMPACTS

(present worthed to 1965 in 1980 dollars at a 10 percent discount rate)

(a) Assuming 4 percent of the run is attributable to the fishway:-

Area	Fishing Income	Workers Wages	Net Corporate Income	Operating and Maintenance Income	Total
Queen Charlottes	5,100	10,600	-	-	62,300
Nass	18,400	-	-	70,200	88,600
Skeena	154,100	95,400	4,400	-	672,900
Central Coast	3,100	-	-	-	3,100
Johnstone Strait	4,600	-	-	-	4,600
W.C.V.I.	400	-	-	-	400
Total LDA	185,700	106,000	4,400	70,200	831,900
Georgia Strait	13,000	-	-	-	13,000
Fraser River	161,200	-	299,800	-	461,000
Total MDA	174,200	-	299,800	-	474,000
Total All Areas	359,900	106,000	304,200	70,200	1,305,900

Table V-1. DISTRIBUTION OF INCOME IMPACTS
(Cont'd.) (present worthed to 1965 in 1980 dollars at a 10 percent discount rate)

(b) Assuming 45 percent of the run is attributable to the fishway:-

Area	Fishing Income	Workers Wages	Net Corporate Income	Operating and Maintenance Income	Total
Queen Charlottes	57,500	119,300	-	-	176,800
Nass	207,300	-	-	70,200	277,500
Skeena	1,733,700	1,072,600	49,100	-	2,855,400
Central Coast	34,400	-	-	-	34,400
Johnstone Strait	51,400	-	-	-	51,400
W.C.V.I.	4,500	-	-	-	4,500
Total LDA	2,088,800	1,191,900	49,100	70,200	3,400,000
Georgia Strait	146,200	-	-	-	146,200
Fraser River	1,813,500	-	3,372,300	-	5,185,800
Total MDA	1,959,700	-	3,372,300	-	5,332,000
Total All Areas	4,048,500	1,191,900	3,421,400	70,200	8,732,000

VI. THE NATIVE PEOPLE ACCOUNT

The Native People Account assesses an enhancement facility's social and economic impacts on Native Indians. Four key indicators have been identified that will allow a thorough analysis of these impacts. They are rated on a scale of low, fair or good and include:

1. Impacts near the project site.
2. Benefits to the Native Indian commercial fleet.
3. Increased employment opportunities in the processing sector.
4. Improvements in the food fishery.

1. Impacts Near the Project Site

Because there are no Indian bands located near the project site, there has been no opportunity for Native People employment or involvement. The impacts near the project site and, consequently, the indicator rating is low.

2. Benefits to the Native Indian Commercial Fleet

Benefits to the Native Indian commercial fleet are the most significant impacts received by Native People from the Meziadin Fishway. According to historical distribution patterns for Nass region sockeye, 30 perent of the incremental sockeye catch, will be caught by the Native Indian commercial fleet. Of the total catch allocated to the Indian fleet, approximately 50% is caught by Nass region bands, while bands in the Skeena region catch approximately 20%. The remainder are distributed throughout the rest of the province. Because it has been estimated that the total Native fleet catch accounts for an annual average of 16 percent of the total B.C. commercial fleet catch,[11] the fact that the Native Indian fleet accounts for over 30 percent of the Meziadin sockeye commercial catch will give this indicator a high rating.

3. Increased Employment Opportunities in the Processing Sector

It is presently assumed that all commercial caught salmon in the North Coast will be processed in that region. Approximately 60 percent of the workers in the processing sector in the North Coast are Native People.[12] Total person-days of employment generated could range from 1,100 to 12,300[13] of which approximately 700 to 7,400 would be Native person-days. Because the total Meziadin sockeye commercial catch is caught and processed in the North Coast where a high proportion of the processing sector is comprised of Native People, this indicator is given a high rating.

4. Improvements in the Food Fishery

Previous to the construction of the fishway, the food fish requirements of the bands in the Nass region were already being met. Therefore, no improvement in the food fishery has resulted from the construction of the fishway, and a low rating is given.

Summary

Although two of the indicators have received high ratings, the low ratings in the other two indicators prevent an overall high rating being assigned. Therefore, a fair rating is given. Like Regional Development, the distribution of benefits to the Native commercial fleet and increased opportunities in the processing sector will be the same for both scenarios. Only the absolute impacts will vary.

VII. THE EMPLOYMENT ACCOUNT

The Employment objective is based on the concern that all Canadians who are able and willing to work should have sufficient opportunities to do so.[14] In the National Income Account, full employment of resources was assumed. In reality, this assumption does not hold. In the construction of a Fisheries project, if a portion of the labour is hired from an unemployed pool, then that should be considered as a benefit, and an attempt should be made to evaluate it. One of the objectives of S.E.P. is to make the most use of unemployed labour.

In the benefit-cost analyses of planned enhancement projects, a methodology has been developed consisting of two indicators.[15] The indicators are:

1. The Absolute Employment Impact

   The total amount of employment for persons who would otherwise be unemployed by direct expenditures on development and operation of the facility.

2. The Relative Employment Efficiency

   Used mainly to rank a series of projects and project options, it is the total employment generated divided by the project costs.

According to Strong, Hall and Associates, based on a survey of the various construction components, the estimated proportion of workers used to construct S.E.P. projects hired from the unemployed pool was 48%.[17] This figure is currently being used to determine the employment benefits of proposed enhancement projects.

For ex-post analyses, however, this figure is not applicable. The probability of hiring construction workers from the unemployed pool is a function of the unemployment rate. In the case of the Meziadin Fishway, the unemployment rates of the various construction trades at the time of construction are not available. Therefore, out of the 40 man-years of construction employment generated by the facility,[17] it is not possible to determine the proportion that was hired from the unemployed pool. As a result, the employment benefits generated by the fishway remains unevaluated and no attempt is made to shadow-price the labour resource.

VIII. THE RESOURCE AND ENVIRONMENTAL PRESERVATION ACCOUNT

This account attempts to measure the resource and environmental impacts, both good and bad, that are caused by an enhancement facility.

"The purpose of the Resource and Environmental Account is threefold:

a) distinguish those key indicators most likely to be affected by a planned salmonid enhancement project;
b) estimate the significance of this impact on the ecological system; and when relevant;
c) suggest appropriate means of mitigation for adverse impacts and of enhancement for beneficial impacts."[18]

To achieve this purpose, a framework was developed consisting of seven key indicators to be evaluated in terms of five criteria. The key indicators are:

1. Change in stock characteristics.
2. Intra- and interspecies interactions.
3. Stock manageability.
4. Cultural and educational potential.
5. Aesthetic values and naturalness.
6. Terrestrial and aquatic ecology.
7. Recreational opportunities.

The five criteria are:

1. The direction of project impact: beneficial (+) or adverse (-)
2. The magnitude of the impact: highly adverse (-5) to highly beneficial (+5).

3. The importance of the impact: not important (0) to very important (1).
4. The probability of occurrence: no probability (0) to 100% probability (1).
5. Mitigation of impacts: good, fair or limited.

Although applying this framework allows for a thorough investigation of the resource and environmental impacts, a great deal of subjective judgement is necessary to complete the evaluation. The structured framework is necessary, however, in order to maintain consistency across projects and to derive a numerical score required to rank a projects when evaluating program proposals.

1. Change in Stock Characteristics (+1)

The obstructions on the Meziadin River consist of two natural falls immediately upstream from the Nass confluence. In 1913, a fishway was built at the site of the falls and was still in operation until it was replaced in 1966 by the present fishway. Even though the mortality at the obstruction was considerable, there was no evidence to suggest that the stock was in danger of extinction or that the size of the stock was declining. It was determined, however, that the Meziadin system was capable of supporting additional sockeye spawners and the resulting juveniles, and that they could be obtained by allowing more fish to surmount the falls. The Meziadin was, therefore, not producing at its natural capacity and was one of the main factors that resulted in the decision to build the fishway.

There does not appear to be any change in the physiological characteristics or the health of the stocks. There are also no

unique features of the Meziadin stock which warrant special consideration.

2. Intra- and Interspecies Interactions (0)

The enhancement of the Meziadin sockeye stocks will result in more adult salmon seeking spawning space, and more juveniles consuming the available food supply, but because of the apparent ability of the system to handle the increase, competition for spawning areas among the adults and for food among the juveniles has been minimal. As for the occurrence of competition during smolt migration and early ocean rearing, very little is known about this stage. It is, therefore, difficult to determine if competition for food and shelter occurs or what the extent of the competition would be.

Other species that inhabit the system include coho, chinook, rainbow trout, dolly varden and various species of coarse fish. Although the enhancement of Meziadin sockeye has increased the food supply for these predators, there has been no noticeable increase in their population or change in their feeding patterns. Meziadin Lake is characterized by fish large in size but few in number. Interspecies interactions have not resulted in any observable negative effects.

3. Stock Manageability (-2)

It is apparent that the Meziadin Fishway has contributed to the manageability problems in the North Coast Region. Historically, the Meziadin system has naturally provided a more productive habitat than other sockeye spawning areas within the Nass system. Although the installation of the fishway has done nothing to alter the productivity of the stock itself, it has allowed the productive Meziadin habitat to be used on a consistent

basis, putting out of balance the productivity of this system to that of other less productive systems such as Kwinageese, Damdochax and Bowser.

Compounding the problem is the fishing strategy employed allowing the relative contribution of the Meziadin stock to grow increasingly out of proportion in mixed stock areas. Meziadin sockeye, having a higher productivity rate are able to withstand a higher exploitation rate while stocks from less productive areas being caught at the same rate may eventually be depleted. How much of the problem is directly attributable to the fishway will depend on the incremental production attributable to the fishway.

4. Cultural and Educational Potential (+1)

The Meziadin Fishway is located 125 miles north east of Prince Rupert with no settlement or paved highway nearby. The remoteness of the site has resulted in few visitors to the facility. A new paved highway being constructed within a few miles of the facility will improve access and increase the number of visitors, but because of the absence of populated centres nearby, the numbers will still be limited to those people that happen to be passing by the facility.

The nature of the structure itself does not appear to enhance the cultural and educational potential of the project. The structure is visible, but, the public cannot view the salmon as they move up the fishway. At present, there is no information stand at the facility to explain the purpose of the fishway, and the benefits generated by it. It might, therefore, be difficult for the general public to fully appreciate the role the fishway plays in the Meziadin system. In general, the cultural and educational potential appears to be low.

In terms of knowledge gained by Fisheries personnel, the facility has provided more experience and insight into the construction and maintenance of a fishway and the benefits that can be realized by employing this method of enhancement. Scale sampling and tagging programs carried out at Meziadin will increase the knowledge of sockeye habits and life cycles while limnological studies of the Meziadin Lake will add to the knowledge of salmon habitats.

5. Aesthetic Values and Naturalness (-1)

The presence of man-made structure in natural settings will obviously reduce the aesthetic quality of the location to some extent. In the case of the Meziadin Fishway, the effects on the aesthetic value of the river are not great. The fishway was constructed along a very wide strip of the river along the bank leaving the turbidity, speed of movement, and volume of water flow virtually unaffected. In addition, the fishway and the walkway above it has stabilized the river bank, stopping erosion and decreasing the deposition of debris. No adverse impacts of terrestrial values such as unstable landforms or decreases in vegetation have been observed.

A chain link fence restricts public access to the river at the site of the fishway. The potential for improving the visibility of significant scenic features, therefore, is not great.

In terms of naturalness, fishways are one of the most natural enhancement techniques employed, next to stream improvement and lake enrichment programs. They allow the fish to bypass obstructions to allow them to spawn naturally in their own environment, unlike spawning channels and hatcheries. One area in which naturalness may have decreased would be in the process of natural selection. Previously, only the strongest fish were able

to surmount the falls and return to spawn. With introduction of the fishway, the weaker fish are now able to make it over the falls and spawn as well. Up to now, no adverse effects from this situation have been observed.

Although historical records of Meziadin sockeye escapements are incomplete, it is probable that the run size has surpassed historical returns. Except for a weir erected across the river, the river has remained relatively unaltered from its historical state. In terms of naturalness of the aquatic system, the fishway's effect on it is insignificant with no adverse effects observed.

6. Terrestrial and Aquatic Ecology (0)

The construction and operation of the fishway has had little effect on the terrestrial ecology. The type, abundance and diversity of plant and animal species has not been altered due to the fishway, nor have the nesting and feeding habitats of the animals been disrupted. There have also been no improvements in local wildlife habitats, nor has the protection of threatened species resulted due to the fishway. So far, no increase in local access can be attributed to the fishway. The new highway may encourage more tourists to visit the fishway. However, it appears that the local environment will be capable of handling the increase with minimal effects.

The increase in the number of sockeye carcasses has increased the metabolite load in the system resulting in added nutrients to the system. Increases in algae bloom have been observed along with an increase in plankton population. The overall impact of increased metabolite load in water quality has remained relatively minor.

There are presently campsites along the Meziadin River and Lake, but their presence cannot be attributable to the fishway. The construction of the paved highway close to the Meziadin will probably result in an increased number of campers to the area, but their increase as well cannot be attributed to the fishway.

7. Recreational Opportunities (0)

The outdoor recreational experiences take place mainly in the area surrounding the lake and in parts of the river away from the fishway. Although restrictions have been placed in some areas of the lake to protect the natural spawning areas, these restrictions would exist regardless of the fishway. The location of the fishway has prevented any interference with the existing recreational opportunities in the area.

On the other hand, the potential for creating new recreational opportunities are limited as well since the area has not been significantly altered because of the fishway. If any new recreational activities are introduced into the area in the future, the fishway should not prove to be any barrier.

Summary

The following table presents the final scoring of the Resource and Environmental Account for the Meziadin Fishway. The low score would seem to indicate that although the overall impact on the environment has not been positive, the adverse impacts have been kept to a minimum. The fishway is, therefore, given a fair rating in this account.

Table VIII-1 SUMMARY OF THE RESOURCE AND ENVIRONMENTAL PRESERVATION ACCOUNT - MEZIADIN FISHWAY -

	Direction and Magnitude (-5 to +5)	Importance (0 to 1)	Probability of Occurrence	Score	Possibilities for Mitigation
1. Changes in Stock Characteristics	+1	0.9	1.0	0.9	
2. Intra and Inter-species Interaction	0	1.0	0.8	0	
3. Stock Manageability	-2	1.0	1.0	-2.0	fair
4. Cultural and Educational Potential	+1	0.4	1.0	0.4	
5. Aesthetic Values and Naturalness	-1	0.5	1.0	-0.5	poor
6. Terrestrial and Aquatic Ecology	0	0.6	0.9	0	
7. Recreational Opportunities	0	0.5	1.0	0	
TOTAL				-1.2	

IX. SUMMARY AND CONCLUSIONS

The final outcome of the analysis will depend on the number of sockeye that can be attributed to the fishway. The National Income and the Resource and Environmental Preservation Accounts are more sensitive to varying production numbers while distributional accounts such is Regional Development and Native People will not be as affected by the different production scenarios.

In summary, the benefit-cost ratio in the National Income Account could vary between 0.18 and 1.08. The regional development impacts appear to be very good, while impacts to the Native People and Resource and Environmental Preservation Accounts are fair. Because of the lack of historical unemployment data for the construction industry, the Employment Account remains unevaluated.

In order to assess the overall economic and social viability of the project, the five accounts must examined as a whole with the benefits and costs of each account being traded with those of another. This is a task for the decision-makers. However, before this can be completed, there are several considerations that should be pointed out.

Because of the lack of data, it was not possible to determine an average number of fish that would be representative of the long term production from the fishway. Therefore, two scenarios were constructed to illustrate the possible range of benefits that would be expected. However, there were only three years of data available. Had there been data available for more years, it is conceivable that the range of benefits would have been different.

Whether or not the discount rate of 10 percent currently recommended by Treasury Board is applicable to the decision making processes in 1965 should also be examined. Factors that determine the social discount rate may have changed since 1965.

Finally, the political priorities of the government will also affect the decision build an enhancement facility. For example, the priority placed on reducing regional disparity may have been much higher in 1965 than it is now, which would have put this project in a favourable light regardless of the outcome in the National Income Account.

By undertaking this ex-post analysis, the applicability of the S.E.P. Five Account Methodology to pre-S.E.P. facilities was examined. The types of benefits and costs that could be expected from a fishway were also illustrated. The analysis is also designed to serve as a guide to decision makers for the purpose of increasing the success of future enhancement projects. By laying out the components and impacts to each account based on historical information, thus having the benefit of hindsight, hopefully this purpose can be accomplished.

FOOTNOTES

1. Resource Development Branch Annual Report 1962, Department of Fisheries and Forestry, Fisheries Service, Pacific Region.

2. R. Palmer, Meziadin Falls Tagging Program(s) - 1956-1958, Department of Fisheries, Canada.

3. Resource Development Branch Annual Report 1966, Department of Fisheries and Forestry, Fisheries Service, Pacific Region.

4. Escapements from 1966-1979 are from Meziadin River escapement records. Escapements from 1980 on are target escapements set by management biologists.

5. See Appendix 1 for derivation of past and projected catch figures.

6. Calculated from information contained in the Annual Summary of British Columbia Catch Statistics 1979, Department of Fisheries and Oceans, Fisheries Management, April, 1980.

7. Don Devoretz, Econometric Demand Models for Canadian Salmon, 1980.

8. Derived from information obtained from Acres Consulting, Employment and Income Multipliers and Impacts Associated with the Proposed Salmonid Enhancement Program, 1976, and UMA/Edwin, Reid and Associates, Competitiveness and Efficiency of the B.C. Salmon Industry, 1976.

9. The Discount Rate currently recommended in Treasury Board's Benefit-Cost Analysis Guide is 10 percent.

FOOTNOTES (Continued)

10. Frank Blasetti and G. Alex Fraser, Salmonid Enhancement Program Regional Development Account Methodology. (Social Account Working Paper No. 1), 1979.

11. Christine Cummins, Michael Friedlaender, and Douglas Williams, Impact of the Salmonid Enhancement Program on Native People, February, 1978.

12. Ibid.

13. Calculated according to the methodology outlined in, The Employment Impacts of Salmonid Enhancement Proposals and the Social Cost of Labour. (preliminary draft), Marvin Shaffer, February, 1977, p. 11, 12.

14. Robert W. Morley, Employment Account Methodology. (unpublished draft), July, 1980.

15. Ibid.

16. Strong, Hall and Associates, Shadow Pricing Construction Labour for Major Salmonid Enhancement Program Projects: A Methodological Account, Vancouver, 1979.

17. Derived according to the methodology outlined in, The Employment Impacts of Salmonid Enhancement Proposals and the Social Cost of Labour. (preliminary draft), Marvin Shaffer, February, 1977, p. 3.

FOOTNOTES (Continued)

18. Robin Gregory, Development of Key Indicators and Evaluation Methodology for the Resource and Environmental Preservation Account. Department of Fisheries and Oceans, Salmonid Enhancement Program, February, 1979.

APPENDIX 1

CALCULATION OF COMMERCIAL CATCH OF MEZIADIN SOCKEYE

A. Historical Catch

1. The proportion of the total Nass River escapements, made up of Meziadin sockeye was used as an approximation for the proportion of total Nass River sockeye stocks made up of Meziadin sockeye.

Recorded Sockeye Escapements

Year	Nass Total Escapements	Meziadin Escapements	Proportion that is Meziadin Sockeye
1970	117,700	77,100	66%
1971	248,100	191,700	77%
1972	180,300	129,500	72%
1973	285,300	234,600	82%
1974	193,700	165,300	85%
1975	74,600	54,100	73%
1976	143,400	102,400	71%
1977	400,400	242,400	61%
1978	144,600	111,000	77%
1979	225,000	193,300	86%

2. All Nass sockeye are assumed to be caught in Statistical Area 3. Total Area 3 sockeye catch is known. A proportion of Area 3 catch is made up of Skeena sockeye. But because of the difference in the timing of the Skeena run it was possible to separate them.

Area 3 Commercial Sockeye Catch

Year	(1) Area 3 Total	(2) Skeena Sockeye Catch in Area 3	(1)-(2) Nass Sockeye	(3) Proportion Meziadin Sockeye	(1)-(2)x(3) Meziadin Sockeye Catch
1970	124,500	46,100	78,400	66%	51,700
1971	194,400	70,200	124,200	77%	95,600
1972	230,200	84,700	145,500	72%	104,800
1973	560,300	60,200	500,100	82%	410,100
1974	559,500	234,500	325,000	85%	276,300
1975	129,900	98,200	31,700	73%	23,100
1976	220,700	56,200	164,500	71%	116,800
1977	727,400	195,300	532,100	61%	324,600
1978	287,200	65,800	221,400	77%	170,500
1979	217,900	184,200	33,700	86%	29,000

Meziadin Sockeye Catch Assuming 4% and 45% of the Run Saved by the Fishway

Year	4%	45%
1970[1]	2,100	23,300
1971	3,800	43,000
1972	4,200	47,200
1973	16,400	184,500
1974	11,100	124,300
1975	900	10,400
1976	4,700	52,600
1977	13,000	146,100
1978	6,800	76,700
1979	1,200	13,100

[1]1970 is assumed to be the first year in which sockeye attributable to the fishway are caught.

B. Projected Catch

1. To project catch for 1980 and subsequent years Table 1-1 was used with the following assumptions: a 2.9:1 rate of return after the Alaskan interception fisheries was applied and on age at catch distribution of 25 percent four-year olds, 68 percent five-year olds, and 7 percent six-year olds.

To obtain catch for 1980, the following procedure was used. Total adult production after the Alaskan interception fisheries was determined, then distributed according to the age at catch distribution. The six-year olds from 1974, five year olds from 1975 and four-year olds from 1976 were then summed to obtain the total available stock. Assuming 130,000 fish would be allowed to escape to spawn, 84,500 fish would be left for the fishermen. The catch for the subsequent years were calculated in the same manner.

Assuming a 40 year operating life for the fishway, the year 2111 is the last year in which fish attributable to the fishway will be caught.

Table 1-1 MEZIADIN SOCKEYE - CALCULATION OF TOTAL RUN SIZE, CATCHES AND ESCAPEMENT (000's IN PIECES)

Recorded Escapement Year	No.	1980	1981	1982	1983	1984	1985	1986	1987	1988	2007	2008	2009	2010	2111
1974	165.3	33.6													
1975	54.1	106.7	11.0												
1976	102.4	74.2	201.9	20.9											
1977	242.4		175.7	478.0	49.3										
1978	111.1			80.5	218.7	22.5									
1979	193.3				140.1	381.2	39.3								
1980[1]	130.0					94.3	256.4	26.3							
1981	130.0						94.3	256.4	26.3						
1982	130.0							94.3	256.4	26.3					
'	'							'	'	'	'	'	'		
'	'							'	'	'	'	'	'		
'	'							'	'	'	'	'	'		
2003	130.0										94.7	256.4	26.3		
2004	130.0											94.7	256.4	26.3	
2005[2]	130.0												94.7	256.4	26.3
Catch		84.5	258.6	449.4	278.3	273.7	260.0	247.0	247.0	247.0	....	....	247.0	185.2[3]	17.0
Escapement		130.0	130.0	130.0	130.0	130.0	130.0	130.0	130.0	130.0	....	....	130.0		
Total Stock		214.5	388.6	579.4	408.3	403.7	390.0	377.0	377.0	377.0	....	....	377.0		

[1]Target Escapement.

[2]The year 2005 is assumed to be the last year of operation of the fishway for the purpose of an economic evaluation.

[3]Catch for the year 2010 and 2111 derived by applying the 1980 to 2009 average catch rate.