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A Review of the Anadromous Fisheries Potential of the Liscomb River

by
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Information Publication No. MAR/N-76-4

Freshwater and Anadromous Division
Resource Branch
Maritimes Region

116859

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DECEMBER, 1976

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FRESHWATER AND ANADROMOUS DIVISION
RESOURCE BRANCH
FISHERIES AND MARINE SERVICE
DEPARTMENT OF FISHERIES AND ENVIRONMENT

HALIFAX, NOVA SCOTIA

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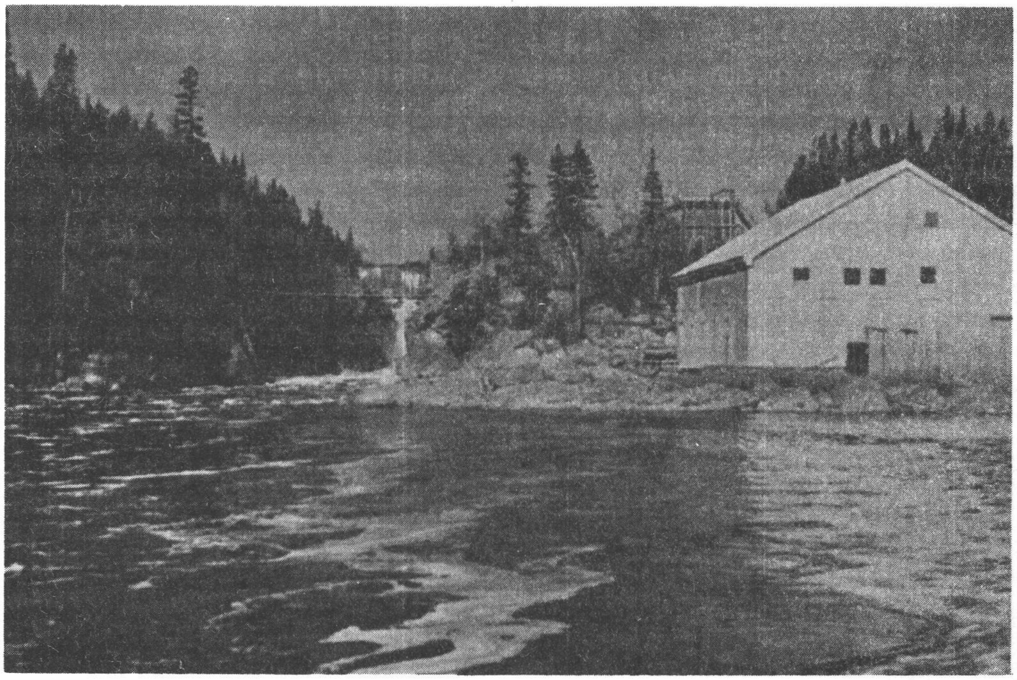
INTRODUCTION

The Liscomb River, located in Guysborough County, Nova Scotia, flows southeast into Liscomb Harbour (Fig. 1). During the 1920's, the river was used primarily for log driving and several dams existed along its length. The river was first used for hydro power by a mining company which located a station at Liscomb Falls. This station was subsequently taken over and expanded by the Nova Scotia Power Corporation (Appendix A).



Liscomb hydro station, located downstream of the gorge below Liscomb Falls.

Originally, the Department of Fisheries did not require that a fishway be constructed because of the presence of a natural falls at this site. However, in 1961, when the Nova Scotia Power Corporation proposed to redevelop the watershed, the Department reassessed its position and requested that a fishway be built, since—depending on water conditions—Liscomb Falls was considered as only a partial barrier to upstream migrations of anadromous fish (MacEachern and MacDonald 1962). Redevelopment, however, did not occur, and the hydro station has been operated in its existing state since that time. The Fisheries and Marine Service's most recent efforts have involved the design of two alternatives for fish passage at Liscomb Falls (Conrad 1974; Hubley 1976), and a review of the fisheries potential of the river, including aerial surveys of salmon spawning and rearing areas and existing obstructions.

The purpose of this report is to condense and summarize the existing data on the anadromous fisheries potential of the

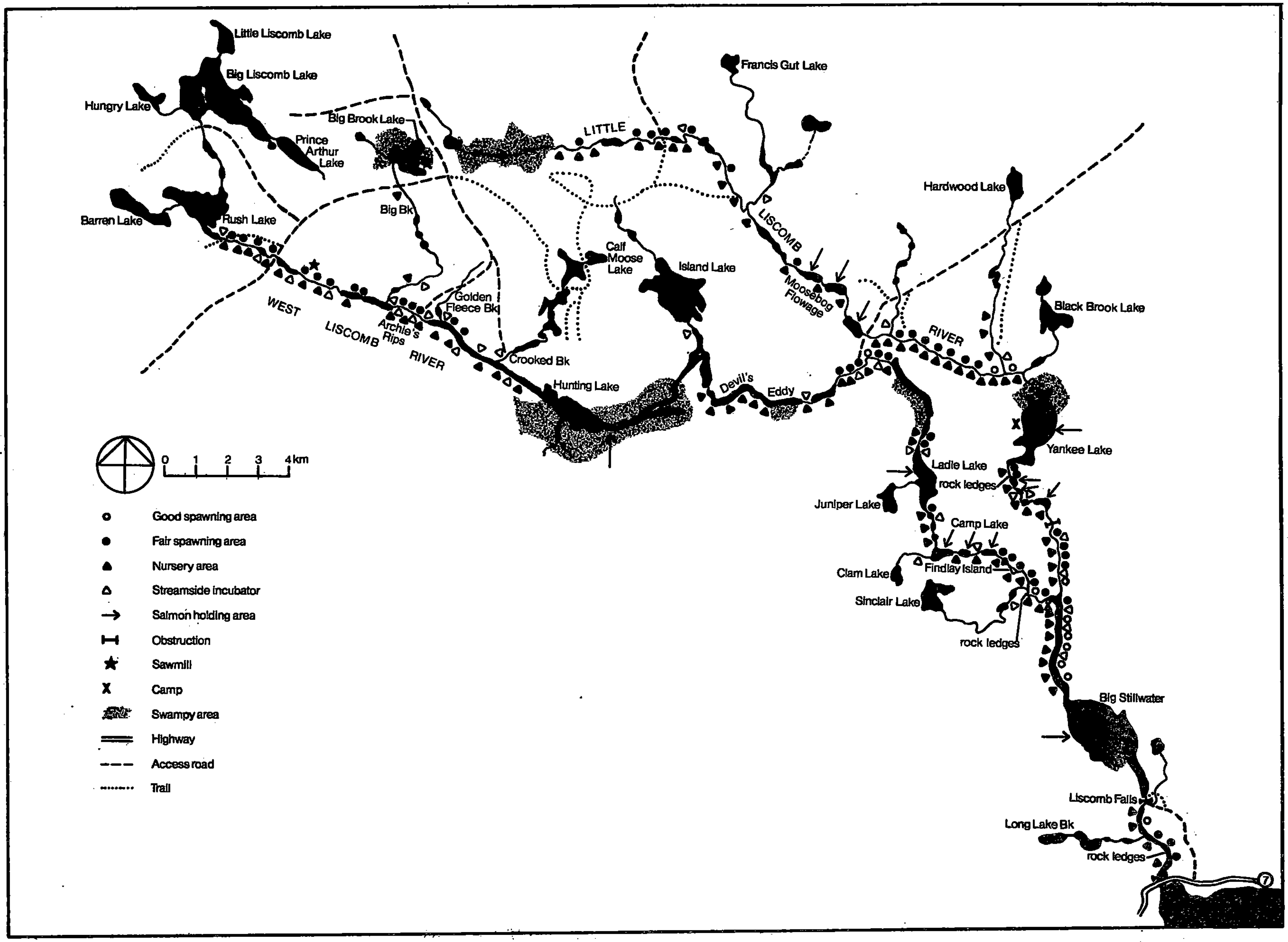


FIG 1. Map of the Liscomb River watershed, showing obstructions, road access, and distribution of the spawning and nursery areas.

Liscomb River; some enhancement alternatives are reviewed for development of the fisheries resource.

GENERAL DESCRIPTION OF THE WATERSHED

The Liscomb River flows through heavily wooded, rocky country-side and drains an area of 154 mi^2 (400 km^2). It is formed by two main tributaries, the Little Liscomb River and the West Liscomb River, which join approximately 6.5 mi (10.5 km) above tidewater. The main river, from Big Liscomb Lake to tidewater, is 35 mi (56.3 km) in length; its main tributary, Little Liscomb River, is 20 mi (32.2 km) in length. The headwaters of both branches consist of lake and stillwater areas, interspersed with rocky, riffle sections. The Scott Paper Company and the Nova Scotia Pulp Company are presently engaged in harvesting the woodland in the upper part of the watershed; several roads are under construction which either cross or parallel the river (Fig. 1). Both branches have several lakes and stillwaters which would provide good holding areas for Atlantic salmon (*Salmo salar* L.) during periods of low water in the summer; these lakes would also provide spawning areas for gaspereau (*Alosa pseudoharengus*) (Figs. 1 and 2). In the flats and stillwater areas, the bottom is composed of rock, sand and mud. In the riffle sections, bottom composition varies from rocks and boulders in some areas to fine gravel and sand in others.

OBSTRUCTIONS

On September 5, 1975, an aerial survey of the Liscomb watershed was carried out using a provincial Department of Lands and Forests helicopter. Three barriers to fish passage remain on the Liscomb River (Fig. 1 and Appendix A). The first obstruction is the Liscomb Falls hydro dam located approximately two miles (3.2 km) upstream from tidewater. Liscomb Falls is 25-30 ft (7.6-9.1 m) in height, and a 15-18 ft (4.6-5.5 m) dam located on its crest presents a total barrier to anadromous fish passage.

The second obstruction is located on the Little Liscomb River approximately 6.4 mi (10.3 km) upstream from the Liscomb Falls hydro station. This barrier consists of two natural rock ledges, each roughly 8 ft (2.4 m) in height, which present an obstruction to fish passage at low water. If the potential of the Little Liscomb River above Yankee Lake is to be realized, this obstruction must be removed. The area from Yankee Lake to the confluence with the West Liscomb River should be surveyed again during low water conditions to determine whether any other rock ledges require removal.

The third barrier on the system consists of an old log dam at the outlet from Island Lake, located on a tributary to the West Liscomb River (Fig. 1). Since no salmon habitat and very limited gaspereau potential exists in or above Island Lake, this dam has no significant impact on the potential of the river.

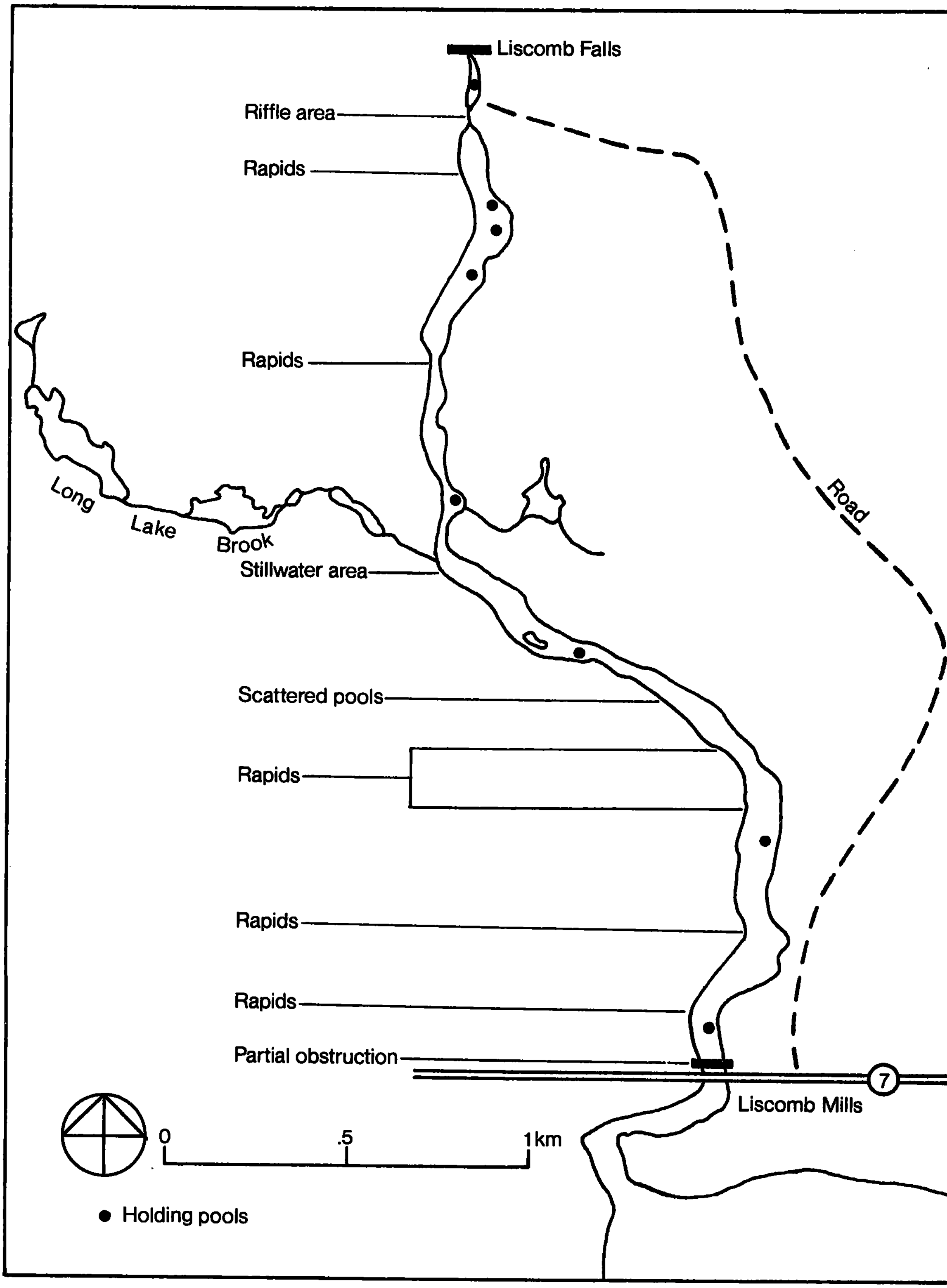


FIG. 2. Map of salmon holding pools along the 2-mi section of river below the Liscomb hydro station.

During extremely low water conditions in the summer, such as those experienced in 1975, several other areas on the river may be impassable for salmon. However, because of the excellent holding areas throughout the system, anadromous fish would have adequate resting areas until fall when higher water levels would enable them to pass through these sections.

WATER QUALITY AND DISCHARGE

The water of the Liscomb River is brownish in colour, with a pH of 6.5-7.0. The only industrial developments in the watershed are the sawmill operations of Louis Erskine Co. Ltd., located on Big Brook Lake, and the woodland operations of the Scott Paper Company and the Nova Scotia Pulp Company.

As part of a province-wide water-quality study (Anonymous 1971), a reconnaissance survey of surface water in the Liscomb River was conducted in 1971 to determine mercury, cadmium and chlorinated insecticide concentrations. Mercury and cadmium concentrations were considered as normal background levels in comparison to other Nova Scotia streams (Table 1). Chlorinated insecticides in the Liscomb River were not detected in measurable concentrations, as most were less than 0.005 µg/l.

TABLE 1. Liscomb River water quality data collected at Liscomb Mills, August 19, 1971.

Parameter	Level[1] (µg/l)
Mercury[2]	0.39
Cadmium[3]	<0.002
Lindane	<0.005
Heptachlor	<0.005
Aldrin	<0.005
Heptachlor epoxide	<0.005
p,p' - DDD	<0.005
Dieldrin	<0.005
p,p' - DDE	<0.005
α - Endosulfan isomers	<0.005
Endrin	<0.005
α - Chlordane	<0.005
δ - Endosulfan	<0.005
o,p - DDT	<0.005
p,p' - DDT	<0.010
p,p' - Methoxychlor	<0.050

[1]Anonymous 1971. Water Quality Division, Environment Canada.
[2]Concentration (ppb).
[3]Concentration (ppm).

In July, 1975, during an electrofishing survey, water samples were analysed for dissolved oxygen, pH and temperature (Table 2). While oxygen and pH were normal, water temperatures at each location were extremely high. However, this survey was conducted during the hot, dry period in 1975 when water levels were abnormally low; water temperatures in other Eastern Shore rivers were similarly elevated during this period. Summer water-temperature profiles would be expected to resemble those of other Eastern Shore rivers.

TABLE 2. Water quality data collected July 22-24, 1975, on the Liscomb River.

Location	Oxygen (ppm)	pH	Temperature (°C)
Below Liscomb hydro station	8.0	6.5	23.8
Little Liscomb River	8.0	7.0	28.6
West Liscomb River	8.0	6.5	25.5

Information on river discharges for the years 1962-74 is summarized (Table 3). The peak discharge periods occurred from March to May and from November to December, while very low water conditions existed from June to September. The mean annual discharge of the river during these years was 572 cfs.

ELECTROFISHING DATA

In July, 1975, three locations on the Liscomb River were electrofished. The data (Table 4) indicate that salmon parr

TABLE 4. A summary of the number and density of fish taken at three locations on the Liscomb River by electrofishing, 1975.

Location	Species	Number collected	Density	
			No./100 yd^2	No./100 m^2
Below Liscomb hydro station[1]	Salmon fry	4	0.37	0.44
	Salmon parr	20	1.87	2.23
	White sucker	1	0.09	0.10
	American eel	54	5.06	6.05
Little Liscomb River	Northern lake chub	30	8.93	10.68
West Liscomb River	Northern lake chub	7	2.16	2.58
	White sucker	2	0.62	0.74
	American eel	6	1.85	2.21

[1]Only area presently accessible to anadromous species.

TABLE 3. Mean monthly discharges for the Liscomb River, recorded at Liscomb Mills, 1962-74[1].

Year	Discharge (cfs)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual mean
1962	—	—	—	1,450	245	238	817	429	314	921	1,330	826	—
1963	1,090	783	415	949	1,280	205	159	146	492	311	647	519	581
1964	830	554	427	1,690	412	319	488	273	380	624	314	1,230	628
1965	650	356	680	944	286	246	97	442	135	150	613	540	428
1966	203	356	891	666	211	230	83	74	139	621	345	697	377
1967	472	210	532	847	1,990	270	135	361	385	739	916	745	637
1968	695	339	975	607	446	278	193	433	544	160	1,170	1,150	631
1969	638	672	458	878	470	314	157	121	69	240	1,820	1,280	593
1970	277	321	271	846	602	522	355	395	341	610	634	383	463
1971	256	1,340	689	1,760	695	234	198	1,230	249	206	701	741	686
1972	756	706	1,270	701	2,040	612	219	402	122	754	1,330	916	819
1973	648	770	751	913	817	523	314	457	58	35	302	651	520
1974	246	521	915	1,030	427	376	338	47	358	425	494	838	501
Monthly mean	563	577	689	1,021	763	336	273	370	276	446	816	809	572

[1]Anonymous. Surface Water Data. Department of Energy, Mines and Resources, Ottawa.

densities were low in comparison to the estimated maximum production potential of Nova Scotia streams. The sites electrofished were not considered good fry nursery areas and, hence, fry densities were extremely low as expected. The American eel, *Anguilla rostrata* (Le Sueur), was abundant both below and above the Liscomb hydro station. The only other species taken at the three sites were the white sucker, *Catostomus commersoni*, and the northern lake chub, *Couesius plumbeus*.

ANGLING STATISTICS[1]

Speckled trout are angled throughout the Liscomb River system; Atlantic salmon have access to only the first 2 mi (3.2 km) of stream below the Liscomb hydro station. As noted by MacEachern and MacDonald (1962), salmon angling in Nova Scotia became popular in the 1930's, with the advent of improved transportation; however, the effort dropped off in the 1940's because of the war. After the war, the interest in angling once again accelerated and has increased rapidly ever since. Between 1931 and 1961, the average annual catch of salmon on the Liscomb River was 59 fish; angling statistics for the system from 1951 to 1974 have been summarized (Table 5). As the data indicate, the salmon population in Liscomb River is predominantly grilse or 1-sea-year salmon. Since 1951, an average of 54 Atlantic salmon have been angled each year. Speckled trout angling statistics have not changed significantly since 1951, with an average of 5,767 taken each year.

COMMERCIAL FISHERIES

At the present time, no licenced commercial salmon fishermen operate in the Liscomb River estuary or adjacent to the river mouth. However, at least five mackerel nets and two gaspereau nets are fished in the area adjacent to the mouth of the river. Hence, Atlantic salmon returning to the river are not as heavily exploited commercially as is the case in some other Eastern Shore rivers. Salmon destined for the Liscomb River would, however, be caught in salmon and other fishing gear in areas along the Atlantic coast east of the river.

PREDATION ON JUVENILE ATLANTIC SALMON

During an aerial survey carried out in 1975, the following bird predators were observed in the watershed: blue heron *(Ardea herodias)*, sparrow hawk *(Falco sparverius)*, belted kingfisher *(Megaceryle alcyon)*, and red-tailed hawk *(Buteo jamaicensis)*. Mergansers *(Mergus merganser)*, cormorants *(Phalacrocorax auritus)* and ospreys *(Pandion haliaetus)*, although not seen, probably occur throughout the system. The only serious

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[1]As reported by the Conservation and Protection Division, Halifax, Nova Scotia.

TABLE 5. Annual sport catch statistics for the Liscomb River system, 1951-74 (Conservation and Protection Division).

Year	Atlantic salmon Grilse	Salmon	Total	Speckled trout
1951	–	–	197	3,698
1952	–	–	77	5,742
1953	–	–	181	6,665
1954	–	–	53	5,295
1955	–	–	68	4,117
1956	–	–	21	4,546
1957	–	–	11	4,200
1958	–	–	14	7,577
1959	–	–	60	6,309
1960	–	–	49	9,014
1961	–	–	33	8,760
1962	–	–	143	6,123
1963	–	–	52	3,921
1964	–	–	42	4,525
1965	10	4	14	5,000
1966	7	19	26	5,105
1967	16	5	21	4,110
1968	20	0	20	5,750
1969	15	4	19	5,200
1970	23	9	32	6,100
1971	26	3	29	5,100
1972	46	9	55	6,650
1973	42	2	44	6,400
1974	47	0	47	8,500
Average			54	5,767

predatory fish present is the American eel. Predatory mammals such as the otter *(Lutra canadensis)* and mink *(Mustela visor)*, although not observed during the surveys, probably inhabit the area.

HATCHERY STOCKING

Atlantic salmon and speckled trout hatchery stocking from 1950 to 1974 in the Liscomb River system is outlined (Table 6). Early plantings of Atlantic salmon and speckled trout were made from Antigonish Hatchery. From 1954 to 1956, Miramichi River genetic stock were released; in 1957, progeny from salmon eggs received from Margaree Hatchery were released, presumably Margaree stock; from 1959 to 1962, Miramichi River genetic stock were released; in 1963, River Philip yearling salmon and Miramichi advanced salmon fry were released (T.K. Lydon, pers.

TABLE 6. A review of hatchery stocking records in the Liscomb River system, 1950-74.

Year of release	Number of fish released by stage									
	Atlantic salmon[1]				Speckled trout[2]					
	Ad	A1	A2	Af	S1	S2	S3	S4	Sf	Sg
1950										
1951										
1952										
1953										
1954		25,000								
1955		20,000								
1956			15,000							
1957		10,000								
1958										
1959			10,000							
1960			15,000							
1961		14,000								
1962		10,000		3,000			8,165			
1963	40,000			4,440	5,000		4,660			
1964				2,520			8,100			
1965				3,000			7,000			
1966						19,250				245
1967						12,000				504
1968								2,000		
1969								1,000		
1970										414
1971									1,200	
1972									1,500	
1973									600	
1974										

[1]Atlantic salmon: Ad = advanced fry; A1-A2 = #1-#2 fingerlings; Af = yearlings.

[2]Speckled trout: S1-S4 = #1-#4 fingerlings; Sf = yearlings; Sg = 2-yr olds.

comm.)[1]. Although the records are not clear, there is a possibility that some New Mills genetic stock salmon fingerlings were released in 1961. No salmon distributions have been made in the river since 1965.

ANADROMOUS FISHERIES POTENTIAL

Atlantic salmon

The major spawning and nursery areas for salmon in the Liscomb River are illustrated (Fig. 1). The estimates of spawning area were made during an aerial survey in 1975 (Table 7).

TABLE 7. A summary of the estimated spawning and nursery areas in the Liscomb River.

Location	Estimated spawning area (yd^2)	Estimated spawning area (m^2)	Nursery area[1] (yd^2)	Nursery area[1] (m^2)
Highway to hydro station	1,000	800	176,000	147,100
Big Stillwater to Findlay Island	27,000	22,600	247,000	206,500
Findlay Island to Ladle Lake	9,000	7,500	132,000	110,400
Ladle Lake to Devil's Eddy	61,000	51,000	324,000	270,900
Devil's Eddy to Archie's Rips			617,000	515,900
Archie's Rips to Rush Lake	1,000	800	132,000	110,400
Headwaters of Little Liscomb to Moosebog Flowage	300	200	47,000	39,300
Moosebog Flowage to Yankee Lake	8,600	7,200	158,000	132,100
Yankee Lake to forks with West Liscomb River	16,000	13,400	183,000	153,000
Total	123,900	103,500	2,016,000	1,685,600

[1]MacEachern (1955).

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[1]Lydon, T.K. Manager (ret.) Antigonish Hatchery.

When manpower permits, a comprehensive survey should be carried out to document in detail the spawning area available for salmon. The estimates of nursery area are based on MacEachern (1955).

A total of 1,036,000 yd^2 (866,200 m^2) of good potential nursery area, and 980,000 yd^2 (819,400 m^2) of fair nursery area, comprised mainly of flat water stretches, exists on the river. At a production capacity of 4 smolts per 100 yd^2 for good nursery area and 1 smolt[1] per 100 yd^2 for fair nursery area, the production capacity of the river is estimated as 51,000 smolts.

No attempt has been made subsequent to MacEachern (1955) to re-evaluate the nursery potential of the river. However, it will be important to study the distribution of nursery area in relation to spawning area in the river because of the dispersal behavior of salmon fry; this relationship will affect the production potential of the river.

More accurate information is also required on the spawning area, since it may be a limiting factor for salmon production in the Liscomb River. Also, the effect which low, warm water in the summer will have on juvenile salmon survival and production in this stream is unknown. Based on the production estimate from maximizing the utilization of the nursery area in the river, 51,000 smolts would contribute to an annual return of 3,060, 4,080 and 6,120 adults at return rates of 6%, 8% and 12%, respectively.

Gaspereau

The total lake-surface acreage in the Liscomb watershed is 3,118 (Table 8). Based on a production potential of 102 returning adult gaspereau per acre (B.M. Jessop, pers. comm)[2], this area has the potential to produce 318,000 returning adult gaspereau. If the stillwater areas and smaller lakes are considered, the production potential is estimated at 400,000 returning gaspereau, of which roughly 20% would be required for spawning; the remainder could be harvested (B.M. Jessop, pers. comm.).

Other Species

Other fisheries resources in the Liscomb River could be harvested. In particular, the American eel appears to be numerous and may be exploitable. If fish passage facilities were constructed, potential also exists for the development of a sea-run population of speckled trout which could harvested by anglers.

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[1]According to Saunders and Gee (1964), salmon parr will utilize both pools and ripple areas in a stream.

[2]Jessop, B.M. Fishery biologist, Resource Branch, Fisheries and Marine Service, Dept. of Fisheries and Environment, Halifax Nova Scotia.

TABLE 8. A summary of the estimated surface acreage of the larger lakes in the Liscomb watershed.

Name	Surface area (acres)
<u>Lower Section</u>	
Long Lake Brook	40
Big Stillwater	247
Total	287
<u>West or Main Branch</u>	
Camp Lake	35
Ladle Lake	139
Sinclair Lake	99
Clam Lake	30
Juniper Lake	45
Island Lake	328
Hunting Lake	274
Calf Moose Lake	22
Crooked Brook	102
Big Brook Lake	137
Rush Lake	295
Barren Lake	59
Big Liscomb Lake	572
Little Liscomb Lake	82
Prince Arthur Lake	87
Hungry Lake	34
Total	2,340
<u>Little Liscomb River</u>	
Yankee Lake	281
Black Brook Lake	142
Hardwood Lake	50
Francis Gut Lake	18
Total	491
<u>Grand total</u>	3,118

BENEFIT-COST RATIO

Ducharme (1971) calculated a benefit-cost ratio of 5.5:1 for the river. Since this calculation was made, the estimated cost of construction of fish passage facilities has escalated considerably. For this reason, as well as the fact that the Ducharme analysis did not consider benefits from species other than salmon, a new benefit-cost ratio has been calculated (Appendix B). The estimated costs for the project are based on available information and are subject to review on completion of the construction phase.

ENHANCEMENT ALTERNATIVES

Atlantic Salmon

A number of possibilities exist which may aid in enhancing the anadromous fisheries potential of the river. These include the following:

1. Natural Straying - Estimates of the salmon population, made from angling statistics for the 2-mi (3.2-km) stretch of river below the hydro station, indicate that approximately 100-150 adults return to spawn each year. On completion of construction of fish passage facilities at Liscomb Falls, some of the predominantly grilse population would be expected to move upstream. However, based on restoration data in rivers such as the LaHave, restoration of a salmon run by straying would be a lengthy procedure (Gray 1974) and hence some form of enhancement is required.

2. Adult Transplantation - Although adult transplantation of a suitable wild genetic stock of salmon is attractive, none is available in sufficient numbers to make this a viable method of enhancement at this time.

3. Stream-Side Incubation - This technique has been employed successfully for west coast species of salmon; however, only recently has this enhancement method been tested for Atlantic salmon. Should other forms of enhancement not be possible in the near future, a pilot study could be considered utilizing this technique (Table 9 and Fig. 1).

4. Semi-Natural Rearing - This enhancement method has received some study in recent years (Gray 1971; Gray 1976; Frantis et al. 1972) and appears to have merit, providing manpower and funds are available to select a suitable site, construct the necessary facilities, and manage a semi-natural pond or lake.

5. Hatchery Stocking - Perhaps the most practical solution to enhancing a salmon run in the river, in view of the scarcity of suitable stocks and in the present financial situation, is a stocking program from existing hatcheries. Care should be taken to insure that stocks released into the Liscomb are parasite-free and disease-free.

An important part of the overall salmon restoration program is the selection of a suitable genetic strain of broodstock salmon. At least two stocks are presently available which may be suitable for the program: recycled LaHave River broodstock held at East River, Sheet Harbour; or the St. Mary's River salmon, collected from the saltwater trap at Sherbrooke. Both broodstock sources could be expanded to meet the requirements of the Liscomb restoration program.

TABLE 9. Proposed distribution of stream-side incubator units[1] throughout the Liscomb watershed.

Location	Nursery area (yd^2)	Number of incubators
Big Stillwater to Findlay Island	247,000	5
Findlay Island to Ladle Lake	132,000	2
Ladle Lake to Devil's Eddy	324,000	6
Devil's Eddy to Archie's Rips	617,000	12
Archie's Rips to Rush Lake	132,000	2
Headwaters to Moosebog Flowage	47,000	1
Moosebog Flowage to Yankee Lake	158,000	3
Yankee Lake to Confluence with West Liscomb	183,000	4

[1]Stream-side incubator units of 100,000 eggs.

Gaspereau

Natural straying of gaspereau to upstream areas, once fish passage facilities are constructed, would account for some expansion in the population. Should it be required, adult transplantation from the nearby Gaspereau Brook would be possible.

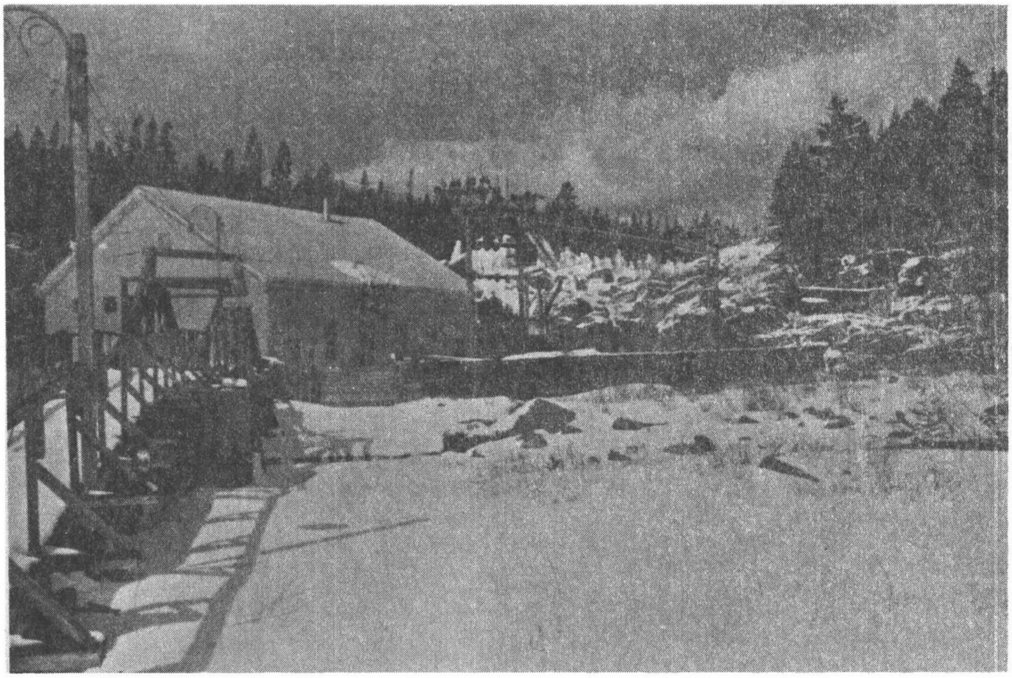
Other Species

It is recommended that no enhancement be undertaken for the American eel at the present time because of the lack of exploitation for this species and its potential competition with, and predation on, Atlantic salmon (Gray 1969).

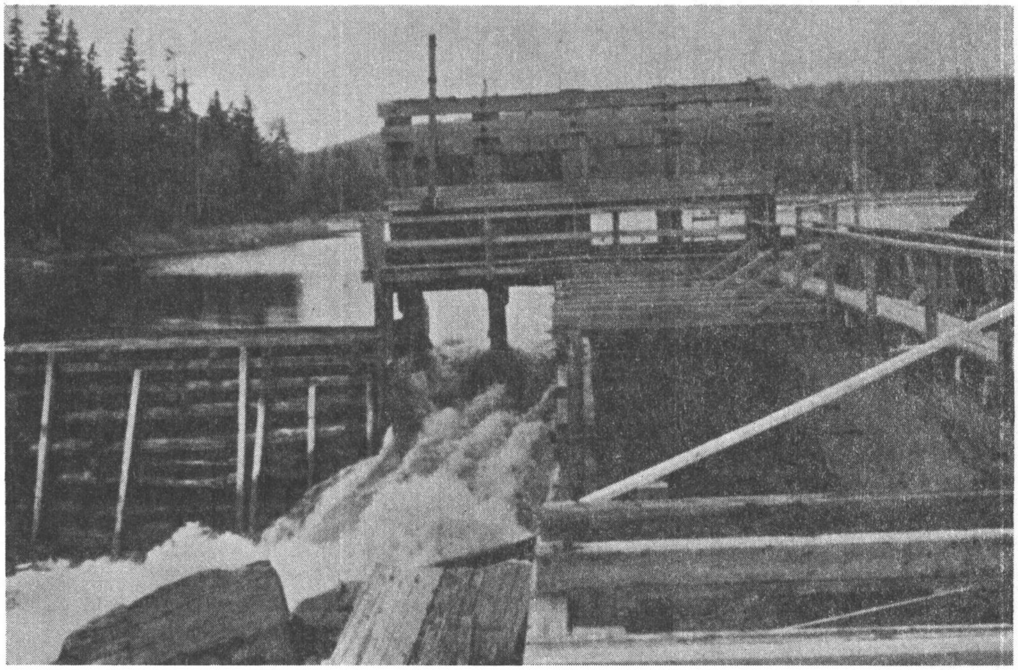
Development of an anadromous run of speckled trout could be undertaken; however, it should take lower priority than salmon. Enhancement could take place by collecting, rearing and stocking a sea-run variety of speckled trout or by adult transplantation from a nearby Eastern Shore river.

APPENDIX A

PHOTOS OF OBSTRUCTIONS, LISCOMB RIVER SYSTEM

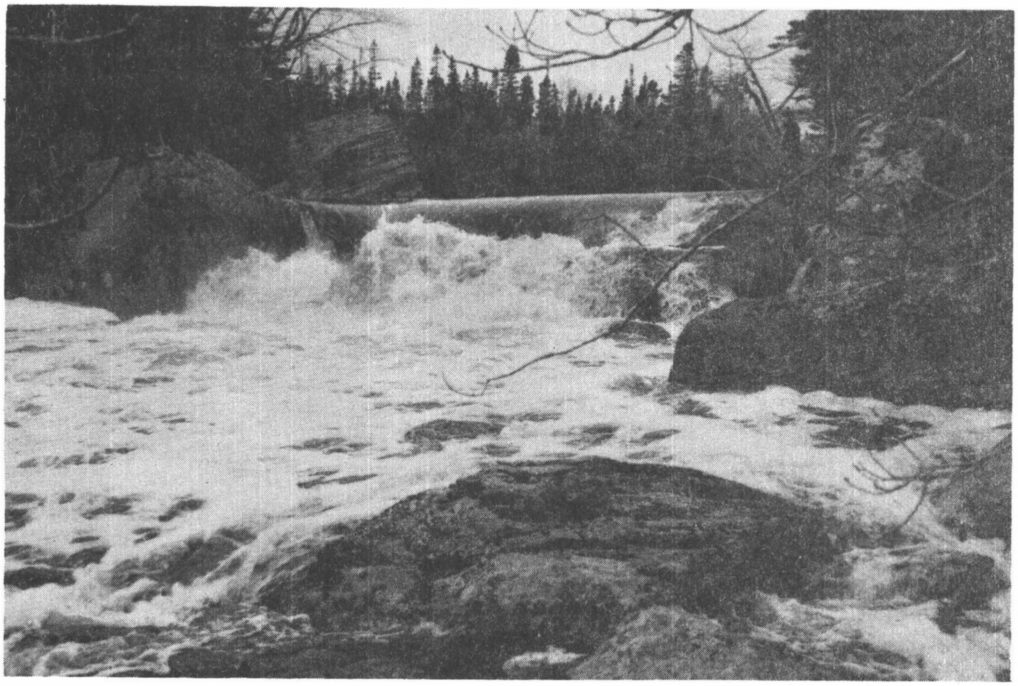


A view of the Liscomb hydro station.

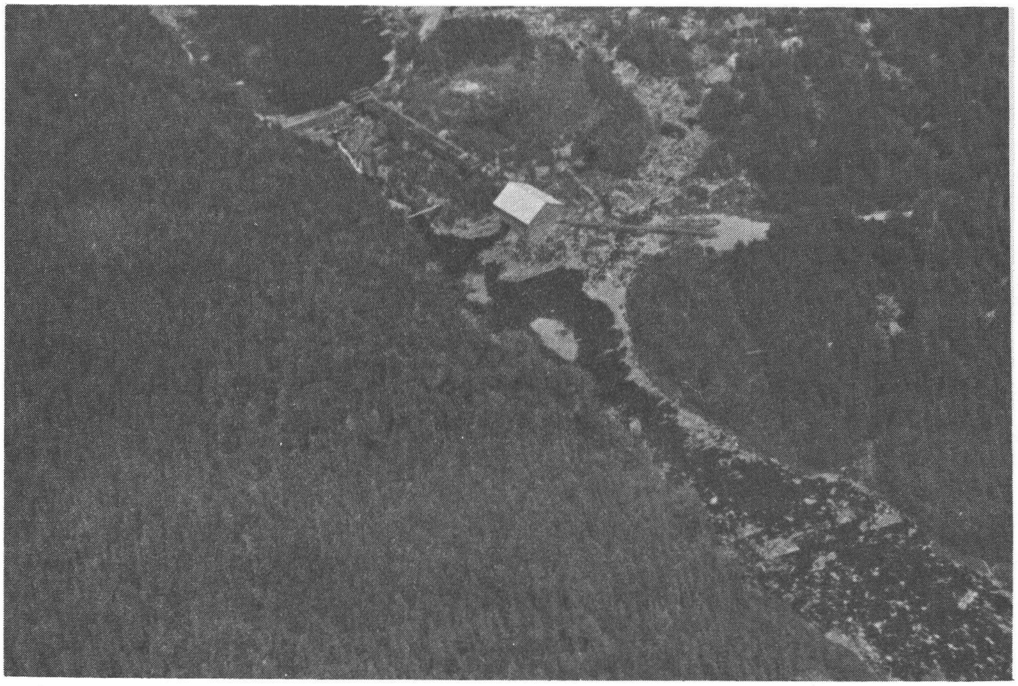


Timber dam, spillway gate and flume of the Liscomb hydro station.

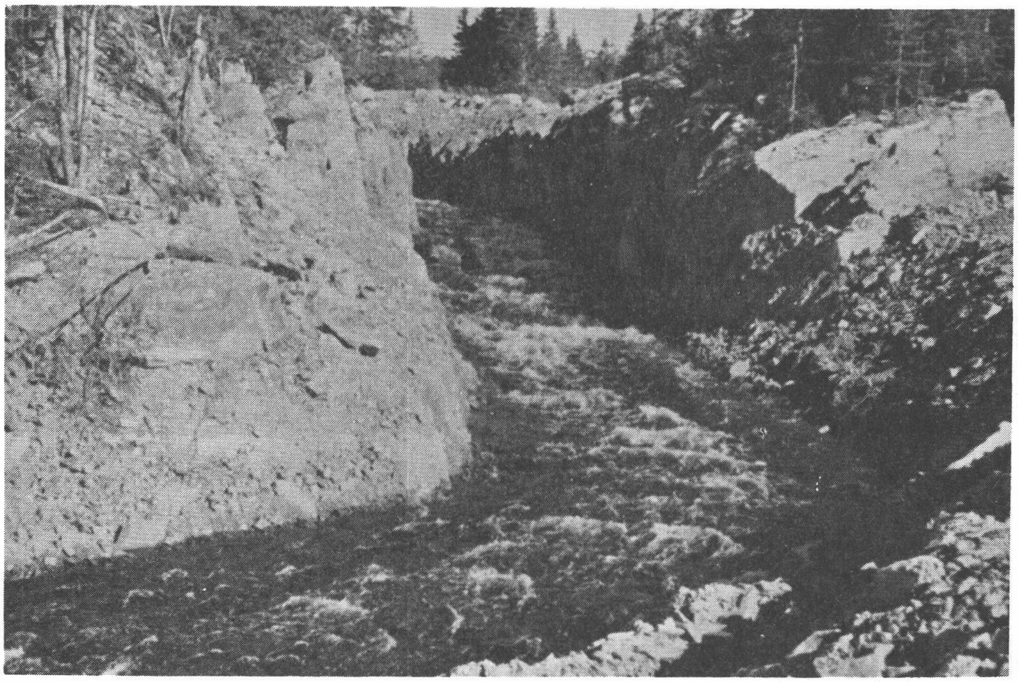
Two small falls on the Little Liscomb River, 1.5 mi above the confluence with the West Liscomb River.



Close-up view of the first falls on the Little Liscomb River.



Aerial view of the Liscomb hydro site, showing headpond, main river dam, wing dam and hydro station.



Bypass channel excavated around Liscomb Falls in 1976.

APPENDIX B

BENEFIT-COST ANALYSIS FOR DEVELOPMENT OF THE ANADROMOUS FISHERIES POTENTIAL OF THE LISCOMB RIVER, NOVA SCOTIA

Statement of the Problem and Background Information

The fishing industry is an important part of the economy of the Eastern Shore in particular, and Nova Scotia in general. Recent encroachment of the freshwater habitat by man's presence and overfishing in the feeding areas, on the migratory routes and in the rivers has caused a rapid decline of various anadromous species, in particular the Atlantic salmon (*Salmo salar* L.). Part of man's disturbance has been the construction of hydro dams and the blocking off and flooding of large portions of Maritime rivers previously used as nursery and spawning areas by Atlantic salmon. Many of the areas above these man-made and natural obstructions not presently utilized by anadromous populations could be brought into production by providing fish passage or transfer facilities. In order to ensure restoration of the anadromous species in these areas, enhancement techniques must be employed. These include transplantation of adult spawning gaspereau (*Alosa pseudoharengus*) and planting hatchery-reared juvenile salmon, usually smolts, in previously unutilized areas.

If fish passage facilities were provided at Liscomb Falls, the site of a small hydroelectric installation, which is scheduled to be phased out in 1976, the unutilized area above the existing dam could be developed for both Atlantic salmon and gaspereau, as well as other anadromous species. The total area was estimated to contain 1,685,600 m^2 of salmon nursery area, capable of sustaining a production of 51,000 smolts or a returning population of adult spawners comprising 3,060 salmon. In addition, the gaspereau potential was estimated at 400,000 returning adults when fully developed. Biological and engineering reports indicated that the development should take place in two stages: 1. construction of fish passage facilities, and 2. enhancement of the Atlantic salmon run and restoration of the gaspereau population.

Statement of the Objective

To expand the catch potential of anadromous salmon and gaspereau—renewable natural resources in the river—to commercial fishermen and to resident and non-resident sport fishermen.

Sub-Objectives

1. To expand the freshwater habitat available to both

Atlantic salmon and gaspereau, thus increasing the potential for these species, in particular for declining stocks of Atlantic salmon.

2. To expand the recreational potential of the scenic Eastern Shore areas by increasing the numbers of Atlantic salmon available to anglers.

3. To expand existing development techniques through the research and development program on the river.

4. To provide new jobs during the construction and operational phases of the project in the Eastern Shore area of Nova Scotia.

Constraints

1. The Atlantic salmon is one of the main anadromous species of interest to commercial fishermen and is the most widely sought after sport fish. Other salmonids, although biologically more prolific, have less aesthetic value for sport fishing in the view of most anglers.

2. The Atlantic salmon stock is already commercially overharvested, and the recreational demand for good sport fishing far exceeds the existing supply. Consequently, more efficient gear or longer periods of exploitation would not increase the catch substantially.

3. The fishery exploits a renewable resource which has an optimum sustainable yield or a yield with an upper limit.

4. Enhancement of existing areas by closing the existing commercial and sport fishery would be unacceptable from both a political and economic standpoint.

5. Availability of new production areas is limited by the environmental requirements of Atlantic salmon and gaspereau.

6. The number of suitable production areas is limited by multiple-use proposals for some rivers and legal problems in buying private land for facilities.

7. Because of overharvest, not enough adult salmon spawners of suitable genetic strains or races are available for transplantation in the areas, hence necessitating the use of hatcheries for rearing juvenile salmon for stocking purposes. Other enhancement techniques, such as stream-side incubation, would require further research and development before they could be considered presently as viable alternatives.

8. Methods of increasing production are limited by the biological characteristics of the species involved and by the present level of technology in the field.

Assumptions

1. The Atlantic salmon and gaspereau are commercially, recreationally and aesthetically important to the people of Canada and of Nova Scotia in particular.

2. Benefits accruing from this project will largely be passed on to the local population in the county, but also to the province and country as a whole.

3. The technology exists and can be successfully applied, within the natural biological constraints of these species, to establish self-perpetuating runs in an area not previously utilized by them.

4. Production of Atlantic salmon and gaspereau from this project will be within the normal range obtained from similar developments in the Maritimes Region.

5. For Atlantic salmon, the commercial and sports fishery could annually harvest approximately 40% and 30% of the returning adults, respectively, and the estimated remaining 30% would be sufficient to maintain a self-sustaining population. For gaspereau, the commercial fishery could harvest annually approximately 80% of the returning population, leaving an estimated 20% for breeding stock to maintain a self-perpetuating run in the river.

6. The provision of fish passage facilities will not result in significant increases in other fish populations or cause adverse interspecific competition.

7. Five years of hatchery stocking will be required in order to build up salmon stocks to their maximum potential. The same period of time will be required to bring gaspereau stocks to their upper production limit in the area.

8. Because of high operational costs and limitations in existing man-years, trapping and trucking facilities are deemed too expensive to be included as a suitable alternative to fishway construction in this system.

Acceptable Alternatives

1. Establishment of a self-sustaining salmon run in an area suitable for production, by

   a. seeding with juvenile fish from an existing hatchery for five years.

   b. utilizing stream-side incubators throughout the river for releasing unfed fry during the restoration period.

c. construction of a fishway over an obstruction to allow access for adult fish.

2. Establishment of a self-sustaining gaspereau run in an area suitable for production, by

a. transplanting adult gaspereau from a nearby river for five years.

b. making available fish passage facilities as in (1).

Unacceptable Alternatives

1. Maintain the status quo—do nothing (situation will deteriorate, since the demand far exceeds the sustaining capacity of the existing resource).

2. Increase fishermen and/or gear (stock already overharvested).

3. Decrease number of fishermen and/or gear or set catch quotas (social and political constraints).

4. Introduce new species (social, political and technological constraints).

5. Increase production in all accessible areas (not economically or biologically feasible).

6. Increase production in all inaccessible areas (financial restraints).

7. Increase production in inaccessible areas without using the above-mentioned techniques (time frame for production of self-perpetuating run not acceptable).

Costs

Costs of Maintaining the Status Quo

1. Eventual increase in unemployment of commercial fishermen, with resulting decrease in human well-being because of the continuing overharvest situation.

2. Retraining costs and loss of manpower to the area would be high because of men leaving the commercial fishery and the general area.

3. Eventual loss of a renewable resource and an important race or genetic strain of Atlantic salmon.

4. Loss of potential sports development, which would mean added revenue for the area. This is further emphasized by the

fact that a provincial game sanctuary exists in the headwater tributaries of the Liscomb River.

Costs for this Proposal

1. Land acquisition for the fishway.

2. Construction of the fishway.

3. Staff accommodations.

4. Access roads.

5. Operational and maintenance costs for the fishway.

6. Operational costs for providing hatchery-reared smolts for the seeding and other enhancement alternatives.

7. Research and development costs.

8. Biological management program costs.

Detailed Cost Analysis

Capital Costs

1. Land Purchase (year 0) (Transfer deed from NSPC)	000
2. Upgrading of access roads (year 0)	$5,000
3. Fishway construction (year 1)	$110,000
4. Fishway trap construction (year 1)	$5,000
5. Staff accommodations (year 1)	$5,000
6. Downstream fish passage facilities - not required.	
7. Stream-side incubators (year 1)	$5,000

Research and Development Costs

1. Engineering survey (year 0)	$3,000
2. Biological survey (year 0)	$1,500
3. Development of a suitable genetic strain of Atlantic salmon, technology development and assessment of the restoration program (years 0-4): Salaries	$20,000
Goods & Services	$10,000

Operational and Maintenance Costs

1. Fishway (years 2-5): Salaries @ 1.5 man years $9,000
   Goods & Services $3,000

2. Hatchery stocking program (years 1-5)
   (50,000 smolts @ $1.50/smolt) $75,000

Detailed Cost Sheet

Year	Description	Expenditure	Compound interest factor to 1980	Compound amount to 1980
1975	Land purchase	$ 000		
	Upgrading access roads	5,000		
	Engineering survey	3,000		
	Biological survey	1,500		
	Development of suitable technology	30,000		
	Total	39,500	1.2763	$ 50,414
1976	Fishway construction	110,000		
	Fishway trap construction	5,000		
	Staff accommodations	5,000		
	Stream-side incubators	5,000		
	Development of suitable technology	30,000		
	Hatchery stocking program	75,000		
	Total	230,000	1.2155	$279,565
1977	Development of suitable technology	30,000		
	Fishway trap operation	12,000		
	Hatchery stocking program	75,000		
	Total	117,000	1.1576	$135,439
1978	Development of suitable technology	30,000		
	Fishway trap operation	12,000		
	Hatchery stocking program	75,000		
	Total	117,000	1.1025	$128,992
1979	Development of suitable technology	30,000		
	Fishway trap operation	12,000		
	Hatchery stocking program	75,000		
	Total	117,000	1.0499	$122,838
1980	Fishway trap operation	12,000		
	Hatchery stocking program	75,000		
	Total	87,000	1.000	$ 87,000
	Total expenditure to 1980 =			$804,248

Benefits

There are no benefits in maintaining the status quo.

Unquantifiable Benefits

1. There will be an increase in the self-respect and dignity of semiskilled laborers, from being gainfully employed during the construction and operational phases.

2. Spillover from technological and biological advances made in the research and development program will result in new and improved approaches to fisheries enhancement.

3. The presence of an existing hatchery and other facilities such as a fishway in the region will attract tourists and will result in spin-offs to the local tourist and commercial interests.

4. Visitors to the facilities will be provided with tours and information which will increase their appreciation of conservation practices.

5. Implementation of this project will expand the resource base of the highly valued and presently overharvested Atlantic salmon by 3,060 fish each year. That is, there will be an environmental benefit, by providing new areas for production to a species considered to be in serious difficulty regarding its continued survival in levels of abundance useful to mankind.

Quantifiable Benefits

1. Increased tourist potential—facilities will draw people to the area from urban and other areas because of interest in high quality angling, which will complement other attractions to the area such as scenery and ocean frontage. This will result in added revenue for the Eastern Shore.

2. Increased commercial catch—this will materially benefit the commercial fishermen, commercial gear manufacturers and merchants.

3. Increased employment:

   a. During the construction of facilities, new jobs will be available for one year.

   b. Because of the establishment of new facilities, new operational jobs will be available.

   c. Establishment of this project will result in reduction in unemployment insurance and welfare payments, utilization of previously unused manpower and improvement in the self-esteem and morale in the community.

Detailed Benefit Analysis

Increased Catch

Angling (years 5-50): Angling in Maritime streams normally accounts for 20%-40% of the total river escapement. For the purposes of this analysis, a median figure of 30% is used, recognizing that this exploitation will vary from year to year depending on environmental conditions and fishing pressure.

Presently, an average of 8.4 rod-days is expended per fish caught in Nova Scotia streams. As the salmon run increases, angling pressure will also increase; however, fishing success is not likely to increase at the same rate. Hence, 9 rod-days per fish is considered a conservative estimate of effort for this calculation. The value of a rod-day of fishing in 1980 is computed as $37.82, whereas the value of salmon sold commercially is $2.00 per pound—both figures being calculated at an interest rate of 5% annually and following the method used by Millen and Ducharme (1971). Because of the current rate of inflation, increases in demand and the uncertainity of interest rates, such figures may in fact be very incorrect in terms of acutal dollar value on the dates computed, but are consistent for both costs and benefits.

It is estimated that 900 Atlantic salmon will be angled annually from 1980 onwards, while maintaining a self-sustaining run in the river. Thus, the annual benefit accured from the sports fishery would be:

900 salmon x 9 rod-days/fish x $37.82/rod-day
(modified from Spargo 1961; Millen and Ducharme 1971)
= $306,342

Commercial (years 5-50): It is estimated that 1,200 Atlantic salmon averaging 7 lb will be taken in commercial fisheries from 1980 onwards, while maintaining adequate breeding stock in the river. Thus, the annual benefit from commercial fisheries would be:

= 1,200 x 7 x $2.00
= $16,800

It is estimated that 80% of the returning adult gaspereau population could be harvested annually, while leaving adequate spawners to maintain the population at its maximum production potential:

= 400,000 @ 0.5 lb/fish x 0.80 x $0.05/lb
= $8,000

Increased Employment (labor benefits)

1. Construction phase (year 1)
   8 man-years @ $2.50/hr x 2,000 hr/yr
   = $40,000

2. Operational phase—fishway (years 2-5)
   1.5 man-years @ $2.50/hr x 2,000 hr/yr
   = $ 7,500

3. Operational phase—hatchery (years 1-5)
   1.5 man-years @ $2.50/hr x 2,000 hr/yr
   = $ 7,500

4. Operational phase—development of suitable technology (years 0-4)
   3.0 man-years @ $2.50/hr x 2,000 hr/yr
   = $15,000

Labor Shadow Pricing Sheet

Year	Description	Benefit	Compound interest factor to 1980	Compound amount to 1980
1975	Technology development	$ 15,000	1.2763	$19,144
1976	Construction	40,000		
	Hatchery operation	7,500		
	Technology development	15,000		
	Total	62,500	1.2155	$75,969
1977	Fishway operation	7,500		
	Hatchery operation	7,500		
	Technology development	15,000		
	Total	30,000	1.1576	$34,728
1978	Fishway operation	7,500		
	Hatchery operation	7,500		
	Technology development	15,000		
	Total	30,000	1.1025	$33,075
1979	Fishway operation	7,500		
	Hatchery operation	7,500		
	Technology development	15,000		
	Total	30,000	1.0499	$31,497
1980	Fishway operation	7,500		
	Hatchery operation	7,500		
	Total	15,000	1.000	$15,000
	Total benefit to 1980 =			$209,413

Benefit-Cost Ratio

Annual Costs (5-50)

In 1980, the balance of cost = \$804,248 - \$209,413
= \$594,835 (i.e., labor benefits)

Therefore, the total expenditure to 1980 = \$594,835

The remaining life of the facilities = 46 years

Capital recovery over 46 yr @ 5% = 0.05597 x \$594,835
= \$33,293

Annual fishery management program = \$10,000

Total annual cost = \$43,293

Annual Benefit (5-50)

Angling	= \$306,342
Commercial	= 24,800
Total	= \$331,142

Calculation of Benefit-Cost Ratio

$$\text{Benefit-cost ratio} = \frac{\text{Annual benefit}}{\text{Annual cost}}$$

$$= \frac{\$331,142}{\$\ 43,293}$$

$$= 7.65$$

Conclusions

Based on the results of this analysis, it has been concluded that the objective of expanding the catch potential of Atlantic salmon in the Liscomb River is technically and economically feasible.

Should a new hatchery be required in order to rear sufficient numbers of Atlantic salmon smolts for the project, a revised benefit-cost analysis would have to be calculated, since capital costs would escalate significantly.

The implementation of this program will have a significant impact on Atlantic salmon stocks in this area; and will improve the well-being of commercial fishermen, sport-fishing guides and semi-skilled laborers. It will also provide spin-off benefits of the local merchant and tourist industries. Indirect benefits to commercial fishermen in Newfoundland and the Eastern Shore of Nova Scotia will also result.

The Research and Development program will provide knowledge which will be applicable to other fisheries enhancement programs in Nova Scotia and southern New Brunswick.

A limiting factor in the analysis is that exploitation, and consequently, benefits cannot be obtained from the project for a period of approximately four years from the time it is initiated, because of the life history of this species.

The aesthetic value of Atlantic salmon (and gaspereau) cannot be measured in terms of monetary value alone. Hence, projects such as this are substantially underrated if only a cost-benefit analysis is considered.

ACKNOWLEDGEMENTS

The author is grateful to the Nova Scotia Department of Lands and Forests for providing a helicopter for the aerial survey work; in particular, the cooperation of pilot Don Munro is appreciated. The information on river discharges was provided by J.E. Peters, District Engineer, Water Survey of Canada. Hatchery stocking records were supplied by Mr. T.K. Lydon, Manager (Ret.), Antigonish Hatchery. The author is grateful to Mr. G.H. Penney, Biologist, Resource Branch, for commenting on the manuscript. Special thanks are due to J.D. Cameron, Biological Technician, Resource Branch, and William Ritchie for assistance in the field work.

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