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REVIEW OF

EAST RIVER SHEET HARBOUR SALMON DEVELOPMENT PROJECT

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FISHERIES SERVICE

DEPARTMENT OF FISHERIES AND FORESTRY OF CANADA

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SUMMARY

Redevelopment of a salmon run on East River, Sheet Harbour, required (1) introduction of suitable stocks, (2) provision of safe downstream passage for smolts, (3) access to the upriver spawning grounds for adults. Transplanting adult salmon from the adjacent West River gave an egg to smolt survival of 1.36% and 1.40% for 1966 and 1967 brood years. Louvers were built for guiding smolts, and in four years of development, guiding efficiency was raised from 50% to 80%. Returning salmon are attracted to a fishway and trucked upstream.

The ratio of tangible benefits to costs of the project is 0.656. This is determined by comparing benefits of $15 per angling day with the sum of capital amortization and operating costs. Intangible benefits not evaluated were: development of methods for guiding smolts; information about transplant of adult stocks.

The experimental nature of the project has resulted in high production costs for the tangible benefits, offset by the development of methods which may be applied to salmon development elsewhere in the region.

INTRODUCTION

Atlantic salmon were eliminated from the East River by hydro-electric installations beginning in the early 1920's. The many powerhouses and retention dams gradually caused the decline in the annual escapement by preventing adult salmon from reaching their upriver spawning grounds, and by causing smolt mortality at the two power stations.

East River is a typical example of the type of problem encountered in many Maritime streams and for which no simple solution has yet been developed. In most cases the problem may be stated in three parts: 1) Re-establish the run with a suitable stock; 2) provide adult access to the upriver spawning grounds around the multiple obstructions; and 3) provide safe downstream passage for migrating smolts.

Because of its relatively large salmon production potential - no severe loss of salmon habitat resulted from the impoundments - East River was a logical choice for the development and implementation of a rehabilitation scheme. The scheme included new and old techniques to be tested and improved for future applications. Thus, the East River development project provided an excellent opportunity to apply and assess techniques for upstream and downstream fish passage and methods of transplantation.

Conventional fishways for upstream migrants were ruled out because of the many obstructions and the high construction cost. As an alternative, a trapping and trucking scheme was chosen. Overland transportation of adults avoided the delays and hazards of three headponds and fishways. Also, far less water is required to operate a single trapping facility, which is an important consideration in the East River system.

Guiding smolts safely around the powerhouses at Ruth and Malay Falls was far more complex. As yet there exists no foolproof solution to this problem and the success of any given system is largely governed by prevailing site conditions. A screening system developed on the American west coast, called louver deflectors, produced high guiding efficiencies with coho and chinook salmon juveniles and steelhead smolts (Bates 1957). Louvers had never been used on Atlantic salmon smolts prior to 1967 but the west coast results were encouraging enough to start louver experimentation at East River. A louver array was installed in the Ruth Falls power canal first, with the understanding that louvers would be built at Malay Falls only if the first installation proved worthwhile.

In 1964 a state of complete depletion had been reached in the East River. The initiation of a new run would require the importation of live stocks. The common practice for the propagation of salmon in eastern Canada is to plant juveniles, usually at the smolt stage, in fresh water. At the time of implementation, and it is still true today, there existed a general shortage of hatchery-reared juveniles of suitable origin; hence the decision to transplant a small portion of the nearby West River adult run to the recipient stream. In this manner, immediate use would be made of at least part of the vast salmon habitat resource of East River, and the transplanted stock would be exposed to any new selective pressures in the East River environment throughout the entire freshwater stage of their life cycle.

PRELIMINARY RESULTS

Louver Testing

Louver deflectors as a means to guide smolts around the Ruth Falls powerhouse have been operated under experimental conditions from 1967 to 1970. The smolts used in testing were reared in hatchery but were comparable in age and size to smolts produced in the West River (adult donor stream). In 1969 and 1970 the louvers guided a portion of the natural smolts from the East River and guiding efficiency compared favorably to that obtained with hatchery smolts.

Average guiding efficiency of the Ruth Falls louvers was raised from 50 to 80 percent over the four year period. This increase was achieved mainly by judicious modifications to the bypass in an effort to even out the vertical distribution of velocity in front of the entrance and increase the ratio between bypass and approach velocities. A summary of performance data shows the progress made during the four years of testing.

Year	% of tests with efficiency >75%	Range of % efficiency
1967	8	18-22
1968	54	21-100
1969	27	17-100
1970	85	59-99

The experimental results at Ruth Falls revealed different ways in which the louver principal can be improved when applied to Atlantic salmon smolts. Taking advantage of certain behavioural traits of the species, louver panels need only extend to a depth of approximately six feet below the surface. Bar spacing could safely be increased to 12 inches and perhaps more. Improved design criteria for the bypass and bypass pipe line were established for Atlantic salmon smolts.

The major conclusion drawn from the louver experimentation is that in spite of the high guiding efficiency, the system as designed lacked practicality and was costly in terms of water supply and operation. Also, louvers are not applicable to Malay Falls power canal due to site conditions. Therefore, the investigation of a different type of smolt guiding system was initiated in 1969 at Malay Falls. Preliminary "skimmer" results are very promising and the Malay Falls site lends itself to such installation.

Adult transplants and progeny

The measure of success of the adult salmon transplant is based on the egg-to-smolt survival of the progeny and the adult return to the river. Sex determination was based on the identification of secondary sexual characters (hooked jaw, loose scales and coloration). Females were weighed individually and the egg potential was estimated using the fecundity figure of 800 eggs per pound of fish. (Table 1).

Table 1. Summary of adult Atlantic salmon transplanted to East River, Sheet Harbour, N.S., 1966-1970

Year	♂	♀	Average Female Weight (lbs.)	Potential Egg Deposition
1966	26	51	7.7	313,000
1967	6	12	3.7	35,500
1968	48	53	4.0	169,600
1969	47	53	4.7	190,480
1970	29	48	3.9	151,360

The egg-to-smolt survival given in Table 2 for the brood years 1966-1967 was three times higher than the norms established by Elson (1957) for Maritime streams. This is attributable in part to the low population densities and correspondingly low intra-specific competition which resulted in smoltification at a relatively early age (2 years).

Table 2. A summary of smolt production in East River's Fifteen Mile Stream at Sheet Harbour, N.S.

Brood Year	Egg Potential	1969	1970	Egg to Smolt % Survival
1966	313,000	3797	480	1.36
1967	35,500		500	1.40

The grilse return from the 1969 smolt production was disappointingly low. The cause of this failure is as yet unknown. It is speculated that either the smolts were overhandled at the counting site, or the trucking of these fish in the peak of their migration was harmful. Seventy percent of the smolt run was trucked from either the Malay Falls skimmer or the Ruth Falls louvers to salt water. A migration delay of up to three weeks in the Malay Falls forebay may have also contributed to the poor grilse return. Some fish may possibly return in 1971 as large salmon.

Benefits of Research and Development

The applied research at East River will permit more economical and improved applications of the development techniques involved. In Nova Scotia alone there are 34 small hydro-electric plants in 22 rivers. In New Brunswick the larger hydro installations present somewhat different problems but there are also 8 smaller stations where the techniques may be applicable. Approximately half of the Nova Scotia rivers harnessed for hydro have potential as salmon producers. The remainder either were initially negligible or had their salmon habitat destroyed by extensive impoundment.

Future louver installations will be more economical because: 1) it was demonstrated at Ruth Falls that 12" bar spacing is permissible with Atlantic salmon smolts - where other species such as gaspereaux and shad are concerned, narrower bar spacings might be necessary. By increasing bar spacing from 2 to 12 inches, head loss is reduced by approximately one foot. The loss of potential is very important to the Power Commission, not only for its energy value but because it reduces the peaking capacity of the plant. Wide bar spacings also reduce material and labor costs in the construction of the louvers; 2) new design criteria have been established for the bypass. The improved version at East River required 25% less water than the original bypass. This saving of 15 c.f.s. represents approximately 600 dollars annually to the Power Commission for its energy value; 3) smolts migrating through a deep, fast flowing flume or canal remain near the surface. This was demonstrated at Ruth Falls during bypass experimentation. The new bypass entrance extends to a depth of 6 feet only - the power canal is 12 feet deep. There are strong indications that louver panels could be just as efficient if their effective depth was also reduced to 6 feet. The reduction in bulk would permit the use of alternative structural supports more economical than the present system at Ruth Falls. Future louvers for Atlantic salmon smolts could be either floated or suspended.

The power intakes at Malay and Ruth Falls are very different in characteristics and perhaps are representative of the two most common situations encountered in the Province of Nova Scotia. The scope of louver deflection for Atlantic salmon smolts was defined as roughly the same as for chinook, coho and sockeye juveniles except for the approach velocity which should be greater. The louver principle is applicable to narrow fast flowing bodies of water where fish to be extracted must be actively guided to a bypass. Such was the situation in the Ruth Falls power canal.

In cases where there is no power canal or where the velocity in the canal is low, such as Malay Falls, louvers are not applicable. The smolt migrants trickle through the canal and concentrate in the narrow forebay area, just above the submerged draft tubes, obviously reluctant to sound the 12 foot depth to the turbine intakes. Preliminary results of experimentation at Malay Falls have indicated that the smolts would be readily attracted to a surface bypass (without active guidance) endowed with suitable hydraulics. The inherent simplicity of such bypass and the low volume of water required for its operation (approximately 15% of the volume required for louvers), make the "skimmer" principle very attactive. Skimmers would be applicable in 50% of Nova Scotia's hydro sites. In some cases, louver guidance and skimmer bypass might be advantageously combined.

The feasibility of transplanting adult salmon spawners to a barren but otherwise suitable stream has been demonstrated. If surplus stocks are available, it is an economical alternative to hatchery reared stock because it relies on the natural rearing potential of the stream. Furthermore, the survival rate of the progeny in the first years of the project exceed by far the normal survival rate in comparable streams. This phenomenon was observed at East River. It was probably a consequence of the initially low population density and correspondingly low intra-specific competition. As an example: 77 adult salmon (males and females) transplanted to East River in 1966 produced 4,000 two-year old smolts in 1969. Raised in a hatchery, the same number of smolts would have cost 1300 dollars. Their adult return potential would also have been less. In the adult transplant scheme the cost of the brood stock was in trapping and trucking only, since the fish were taken in the fall after both commercial and angling fisheries had taken their toll. The transplanted West River fish were surplus in the sense that they were not essential for reaching the maximum seeding level of that stream.

PROJECT EXPENDITURES

Capital Cost of Facilities

This table lists the capital expenditures made on the project and includes some items which pertain directly or indirectly to the assessment phase.

Cost of Brood Stock

West River Fence		$7,839.	
Fifteen Mile Stream Fence	(1968)	10,780.	
Fifteen Mile Stream Fence	(1970)	7,800.	
Share in Trucking Cost		2,000.	
		$28,419.	$28,419.00

Cost of Adult Return Trapping and Transport

Barrier Dam	(1965)	$23,000.	
	(1966)	5,326.	
	(1970)	435.	
Fishway	(1966)	63,219.	
	(1966)	7,554.	
	(1970)	9,400.	
	(1970)	2,000.	
Trucking	(1966)	4,150.	
		$115,084.	$115,084.00

Cost of Smolt Guidance

Louvers	(1966)	86,413.	
	(1966)	2,732.	
	(1967)	10,000.	
	(1970)	1,450.	
		$100,595.	$100,595.00

Total = $244,098.00

Yearly Operational Cost

The yearly operational cost for the typical assessment year of 1970 is presented below. Since the most expensive assessment procedures are scheduled to end in 2 or 3 years, the table also shows separately the figures for operation without assessment at present day costs.

	Primary	Operation & Assessment	Operations only
01	Casual Wages	$16,288.00 (3.8 man/year)	$6,786.00 (1.5 man/year)
02	Travel & Communications	6,695.00	1,000.00
05	Rentals	900.00	50.00
06	Purchases, Repairs & Upkeeps	260.00	240.00
07	Materials & Supplies	3,850.00	1,000.00
09	Equipment	3,250.00	200.00
		$31,243.00	$9,276.00

METHOD OF COST-BENEFIT ANALYSIS FOR COMPARING SALMON DEVELOPMENT PROJECTS

The objective is to derive a numerical ratio for each project which expresses the relation between costs and benefits for that project. The method used will be standardized so that valid comparisons can be made between projects.

Time Series of Costs and Benefits

The pattern of a development project over its life normally includes early capital expenditures followed by eventual build-up of benefits to a steady level at some later date. See Fig. 1. The steady flow of benefits is usually associated with an operating cost which is also fairly constant in the later years of the project. It is intended in this method to compare the annual benefit in these 'steady state' years with the annual cost. For our purposes the annual cost will comprise the sum of the operating cost and the amortization of the capital cost. To simplify the calculation, a year is chosen as the starting year of benefits, such that if the flow of steady annual benefit commenced in that year it would be of equal value to the sum of actual benefits. See Fig. 1. All costs incurred before this date shall be brought forward with appropriate interest charges to the starting date and totalled to make the capital cost. In addition, any subsequent anticipated capital costs should be discounted to the starting date and added to the capital cost.

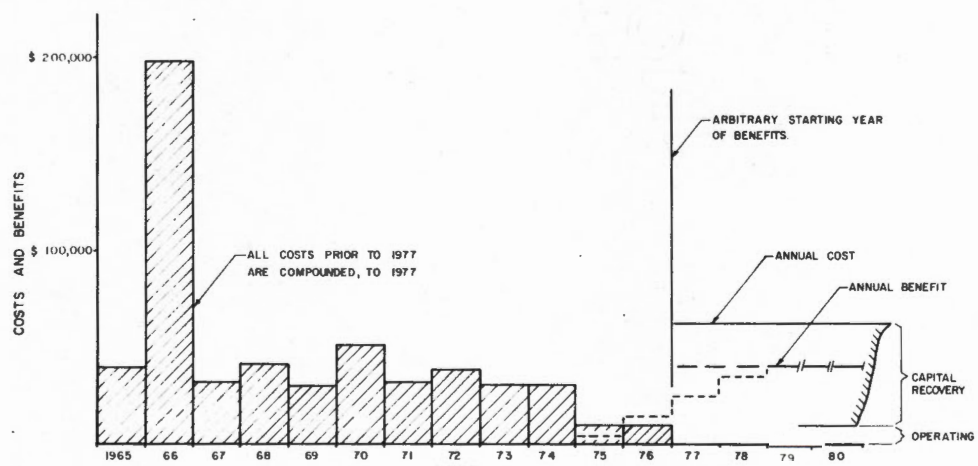

FIGURE I
EAST RIVER SHEET HARBOUR
BENEFIT : COST

Life of Project Structures

A life of 50 years is to be taken for all permanent concrete structures. Any equipment which is expected to require renewal within this period should be provided for, either in operating costs as a maintenance item or as mentioned above in the capital costs.

Rate of Interest

The reason for using a rate of interest in this analysis is to include the cost of having to make early capital expenditures to achieve later benefits. The whole calculation is to be made in constant value dollars, no allowance being made for inflation of costs or benefits. Under these conditions a lower interest rate than presently occurs in the market place is appropriate. (Spargo, 1961). Accordingly, a rate of interest equal to the cost to Canada of borrowing, less the rate of inflation, is chosen. This is calculated as follows:

Rate on Canada Bonds..................	8%
Less Rate of Inflation	3%
Rate of Interest for our Purposes	5%

Costs to be Included

All expenditures which are incurred in the project, or are necessary to produce the benefits, should be included.
Include: preliminary investigation costs
engineering and design costs
construction costs
operation and management costs
assessment costs

If scientific research is associated with the project, then the cost of this work should be included unless the research was not necessary for the successful completion and assessment of the project.

If the success of the project was not dependent on the research, then the costs and benefits of the research should be assessed separately.

It is not proposed to include opportunity costs such as the restriction of other fisheries developments on that river, or power lost in diverting water through fishways.

Another class of costs which could occur are risk of damage by introductions of exotic species, or diseases, or damage to the environment due to diversions or flow control. These risk factors are not included as it is assumed they have been shown to be negligible.

The value of lost production of agricultural or forest land, due to flooding, or of lost recreational property should be included in the costs.

Benefits

It is assumed that the benefits from the project to be evaluated can be estimated as a number of salmon to be caught in a commercial fishery and a number of salmon which can be taken by angling.

The value of fish caught in the commercial fishery is taken as the retail sales value if the fish are sold in the Province of origin, or as the export value if the fish are exported from that Province.

There are many difficulties in placing a dollar value on an angling fishery. The requirement for this analysis is to put a value on an increment to the fishery rather than to value the whole sport fishery. Therefore, the existing local intensity of fishing pressure is thought to be an important variable. The value of additional fishing waters is recognized, but as intensity of fishing expressed in anglers per day per mile of stream is generally far less than saturation intensity in the Maritimes, this is considered a less important variable.

The value of $15 per rod day was selected for the public fisheries of Nova Scotia and this results in a range of values per fish from $50 on the Stewiacke late-run fishery to $150 on the Saint Mary's River. Since a comparative ranking of salmon development projects is sought, the amount per day chosen is not critical.

This method of evaluating angling benefits is not considered suitable for valuing benefits which will be realized in privately leased angling waters. In those waters a higher daily figure may be applicable.

The value of salmon angled is computed as follows: An existing salmon angling fishery as near and similar to the development project fishery is taken as a reference fishery.

The number of rod days per fish angled in the reference fishery is calculated. Then the project angling benefit is as follows:

Benefit = No. of fish angled x rod days/fish x $15.

No separate benefits may be imputed to scientific research which was necessary for the success of the project. (Cost of other research has not been included).

EAST RIVER, SHEET HARBOUR, COST BENEFIT ANALYSIS

This analysis follows the outline of the previous section.

a. Selection of Arbitrary Starting Year of Benefits

Stocking of the East River system is being accomplished by adult transfer from West River. It is estimated that the first generation returns to East River will not occur in sufficient numbers to allow angling on these stocks. Experience with the first year's return has confirmed this. Consequently, it is estimated that angling benefits will occur from 1975 onward, reaching the normal level by 1979. The year 1977 was therefore selected as the mean starting year of benefits.

b. Annual Cost Detail Sheet

		Expenditure		Compound Interest Factor to 1977	Compound Amount to 1977
1965-66	Construction	23,000			
	"	6,150			
	*Engineering (20%)	6,000			
	*Biology	4,000			
		32,150	x	1.7958	70,300
66-67	Construction	7,839			
		5,326			
		63,219			
		7,554			
		86,413			
		2,732			
	*Engineering (10%)	17,000			
	*Biology	8,000			
		198,083	x	1.7103	339,200
67-68	Construction	10,000			
	*Engineering	2,000			
	*Biology	20,000			
		32,000	x	1.6289	52,100
68-69	Construction	10,780			
	*Engineering	5,000			
	*Biology	25,000			
		40,780	x	1.5513	63,400
69-70	Construction	5,000			
	*Engineering	2,000			
	*Biology	25,000			
		32,000	x	1.4775	42,200
70-71	Construction	16,000			
	*Engineering	5,000			
	*Biology	31,000			
		52,000	x	1.4071	73,100

*Estimated

		Expenditure		Compound Interest Factor to 1977	Compound Amount to 1977
	Brought Forward				640,300
71-72	[1]Engineering	3,000			
	Operation & Assessment	31,000			
		34,000	x	1.3401	45,600
72-73	[2]Construction	5,000			
	Engineering	2,000			
	Operation & Assessment[3]	32,000			
		39,000	x	1.2762	49,700
73-74	Operation & Assessment	32,000	x	1.2155	38,900
74-75	Operation & Assessment	32,000	x	1.1567	37,000
75-76	Operation & Assessment	32,000	x	1.103	35,300
76-77	Operation & Assessment	32,000	x	1.05	33,600
		Up to 1977...		Capital	$ 880,400
Mechanical equipment renewal (1990) $40,000 in 1990 discounted to 1977					
		40,000	x	.5303	21,200
				Total Capital	$ 901,600

[1] Prototype Skimmer built

[2] Skimmer Bypass installed at Malay Falls

[3] It is assumed that operation and assessment is continued at the 1970 level until the second generation return of salmon occurs.

c. Calculation of Annual Cost

Total capital expenditure compounded at 5% interest to 1977	=	$ 880,400
Future expenditure discounted to 1977	=	21,200
Total Capital	=	$ 901,600
Remaining life of facilities in 1977	=	40 years
Capital recovery over 40 years at 5% = .05828 x $901,600	=	$ 52,500
Annual operating cost estimated @		10,000
Total Annual Cost	=	$ 62,500

d. Calculation of Annual Benefit

The angling yield in Maritime streams normally represents 20 to 40 percent of the river escapement. Using a median figure of 30 percent, it is estimated that 325 fish will be available to the anglers each year in the operational phase of the project.

As a reference river, the West River, Sheet Harbour, is chosen. In 1967 to 1970 inclusive, a total of 6582 rod days were expended in catching 784 salmon according to Departmental records. This is an average of 8.4 rod days per fish. (This compares with a figure of 10 r.d./fish for the Saint Mary's River). The expected benefit is therefore 325 x 8.4 x $15 = $41,000 per year.

2. Calculation of Benefit/Cost Ratio

$$\frac{\text{Annual Benefit}}{\text{Annual Cost}} : \frac{41{,}000}{62{,}500} = 0.656$$

CONCLUSIONS

The East River project is now close to its turning point. The bulk of the costs are behind, the benefits ahead. On the evidence now available, the methods adopted have been vindicated on an individual basis. Transplanted broodstock have successfully reproduced, smolts have been guided and returning adults captured and transported. However, the analysis contained in this review indicates that the project as a whole must be considered an expensive means of producing salmon for the angler's creel. The reasons for this deserve further examination.

From its inception, the project was considered to be experimental in nature. The intangible benefits resulting from the project should therefore be noted.

- Methods of guiding downstream migrants, which are applicable to many situations in the region, have been adapted from methods proven with other species. As demands for multiple use of water grows, the requirement for such fish-from-water separation methods will increase.

- There are indications of a high probability of success in the use of a skimmer device for similar purposes, but under different hydraulic conditions from those which suit louvers.

- A considerable body of knowledge on dispersal behaviour of adult and juvenile salmon, and freshwater survival has been obtained from detailed records of the transferred broodstock and their progeny.

In planning future development projects, using the East River techniques, it would not be necessary to repeat the same procedures and incur the same costs. The same result could be achieved at lower cost by earlier heavy stocking of the headwaters. The earlier benefits would reduce the carrying charges on the capital expenditure. This was not possible under the conditions at East River, because suitable stocks were not available. An improvement in the performance of the project could be achieved even now if suitable stocks could be found to augment the present source of broodstock. Without the necessity to experiment, a more suitable scheduling of capital works would minimize carrying charges while the facilities remained virtually idle. The trapping and trucking works, and barrier dam, should probably have been built last instead of first. An improved version of the louvers could be built at less cost than the original set.

With the advantages of present knowledge, it is probable that East River could have been reclaimed for salmon production at a cost which would produce a benefit/cost ratio greater than one. (That is assuming the form of analysis used in this review). This would still be an expensive way of increasing salmon angling, reflecting the inherent high cost of developing small river systems typical of Nova Scotia.

LITERATURE CITED

Bates, Daniel W. and Russell Vinsonhaler, 1957, Use of Louvers for Guiding Fish. Trans. Am. Fish. Soc., 86:38-57.

Elson, P.F., 1957. Number of Atlantic Salmon Needed to Maintain Stocks. Canadian Fish Culturist, No. 21, 1957.

Spargo, R.A., 1961. Benefit-Cost Analysis and Project Evaluation, p. 299-310. In "Resources for Tomorrow" Conference in Montreal, Oct. 23-38, 1961. Vol. 1