

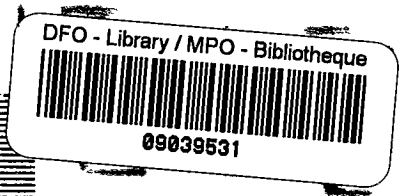
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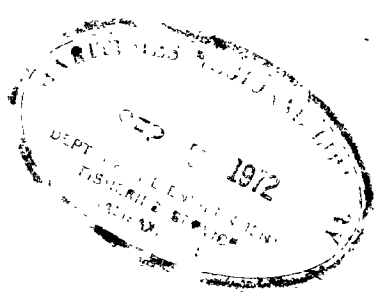


PROGRESS REPORT

No. 4

2979

Atlantic salmon (*Salmo salar*) rehabilitation in the East River, Sheet Harbour, Nova Scotia — Project description and initial results



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by

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Resource Development Branch
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Halifax, N.S.

AUGUST 1972

Progress Report

No. 4

ATLANTIC SALMON (*Salmo salar*) REHABILITATION IN THE
EAST RIVER, SHEET HARBOUR, NOVA SCOTIA
-PROJECT DESCRIPTION AND INITIAL RESULTS

by

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Resource Development Branch
Department of the Environment

Fisheries Service

Halifax, N. S.

July, 1972

C O N T E N T S

	P A G E
INTRODUCTION	1
HISTORICAL BACKGROUND	1
GENERAL DESCRIPTION OF THE DEVELOPMENT SCHEME	4
Source of Seeding Stock	4
Downstream Migrant Protection	7
Adult Collection and Transportation	7
PHYSICAL DESCRIPTION OF EAST RIVER	9
General	9
Obstructions	9
Flow	9
Pollution	11
PHYSICAL DESCRIPTION OF WEST RIVER	11
General	11
Temperatures	11
BIOLOGICAL DESCRIPTION OF EAST AND WEST RIVERS	12
Fish Population Investigation	13
Predators	14
Salmon Habitat Estimates	15
Estimates of Salmon Production Potential of East River	18
COLLECTION, TRANSFER AND DISTRIBUTION OF BROODSTOCK .	19
Facilities	19
Collection, Transfer and Distribution of Broodstock	22

C O N T E N T S

(cont'd)

	P A G E
COLLECTION, TRANSFER AND DISTRIBUTION OF BROODSTOCK (cont'd)	
Survival of Juveniles	25
Smolt Migration	25
Adult Returns	29
CONCLUDING REMARKS	30
ACKNOWLEDGEMENTS	30
LITERATURE CITED	31

INTRODUCTION

The Atlantic salmon run in the once-productive East River, Sheet Harbour, Nova Scotia (Fig. 1), has been virtually eliminated by the development of that river for hydro-electric generation. Since the early 1920's, hydro-electric stations and water storage dams have prevented adult salmon from reaching their upriver spawning grounds. This has caused the annual escapement to decline from an estimated 2,000 fish to a level of less than 100 fish in recent years.

The East River offered an excellent opportunity for the application of resource development techniques to the re-establishment of a self-sustaining salmon run. A salmon rehabilitation project was initiated in 1961. The project involved the transportation of brood stock, the provision of facilities to permit both access to the upriver spawning grounds and the protection of seaward-migrant juveniles from passage through the powerhouse turbines.

This report gives background to the project, describes the facilities and their effectiveness, and provides preliminary information on the results of adult salmon transplantation.

HISTORICAL BACKGROUND

The decline of the East River salmon runs began over 100 years ago with water usage for log drives and saw-mill operations. At that time, reports to the Government of Nova Scotia commented on the detrimental effects to salmon of 2 large dams, one at the head of tide and one 12 miles upstream on the Fifteen Mile Stream (Vieth, 1868). After the large dam at the head of tide was removed (date unknown), the salmon runs to the river gradually increased (Rutledge, 1954). Written records of past salmon stocks are lacking, but older local residents contend that East River became one of the best angling rivers in Nova Scotia. Later, in the early 1920's, the Nova Scotia Power Commission began harnessing the East River for hydro-electric purposes. The first of three major dams, Malay Falls (Fig. 2), was built in 1922. A diversion dam and a short power canal served to increase the water head to 43 feet. Malay Falls is situated approximately 5 miles from tidal limits. A second diversion dam was built in 1924 at Ruth Falls (Fig. 3), 1.5 miles from head of tide. The dam and a side-hill canal, running parallel to the natural river course for 8,000 feet, produced a static water head of 110 feet. A third dam, strictly for water

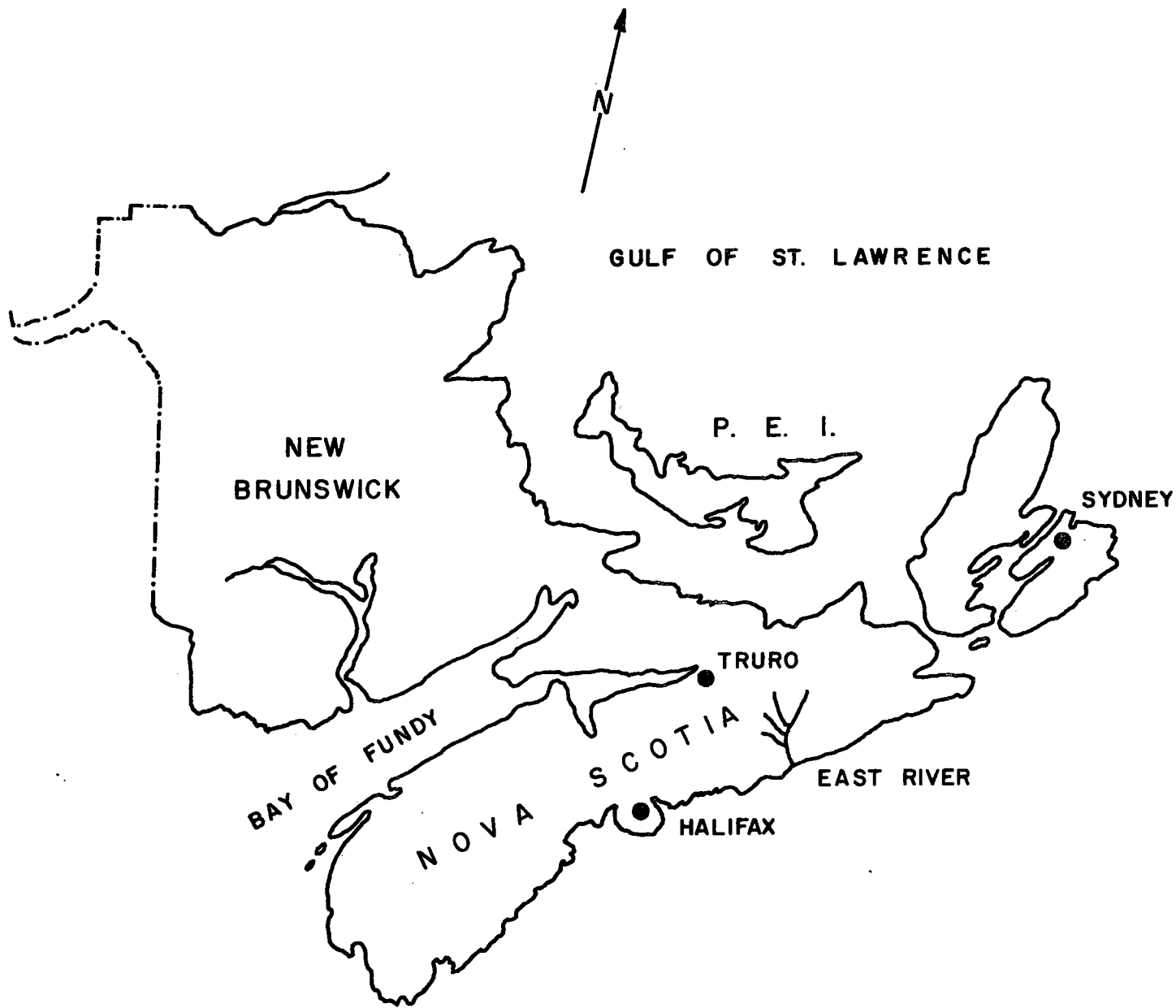


Fig. 1. Location of East River, Sheet Harbour, Nova Scotia

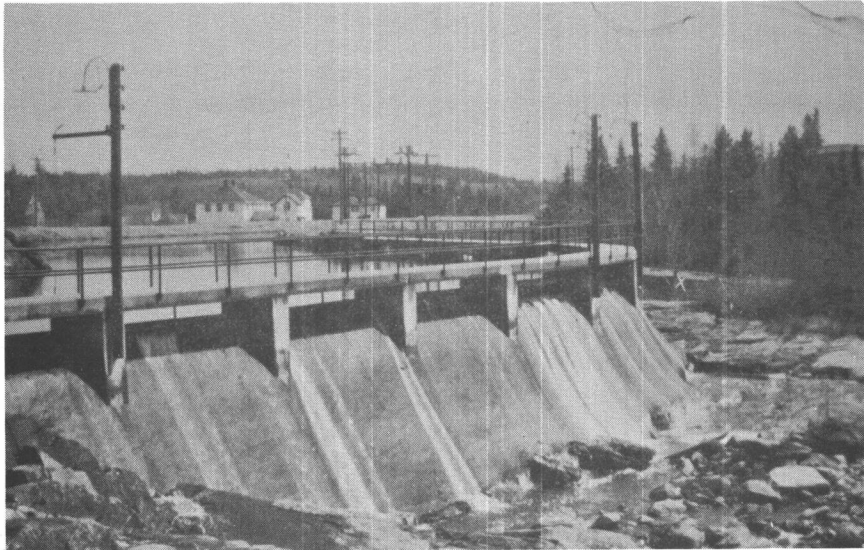


Fig. 2. Malay Falls Diversion Dam, East River, Sheet Harbour, built in 1922.



Fig. 3. Ruth Falls Dam, East River, Sheet Harbour, built in 1923 and rebuilt in 1964-65.

storage purposes, was built in 1928 at Marshall Falls, less than 1 mile upstream of Malay Falls dam. Fishways were incorporated in both Malay and Ruth Falls dam, but no facility was built at Marshall Falls, even though the dam was a total obstruction to salmon at most water levels. This rendered the Malay Falls fishway virtually useless since no salmon habitat existed in the river section between the two obstructions. The Ruth Falls fishway continued operating until the reconstruction of the dam in 1964. The East River salmon run had then declined from an estimated 2,000 to approximately 70 fish per year. By 1965, salmon had been eliminated from the watershed upstream of Malay Falls which harbours approximately 95% of the potential salmon habitat in the system (Fig. 4).

Ten intermediate water storage dams were placed in the upper reaches of the tributaries during the period (1924-1930). Six were breached in the interim, and 3 more will be removed as they become unsafe (Table 1). Recently, a large storage dam (Anti-dam 1966), located approximately 12 miles from tidal limits on the Fifteen Mile Stream, was re-constructed.

The reconstruction of Ruth Falls dam in 1964 and the announcement by the Nova Scotia Power Commission that the total storage in the system would be limited to Ruth Falls, Marshall Falls and Anti dams provided an opportunity for the Branch to develop and initiate a plan for the rehabilitation of the Atlantic salmon run.

GENERAL DESCRIPTION OF THE DEVELOPMENT SCHEME

To re-establish an Atlantic salmon run in the East River system, it was necessary to (1) find a suitable source of stock to initiate a new run, (2) protect the seaward smolt migration from the hazards of turbines at the two power stations, and (3) provide adult salmon access to the upriver spawning and rearing areas.

Source of Seeding Stock

Two sources of stock were considered for simultaneous use in the restoration of the East River salmon run: (1) adult salmon transported from the nearby West River, Sheet Harbour; and, (2) available hatchery-reared juveniles from non-local (early-run New Brunswick) stock. In view of the difficulties of keeping the returning adults of 2 different stocks identifiable for assessment purposes, it was decided to use only the adult salmon from West River. This decision was

Table 1. A listing and description of man-made obstructions in the East River watershed, Sheet Harbour, N. S.

Name	Type	Location	Comments
Ruth Falls	Concrete gravity dam, power canal and powerhouse	Mainstem	Total barrier
Malay Falls	Concrete gravity dam, power canal (short), and powerhouse	Mainstem	Total barrier
Marshall Falls	Earth-fill dam, concrete gateway and spill section	Mainstem	Total barrier
Anti Dam	Earth-fill dam, concrete gateway and spill section	Fifteen Mile Stream	Partial barrier, rebuilt in 1966.
Union Dam	Earth-fill dam, wooden gateway and spill section	Twelve Mile Stream	Breached in 1964 (approx.)
Seloam L.Dam	Earth-fill dam, wooden gateway	Fifteen Mile Stream	Breached
Grassy L.Dam	Earth-fill dam, wooden gateway	Ten Mile Stream	Breached
Mulgrave L.Dam	Earth-filled dam, wooden gateway	Mulgrave River	Breached
Como L. Dam	Earth-fill dam	Mulgrave River	Breached
Grant River Dam	Earth-fill dam	Grant River	Breached
Governor L.Dam	Wooden cribworks and gateway	Twelve Mile Stream	Partial barrier
Ten Mile L.Dam	Wooden cribworks and gateway, earth-fill wing	Ten Mile Stream	Partial barrier

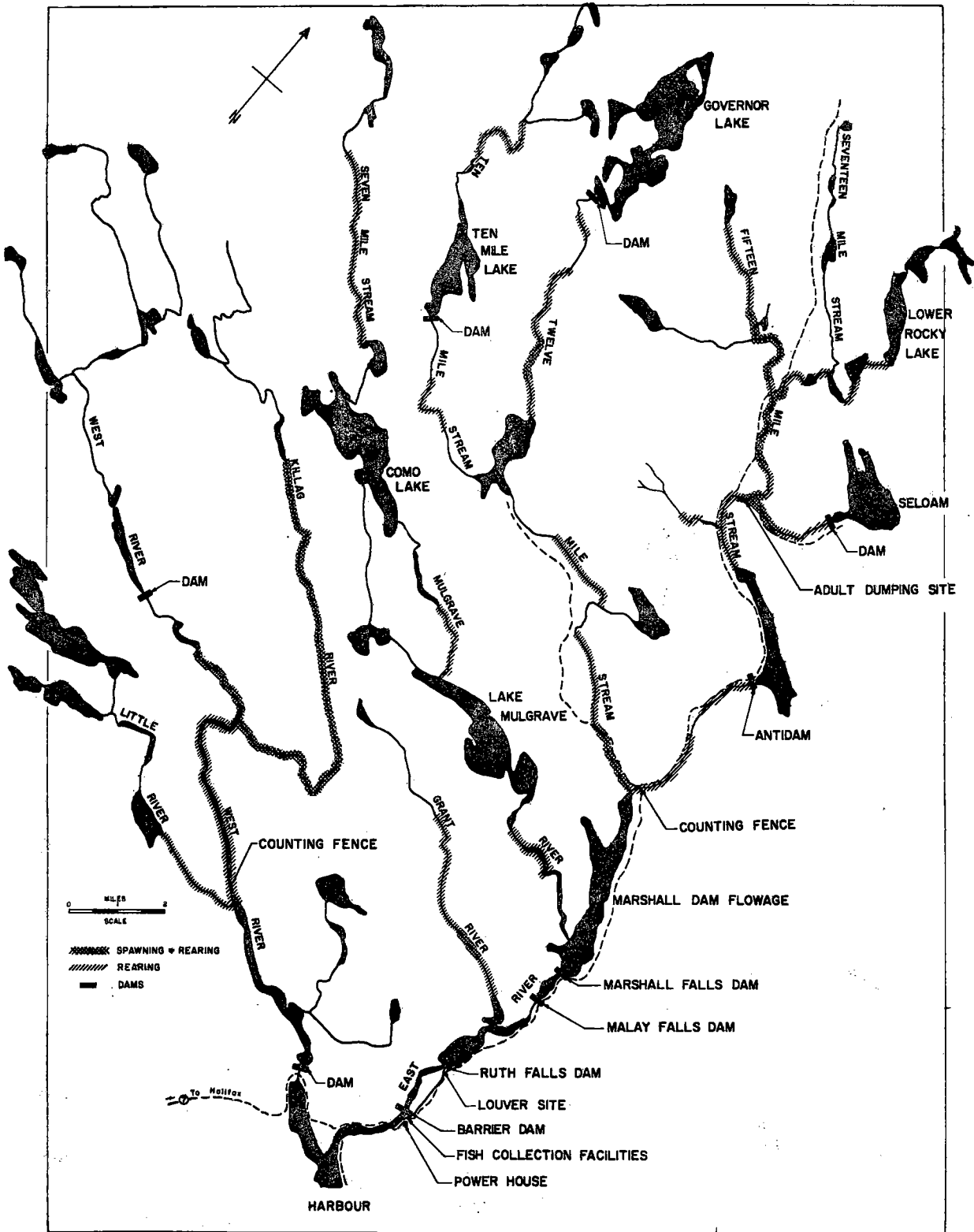


Fig. 4. Map showing the locations of obstructions and the distribution of salmon habitat in the East and West River System, Sheet Harbour, Nova Scotia.

made on the basis that East and West Rivers are very similar in their physical characteristics and the assumption that the original native salmon stocks were once also genetically similar. The adult transplant method also allowed the fish to spawn naturally and their progeny to be exposed during all stages of fresh-water life to the natural conditions of the stream. It was assumed that the returning adults would home to East River.

Downstream Migrant Protection

Smolt migrants were expected to migrate through the power canals rather than over the spillways at Malay and Ruth Falls power stations. The period when water is allowed to spill from the diversion dams on the East River is relatively short and does not coincide with the major period of smolt migration. Louver deflectors were selected to prevent fish from entering the turbines, where mortalities in the order of 10-25% were expected (Cramer and Oligher, 1964). The louver system is still in the experimental stage, particularly where Atlantic salmon smolts are concerned, but high guiding efficiencies have been obtained under test conditions with Pacific salmon species (Ruggles and Ryan, 1964; Bates and Vinsonhaler, 1957). Louver deflectors were considered to have the following attributes: (1) high guiding efficiency; (2) minimum of physical contact with smolts; (3) high tolerance of flow variations; and (4) relatively low maintenance cost and sturdiness.

A V-shaped array of louvers was installed in the upstream end of Ruth Falls power canal in 1966 (Fig. 5). It was also planned that should a guiding system be needed at Malay Falls, consideration would be given to the use of louvers, provided the Ruth Falls installation was satisfactory.

Adult Collection and Transportation

Conventional fishways for adults were deemed uneconomical because of the multiplicity of obstructions, and impractical because of the migration delay which would likely be imposed by the existence of three fishways and headponds. A trapping and trucking system (Fig. 6) was adopted to convey fish safely around the obstructions and to those locations best suited for reproduction or angling purposes. This was constructed in 1966. Fish trapped at the head of tide would be transported overland (approximately 6 miles) to the Marshall Falls impoundment, and would have access to any of East River's three main tributaries. Anti dam on the Fifteen Mile Stream does not constitute an obstruction to Atlantic salmon from August to October as the control gate is left open to allow the natural flow of the river through the dam.

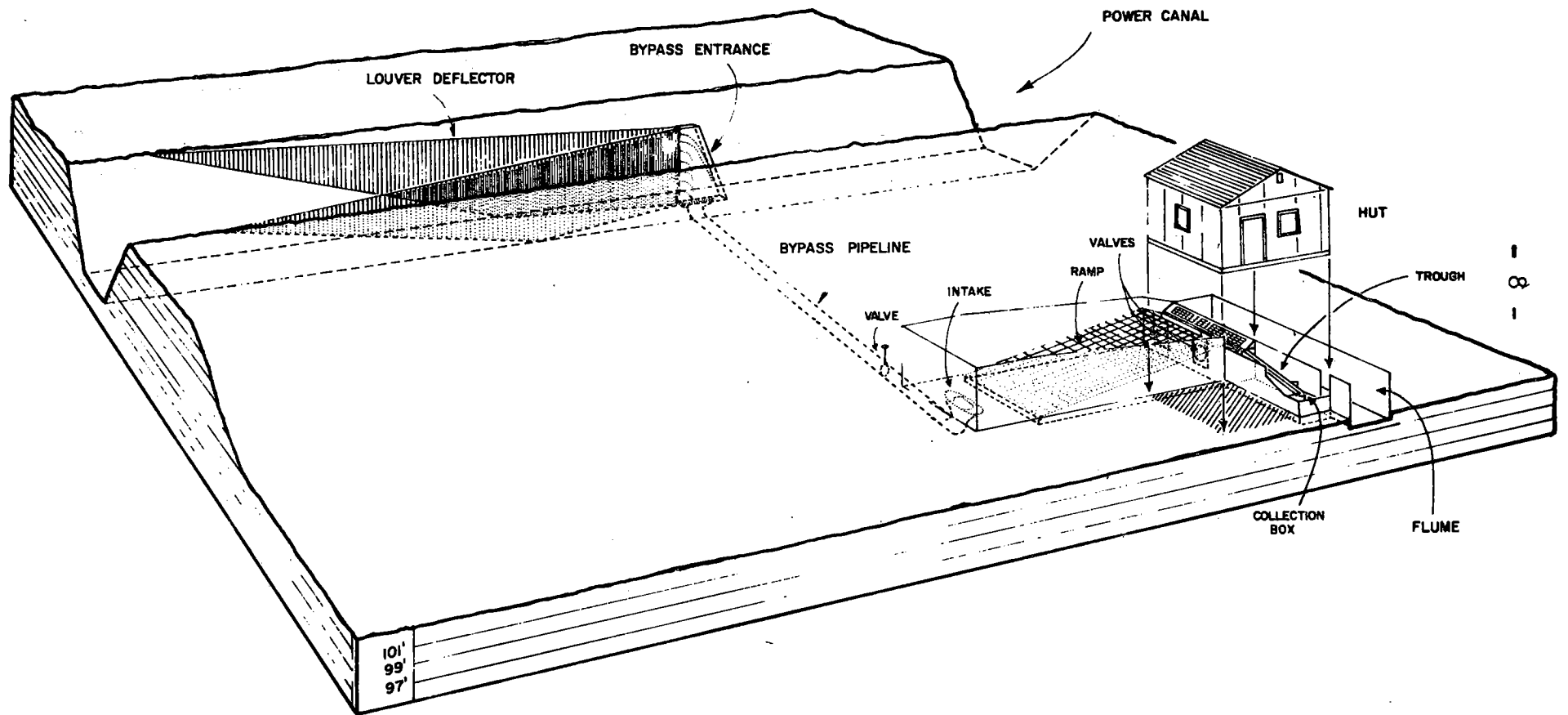


Fig. 5. Three-dimension diagram of the Ruth Falls louver deflectors, by-pass, Wolf trap, and fish counting facilities' details.

PHYSICAL DESCRIPTION OF EAST RIVER

General

The East River is formed by the confluence of two major streams 10 miles from salt water (Fig. 4). It flows south on the eastern seaboard of Nova Scotia within Halifax County. The total catchment area of the system is 250 square miles. From headwaters to head of tide, the river descends 700 feet and travels through some 28 miles of heavily-forested country. The drainage basin lies on sedimentary rocks of the late Precambrian, known as rocks of the Meguma (or gold-bearing) formation. These rocks include two formations, the Halifax (upper) and Goldenville (lower). The hard beds of quartzite and slate of these formations yield water with low conductivity (20 to 70 micromhos/cm). All salmon habitats are situated in the tributary streams. The main trunk of the river is lost to Atlantic salmon production because of extensive impoundment. Roughly 40 miles of stream are contained in 3 major tributaries. There are 11,276 acres of open water in 8 of the largest lakes and flowages, not including the abundant still water areas found in all parts of the East River system. This extensive network of lakes, impoundment, stillwaters and riffles is the striking feature of the East River system.

Obstructions

All major obstructions on the river are man-made and strictly related to hydro-electric development. Of the original 13 dams in the system (Table 1), only 7 remain. Of these, 3 are located in minor tributaries and do not interfere with migration of Atlantic salmon. These will be breached as they become unsafe.

There is a 10 foot natural falls at the mouth of the Fifteen Mile Stream. It constitutes a partial barrier during low water level periods. No plans have been made to remove this obstruction. Several rapids exist on the lower reaches of the Twelve and Fifteen Mile Streams, but are not expected to impede fish migrations. There is little beaver activity in the East River system.

Flow

Considerable flow variations occurs in the system during the course of a year, but the total mean monthly discharge has not been recorded below 250 c.f.s. (1915-1923). Data accumulated through the years 1915 to 1923, prior to the

harnessing of the river for hydro purposes, is presented in Figure 6; it shows that maximum discharge occurs in early April following spring thaws. A second peak occurs in December after heavy precipitations. During this period, the extremes recorded were: Maximum: January 5, 1918 - 8, 550 c.f.s.; Minimum: September 16, 1921 - 21 c.f.s.

Water is liberated through the gates at Ruth and Malay Falls dams when the river discharge exceeds the maximum combined capacity of the turbines at each station, and water storage at Marshall and Ruth Falls reservoirs is no longer possible. This limit is approximately 1200 c.f.s. for Ruth Falls (3 turbines), where the water carrying capacity of the power canal limits the rate at which water may be drawn from the reservoir. Ruth Falls also receives the discharge from 17.5 square miles of uncontrolled drainage from the Grant River. The maximum turbine discharge capacity of Malay Falls (3 turbines) is slightly higher at 1,280 c.f.s., and spillage there is always of short duration if it occurs.

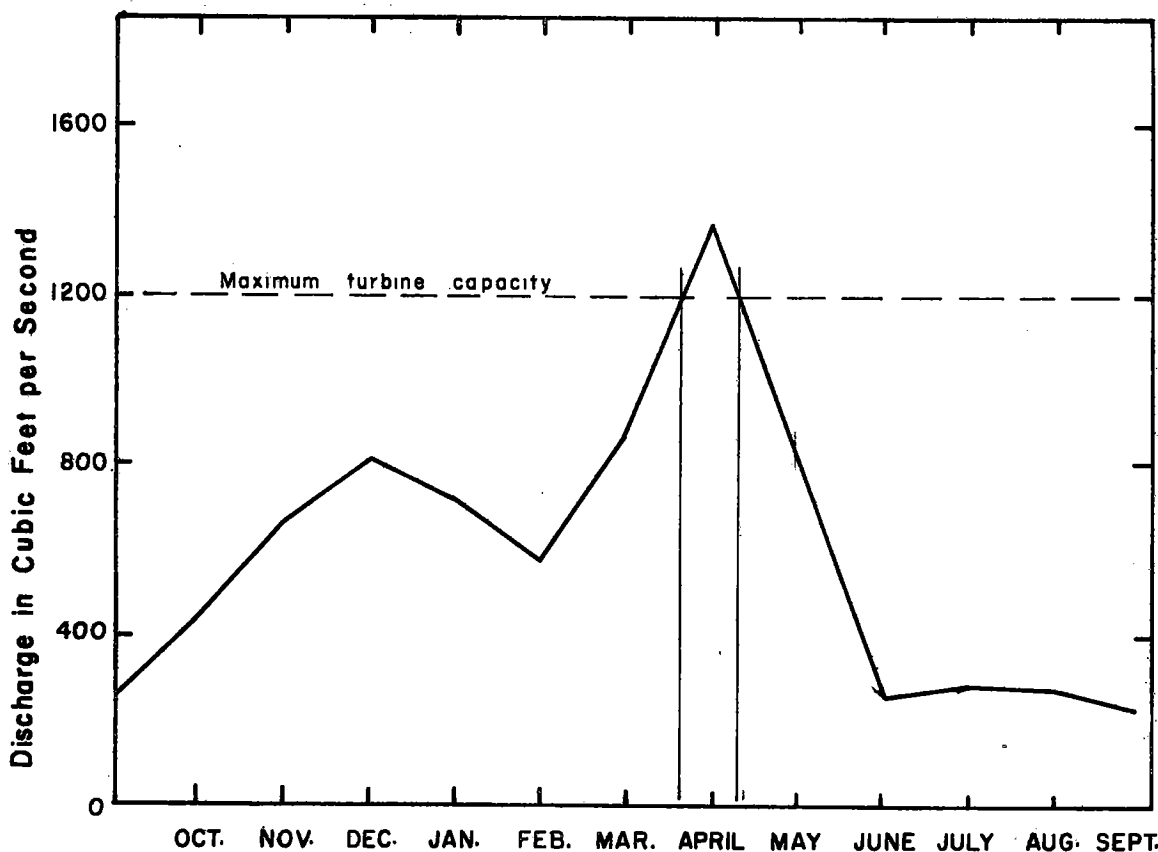


Fig. 6. Mean monthly discharge of East River, Sheet Harbour, recorded below Malay Falls from 1915 to 1925. Drainage area above gauging station was 216 square miles.

Pollution

The only evidence of pollution in East River is the presence of sawdust piles, these being remnants of old saw mills which were found along most tributary streams as well as along the main river. One sawmill is still in operation on the headwaters of the Twelve Mile Stream, but there is no evidence of sawdust in the stream.

PHYSICAL DESCRIPTION OF WEST RIVER

General

The West River flows southeasterly into the north-west arm of Sheet Harbour (Fig. 4). Twenty-six miles in length, it drains an area of 104 miles of forested country and descends approximately 600 feet from headwaters to head of tide. Five miles from saltwater, the river broadens to form a long, shallow lake. In the early 1900's, the lake level was elevated by the presence of a dam at the crest of the West River cascades, 500 yards from saltwater. Of the 3 main tributaries, the Killag River is the most important for salmon production because of its excellent spawning grounds. The geology of the West River drainage basin is virtually the same as that of the East River.

A portion of the West River discharge is diverted through a pulp mill situated at the mouth of the river. Consequently, water storage dams have been constructed at various points in the system. The largest is Beaver Dam, located on the main stem of the river 12 miles from saltwater (Fig. 4). It prevents salmon from gaining access to 11 miles of potential salmon-rearing water. The dam was built prior to 1919 (exact date unknown) and no fish passage was ever provided. The remaining 25 miles of stream in the watershed is presently utilized by salmon.

Temperatures

Daily minimum and maximum water temperatures were recorded at the West River counting fence during 1966, 1967 and 1968, from April to December. The highest temperature on record was 29°C (84°F), and temperatures of 24-27°C (75-80°F) were reached on several days during the month of July (Fig. 7). The highest temperatures were recorded at mid-day. Since Dymond (1963) gives lethal temperatures of 30.5°C (86.9°F) for salmon fingerlings and 28-29.5°C (82.4-85.1°F) for adults, water temperature is not considered a limiting factor to salmon production in the Sheet Harbour Rivers. The drainage basins of

these rivers are well forested, and large natural lakes and man-made reservoirs help regulate the flow during summer, which indirectly favourably influences temperatures.

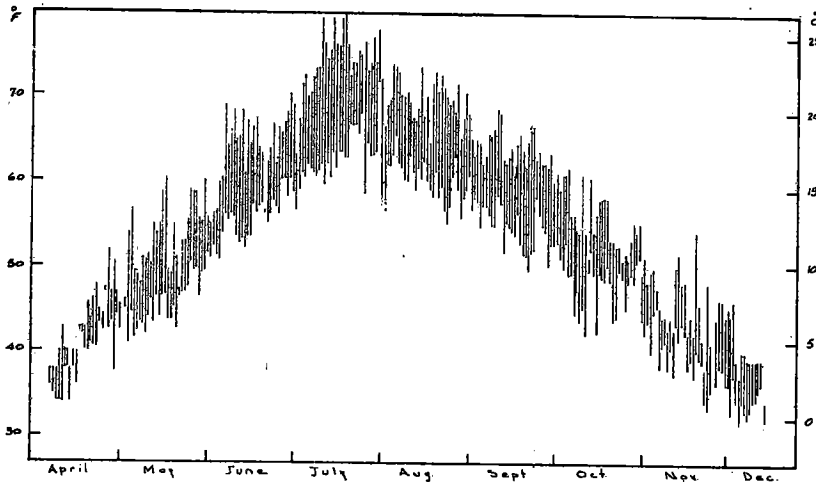


Fig. 7. Daily stream temperature variations at West River Counting Fence, Sheet Harbour, Nova Scotia, 1966-1968

BIOLOGICAL DESCRIPTION OF EAST AND WEST RIVERS

A biological survey was conducted on the East River and West River systems in 1965. The objective of the biological survey was to delimitate and estimate the extent of salmon habitat in the East River system. Because of the lack of biological data on the East River salmon in pre-hydro days and for comparison purposes, the surveys were extended to include the adjacent West River. To help estimate the salmon production potential of the East River, the West River Juvenile salmon population was studied, by means of electro-fishing, to determine population density and age composition. The East River, known to be devoid of salmon was also investigated by electro-fishing to determine the fish species present, in particular the abundance and distribution of brown trout (*Salmo trutta*) which was introduced into the watershed in 1956. Investigations of the West River smolt and adult runs also provided valuable information on the life history of Sheet Harbour salmon.

Fish Population Investigation

A study of fish population density of the East and West Rivers was carried out annually from 1965 to 1968. The investigation had a dual purpose: (1) to establish the presence and abundance of fish species occupying salmon habitat in East River; and (2) to obtain quantitative information on the juvenile salmon population of the neighbouring West River.

A direct current electro-fishing unit similar to that described by Smith and Elson (1950) was used. The area under study was enclosed by fine mesh nets to prevent both escape and recruitment. Fish were collected in 5 consecutive sweeps of the enclosed area. Data was submitted to the catch/effort estimate method described by Delury (1951) to estimate population densities.

In 1965, the entire East River system, except the Grant River tributary, was devoid of salmon juveniles. On the rearing grounds of Twelve and Fifteen Mile Streams, the normal cohabitants with Atlantic salmon were found in low densities (Table 2). Juvenile suckers (*Catostomus commersoni*) were present in large numbers in both river systems, but due to their very small size it was impossible to obtain a reliable estimate of density. Eels (*Anguilla Americana*) were scarce in the East River, evidence that the obstructions at Ruth, Malay and Marshall Falls have prevented most migrants of this species from reaching the upper sections of the river. Brown trout were also not very abundant in the East River.

Table 2. A comparison of fish population densities of species inhabiting salmon habitat in West River and East River, Sheet Harbour, N. S. in 1965.

Stream	Number of fish per 100 sq. yds.				
	Speckled Trout	Brown Trout	Eels	Northern Lake Club	Stickleback
West River (all stations)	0.0	0.0	1.1	7.0	0.4
East River (all stations)	0.7	0.1	0.2	6.6	0.4

The West River rearing grounds were populated at an average rate of 40 fry and 5 parr per hundred square yards. This was a substantial departure from the normal densities established for the Stewiacke River (Carey, MS, 1968) (Table 3). Since one and two-year-old parr were not readily distinguishable on the basis of size, the parr densities derived from the Stewiacke River and West River (Table 3) include both age classes. The comparatively high fry density and low parr density in the West River may be due to bias in selection of the sampling stations. A good cross-section of the West River salmon parr habitat was difficult to obtain due to a lack of access roads.

Table 3. Comparison of salmon juvenile population density in West River, (Sheet Harbour), N.S., with that in the Stewiacke River, N.S.

Stream	Number of fish per 100 square yards	
	Fry	Parr (2 year classes)
Stewiacke River	29.0	12.3
West River (Sheet Harbour)	40.0	5.0

Electro-fishing was carried out at low river flows. The abnormal fry to parr ratio may also be due to a temporary migration of the larger fish from the shallow riffles to the pools. A portion of the West River parr population may migrate downstream to the Sheet Harbour Lakes. Such a migration was observed at the West River fence in 1966 and 1967, coinciding with spring smolt migration. The parr migrants were Age 1 and 2 (smolt migrants were Age 2 and 3), and in colouration and size were not at all similar to smolts.

Predators

There were several potential predators which could affect salmon juveniles in East River, including brown trout, the American eel, mergansers, kingfishers, sea gulls and cormorants.

However, no efforts will be made to control predator populations because they are present only in small numbers.

Salmon Habitat Estimates

In the survey of salmon habitat, pertinent information was recorded on flood levels, obstructions, watershed characteristics, stream bottom composition, gradient, velocity, depth, width, pool frequency and protective cover of all sorts.

The estimate of potential salmon habitat in the East River was based on both previous descriptions of such habitats (Belding, 1934; Jones, 1959), and the practical knowledge acquired from the study of juvenile populations in the West River. The term "salmon habitat" includes spawning and rearing areas. Stream sections with a gentle gradient (velocities of 0.5 - 1.5 ft/sec) and clean gravel ranging from 1 to 3 inches in diameter and interspersed with a few large stones, were classified as potential spawning grounds. Loose, moving gravel (lacking the larger stones) which had accumulated on the inside of river bends was not included in the estimates. Stream sections with a steeper gradient (1.5 - 3.5 ft/sec), where the bottom composition ranged from coarse gravel to small boulders, were classified as rearing areas.

In West River, excellent rearing grounds were found in the mainstem between Beaver Dam and the Sheet Harbour Lakes (Fig. 4; Table 4). Spawning grounds are plentiful in the middle and lower Killag River. Four years of observations on the West River spawning escapement have shown that most of the spawning takes place in the Killag River. There is an estimated 24,600 square yards of salmon habitat upstream of Beaver Dam.

Table 4. A summary of salmon habitat distribution in the West River, Sheet Harbour, watershed.

Stream Section	Area in number of square yards			Salmon Habitat as a percent of total stream area
	Spawning	Rearing	Pools and stills	
West River Main				
Upper	Scattered	24,000	47,000	60%
Middle	29,300	167,200	--	
Lower	--	--	--	
Killag River				
Upper	Scattered	63,400		36%
Lower	31,700	31,700	18,800	
Black Brook	Scattered	5,900	--	
Little River				
Upper		Unutilized	--	4%
Lower	Scattered	16,400		
TOTALS	61,000	309,200	65,800	100%

In East River, all salmon habitat is located within the tributaries (Fig. 4; Table 5). Extensive spawning areas are located in the Fifteen Miles Stream above Anti Dam, at Anderson Intervale. Excellent rearing grounds are located between Anti Dam and the mouth of the stream. In the Twelve Mile Stream, the spawning area is generally more evenly distributed than in the Fifteen Mile Stream. In all other tributaries, the spawning grounds are scattered and less abundant. In East River, frequent deep pools and long stillwater stretches provide good resting areas for adults and some stabilizing effect on the stream's discharge.

The East River contains roughly twice as much spawning and rearing area as the West River (Table 4 and 5) and a considerably higher proportion of pool area. Under certain circumstances, Atlantic salmon parr may take up residency in stillwater and pool areas (Dymond, 1963). The available information on hand from West River is too incomplete to draw any conclusions.

However, even if the level of salmon production in pools is below that in riffle areas, pool areas could still contribute substantially to salmon smolt production in East River.

Table 5. A summary of salmon habitat distribution in the East River, Sheet Harbour, watershed.

Stream Section	Area in number of sq. yds.			Salmon habitat as a percent of the total stream area
	Spawning	Rearing	Pools and Stillwaters	
Fifteen Mile Stream				
Upper	22,000	14,800	12,900	
Middle	21,800	66,000	17,600	
Lower	7,000	105,600	44,000	39%
Rocky Lake Outlet	1,200	14,100	14,600	
Seloam Lake Outlet	Scattered	5,900	5,900	
Bear Brook	Scattered	4,500	--	
Twelve Mile Stream				
Upper	3,500	51,700	34,000	
Middle	Scattered	49,300	90,900	39%
Lower	40,900	122,500	25,500	
Ten Mile Stream				
Upper	Scattered	23,500	45,800	
Lower	Scattered	17,600	65,700	6%
Mulgrave River				
Upper	Scattered	47,000	28,200	
Middle	Scattered	18,800	31,700	11%
Lower	Scattered	10,900	82,200	
Grant River	Scattered	32,300	28,200	5%
TOTALS	96,400	584,500	527,200	100%

Estimates of Salmon Production Potential of East River

Little is known about the salmon rearing capacity of Nova Scotia rivers. Elson (1962), working on two New Brunswick rivers, found that without protection from predation by mergansers, the rate of production in these streams ranged from 1 to 2 smolts per 100 square yards. The average survival rate from smolt to returning adult given by Elson (1957) is 8 per cent.

Nova Scotia rivers tend to produce a higher percentage of two year old smolts than most New Brunswick rivers. (Table 6).

Table 6. Smolt age distribution from six Maritime Streams

Stream	Age Classes (Percent)				
	1	2	3	4	5
West River, N. S.	0.	48.7	50.8	0.7	0.
Stewiacke River, N.S. ¹	0.	82.5	17.5	0.0	0.
Medway River, N. S. ¹	1.3	89.5	7.3	0.4	0.4
Miramichi River, N. B. ¹	0.	15.1	78.1	6.6	0.2
Big Salmon River, N. S. ¹	0.	45.0	55.0	0.0	0.0
Restigouche River, N. B. ¹	0.	18.8	74.1	7.0	0.0

1. T. G. Carey, MS. 1968.

This may result in a higher egg-to-smolt survival. The estimate of East River salmon run based on Elson's survival rates would be approximately 1090 fish (river escapement). Since Elson's rate is given for the stream as a whole, the East River run estimate is considered minimal as only the rearing and spawning area was used in the calculations. No prediction was made concerning the contribution of extensive pool, stillwater and lake areas in the East River system.

At West River, Sheet Harbour, fence counts of the smolt and adult runs have not corroborated Elson's production rate of two smolts per hundred square yards and adult sea survival of 8%. The West River average smolt production rate (1966-1969 inclusive) was 0.54 smolt per unit of rearing area (100 sq. yds.), the average adult survival for that period was 19% of smolt output. The estimation of East River run based on West River's survival rate would be approximately 700 fish.

COLLECTION, TRANSFER AND DISTRIBUTION OF BROODSTOCK

Facilities

In order to obviate the dams between the estuary of East River and the spawning areas, it was decided to transport fish by truck from Ruth Falls to Marshall flowage approximately six miles upriver. Associated trapping facilities were constructed in August 1966, and completed in December of that year. The structure was built adjacent to the Ruth Falls power house and the tailrace (Fig. 8). A concrete vertical slot fishway consisting of 9 pools attracts fish from the tailrace. The standard fishway pool size is 7 x 9 feet. With a vertical slot opening of 12 inches, this size combination was found to be most satisfactory when tested with the aid of hydraulic models on the Canadian West Coast (Clay, 1961). The water supplied to the fishway is drawn from the power canal in 2 stages: (a) from the downstream end of the power canal to a small open reservoir or energy dissipator, and (b) from the reservoir to the trapping facilities via an underground 18" transite pipe branching off in three separate outlets to the three upper pools of the fishway. An auxiliary pump set in the trailrace can deliver an additional 15 cfs to the fishway.

The upper two pools are modified to trap and hold fish for transportation upriver. Trapped fish are hoisted out of the pool in a 200 gallon "hopper" and unloaded into the fish transport unit. The lifting device consists of a 2 ton capacity hoist electrically operated and running on a steel monorail supported by two steel A-frames.

Seventy-three salmon entered the fishway in 1967 and 1968. Observations made on rate of passage through the fishway to the brail pool indicated several faults related to flow conditions in the brail pool, and flow through the vertical slots of the standard pools. Initially, the brail pool received water from two 10 inch pipes set at the bottom of the pool. Flow diffusers installed over both inlet pipes failed to eliminate the resulting high water turbulence. Strong upwelling in the brail area caused adult fish to retreat downstream. This problem was eliminated by: (1) re-routing one of the 10" pipes

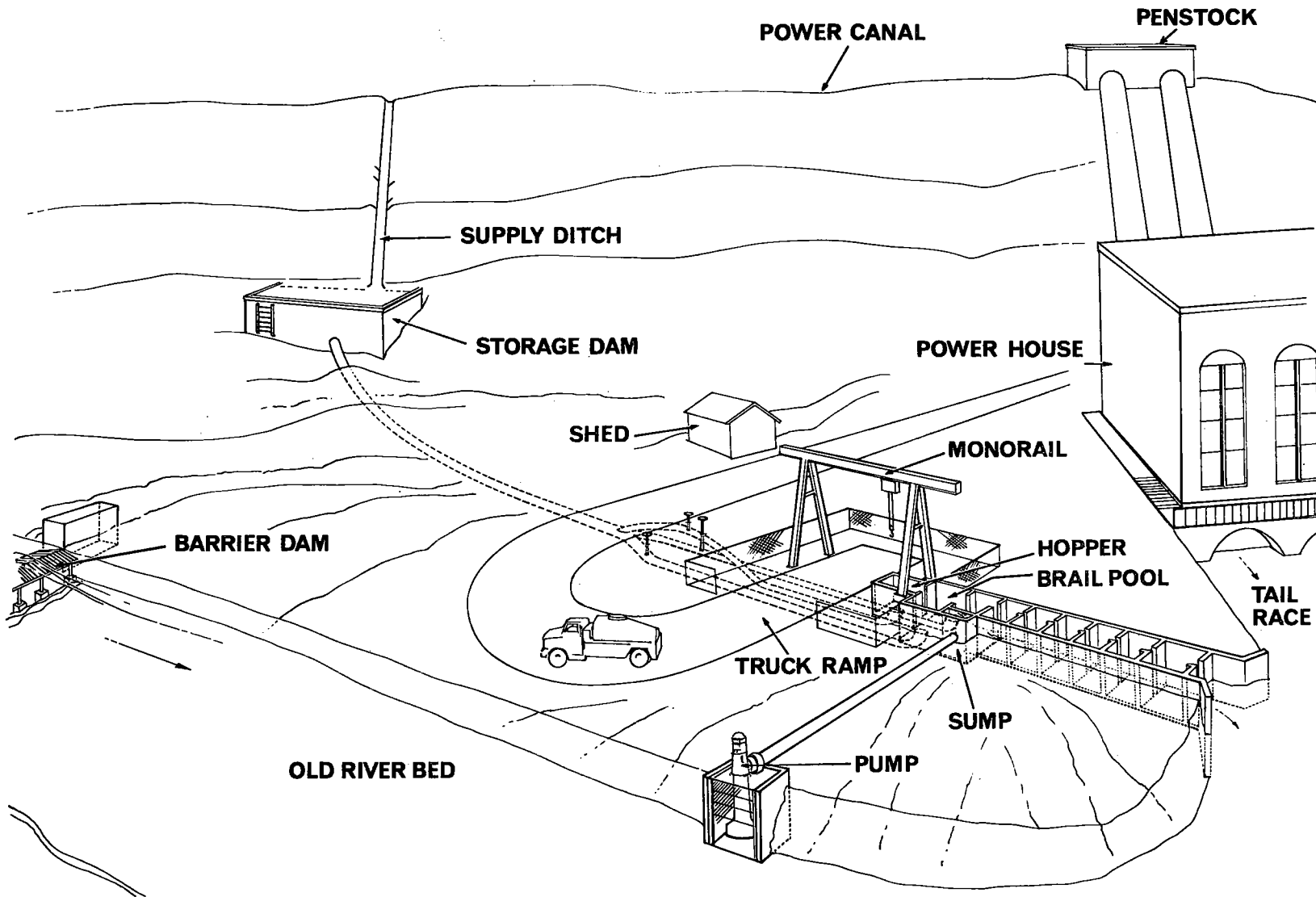


Fig. 8. Three-dimensional diagram of the Ruth Falls trapping and trucking facilities.

to the pool below the brail pool, which also had the effect of reducing the water level differential between the two pools; (2) by installing an improved flow diffuser over the remaining inlet pipe in the brail; and (3) by reducing the width of the weir opening at the outlet of the brail pool and installing adequate finger traps to prevent fish from returning downstream. Adult salmon now gain access to the brail area by leaping the 18-inch water fall over the brail pool weir. The sill at the bottom of each of the seven vertical slots was also raised to provide a quiet area and further reduce the height of jump over the brail pool weir.

To prevent adult salmon from migrating into a two mile long cul-de-sac above the Ruth Falls fishway, a small concrete gravity dam was erected across the old river bed at the head of tide. This barrier dam is equipped with steel racks preventing fish from leaping over the obstruction (Fig. 9).

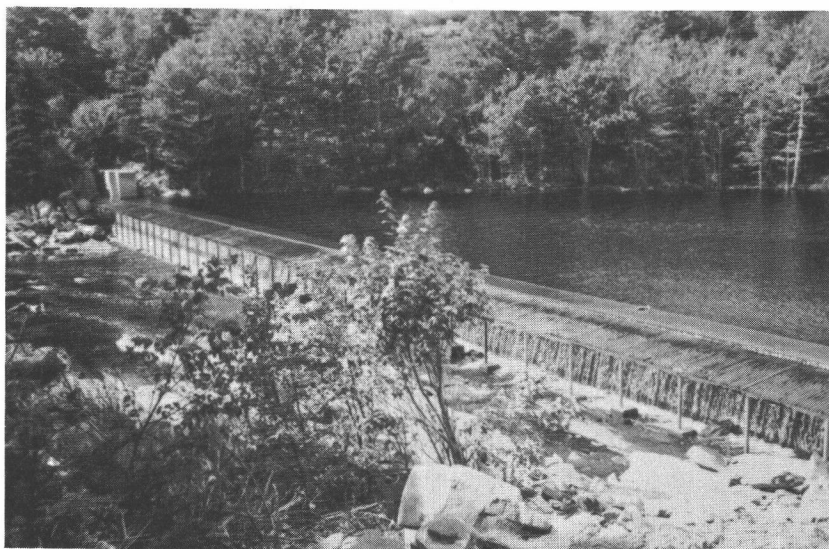


Fig. 9. The Barrier dam at Ruth Falls prevents adult migrants from entering a two-mile long dead section of river.

The upriver fish transportation unit consists of a 600 gallon FRP tank mounted on the chassis of a conventional 4-ton truck (Fig. 10). Accessories and equipment are lodged under or mounted on top of the tank platform; these include: two compressed oxygen bottles, a water pump used both to fill the tank and to recirculate the water, a small air compressor, forty feet of suction hose and two drain valves. The oxygen or air supply is distributed along the bottom of the tank through eight individual outlets equipped with small carborandum cylinders (air stones) for better diffusion. An electric water temperature

gauge mounted in the truck cab gives instant reading of water temperature in the tank. Water and fish are released from tank by opening the three foot diameter tail gate. Total discharge time is approximately 4 seconds.

Collection, Transfer and Distribution of Broodstock

Adult Atlantic salmon were captured in a trap at West River, marked and transported to the headwaters of the East River's Fifteen Mile Stream. From 16 to 32% of the annual spawning escapement (through fence) to West River was relocated in this manner from 1966 to 1970 (Table 7).



Fig. 10. The trucking unit used for adult fish transfer from West to East River.

Table 7. Summary of total adult Atlantic salmon distributed to East River, Sheet Harbour, 1966 to 1968.

Brood Year	Males	Females	Average Female Weight (lbs)	Potential ¹ Egg Deposition
1966	26	51	7.7	313,600
1967	6	12	3.7	35,520
1968	48	53	4.0	169,600
1969	47	53	4.7	190,480
1970	29	48	4.0	153,000

1. Based on an "assumed" average fecundity of 800 eggs per pound of female fish.

Starting in 1967, the remnants of the Grant River run, a tributary to East River accessible to salmon until 1964, were also trapped in the new collection facilities at Ruth Falls and transported to the Fifteen Mile Stream. These totalled 3 grilse in 1967, 55 grilse in 1968, and 15 grilse in 1969, and are included in Table 7.

The average weight of female fish was much higher in 1966 due to the presence of several large fish. In 1967, only 18 fish were available for transplant because of heavy floods on the West River. The majority of the fish used as broodstock were grilse (Table 8).

Table 8. Age composition of the adult Atlantic salmon transferred from West to East River, Sheet Harbour, N. S.

	Freshwater Age				Saltwater Age			
	2 (% sample)	3	4	#(fish in sample)	1+ (% sample)	2+	3+	#fish in sample
1966	42.2	56.0	2.0	74	59.4	32.4	7.2	74
1967	66.3	33.7	0.	15	100.	0.	0.	15
1968	76.	21.5	2.5	42	89.	6.5	4.5	44
1969	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1970	39.5	58.2	2.3	43	62.8	37.2	-	43

To prevent possible scattering of the broodstock to other parts of the East River system, and to reduce the risk of fish returning to the stream of origin, the transplanted fish were placed above Anti Dam in the Fifteen Mile Stream tributary.

Most adult fish transplants were made in late summer and early fall during low flow period. Observation of fish marked with Peterson disks revealed that many of the relocated fish were moving downstream after released. However, fish were never seen below the Anti Dam (4 miles downstream) or caught in the downstream migrant fence at the mouth of the Fifteen Mile Stream except in the spring as kelts. In late October, the

transplanted fish were observed as they resumed their upstream migration. Spawning occurred from the last week in October to the middle of November. Most of the spawners utilized the gravel beds at Anderson Intervale. Some fish migrated several miles upstream to spawn in the little Fifteen Mile Stream tributary.

Many of the transplanted fish remained in East River through the winter as indicated by Kelt recaptures in the Ruth Falls louvers in May, 1968 and 1970. From 10 to 30% of the fish transplanted to East River were recaptured after a lapse of seven months in freshwater. Autopsies performed on three females revealed no trace of feeding and very few eggs were found left in the body cavity. Scales collected from individual fish in the fall of 1966 had revealed commencing erosion (reabsorption) in the shoulder and side areas of the scales. Examination of the scales removed after recapture in the spring of 1967 revealed advanced marginal erosion in all cases but no growth beyond the spawning scar (Fig. 11). The average weight loss was 38.6 percent and the average length gain was 1.0% (Table 9). The weight loss recorded is minimal since the West River salmon enter freshwater early in May and June, and the transplanted fish were not captured and weighed until September and October.



Fig. 11. Scales of a grilse spawner; (A) October 1966. Note commencing erosion in shoulder area; (B) May 1967. Note advanced erosion and absence of new growth. Fish was recaptured in freshwater.

Table 9. Average Fork Lengths and Weights in three samples of adult Atlantic salmon captured before and after spawning.

Prespawning Data				Postspawning Data			Change in Body Condition (%)	
Capture Date	No. Fish	Average F. Length cm	Average Weight kg	Recapture Date	Average F. Length cm	Average Weight kg	Length	Weight
1966 (Sept-Oct)	22	61.9	2.93	1967 (May)	62.7	1.90	+1.2	35%
1968 (Aug-Oct)	7	53.6	1.78	1969 (Apr-May)	55.4	1.16	+3.3	34%
1969	8	58.8	2.19	1970	57.9	1.16	-1.5	47%
						Average	1.0%	38.6%

Survival and Growth of Juveniles

Total freshwater survival was based on the potential egg deposition and the smolt output from the Fifteen Mile Stream tributary. Total populations of fry and parr for the brood years 1966 and 1967 were estimated by the same quantitative electric-fishing method described earlier in this report. Fry from East and West Rivers did not differ in size and weight. Parr produced in East River were only slightly bigger than in the West River (Table 10).

Table 10. Comparison of growth in Atlantic salmon juvenile samples from East and West Rivers, Sheet Harbour, Nova Scotia.

Stream	Age Classes	# in Sample	Average Fork Length	Average Weight gms	Condition Factor K(F.L.)
East River	0+ (fry)	109	6.3	3.2	1.19
	1+ (parr)	74	11.0	11.1	1.04
West River	0+ (fry)	51	6.3	3.0	1.11
	1+ (parr)	19	9.5	9.7	1.07

The results of investigations made in the summers of 1967 and 1968 are summarized in the table below and compared to the norms established by Elson (1962) in two New Brunswick streams.

	Percent Survival	
	1967 (Fry)	1968 (Parr)
Fifteen Mile Stream (East River)	9.6% (30,000)	2.0% (6,200)
Norms (100)	6.0%	3.6%

Due to the difficulties experienced in obtaining a truly representative cross-section of the parr habitats of the Fifteen Mile Stream, it is felt that the parr population was under-estimated.

Smolt Migration

Smolt produced in the Fifteen Mile Stream were enumerated through a counting fence at the mouth of the stream. The principal statistics of the run are given in the table below.

	1969	1970	1971
<u>Migration timing</u>			
Range	May 11-June 11	May 16-June 15	May 15-June 15
Peak	May 22	May 29	May 25
<u>Temperature C°</u>			
Minimum	9°	7.8°	N/A
Maximum	12.8°	12.2°	N/A
<u>Age Composition %</u>			
2 years old (mean F.L. cm)	100 (15 cm)	53 (17.1 cm)	90.4 (17.3 cm)
3 years old (mean F.L. cm)		47 (19.5 cm)	8.6 (20.8 cm)

Egg-to-smolt survival (all brood years) in Fifteen Mile Stream has exceeded, by two or more times, the norms established by Elson (1962) for Maritime streams (Table 11). This may be attributable to one or more of the following factors: (1) shorter freshwater life, (2) low juvenile population density, (3) equally low intra-specific competition, and (4) low predator density (eel, merganser) in the transplant stream.

Table 11. Atlantic salmon smolt output from Fifteen Mile Stream, East River, Sheet Harbour, Nova Scotia.

Brood Year	Estimated Egg Deposition	Smolt Output			% egg-smolt Survival
		1969	1970	1971	
1966	313,600	4000	470		1.42
1967	35,500		530	280	2.28
1968	169,600			2993	1.76
Norms	100				0.57

Smolt runs from the Fifteen Mile Stream were confronted with the obstructions at Marshall Falls storage dam and at Malay Falls power station (Fig. 4). To prevent migration delays, portions of the 1969 and 1970 smolt runs were trucked to saltwater.

A temporary skimmer facility was installed at Malay Falls in 1971. Consequently, migrating smolts were no longer seen in large numbers in the Penstock area and the total migration time lag from Fifteen Mile Stream fence to the Ruth Falls louvers, a river distance of 11.5 kilometers, was only 5 days (Fig. 12). Artificially reared salmon smolts released in West River's Killag tributary in 1968 revealed a downstream migration rate of 4 kilometers per day (Carey, MS, 1968). On this basis, smolts from Fifteen Mile Stream should have travelled the 11.5 kilometers to the louver site in approximately 3 days. At least part of the two-day delay recorded in 1971 is imputable to a modified wolf trap which was an integral part of the Ruth Falls louver bypass system (Ducharme, 1971, in press).

Adult Returns

The adult returns to the Ruth Falls fishway for the brood-years 1969-1970 have been disappointingly low but were greatly improved in 1972 (broodyear 1971), probably due to improvements in smolt handling methods (1971). Percent smolt-to-grilse survival is given in the table below.

	Minimum Estimated No. of smolts to reach saltwater	No. Adults returning (grilse)	Survival %
1969	3385	31	0.9
1970	726	21	2.8
1971	2600	108 (incomplete)	4.0

The minimum number of smolts to reach saltwater was estimated by introducing a correction factor of 13% mortality for those portions of the runs exposed to turbine passage at Malay and Ruth Falls power stations (Ducharme, 1971, in press).

Trucking of smolts from Fifteen Mile Stream and Malay Falls may have had a detrimental effect on grilse return from the sea. 77% and 18% of the 1969 and 1970 smolt run respectively were trucked from Fifteen Mile Stream and Malay Falls and released in the estuary. This practice was discontinued in 1971.

It is felt other causes may have affected smolt survival and therefore adult return in 1969 and 1970. Water turbulence in the trap at Fifteen Mile Stream caused fish to lose scales.

The necessary testing of the Ruth Falls louver deflectors during smolt migration possibly stressed the wild smolts. High water turbulence in the louver release channel (flume) may have caused mechanical injury or death to smolt migrants. Finally the 1969 smolts were delayed substantially (no time estimate available by the adult barrier dam at the head of tide.

Several modifications to the trapping facilities at Ruth Falls were indicated in spite of the lack of fish for testing purposes. The alterations dealt with turbulence in the trail and in the vertical slot pools. These minor modifications were completed in 1970 in time for the first adult (grilse) return to the river. A second fish transportation unit, smaller and with removable tank, was acquired to take care of future increase in numbers of returning adults.

CONCLUDING REMARKS

The chances of success in rebuilding Atlantic salmon runs in the East River, Sheet Harbour, by importation of adults from the neighbouring West River are promising. The introduced fish have shown their ability to adapt to conditions in the recipient stream. Egg-to-smolt survival of the progeny has exceeded the anticipated level of 0.5 percent by nearly twofold. The grilse return from the 1969 and 1970 smolts production has been disappointingly low but the causes of this were deemed technical rather than biological and have been alleviated.

A serious impediment to more rapid repopulation of the East River system with Atlantic salmon is the shortage of suitable stocks. Plans are being made to increase the number of adults available for transfer to East River by direct acquisition of broodstock from the Sheet Harbour commercial fishery, and by the artificial reconditioning of kelts from previous brood years.

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