Atlantic Salmon and Alewife Passage at the Fishway on the Magaguadavic River, New Brunswick, During 1984.

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ATLANTIC SALMON AND ALEWIFE PASSAGE AT THE FISHWAY ON THE MAGAGUADAVIC RIVER, NEW BRUNSWICK, DURING 1984

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ABSTRACT

Martin, J. D. 1987. Atlantic salmon and alewife passage at the fishway on the Magaguadavic River, New Brunswick, during 1984. Can. MS Rep. Fish. Aquat. Sci. 1938: iii + 7p.

The 1984 Atlantic salmon (Salmo salar) run on the Magaguadavic River, New Brunswick, monitored at the St. George fishway numbered 767 fish (512 multi-sea-winter salmon and 255 grilse). The alewife run was estimated at 43,720 ± 8665 fish within 95% confidence limits. Biological data for the 1984 and 1985 alewife spawning runs are presented. Timing of runs of alewives and salmon passing through the fishway was similar to 1983 and could serve as a guideline to schedule fishway maintenance. Observations on fish use of a newly installed downstream bypass sluice and predation by gulls are also presented. Cannibalism of emigrating juvenile alewives by subadults in the estuary was considered a major source of mortality.

RÉSUMÉ

Martin, J. D. 1987. Atlantic salmon and alewife passage at the fishway on the Magaguadavic River, New Brunswick, during 1984. Can. MS Rep. Fish. Aquat. Sci. 1938: iii + 7 p.

Au cours de la montaison du saumon de l'Atlantique (Salmo salar) en 1984 dans la rivière Magaguadavic, Nouveau-Brunswick, que l'on a surveillée à la passe à poissons St. George, on a compté 767 poissons dont 512 saumons de plusieurs hivers en mer et 225 castillons. La montaison du gaspareau a été estimée à 43 720 poisons, - plus ou moins 8 665 - dans les limites de certitude de 95 p. 100. Le rapport contient également des données biologiques sur la montaison du gaspareau vers les frayères en 1984 et 1985. On a remarqué qu'en 1984, le gaspareau et le saumon ont traversé la passe migratoire à la même période qu'en 1983 ce qui pourrait aider à prévoir l'entretien de la passe migratoire. On présente également certaines observations sur l'utilisation par les poissons d'une vannelle de déviation nouvellement installée en aval et sur la prédation des goélands. On estime que le taux élevé de mortalité des jeunes gaspareaux en émigration dans l'estuaire est en grande partie dû à la prédation des jeunes goélands.

INTRODUCTION

Mining development at Mount Pleasant by Billiton Canada in 1980 prompted biological studies and an inventory of the 1983 Atlantic salmon spawning run on the Magaguadavic River (Martin 1984). The need for repairs to the existing fishway at St. George was also identified. In response to this need, reconstruction of the dilapidated lower section occurred during the summer and fall of 1984 through a job creation project sponsored by the New Brunswick Wildlife Federation. Design and supervision of construction was by the Engineering Services Section of the Freshwater and Anadromous Division, Department of Fisheries and Oceans. Another 1984 job creation project, sponsored by the Fundy Weir Fishermens Association, to assist with fish passage during fishway construction activities, provided the means to inventory the 1984 Magaguadavic River alewife and Atlantic salmon runs. General observations from 1983 studies (Martin 1984) and concern by power station and fishway crews for downstream passage of kelts over the hydroelectric dam at St. George led to the installation of a bypass sluice near the trash racks of the penstock intake during summer low-water periods in 1984.

This report presents information on numbers, timing and life history of anadromous alewife and Atlantic salmon spawning runs in 1984 and 1985, as well as some general observations relative to a hydroelectric generating station which are considered to be of biological interest.

STUDY AREA

Fish counts, sampling and observations were done in the fishway, headpond or tailrace of the St. George Pulp and Paper Mill dam located on the Magaguadavic River at the town of St. George. The Magaguadavic River originates in Magaguadavic Lake in southwest New Brunswick and flows in a southeasterly direction for 80 km, emptying into the Bay of Fundy at St. George. The drainage area is 1812 km². A dam was constructed in 1903 at a rock gorge at the head of tide in St. George to provide a headpond for the former St. George Pulp and Paper Mill. This dam is still maintained for a 3700 kw hydroelectric generation facility utilizing Francis runner-type turbines. Fish passage is by way of a pool-weir type fishway over the 13.4-m high dam. Additional details pertaining to the fishway, river system and sports fisheries are contained in an earlier report (Martin 1984).

METHODS

In 1984, alewives were counted manually as they swam upstream through the fishway weir between pools 5 and 6. The weir apron was fitted with a white flashboard to improve visibility. Alewife counts were conducted for a 15-min period of each hour from 0800 until 2000 h daily for the duration of the 1984 spawning run. During the period of alewife counting, the barricade screen of the upstream trap was removed to facilitate unhindered passage of large numbers of alewives. At night, from 2000 to 0800 h of the next day, passage was halted by barricade screens.

Water temperatures were recorded daily at 0800 h by means of a hand-held mercury thermometer read to the nearest 0.1°C. Headpond water levels, as indicated by a permanently fixed scale maintained on the dam face by St. George Pulp and Paper, were also recorded at 0800 h daily.

Random samples of 50 alewives were dipnetted from the fishway periodically over the duration of the spawning runs in both 1984 and 1985 and sacrificed to collect information pertaining to length, weight, age and previous spawning history. Total and fork lengths were recorded to the nearest 0.1 mm and weights to the nearest 0.1 g. Color of the peritonial lining was assessed for the presence of *Alosa aestivalis*. Ageing was determined by microscopic examination of a sample of 10 scales, taken from the area between the posterior of the dorsal fin and lateral line, which were mounted on glass or acetate slides (Power 1964).

Salmon were trapped in the third pool from the top of the fishway which is located under the dam deck in a screened enclosure. A 2.5-cm square mesh galvanized wire screen was installed in the weir between pools 2 and 3 to block upstream fish movement and a funnel of the same mesh narrowed the horizontal opening of the weir between pools 3 and 4 to 17.5 cm to prevent downstream movement of trapped fish.

A temporary trap was installed in a narrow run at the base of the pool immediately below the dam on Aug. 17, 1984, when reconstruction of the fishway necessitated stop-logging and draining (Fig. 1). This trap was maintained until Oct. 9, 1984. Salmon were guided into a weir-type trap formed by sand bags with a barricade of 2.5-cm² wire mesh at the upstream end. Salmon were then collected by dipnet, placed in a water-filled rubber sling made from a section of truck inner tube, transported manually over the dam and released in the headpond.

Separation of multi-sea-winter (MSW) salmon and grilse was according to New Brunswick provincial angling regulations based on fork length of salmon being greater than 630 mm.

Limited tagging and measuring of salmon was conducted until July 22 of 1984 when it was decided not to further stress the salmon due to the construction activities and water temperatures in excess of 22°C (Fig. 2).

RESULTS AND OBSERVATIONS

ALEWIVES

The fishway trap began continuous daily operation in 1984 on May 7, but no fish were caught until the spring freshet subsided sufficiently to permit fish to locate the fishway attraction water.

Although alewives had been sighted in tidal waters of the Magaguadavic Basin in late May only a few hundred meters below the fishway during both 1984 and 1985, they did not enter the fishway until June 18 and June 15 of these years, respectively. Water temperatures on both of these days were recorded at 18.5°C and the St. George Pulp and Paper

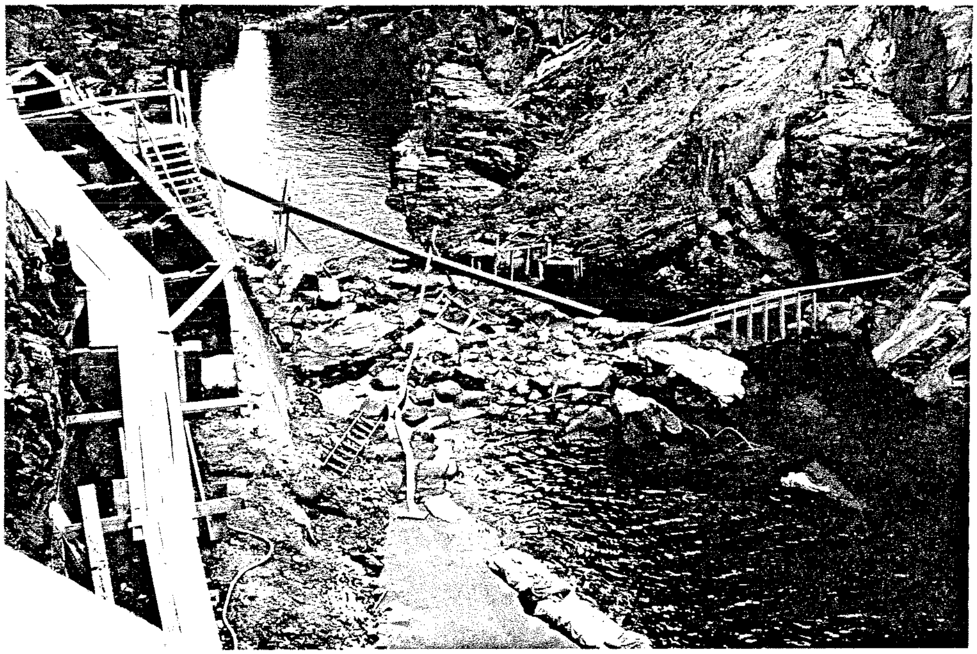

Fig. 1. Temporary trap used during fishway repairs.

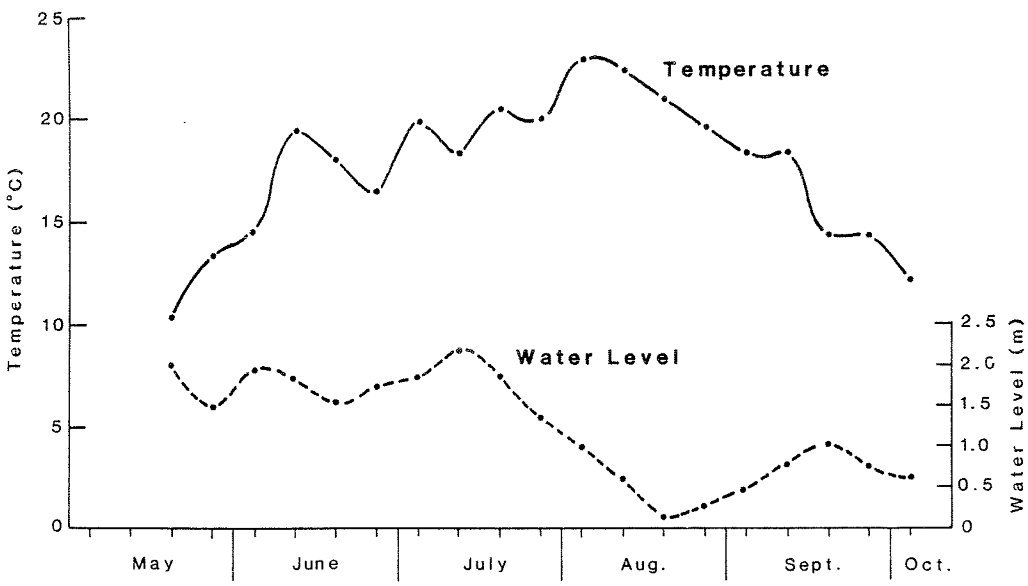

Fig. 2. Mean weekly water temperatures and levels for the Magaguadavic River 1984.

scale at the face of the dam indicated the headpond levels at 5.9 ft and 5.8 ft, respectively. Spawning runs in other nearby rivers were generally over by this time. Dominy (1971) documented the alewife run through the fishway at White Rock on the Gaspereau River, N.S., to occur May 18-27, peaking on May 22 at daily mean water temperatures ranging from 12.2-14.4°C. He was able to correlate alewife fishway activity with both water temperature and tailrace water levels and concluded that water levels had the greatest influence on fish movement. It seems apparent that high-water levels which persist from the spring freshet delay the alewife spawning migration as mentioned in an earlier report (Martin 1984). Many of the alewives passing through the fishway were very ripe; however, the upstream distance to the major spawning area in Lake Utopia is only 6.5 km. With the exception of a few stragglers, the run was over by June 26.

1984 alewife population estimate

Visual counts were conducted for a 15-min period of each hour of the 13 h per day during which the alewives were permitted to run. The run lasted for 11 d. The population estimate was determined by the method described by Rideout et al. (1979) for migrating alewives in the Parker River, Massachusetts:

$$P_e = \bar{X}\ N$$

where: P_e = population estimate
$\bar{X}$ = mean number of fish per sampling interval
N = total number of possible sampling intervals.

Confidence intervals of the population estimate at the .05 probability were determined by the following formula:

$$CI_{.05} = \pm 1.96\ N \sqrt{\frac{S^2}{n} \cdot \frac{N-n}{N}}$$

where: $CI_{.05}$ = confidence interval on population estimate, P_e, for the .05 probability level
1.96 = t.05 (assuming 120 or more sample counts)
S^2 = variance of sample counts
n = number of sample counts.

The population estimate of the 1984 Magaguadavic River spawning run through the fishway was determined to be 43,720 ± 8665 (95% C.I.).

A small commercial alewife gillnet fishery, consisting of four licenses fishing during May and June to supply bait for the local lobster fishery, harvested 6136 kg (H. Futerko, Dept. of Fisheries and Oceans, Conservation and Protection, St. George, N.B., pers. comm.). This represents 26,166 alewives or 37% of the total spawning run.

In 1985, it was not possible to count the salmon and alewife runs; however, random samples of 50 alewives were collected regularly through the duration of the spawning run which began June 15 and ended July 4. Examination of the peritoneal linings of these samples indicated all fish to be *Alosa pseudoharengus* with no *Alosa aestivalis* present. There were no *Alosa aestivalis* in the 1984 samples either.

Length and weight

The weight-length relationships for males and females in 1984 and 1985 were:

1984 males	Log W = 3.10 (Log FL) - 5.16	r^2=0.63
1985 males	Log W = 2.85 (Log FL) - 4.54	r^2=0.86
1984 females	Log W = 2.87 (Log FL) - 4.58	r^2=0.76
1985 females	Log W = 2.78 (Log FL) - 4.35	r^2=0.72

where W = weight (g) and L = fork length (mm).

The mean fork length of the 1984 samples, sexes combined, was 266.6 ± 16.0 mm and the mean weight was 234.5 ± 52.3. The mean fork length of the 1985 samples, sexes combined, was 267.9 ± 18.7 mm and the mean weight was 248.3 ± 54.6 g.

Mean fork lengths of males in both years were less than females (Table 1). Havey (1961) also observed a smaller size for male alewives in comparison to females of the same age in Maine rivers. He attributed the slower growth of males to earlier maturation. Messieh (1977) noted for male and female alewives from the Saint John River, the 50% point of maturity coincides with 4.4 and 4.8 yr old, respectively, at which ages they are about 255 and 265 mm in fork length.

SALMON

The 1984 salmon run totalled 767, comprised of 512 MSW salmon and 255 grilse. Weekly runs of salmon are presented in Fig. 3.

During July of 1984, orange dart tags were applied to 67 MSW salmon, 17 grilse and 2 land-locked salmon (confirmed by scale analysis) trapped during passage through the fishway.

The temporary trap was taken out on Oct. 9 as the salmon run appeared to be over and the work project for the fishway crew had terminated. However, a few salmon were observed jumping in the pool below the fishway on Oct. 17. A gillnet was set across the lower end of the pool and rocks were thrown into the upper end to scare fish into the net. Fish were then immediately removed from the net and released over the dam. This procedure was done almost daily between Oct. 25 and Nov. 4, and resulted in transferring 19 MSW salmon and 3 grilse over the dam with no mortalities.

Tag returns

A report of a tagged salmon hooked and released at the Piskahegan pool approximately 45 km upstream was received in August of 1984. A tag was returned from a grilse angled in August at the Mill Pond pool which is located 58 km upstream. One of the tags that had been applied to the two landlocked salmon was returned by an angler who caught the fish May 13, 1985, in Magaguadavic Lake located 80 km upstream.

Mortalities

A total of 12 MSW salmon and grilse mortalities were collected from the fishway area during 1984. These fish were necropsied by the Fish Health Service Unit in Halifax. Bacterial examination showed no evidence of disease. There was no reoccurrence of *Edwardsiella tarda* which had been previously detected in four mortalities from the 1983 salmon run. The 1984 mortalities were due to

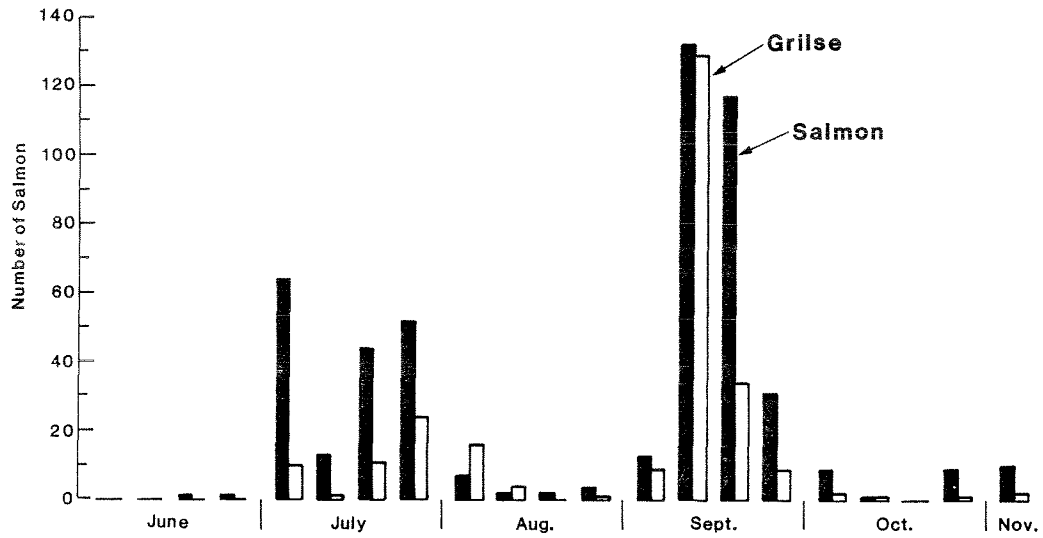

Fig. 3. Weekly numbers of MSW salmon and grilse ascending the Magaguadavic River fishway during 1984.

physical injuries or asphyxiation when they managed to jump out of the temporary trap and become stranded. Remedial preventative action was taken as soon as the problems were recognized.

BYPASS SLUICE

The downstream bypass sluice that was installed in the summer of 1984 was opened on May 1, 1985 (Fig. 4). Emigrating fish had accumulated in the headpond and, during the first 2½ h of operation of the sluice, several hundred smolts and 28 salmon kelts were passed (R. Semple, Dept. of Fisheries and Oceans, Halifax, N.S., pers. comm.). Six of the kelts carried orange spaghetti tags that had been applied in 1984. All fish appeared to survive the 6- to 7-m drop from the end of the sluice pipe to the plunge pool. Regular observation of fish usage of the sluice was not continued; however, on Aug. 2, 1985, a school of about 400 juvenile alewives estimated at 4.0-4.5 cm were observed in the headpond in the vicinity of the sluice. The school was oriented upstream but repeatedly slowly dropped down to the trash racks at the penstock near the opening of the sluice pipe, then quite quickly moved upstream a few meters. This behavior was observed several times until the final downstream tail-first approach when the entire school turned head-first downstream and went through the sluice. Similar behavior has been described by Libey and Beltz (1980) for juvenile alewives migrating downstream in a Massachusetts river. Kissil (1974) acknowledged that downstream juvenile movement generally occurred after periods of heavy rainfall. Further observation in the drainage ditch linking the plunge pool to the main channel indicated several juvenile alewives drifting downstream, tail-first in apparent good health.

PREDATION

Also on Aug. 2, 1985, a large school of subadult alewives which extended throughout the entire basin were observed in the tailrace of the generating station. These fish seemed to stay in about the top meter of water and were continuously flipping and breaking the water surface. A sample of these fish was obtained from an angler at the head of tide below the fishway on the Magaguadavic River on Sept. 6. These fish were mainly 3-yr-olds and they were feeding on young-of-the-year alewives ($\bar{X}$ FL = 4.9, SD = 1.01, range = 3.7-6.0 cm) as well as detritus and freshwater aquatic invertebrates, mainly trichoptera (Table 2). When turbulence in the tailrace subsided due to tidal cycles and the turbine speed being subsequently reduced, it was easy to visually observe subadult alewives feeding on young-of-the-year downstream migrating juveniles. The juveniles appeared stunned or disoriented after passing through the turbine and were easy prey for the subadults which held position in the current and readily fed on juveniles drifting by them.

Another source of predation of juvenile alewives in the tailrace during slack water was by ring-billed gulls, _Larus delawarensis_ which swam into the current while steadily picking up juvenile alewives. Great black-backed gulls, _Larus marinus_, sometimes numbering up to 50 or so, preyed on the adult spawning run of alewives as they passed through the weirs of the fishway. They were able to take alewives at will and, after eating their fill, often persisted in grabbing and releasing fish. Injuries in the form of lacerations and scale loss were evident on considerable numbers of fish and there appeared to be associated mortality.

DISCUSSION

The 1984 Magaguadavic River MSW salmon and grilse run was 18% less than the 1983 run, 767 fish compared with 940; however, the ratio of MSW salmon to grilse remained constant. The 1983 run was comprised of 67.8% MSW salmon and 32.2% grilse, and the 1984 run 66.7% MSW salmon and 33.3% grilse.

The bypass sluice for downstream fish passage seemed to work very well. Water levels in the spring of 1985 were exceptionally low and it was

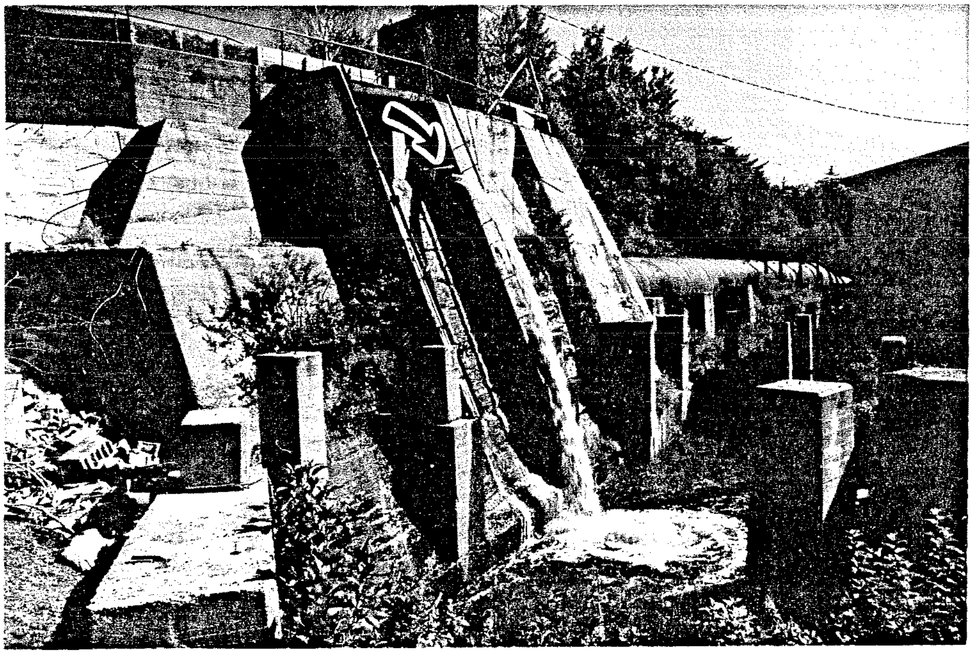

Fig. 4. Downstream bypass sluice.

unusual that no spilling had occurred over the dam at St. George due to spring runoff by May 1. As a result, considerable numbers of kelts and smolts had accumulated in the headpond. Kelts are unable to pass through the trashracks (Fig. 5) into the penstock leading to the turbines due to the spacing of the bars and, although smolts could pass through these screens, they must have been reluctant to do so. However, when the bypass sluice was opened, the fish were quick to use it as described previously in this report. For most years, kelts and smolts are flushed over the spillway in the dam; however, when the freshet subsides and spilling stops, there always seems to be some fish that are late emigrating. In the past, kelts in this situation eventually died and collected on the trashracks.

Late-running smolts that are forced to pass through the turbines may be susceptible to increased mortality. Semple (1979) determined smolt mortality to average 10% during passage trials through similar Francis runner-type turbines at Malay Falls, Nova Scotia. Enhancement of the repeat spawning component of the Magaguadavic River salmon stock is considered important as 14% of the total run is repeat spawners (Martin 1984) and, since no maiden spawning three-sea-winter salmon have been observed, the largest and probably most fecund fish are the repeat spawners. A repeat spawning component in a fish stock also helps serve as insurance in case of a year-class failure.

Cannibalism of emigrating juvenile alewives by subadults in the marine phase was observed but not extensively monitored. The vulnerability of juveniles in this particular situation and the extensive period during which subadult alewives were present in the Magaguadavic Basin suggests that cannibalism may be a major source of mortality. Piscivority has been previously noted in the literature (Kohler and Ney 1980), but cannibalism was described as occasional and infrequent relative to total fish consumption.

Scavenging by gulls in the outflows of hydroelectric facilities is a common occurrence and avian predation on migrating juvenile anadromous species can have a considerable impact on populations. Ruggerone (1986) estimated the consumption of migrating juvenile salmonids by gulls foraging below a Columbia River dam to be 2% of the estimated spring migration and references other studies where avian predators consumed up to 24% of the total annual production. The foraging of gulls on juvenile alewives, many of which appeared to be disorientated by the turbulence and upwelling of the tailrace, was identified for the St. George Pulp and Paper generating station on the Magaguadavic River, but the impact was not determined. Gull predation on the spawning run of alewives ascending the fishway was also observed. Enclosing the fishway with wire screening would eliminate gull predation in this case and also serve to reduce or hinder salmon poaching by humans.

Extrapolation of alewife commercial catch records indicates that 37% of the 1984 spawning run was harvested, assuming that all unharvested alewives were able to ascend the fishway.

The 1985 alewife spawning run was not counted but regular random sampling indicated the mean lengths and weights of these fish to be slightly larger than the 1984 run. The mean age was also older in 1985 (Table 1) and this was reflected in the repeat spawning component which was 50% of the run compared to 28% of the run in 1984. This information seems to indicate that the current commercial fishery is probably not overharvesting the population. Information presented by Dominy (1971) for the Gaspereau River in Nova Scotia suggests a commercial harvest of approximately 87% of the spawning run. This information seems to indicate that the commercial catch of alewives on the Magaguadavic River is well below the potential harvest.

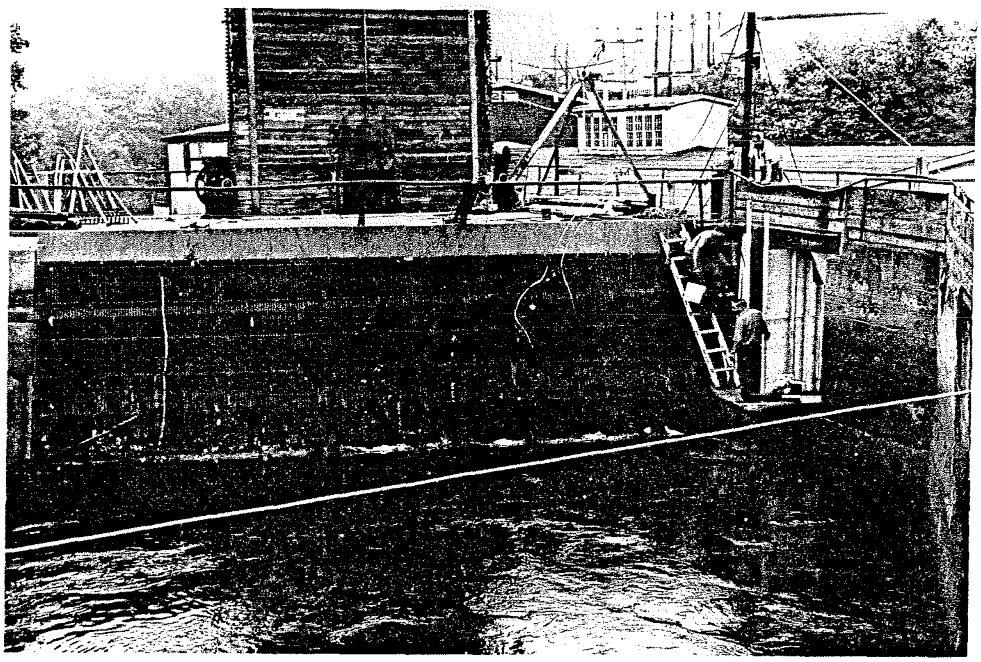

Fig. 5. Trashracks on penstock at the St. George Pulp and Paper generating station.

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Table 1. Mean fork lengths, weights, ages and previous spawning history of Magaguadavic River alewives (n = number of fish).

	X FL SD	X WT SD	X age	% spn 1(n)	% spn 2(n)	% spn 3(n)
1984 males	262.4±13.5	218.5±44.2	4.2 (160)	27 (43)	6 (9)	- (0)
females	271.9±17.4	255.3±54.8	4.4 (127)	22 (28)	6 (8)	- (1)
Sexes combined	266.6±16.0	234.5±63.4	4.3 (287)	26 (71)	5(17)	- (1)
1985 males	264.4±18.5	235.1±49.4	4.8 (235)	44(103)	7(17)	1 (2)
females	273.1±17.9	267.8±56.1	4.9 (160)	40 (64)	5 (8)	- (0)
Sexes combined	267.9±18.7	248.3±54.6	4.8 (395)	42(167)	6(25)	1 (2)

Table 2. Details of subadult alewives in the marine phase collected at the head of tide on the Magaguadavic River.

Fish no.	Fork L (cm)	Total L (cm)	Weight (g)	Age	Sex	Maturity stage	No. of juvenile alevins in stomach
1	22.7	26.0	149.5	3	M	3	-
2	23.9	27.1	177.5	3	F	3	2
3	23.4	26.9	167.4	3	M	2	2
4	24.1	27.4	169.8	3	F	3	-
5	22.6	26.3	165.1	3	F	3	2
6	23.3	26.9	184.0	3	F	3	-
7	23.9	27.8	193.0	3	F	3	1
8	22.2	25.7	137.8	2	F	3	1
9	22.0	26.4	172.4	3	M	3	2
10	25.0	28.4	205.0	3	M	3	2
11	19.7	22.8	89.9	2	F	2	-
12	21.2	24.7	117.6	2	F	2	-