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# RESOURCE DEVELOPMENT BRANCH

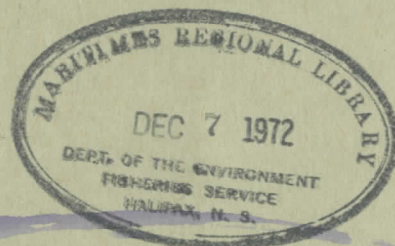
## MANUSCRIPT REPORT

No. 70 - 3

Petitcodiac River Causeway - Fishway Evaluation Studies

by

C.L. Dominy



FISHERIES SERVICE  
DEPARTMENT OF FISHERIES AND FORESTRY OF CANADA  
HALIFAX, N.S.

MEMORANDUM

170-3  
CLASSIFICATION

TO  
A  
Mr. D. C. Riley, Head  
Environmental Protection Section

YOUR FILE No.  
Votre dossier

FROM  
De  
C. L. Dominy  
Biologist

OUR FILE No.  
Notre dossier

DATE  
16 March 1970

SUBJECT  
Sujet  
Petitcodiac River Causeway - Fishway Evaluation Studies

PROGRESS REPORT 1969

1.0 INTRODUCTION

The Petitcodiac River is located in Southeastern New Brunswick (Figure 1) and has a drainage basin area of 693 square miles, a total length of 35 miles and has few lakes (0.34 percent of drainage basin area) flowing into it. The headwaters of the basin are fairly fast flowing as far as the town of Petitcodiac, and between Petitcodiac and Salisbury the rate of descent of the river bed decreases and the river broadens. In the lower reaches between Salisbury and its mouth, the river is wide and forms a reservoir down to the causeway at Moncton.

The river is subject to high tidal variations (approximate mean 30 feet) and at one time the tidal effects were felt as far upstream as Salisbury but the addition of a causeway in 1968 has limited the effects to the downstream side of the causeway.

From 82 to 670 Atlantic salmon are taken for sport each year in this river; the total annual run prior to completion of the causeway in 1968 was estimated to range from 2,000 to 3,000 fish. A small percentage of these fish may enter the river in mid-June but the main run does not begin until September, reaching its maximum in October-November. Angling for bright salmon is permitted until October 15 (September 30 for Pollett River tributary) while black salmon fishing is popular in the spring of each year beginning May 15 (June 1 for Pollett River).

Other species of anadromous fish which use the Petitcodiac River include speckled trout, striped bass, shad, alewives, smelt and sturgeon. The catadromous eel is abundant in all parts of the river and although attracting little or no direct use they appear to absorb one-quarter to one-half of the fish-producing capacity of the waters (Elson memorandum 1961).

From the time that the causeway was first proposed, concern has been expressed as to the possible detrimental effects of the structure and its operation on the migratory behavior of anadromous fish in the river. The Resource Development Branch biological evaluation study is concentrating on Atlantic salmon and data are being collected on the following: (1) approach delays to upstream migrants; (2) fishway passage efficiency; (3) use of control gates by adult migrants as a passage route; (4) life stages, abundance and growth of juvenile salmon in freshwater; and (5) delays to smolt during their seaward migration.

## 2.0 METHODS

A fishway trap complete with an electrically operated rising floor or false bottom was located in the exit pool of the causeway passage facility. All fish that passed upstream via the fishway were enumerated, marked by a caudal and/or dorsal fin punch, measured for fork length, and a scale sample taken for age determination. The fishway trap was operated from September 4 to December 11, 1969.

An experimental spear-head floating salmon net similar to that used in the Bay of Chaleur commercial fishery was positioned on south side of the reservoir approximately 800-900 yards above the causeway for the purpose of capturing marked and unmarked salmon. It extended at a right angle from the shoreline out into the reservoir 180 feet and had stretched mesh sizes of five inches in the leader and four inches in the trap portion. The trap remained in this location from September 4 to October 27 at which time it was moved to a point 300 yards above the causeway until November 24 when it was removed from the reservoir.

Ultrasonic transmitter tags were inserted in the stomach of fishway-trapped salmon via the mouth and esophagus, and these fish were then carried by hand across the causeway and placed in the water on the downstream side. Shore-based tracking equipment (developed by Smith Root Electronics, Seattle, USA) including two bottom-mounted hydrophones and a receiver was used to monitor the passage of any of these fish through the open causeway control gates.

A gill net, 100 feet long with a stretched mesh of 1 1/2 inches, was used on July 9 and 10 in that part of the reservoir within 900 yards of the causeway. The net hung from the surface to a depth of six feet and remained in the water a total of 20 hours; 18 hours on the south side and 2 hours on the north side.

Juvenile salmon and other stream-dwelling species of fish were sampled throughout the freshwater reaches of the river in July using an electric fish shocker without barrier nets at twelve sites: six sites on Coverdale River; two sites on Pollett River; two sites on North River; and two sites on the main stem.

## 3.0 RESULTS

### 3.1 Factors influencing movements from the estuary up to the causeway

The first salmon entered the fishway trap on September 8, a peak occurred on November 4 when 17 were counted, and the last fish was recorded on December 8. Half-monthly totals for salmon at this facility are listed on the next page.

<u>Half-Month</u>	<u>Number Salmon</u>
September 5 - 15	1
16 - 30	14
October 1 - 15	16
16 - 31	21
November 1 - 15	56
16 - 30	22
December 1 - 11	<u>1</u>
Total	131

Daily totals of salmon are plotted in Figure 2 together with: (1) water releases at control gates; (2) daily maximum temperatures in the reservoir; (3) tidal range at the causeway; (4) incidence of rain, and (5) fullness of the moon.

The following observations are pertinent:

1. Highest daily trap counts (greater than 5 salmon per day) were recorded when relatively little water (less than 150 minutes open gate(s)) was released from the control gates (October 3, November 4, 5, 6, 8 and 21). Support for this statement may also be found by examining the period November 7 to 20 when significant releases of water were made every day except one (November 8) and it was on that day that a peak movement of salmon was recorded; similarly on November 17 another slight peak occurred although very little water was released.

2. There appears to be a lag time, particularly during the early part of the run, of at least one to two days between water release at the causeway and the appearance of fish in the fishway (c.f. September 17, 23, October 28, 31, and November 8).

3. Precipitation in the form of rain or snow together with associated cloudy weather may have influenced salmon movement on three occasions (c.f. October 3, 20 and November 4). Relatively little reservoir water was released on these days. It is also apparent that salmon movement tended to be discouraged on the days following these examples (c.f. October 4, 21 and November 5); this may have been associated with the rather abrupt changes in the temperature of the reservoir water at these times.

4. Seventy-two percent of the run moved upriver through the fishway after the daily high reservoir temperature fell and remained below 50°F.

### 3.2 Factors influencing salmon entry in the fishway

The times of daily tidal periods at Moncton causeway from September 18 to November 24 are plotted in Figure 3 together with: (1) time and number of salmon caught in the trap; and (2) length of time that the control gates were open. It is clear that (a) few fish moved into the fishway trap at periods of low tide, (b) no fish moved into the trap when the control gates were open, and (c) 64 percent of all fish moved into the trap when the tidal stages was within three hours of high tide.

Figure 4 illustrates that the majority of salmon moved into the fishway within the 14-hour period from 6 p.m. to 8 a.m.

### 3.3 Fallback through the control gates: re-ascent and loss

Seven salmon (Table 1) which were marked and passed upstream from the fishway trap into the reservoir were subsequently recaptured in the same trap following an average absence of 12 days (median 8 days: range 1 day to 43 days). These data indicate that velocities created by reservoir drawdowns when the control gates are open are strong enough to force salmon back downstream from the reservoir. The only possible downstream route available to these salmon was through the open control gates.

It is also apparent from the data that, in these instances, the fishway is successful in passing salmon upstream. Ultrasonic tracking studies also supported this conclusion (Table 1): no salmon were tracked through the control gates; those that did return all used the fishway.

In 1968, thirteen salmon were marked in the fishway and released downstream; none of these returned through the fishway. In 1969 (Table 1) eleven fish were treated in the same way except that an ultrasonic tag had been inserted in their stomachs; only three of these returned through the fishway. Although no salmon were electronically tracked as they passed through the open control gates in 1969, visual observations in 1968 indicate that four fish were seen passing through the gates. This reflects that at certain stages of the tide it is possible for fish to negotiate the open control gates.

The proportion of the Petitcodiac River salmon run which passes upstream without using the fishway has not been fully determined. Two methods were attempted in 1969 in an attempt to estimate the order of magnitude involved: (1) Ultrasonic tracking showed that no salmon passed through the control gates and (2) a floating trap net for recapture in the reservoir failed to capture any salmon.

### 3.4 Age, Length and Sex Composition of the Salmon Run

Figure 5 contains three series of histograms illustrating the mean length and sex of the twelve age groups present in the Petitcodiac River salmon run in 1969. The total number counted at the fishway trap was 131 salmon and, of these, 24 percent were grilse and virgin salmon. The proportion of females in this group was almost 39 percent and for older salmon returning to spawn for the second or third time, the proportion rose to 67 percent.

Table 1. Salmon marked, released and recaptured at Moncton causeway fishway, 1968

<u>Fish Number</u>	<u>Date Marked</u>		<u>Date Recaptured</u>		<u>Number Days at Large</u>
(Mark: Fin Punch)					
1	October	5	November	17	43
2	October	28	October	30	2
3	November	3	November	11	8
4	November	3	November	11	8
5	November	4	November	5	1
6	November	5	November	10	5
7	November	7	November	23	16

(Mark: Ultrasonic transmitter capsule)

1	November	17	-	-	-
2	November	17	-	-	-
3	November	17	-	-	-
4	November	17	November	24	7
5	November	18	-	-	-
6	November	19	-	-	-
7	November	20	November	21	1
8	November	20	November	21	1
9	November	20	-	-	-
10	November	25	-	-	-
11	November	25	-	-	-

The low proportion of grilse (18 percent) in the run is believed to be unusual. Data from Big Salmon River in New Brunswick (Canada, 1970) points to a similar occurrence (15 percent grilse) in 1969 which is irregular when compared to data from the previous five years; the composition of the runs in this river for the years 1964 to 1968 inclusive ranged from 32 percent to 56 percent grilse.

Approximately 58 percent of the returning adults had originally left the river as 2-year old smolts and the weighted mean length (64.4 mm) of this group was slightly larger than that of adults which had left the river as 3-year old smolts (63.2 mm). All salmon had originally left the river as either 2-year or 3-year old smolts.

### 3.5 Relative Abundance and Growth in Length and Weight of Juvenile Salmon

The abundance of juvenile salmon throughout the freshwater reaches of the Petitcodiac River basin in 1969 was measured crudely during the period July 15 to 18 inclusive by single sweep electro-seining at twelve sites without the use of barrier nets; the results are presented below in terms of relative abundance per 100 square yards (number of stations in brackets):

	<u>Fry</u>	<u>Small parr</u>	<u>Large parr</u>
Main Stem (2)	trace	0	1
Coverdale R. (6)	6	23	2
Pollett R. (1) *	trace	2	1
North R. (2)	0	1	trace

\* An additional station on the Pollett River tributary was located above an impassable barrier.

These results are comparable within themselves and reflect the fact that the majority of juvenile salmon in the Petitcodiac River Basin during the year of study were found in the Coverdale River tributary. One other tributary, Turtle Creek, has very little salmon rearing capacity since the construction in 1966 of a municipal water supply dam within three miles of its confluence with the main stem.

Small parr appeared to be more abundant than either fry or large parr, except in the main stem where large parr was the only life stage captured. The fry data reveal uncommonly low abundance.

Somewhat slower growth in length and weight was demonstrated by the juveniles in Coverdale tributary when compared to the rest of the river basin (sample size in brackets):

	Mean fork length (mm)		Mean weight (g)	
	Age 1+	Age 2+	Age 1+	Age 2+
Main Stem	100.0 (1)	109.0 (4)	13.7 (1)	19.4 (4)
Coverdale River	73.8 (361)	104.5 (38)	5.5 (361)	15.7 (38)
Pollett River	91.5 (9)	109.0 (1)	10.3 (9)	16.6 (1)
North River	90.5 (4)	110.0 (1)	9.5 (4)	7.1 (1)

Growth is extremely slow during the salmon's first year of freshwater residence in Coverdale River but by the beginning of the third year (age 2+) the difference in size, although still manifest, is not as extreme. Age 3+ juvenile salmon were not found.

### 3.6 Smolt migration delay in the causeway reservoir

Small mesh gill nets captured a total of 20 salmon smolt (index: one per hour fishing effort) in the reservoir on July 9 and 10. These fish were all aged 2+ years and had a mean length of 141.7 millimeters and a mean weight of 26.8 grams. Scales from the entire group exhibited some good growth following the last freshwater winter after which was an unmistakable check on the perimeter of the scales. This phenomenon is also exhibited on a number of adult fish which had spent 2+ years in freshwater and 1+, 2+ and 3+, respectively, in the sea.

## 4.0 DISCUSSION

Construction of a causeway-dam in tidal water across the Petitcodiac River in 1968 has altered physically the migration route of both river-bound and ocean-bound Atlantic salmon. Obvious hazards include possible obstruction and delay to migrating fish.

A regular flow of freshwater from the river into the estuary is necessary to stimulate salmon movement upstream and the success of the Petitcodiac River run is partially determined by the frequency and amount of water released from the newly formed reservoir. Other factors including tides, winds, rain, temperature and time of the year have also been shown to influence the movement of fish into the estuary and from the estuary into freshwater (Hayes 1953, Huntsman 1936, and Saunders 1960).

The amount of water which should be permitted to flow into the Petitcodiac estuary in order to ensure undelayed migration is difficult to determine because of these other complicating factors. The release of too much water may tend to act as a strong freshet and "hold back" the fish, as Huntsman (ibid) found in the Saint John River. Huntsman also observed that as the freshet subsides, the salmon rapidly enter the river. The situation in the Petitcodiac River is different from most natural river flows in that, under the present operating schedule, one or more gates are either completely open or completely shut and there is no provision for maintenance flows below the causeway except for the small continuous flow through the fishway.

The 1969 data show that the highest daily trap counts in the fishway were recorded on days when relatively little water was being released from the control gates. Alabaster (1970) found in four British rivers that upstream migrant salmon tend to be intercepted at counting fences when river flows are somewhat higher than average and not when they are at their extreme values.

These comments reflect the need for an increased maintenance flow to be delivered from the causeway control gates on a regular schedule. The difficulties experienced by salmon during their migration through the Petitcodiac River estuary may be likened to those of Huntsman's (ibid) "lost" salmon of the upper Bay of Fundy: "the water is quite dirty, being thoroughly mixed by the strong tidal currents, and there is no gradient of river water to influence them". There is some evidence that the stimulus to salmon movement does not necessarily have to be in the form of reservoir water releases: rain or snow may do this independently but unfortunately the effect of such precipitation is usually masked by water releases which often occur shortly after the rain or snow commences. Hayes (1953) suggests that a rainstorm may bring a run of salmon into the estuary, but if the flow is controlled upstream, rain alone will not usually be a sufficient enough stimulus to move them into freshwater.

Of particular interest to the current study is the effect of daily tidal fluctuations on salmon movement into the fishway trap. It is local opinion that salmon move back and forth on the tides each day, entering freshwater at each flood. Fishway trap records for 1969 indicate that this is largely the case in the Petitcodiac River and unpublished data (Resource Development Branch, Halifax) from Great Village River, Nova Scotia also support this contention.

Fifty-one percent of the trap count was captured between the late afternoon, night and early morning hours of 1800 and 0800, and if the morning period is extended to 1230 hours, the total proportion of fish captured rises to eighty-five percent. Hayes (1953) found on the LaHave River that the main salmon run occurred at dusk and a secondary run occurred at dawn: the operative factor appeared to be the rate of change of light intensity.

No estimates other than visual sightings were made in 1968 of the number of salmon which may have passed upstream via the control gates, but in 1969 ultrasonic tracking revealed that no fish in the test group used the control gates. Preliminary velocity measurements at the gates indicate that unless the gates are opened to coincide with the falling tide, or just before high tide occurs, velocities are too high (greater than 25 feet per second) to allow fish passage. In other words, the differential between the height of water in the reservoir and that in the estuary below the causeway must be slight (less than 2 feet) in order to permit passage through the control gates.

On the basis of these data and a review of the work of others it is possible to recommend a more suitable flow release schedule than the existing haphazard arrangement. It would appear that smaller volume water releases from the causeway control gates should commence about six hours before the arrival of each high tide. A reasonable attraction flow is estimated to be 500 to 1,000 cubic feet per second (compared to approximately 12,000 cubic

feet per second measured at one gate fully open) and it is therefore recommended that this be considered as a fisheries requirement beginning in 1970. This can be accomplished by opening the gates part way in a pre-determined manner to suit the owners.

There are indications from these data that a certain portion of the Petitcodiac River salmon run may suffer great delays in the estuary below the causeway and that some fish may never find their way upstream. Additional data on this aspect of the problem will be collected in 1970 when it is planned to mark fish in the lower estuary before they ascent to the causeway. This work will begin early in the season (September) because, as Huntsman (1936) has pointed out, "salmon exhibit an increased tendency to enter the river as they develop in sexual maturity with progress of the season".

The low fry abundance recorded in 1969 may point to a serious potential problem affecting, to an undetermined degree, salmon runs to this river in 1972 through 1975. Fry scarcity in New Brunswick during 1969 was also reported by District Biologists (Canada, 1970), and poor natural seeding in 1968 has been offered as an explanation. If this was the case in the Petitcodiac in 1968 when the total run amounted to 101 fish, than a great improvement cannot be expected from the 1969 spawning escapement of 131 salmon. Differential survival of the juvenile life staged in freshwater may operate to offset severe reduction to any one particular year class.

Petitcodiac River parr tend to spend less time in the river than Miramichi River parr. This is in all probability related to size at smoltification. Elson (1957) states that "As a working approximation an arbitrary dividing line between large parr ... and small parr ... has been set at about 10 centimeters or 4 inches total length ...". Indeed, when the present data on average fork lengths of parr are compared with similar data from the Miramichi (Kerr 1961), it is seen that age 1+ juveniles in the Petitcodiac (89 mm) are almost identical in size to age 2+ fish in the Miramichi sample (86 mm). The same author reports that 78 percent of the Miramichi fish had migrated to sea as 3-year smolts. He also found that salmon in the 3-year smolt age group were slightly larger after two years at sea than those from other smolt age groups in the Miramichi commercial fisheries; the equivalent larger size after two years at sea in the Petitcodiac was the 2-year smolt age group.

An unused impassable dam is located on Pollett River at the site of a former saw mill at the village of Pollett River, approximately ten miles above its confluence with the main Petitcodiac River. This dam is in disrepair and should be removed in order to provide unobstructed passage for future salmon spawning runs to that portion of Pollett River up to Gordon Falls, a natural barrier, at mile 18. Electro-seining above the dam at Pollett River in 1969 revealed that no juvenile salmon were present in this part of the river, although they were found below the dam.

The occurrence of a growth check between smoltification and the first year at sea on scales of smolt, grilse, 2-sea-year salmon and 3-sea-year salmon would seem to eliminate the causeway as a casual influence operating to slow smolt growth, since the oldest of these fish had left the river as smolt in 1966, two years before the causeway - dam was completed.

The extent of delay to smolts as a result of temporary residence in the reservoir is judged to be relatively slight on the basis of comparable data from other areas. In Middle River (Pictou) the delay is much greater as evidenced by the fact that 30 smolts per hour of fishing effort were taken on July 8 by the same gill nets that were used in the Petitcodiac River survey. (c.f. one smolt per hour fishing effort in the Petitcodiac River reservoir).

A good indication of the changes to salmon spawning migrations in the Petitcodiac River which have taken place since construction of the causeway in 1968 is revealed by the salmon angling statistics summarized below from 1965 to 1969 inclusive.

	1965	1966	1967	1968	1969
Black Salmon	288	149	645	275	21
Bright Salmon	41	163	495	---	---

The first noticeable change occurred in the fall of 1968 when no bright salmon were available to anglers; this absence of bright salmon is also evident in the 1969 statistics. It is clear from the fishway records that in each year, very few fish ascended the river into freshwater until the angling season closed on October 15; the causeway appears to have created conditions which cause the run to be delayed in the estuary.

Black salmon fishermen caught 21 salmon in 1969. This statistic points to the possibility that the spawning run in 1968 was severely reduced from previous years.

## 5.0 SUMMARY AND CONCLUSIONS

1. The Moncton Causeway fishway is successful in passing Atlantic salmon once they arrive immediately below the structure and provided the causeway gates are closed.
2. There is generally insufficient attraction water to move salmon from the estuary up to the area of the causeway. A need was identified for increased maintenance flows to be delivered from the control gates on a routine basis. A more suitable flow release schedule would be to release a smaller volume of water (500-1000 cubic feet per second) about six hours before each high tide and continue until the estuary and reservoir water levels equal each other.
3. The extent of fish passage through the open control gates is not fully understood but there appear to be few opportunities for fish to use this route because of extremely high water velocities.
4. Fry and two stages of parr were found throughout the river basin and were most abundant in the Coverdale tributary. Fry abundance was particularly low but this seems to have been a province-wide phenomenon and cannot be attributed to the effects of the causeway.

5. Eighteen percent of the returning salmon run was grilse. A majority (58 percent) of the 1969 adult run had originally left the river as 2-year old smolt.
6. The presence of the causeway did not appear to differently alter the growth pattern of descending smolt or to seriously impede their descent.
7. An impassable dam on the Pollett River at the village of Pollett River should be breached or removed to provide additional spawning area for adult salmon.
8. Angling statistics show that there has been a marked change in the availability of salmon to anglers since the causeway was constructed.

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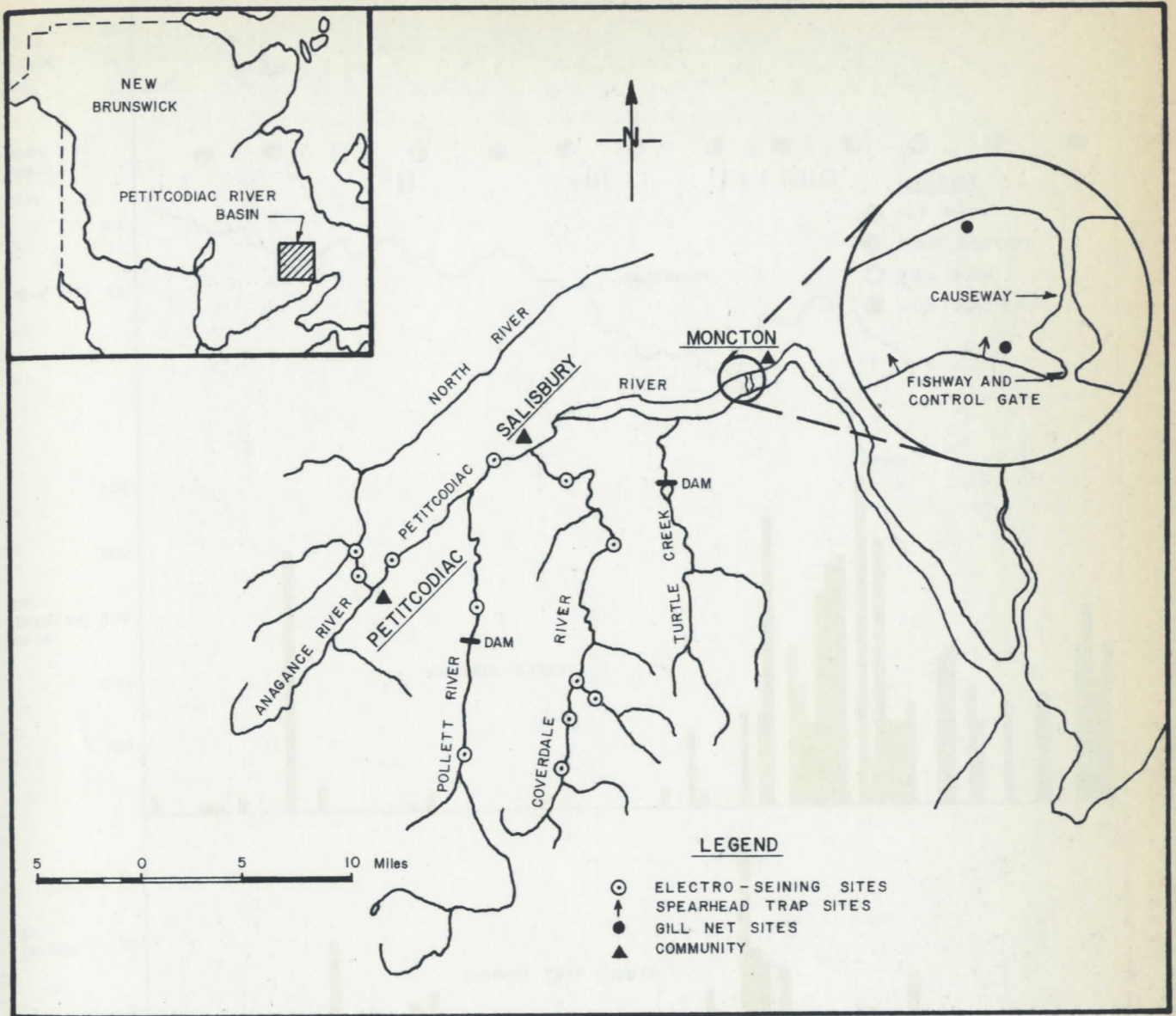


FIGURE 1. Location map of Petitcodiac River Basin

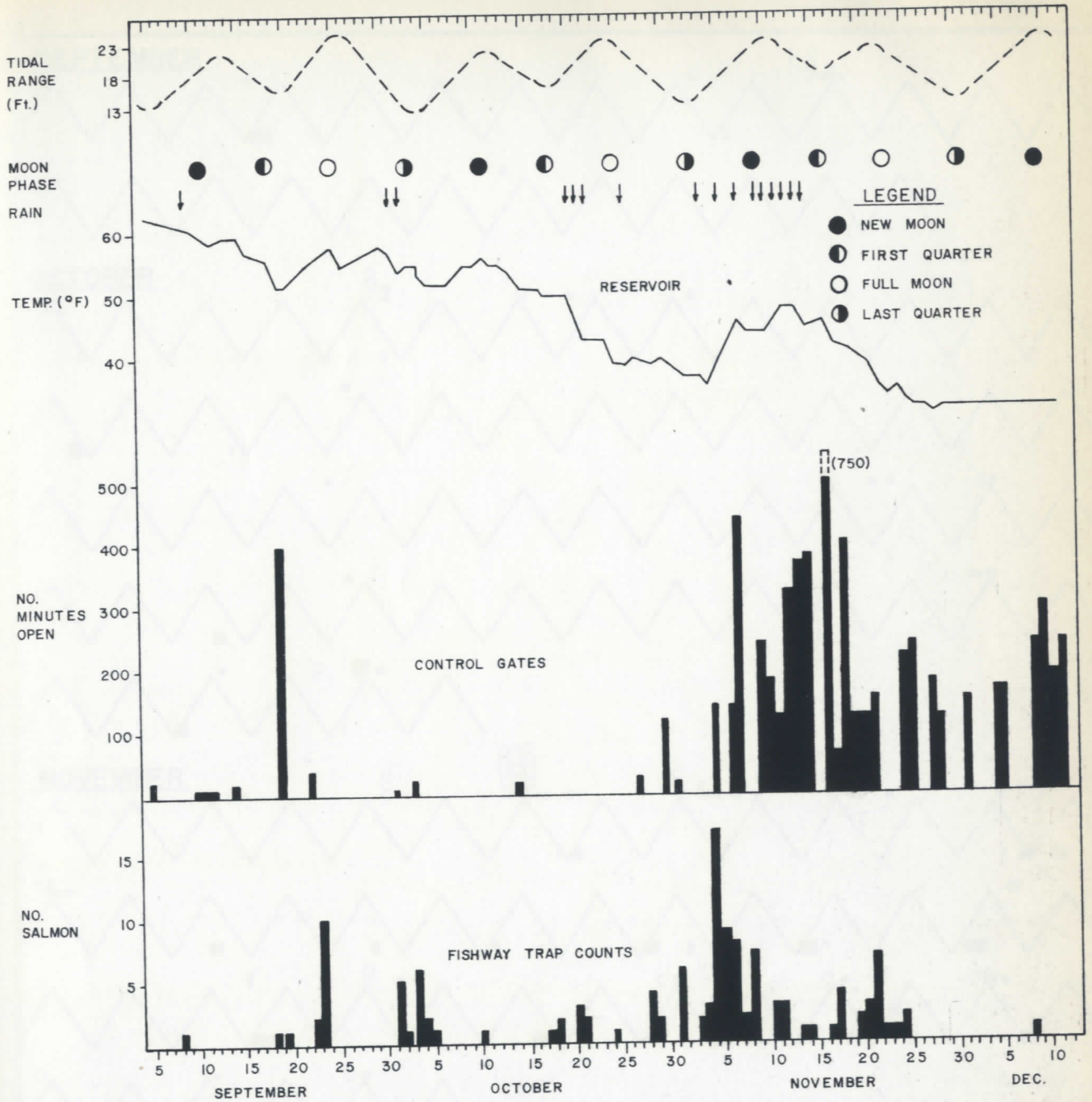


FIGURE 2. Number of adult salmon in fishway trap at Moncton Causeway, Petitcodiac River, versus: magnitude of daily water releases from the causeway control gates; reservoir water temperature; incidence of rain; moon phases; and daily tidal range. All data for 1969.

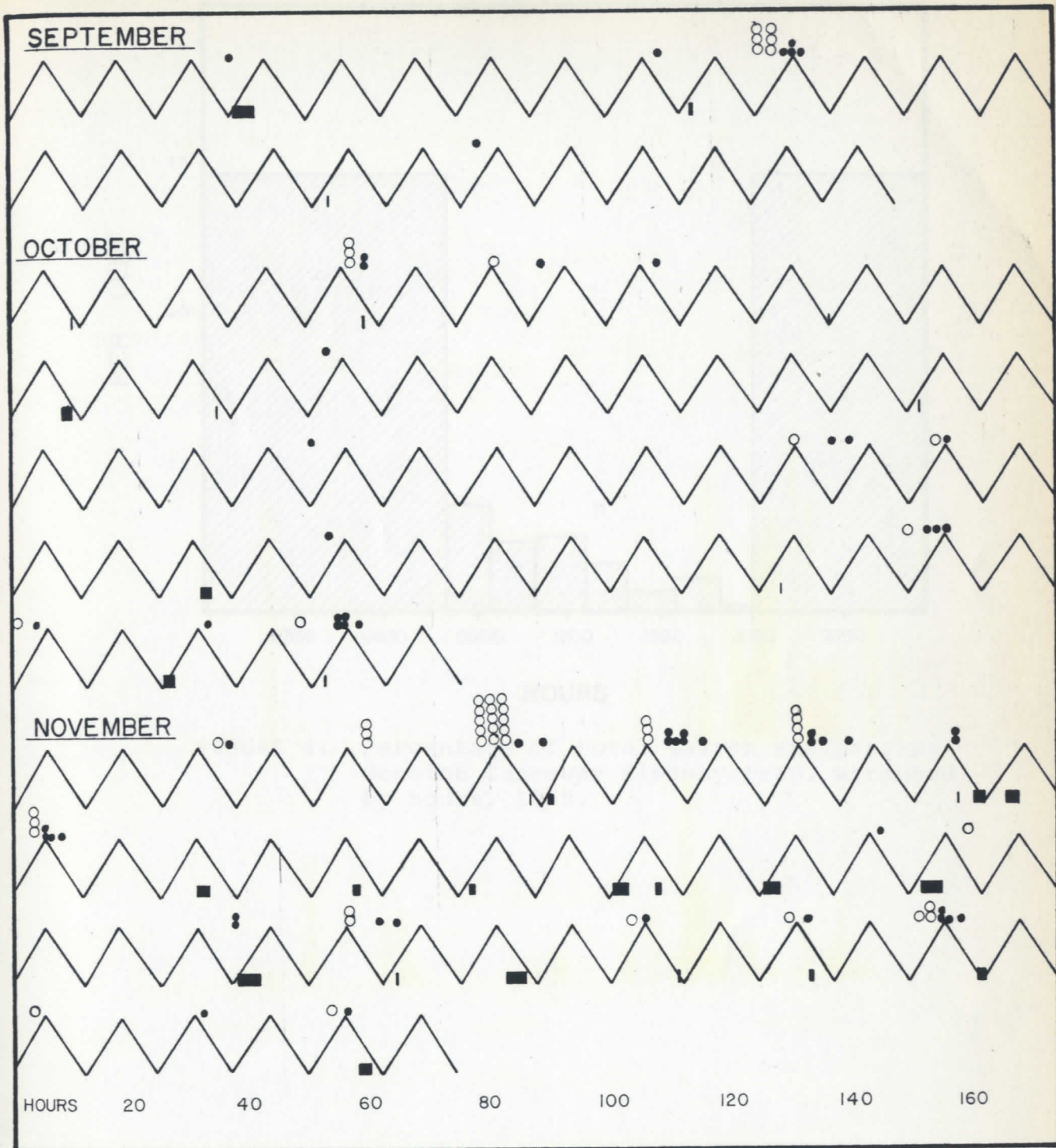


FIGURE 3. Salmon movements into fishway trap at Moncton Causeway, Petitcodiac River; daily high and low tide; and the magnitude and time of water releases from the causeway control gates. Unshaded circles represent overnight fish counts, while shaded circles represent fish movement at one and one-half hour intervals during the working day; short vertical lines and shaded rectangles represent the length of time the gates were open. September 18 to November 24, 1969.

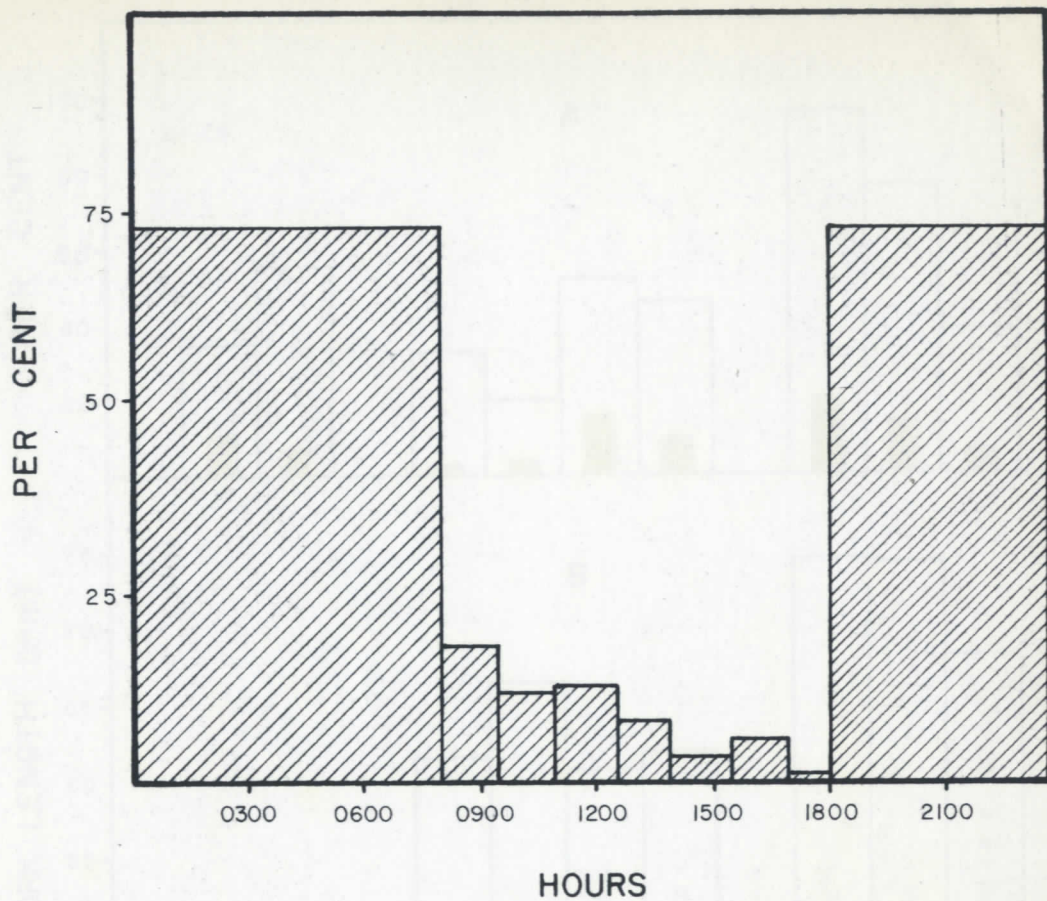


FIGURE 4. Percentage of total salmon run passing Moncton Causeway fishway trap, arranged by hours, 1969.

SEA AGE

Age and length of salmon in the fishway trap at Moncton, New Brunswick, 1969. The data represent the percentage of total salmon run passing the fishway trap at Moncton, New Brunswick, 1969. The data are presented in the following table.

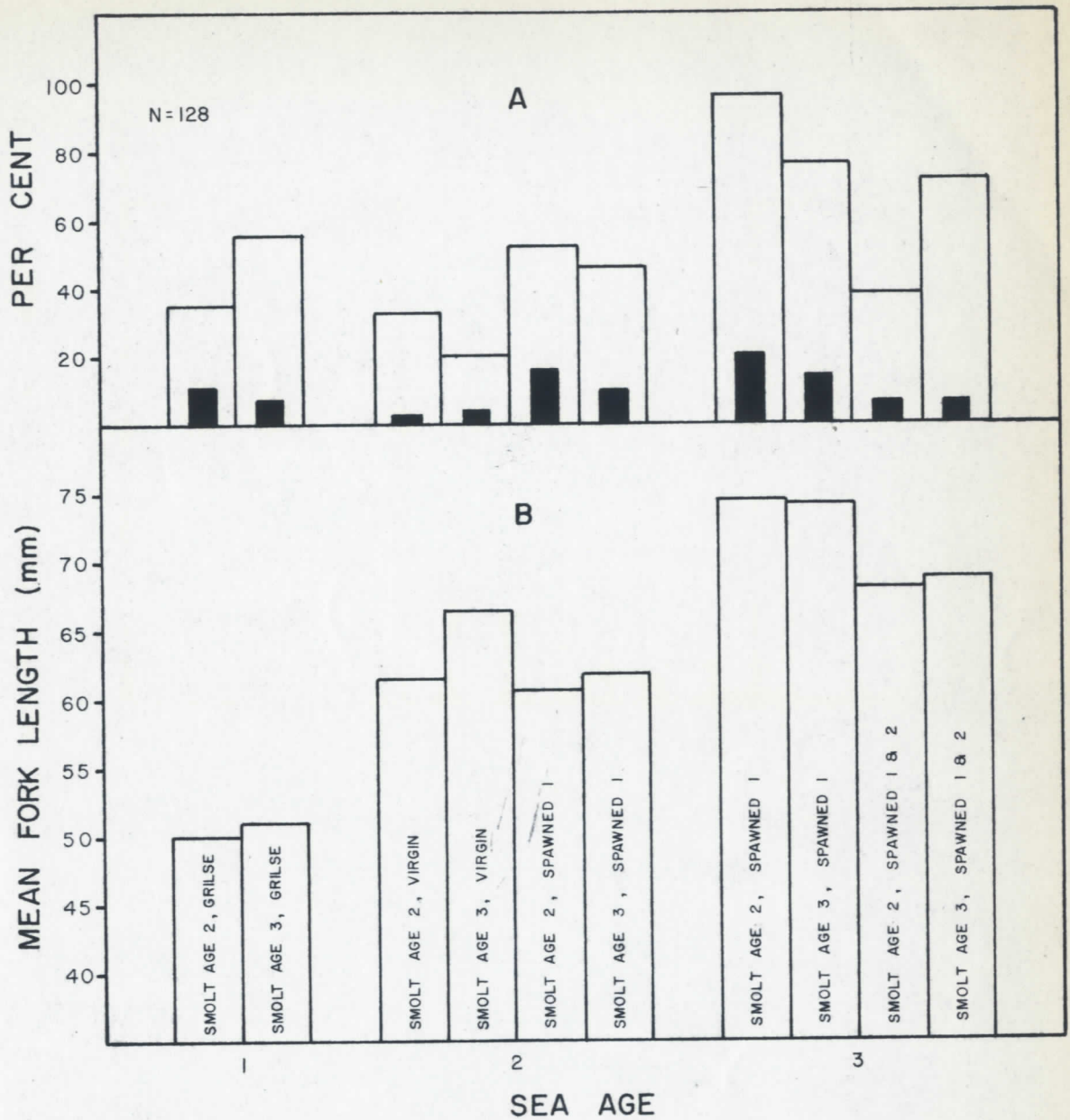


FIGURE 5. Age, mean length and sex ratio of adult salmon in fishway trap at Moncton Causeway, Petitcodiac River. Chart A: unshaded portion represents percentage female; shaded portion represents percentage of total run. Chart B: mean fork length of specified age groups.