Annotated Bibliography of Aquatic Biology and Habitat of the Petitcodiac River system, New Brunswick

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Abstract

The results of 251 published and unpublished reports on the aquatic biology and habitat of the Petitcodiac River system, New Brunswick, are summarized. The geographic limits of the area considered are the freshwater Petitcodiac River and its tributaries, and the estuarine/marine system down to the mouth of Shepody Bay. Documents from the mid-1800s to March 2000 are included.

Résumé

Les résultats de 251 rapports publiés ou non-publiés, au sujet de la biologie aquatique et de l'habitat de la rivière Petitcodiac situé au Nouveau-Brunswick, sont résumés. Les limites géographiques de la région sont définies comme étant les eaux douces de la rivière Petitcodiac et ses tributaires, et le système marin-estuarien jusqu'à l'embouchure de la Baie de Shepody. Des publications datées à partir de 1852 jusqu'à l'an 2000 sont incluses.

Introduction

In this document we have attempted to create a reasonably complete list of the published scientific literature on the aquatic biology and habitat of the Petitcodiac River system. The unpublished material included here is not intended to be comprehensive. We have included a number of government memos, briefing notes, letters, and unpublished manuscripts which present novel data – i.e., data which are not otherwise available in published form. We did not include newspaper or magazine articles, publications or briefs by advocacy groups, or citations of internet web sites.

Habitats and organisms that are "transitional" between aquatic and terrestrial systems are not included in this report. Thus, we did not list publications on wetlands, or on riparian mammals and birds, except in cases of material dealing with direct interactions with aquatic biota or habitats in the watershed.

The geographic limits of most of the material summarized here are the freshwater Petitcodiac system, and the estuarine/marine system downstream to the mouth of Shepody Bay –approximating a line drawn between Mary's Point, Grindstone Island and Lower Rockport. A few of the references cited here refer to findings downstream of this line, but rarely beyond the mouth of Chignecto Bay.

The full literature citation of all material is listed alphabetically by first author. We have summarized the major findings of each paper in the form of an extended abstract. The titles of several papers which were cited in other reports, but which we were unable to locate, were included without abstracts.

Measurements originally expressed in non-metric format have been converted to the metric system, with the original measurement following in parentheses. Any material enclosed in square brackets is our comment.

A work of this kind will inevitably contain some errors or omissions. We recommend that the reader consult the original publications; this document is intended to serve primarily as a guide to the available literature and as a quick overview of the material.

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ADI Ltd. 1979. Study of operational problems, Petitcodiac River causeway, Moncton, N.B. Report to New Brunswick Department of Transportation, File 600-154. December 1979. 122 p.

This document discusses operational problems that had developed in the first decade of causeway operation and suggested solutions. The problems included:

(1) Erosion along the banks of the reservoir, as a result of undercutting by wave action: Bank erosion was most extensive on the lower 6-10 km (4-6 miles) of reservoir. There was no significant erosion along the flat marshland sections. Erosion was most severe at high water levels and a reservoir operating level of 5.9 m (19.5 ft) or less was recommended to stabilize bank erosion at its present level.

(2) Inability to maintain stable reservoir levels during the summer, due to leakage of fresh water past the sluice gates. Leakage was estimated to be >17 m^3/sec (600 cfs), which exceeds the mean monthly stream flow for six months of the year. In general, August and September were the months of lowest flow, when there was ~20% probability that inflow would be less than the requirements for normal fishway operation plus surface evaporation. The design operating levels of the reservoir were 5.2 m (17 ft) normal, 6.7 m (22 ft) maximum and 2.1 m (7 ft) low level. In practice the aim had been to operate at ~6.1 m (20 ft). The maximum summer level was limited to 6.6 m (21.5 ft) to provide drainage for low-lying farmland upstream. During high runoff, the reservoir was generally lowered to 3.7-4 m (12-13 ft) during the ebb tide period. Installation of new gate seals to reduce leakage was recommended. Some leakage of fresh water at ebb tide, but prevention of salt water entry to the reservoir, was a design feature of the gates. Freshwater leakage was intended to flush silt accumulations away from the downstream side of the gates, and to provide a continuous flow of attraction water for fish migrating up the river. In 1979, the gates were leaking in both directions and the aperture was 3-4 times the intended size. Gate leakage did not attract fish to the fishway since it was spread out across the width of the channel. It was noted that if the gates were sealed, it would be necessary to operate them much more frequently (every few days) to control the reservoir and to prevent buildup of silt in front of them.

(3) Siltation both upstream and downstream of the causeway: Siltation in the reservoir was caused by salt water inflow through the fishway and gate leakage when the tide was higher than the reservoir. Up to 3.7-4.3 m (12-14 ft) of silt had accumulated in the reservoir since 1968, amounting to an estimated 1.1-1.7 million m^3 (40-60 million ft^3) of silt, or 10% of the reservoir volume. At the current rate of sedimentation, it was estimated that the lake would be filled "in the foreseeable future" (50-100 years). The lower the reservoir level, the more silt entered. Incoming salt water caused flocculation of the clay-sized suspended sediment in the river inflow. These particles then settled out in the reservoir near the causeway. At high reservoir elevations, fishway and gate leakage inflow on a yearly basis were approximately equal and combined were equivalent to about 40% of the reservoir volume. At lower reservoir elevations the gate leakage increased to about double the fishway inflow. At a reservoir elevation of 4.6 m (15 ft), the combined saltwater inflow on a yearly basis would be more than double the reservoir volume at that elevation. Virtually no silt was carried out on normal fishway flow because the silt laden salt water was denser than the reservoir fresh water, and sank to the bottom. The accumulation of silt from saltwater inflow was ≥10 times what might be expected from the downstream flow of the river itself. To reduce the inflow of silt-laden salt water, it was recommended that the gates be sealed, the reservoir level be maintained at 6.1 m (20 ft), and the fishway be modified to reduce the inflow of salt water. It was also recommended that the fishway be closed during December-March.

Siltation of the river downstream "has been caused on a massive scale" due to elimination of part of the tidal prism (volume of water between high and low tide levels) on construction of the causeway. Siltation on the order of 3-3.7 m (10-12 ft) had occurred since construction of the causeway. A seasonal siltation effect also caused a seasonal variation of ~6.1 m (20 ft) in the elevation of the river bed downstream of the causeway.

(4) Unsatisfactory fishway operation: Fishway operation was inefficient, especially in summer or low flow months. The design fishway flow at design normal operating levels (reservoir at 4.6 m (15 ft) and downstream at 0 m (0 ft)) was ~0.85 m^3/sec (~30 cfs). However, these design characteristics were not being achieved. The exit velocity of water from the fishway was only about 1/3 the design value, because of seasonal siltation below the causeway. The downstream elevation built up each summer due to silting. According to the design, the flow should have exited through a slot, 0.3 m (1 ft) wide by 1.4 m (4.5 ft) high (i.e., entrance sill at –1.4 m (-4.5 ft), water level 0 m (0 ft), whereas for most of the summer the exit was up to 4.3 m (14 ft) higher, because of the siltation problems. Low reservoir levels also contributed to reducing

the fishway flow. The net effect was that fish were not attracted into the entrance of the fishway because there was insufficient freshwater signal, especially when combined with the leaky gates. An additional problem arose in low flow years such as 1978, when the upstream siltation was so extensive that fish passage upstream of the fishway was effectively blocked. The optimum river flow for fish movement during the low water interval was ~14.2-28.4 m^3/sec (500-1000 cfs). Fish passage was only possible through open control gates when the difference in elevation between the reservoir and tide was <0.6 m (<2 ft).

It was proposed that (1) a stable reservoir level should be maintained at ~6.1 m (20 ft), to provide an assured flow to the fishway, (2) attraction water and river maintenance flow would be provided by operation of one of the main gates on each tidal cycle to provide ~1.5 times the normal stream flow, (3) the downstream entrance baffle of the fishway should be built up to elevation 6.7 m (22 ft) so that exit water would always pass through the 0.3 m (1 ft) wide slot. With the original specifications, the effect of tide exceeding the top of the baffles (elevation 4.9 m (16 ft)), was to cause outward flow as a combination weir flow over the baffle and through the slot, lessening the attraction effect for fish. Further modifications to reduce salt water inflow at the fishway were suggested. These included extending the upstream perimeter wall from elevation 7 m (23 ft) to 7.9 m (26 ft). The baffles in the upper four pools would be similarly raised, and changed vertical orifices only with the elimination of weirs. The floor level of these pools would be raised to 4 m (13 ft) from 2.7 m (9 ft) with the difference being made up in the upper 15 pools. These modifications would result in a 25% decrease in tidal inflow. If necessary, once the gates were effectively sealed, allowing storage of water upstream, an additional 1.4 m^3/sec (50 cfs) of attraction water could be piped over the tops of the existing weirs to the two entrance pools or directly to the exit providing for enhanced attraction flow at this location.

(5) Ice jamming at the end of the reservoir: Ice jamming below the railway bridge was probably aggravated by the ice sheet in the reservoir, but the reservoir should not have affected ice jamming above the highway bridge at Salisbury. Recent flooding at Salisbury was believed to be the result of record-setting high midwinter river flows (records were kept since 1962).

(6) Gate operation and maintenance problems: Three options were considered: operation of the causeway "as is", operation without gates, and elimination of gate leakage. The recommended alternative was to reduce leakage at the gates and fishway. Operation "as-is" was not considered a feasible alternative because of the accumulation of silt in the reservoir. Removal of the control gates was also not recommended because it would lead to "massive erosion of the river downstream, probably reverting to between 60 and 80% of its pre-causeway width. Equally massive siltation would result upstream in the present reservoir." There was also concern about water velocities through the control gates perhaps being too high for fish passage, and the expense of restoring the former aboiteaux and dyke system. A computer simulation suggested that the reservoir level would not rise as high as the tide, the difference being ~0.6 m (2 ft). The time required to drain would be ~9 hr as opposed to ~3 hr ebb tide and 6 hours of river flow at present. Even at mean river flows, the reservoir would not drain completely on most tides. Under this mode of operation, the tidal prism upstream of the causeway would be reduced by the lag in reservoir level to about 80% of its pre-causeway level. There would probably be a rapid readjustment by silting up of the reservoir, which would bring the upstream levels on each tide in closer agreement with the downstream levels. The estuary would tend to revert to a configuration such that the time required to drain the present reservoir would be the same as the ebb tide period (3-4 hr) followed by 4-6 hr of river flow. In order to accomplish this with the fixed discharge capacity of the existing sluice structure, the upstream tidal prism would have to reduce to about 60% of its pre-causeway value. Thus, the width of the river upstream would be reduced to 60-80% of its present width. The most dramatic changes would be in the section between the causeway and Turtle Creek. Reversion of the river downstream of the causeway to 60-80% of its original width would involve massive erosion on the scale of ~100 m (several hundred ft) in width near the causeway. There would also be extensive local erosion around the sluice gate structure itself, which was designed to discharge in the downstream direction only, with no provision upstream for energy dissipation or scour protection. Fish passage would be improved on flood tide, although velocities of 0-0.5 m^3/sec (0-18 cfs) combined with turbulence might be detrimental to fish passage. During downstream flow, discharge velocities would be ~0.4 m^3/sec (~13 cfs), making it difficult for fish to ascend against the current. To avoid massive siltation upstream it would probably be necessary to at least double the width of the existing sluice, requiring a bridge span of 46-61 m (150-200 ft). There would be no way to avoid massive erosion of the channel downstream.

Modification of one of the gates was suggested as a means of improving fish passage. The upper section of the gate would be fitted with two 137 x 152 cm (54 x 60 in) ports with sluice gates upstream and flap gates downstream to automatically regulate the low flow water releases. The sluice gates would provide regulation, and flap gates would prevent reverse flow. These units would be mounted above elevation 3 m (10 ft).

Mean tides at Moncton were 6.1 m (19.9 ft), the mean large (spring) tide (years 1887-1917) was 8.1 m (26.7 ft), and the highest recorded tide (Saxby) was 10.1 m (33.25 ft). Approximately 50% of the high tides were higher than the "normal" reservoir level of geodetic elevation 6.1 m (20 ft). In general the height of tide increased with distance up the estuary so that at the head of tide near the railway bridge the water levels were estimated to have been ~0.5 m (1.8 ft) higher than at Moncton on the same tide. High tide at Moncton occurs ~45 min after high tide at Saint John. Due to the shallowing of the estuary at Moncton, the flood tide occurs over ~3 hr, but the ebb tide and low water period is ~10 hr. The causeway did not result in any noticeable change in tidal amplitude. Comparison of the tidal cycle in 1898, 1968 and 1979 suggested that the duration of flood tide might have increased slightly since 1898; this may have increased the rates of siltation in the estuary.

The tidal prism for the section of estuary above the causeway was equal to ~170 x 10^6 m3 (600 x 10^6 ft^3) of water, for an average tide. This water normally carried an extremely high suspended sediment load, ranging from 10-50 g suspended sediment/L of water (0.6-3 lb sediment/ft^3 of water). The average load was 24 g/L (1.5 lb/ft^3). For the average tidal prism, this was equivalent to 508,000 tonnes (500,000 tons) of sediment moved on each tide. Under normal circumstances, this material would have been maintained in suspension by turbulence of the water, and any which settled out at slack tide would have been eroded during ebb tide. Apparently, the estuary had attempted to compensate for change in tidal volume by altering its cross-sectional area by approximately the same ratio. Construction of the causeway reduced the tidal volume just below the causeway to zero, and the area silted up such that only the low water channel width was still open. During the summer, further sedimentation caused this channel to silt up by a depth of 2.4-3 m (8-10 ft). At Dieppe, the change in the tidal prism was about 50%, and the cross section at geodetic elevation 6.1 m (20 ft) changed from 5,017 m^2 (54,000 ft^2) in 1960 to 2,322 m^2 (25,000 ft^2) in 1971. The process of readjustment was very rapid with the major changes occurring within one year of causeway completion.

The rapid accumulation of silt below the causeway has implications for the erosive capacity of the river water. Clear water has a greater erosive capacity than sediment laden water. With the deposition of silt at the causeway, the concentration of suspended materials on ebb tide was reduced relative to normal or pre-causeway values. Therefore, it might be anticipated that erosion would occur further down the estuary because of the lower sediment concentrations on ebb tide.

The largest of the inflows to date had been less than half the design flow of 937 m^3/sec (33,000 cfs) which corresponds to the 100 year flood. It was reported that there had never been a requirement to open more than 3 of the 5 sluice gates at one time since construction. The maximum discharge capacity of each gate was estimated as 341-398 m^3/sec (12,000-14,000 cfs).

ADI Ltd. 1996. Technical evaluation and monitoring program for an option to operate the gates to clip the tides at the Petitcodiac River causeway. Report to Environmental Sciences Research Centre, Université de Moncton. File 55-307-51.1. February 1996. 70 p.

This report addresses options for achieving the following concept:

"From May to December, open the gates to allow tidal water to flow upstream, past the control structure. However, operate the gates to control or "clip" the tides such that agricultural land located upstream from the causeway is not flooded with tidal water. Also, operate the gates on the falling tide to control the outflow of water through the gates, such that the effects of erosion are reduced. From December to May, leave the gates closed to avoid ice damage, operating them only as necessary for maintenance or water flow considerations."

This concept was somewhat similar to the "Open gates" option addressed by ADI and Washburn and Gillis (1992), in that fish passage would be possible, the tidal bore would be partially restored, and the headpond would be drained during low tides from May to December. As a result of opening the gates, the headpond would partially silt in and some areas along the river would experience erosion, unless protected. However, agricultural land would not be flooded, and erosion protection would be less expensive than with five gates open.

The following approaches were evaluated:

(A) Stifle tides: Open one or more gates (partially or fully) and leave them in that position over a tidal cycle. This approach, with four variations listed below, was determined to be impracticable because tidal and fresh water accumulating in the headpond area during high tide could not be drained during the time available during low tide.

(A1) One or more gates fully open. Gate position fixed throughout a tidal cycle, but varied over the season.

(A2) All gates partially open. Gate position fixed throughout a tidal cycle, but varied over the season.

(A3) One or more gates fully open. Gate position fixed throughout the season.

(A4) All gates partially open. Gate position fixed throughout the season.

(B) Clip tides: Open one or more gates fully, but close them when a certain water level upstream of the causeway has been reached. Open gates when the water levels downstream have fallen below the upstream water level. This approach was determined to be technically feasible. It would allow fish passage through at least one fully opened gate for a limited period of time, and since the gate(s) would be fully open, fish would not have to sound under a gate when passing the structure.

(C) Stifle tides: A combination of (A) and (B), with one or more gates partially or fully open during rising tides, but increasing the gate opening during falling tides by raising one or more gates. This differs from (B) in that the gates would never have to be closed. This procedure would allow upstream fish passage for the duration of upstream flow, but in some cases the fish would have to sound under a partially submerged gate. This approach was also determined to be technically feasible. Sedimentation and erosion effects would be similar to (B).

In addition to the options to regulate flow through the gates, three scenarios for controlling the upstream flow regime were explored:

(1) Maintain a maximum water level of 2.5 m upstream of the gates, resulting in a very small headpond volume with a relatively narrow channel. Siltation would be limited to the lower sections and elevations of the current headpond and would allow reverting back to conditions similar to the current headpond if necessary in the future. Large mud flats would be exposed, somewhat similar to current conditions below the causeway. The mud flats would be flooded during high freshwater runoff situations and during the winter when the headpond would be restored.

Under option (B), operating one gate that would be closed at an upstream water level of 1.3 m would ensure that a level of 2.5 m would not be exceeded. Tidal water would flow upstream through the gates for approximately 1.5 hours before the gates would be closed. The volume of water passing upstream would be 900,000 m^3 or 4% of the pre-causeway tidal prism. At an average inflow and outflow duration of 2 hours, this flow would be equivalent to a flow of 122 m^3/sec or five times the average annual flow of the Petitcodiac River. There would be erosion immediately upstream and downstream of the causeway but minor effects on the tidal bore and channel configuration below the Gunningsville Bridge.

Under option (C), leaving one gate partially open during rising tides would result in a water level of 2.5 m. The gate would be set at a geodetic elevation of -0.7 m, leaving an effective opening of 0.8 m in height for upstream fish passage.

(2) Maintain a maximum water level of 4.0 m upstream of the gates, resulting in a medium headpond volume with a medium wide channel. Siltation would be larger than in scenario (1). The mud flats would be smaller than in scenario (1).

Under option (B), having two gates open during medium tides and high tides and closing the gates at an upstream water level of 3.5 m would keep the reservoir level $\leq$4.0 m. During low tides, all gates could remain open. During medium tides, tidal water would flow upstream through the gates for approximately 3 hr. The volume of tidal water passing upstream would be equivalent to 14% of the average pre-causeway tidal prism. At an average inflow and outflow duration of 4 hr, the flow would be equivalent to 9.5 times the average annual flow of the Petitcodiac River. The flow would approach the average flood flow (1 in 2 years) of 280 m^3/sec. Significant erosion would result as well as noticeable impacts on the tidal bore.

Under option (C), one gate would be opened to elevation 4.0 m during rising tides. During falling tides, a second gate would have to be raised.

(3) Maintain a maximum water level of 5.5 m upstream of the gates, resulting in an initially large headpond volume with a wide channel. Siltation would be significant, reducing the headpond volume over time. There would be small mud flats at high tide. This scenario could result in the creation of large salt marshes upstream of the causeway, similar to those which established downstream of the causeway after its construction in 1968.

Under option (B), this setting could be achieved only at medium and high tides. Opening 3 gates during medium and high tides and closing the gates at a level of 5.0 m would result in a maximum upstream level of 5.5 m. All gates could remain open during periods with small tides, resulting in a maximum upstream water level of 4.0 m. During low and medium tides, tidal water would flow upstream through the gates for approximately 4 hr. The gates would close only at large tides. The volume of water passing upstream would be equivalent to 34% of the pre-causeway tidal prism. Assuming outflow duration to be 5 hr, this flow would be equivalent to 17 times the average annual flow of the Petitcodiac River. This flow exceeds the one in two year flood flow by a factor of 1.5. There would be significant effects on the tidal bore and channel below the Gunningsville Bridge. The predicted tidal bore height would be 0.4 m.

Under option (C), three gates would be opened fully during rising tides and a fourth would be opened during falling tides.

All three scenarios would maintain water levels at or below the current headpond water levels. If, after a trial period, it was decided to revert back to current conditions, the appearance of the headpond could be restored by raising the upstream water level to elevation 6.1 m. The surface appearance of the headpond would be unchanged from current conditions. However, the bottom of the headpond would be higher due to silt deposition. The degree of silt deposition depends on the scenario chosen for the trial period, and the duration of the trial period.

Concerns regarding possible sediment deposition near Hopewell Rocks were discussed. New Brunswick Department of Natural Resources and Energy officials responsible for Hopewell Rocks Park had not identified a sediment deposition problem. Based on geometry of the estuary, changes to the causeway operation should not have an effect on the Petitcodiac estuary past Memramcook. A computer model indicated a slight possibility that sedimentation near Hopewell Cape is affected by the presence of the causeway in Moncton, but the operational changes considered in this study were judged unlikely to result in significant changes to the sedimentation regime near Hopewell Cape.

ADI Ltd. and Washburn and Gillis Associates Ltd. 1992. Analysis of options for the future of the Petitcodiac River dam and causeway. Report to New Brunswick Dept. of Transportation, Fredericton, NB. Project No. 55-600-320-1. May 1992. 167 p.

This report expanded on the ideas of the "Review committee on options for the future of the Petitcodiac River dam and causeway" (1991). The consultants assessed the options and issues identified by the committee, with information on the costs, benefits and effects of each option.

1. Gates closed – status quo
    - advantages: headpond maintained, upriver agricultural land protected from flooding, no large capital cost
    - disadvantages: no improvement in fish passage, continued operational cost, no economic and recreational benefits of improved fishery, no improvement in tidal bore
2. Operate gates – similar to 1989-1991 experiment
    - advantages: headpond maintained for most of year, upriver agricultural land protected from flooding, no large capital cost
    - disadvantages: theoretically improved smolt passage in 1988-1991 had not resulted in increased salmon runs, continued operational cost, no economic and recreational benefits of improved fishery, no improvement in tidal bore
3. New fishway design
    - original committee envisioned gate operation similar to status quo

- consultants believed this would not be feasible; the fishway might improve upstream passage but not downstream; it would be necessary to operate gates from mid-May to late June and late August or September onwards to provide downstream passage
- advantages: improved fish passage, economic and recreational benefits of increased fishery, upriver agricultural land protected from flooding
- disadvantages: headpond drained for half the year, continued operational cost, no improvement in tidal bore
- cost: fishway design and construction, $2,500,000; annual operation $150,000

4. Fish trap and transport
   - original committee envisioned gate operation similar to status quo
   - consultants believe this would not be feasible; trucking would improve upstream passage but not downstream; it would be necessary to operate gates from mid-May to late June and from late August or September onwards to provide downstream passage
   - advantages: improved fish passage, economic and recreational benefits of increased fishery, upriver agricultural land protected from flooding
   - disadvantages: headpond drained for half the year, continued operational cost, no improvement in tidal bore
   - cost: design and construction of trapping/transport system, $2,500,000; annual operation $150,000

5a. One gate open
   - the "open gate" would be alternated among the 5 gates to keep them all operable (to avoid siltation)
   - advantages: improved fish passage, economic and recreational benefits of increased fishery
   - disadvantages: headpond permanently eliminated, upriver agricultural land not protected from flooding, erosion protection required, continued operational costs of gates
   - cost: $2,200,000 for erosion protection

5b. Five gates open
   - advantages: improved fish passage, economic and recreational benefits of increased fishery, enhanced tidal bore, decreased annual operating costs
   - disadvantages: headpond permanently eliminated, upriver agricultural land not protected from flooding, erosion protection required
   - cost: $4,500,000 for erosion protection

6. Replace causeway with bridge
   - would involve removing 250 m of causeway and installing a bridge
   - advantages: improved fish passage, economic and recreational benefits of increased fishery, enhanced tidal bore, decreased annual operating costs
   - disadvantages: headpond permanently eliminated, upriver agricultural land not protected from flooding, erosion protection required
   - cost: construction, $10,000,000; erosion protection, $6,750,000

7. Separate river from headpond
   - construct a diversion channel to take a portion of the Petitcodiac River discharge around the headpond, close existing fishway
   - advantages: improved fish passage, economic and recreational benefits of increased fishery, upriver agricultural land protected from flooding
   - disadvantages: headpond would become narrower and shallower, with loss of recreation and aesthetic benefits
   - cost: $60,000,000

None of the options had quantifiable benefits which were greater than the associated costs; therefore, on a cost-benefit basis there was no option which could be recommended. However, it was recommended that options 2, 3, 4, 5a, 6 and 7 should be eliminated because they were too expensive or likely to fail for technical reasons. Only options 1 (close gates) and 5b (open 5 gates) were found to merit further consideration. It was noted that the number of people positively impacted would be far greater under option 5b.

The 1968 salmon smolt emigration would have been the last to have unimpeded downstream passage. The fish returning in 1970 were 95% grilse, and this was the first spawning class to have encountered the causeway on both downstream and upstream migrations. Angling catch/rod-day from 1950 through 1967 inclusive was 0.277 for black and bright fish combined. For the decade of the 1970s, during which all salmon experienced regulated conditions, catch/rod-day was 0.127. During the 1980s a total of 17 salmon was caught, only 0.06 fish/rod-day.

The causeway gates were opened from April 15-June 7 1988 in an attempt to improve fish passage but this was less successful than expected. The return of salmon in 1989 was only 25% of the expected numbers. It was suggested that the poor returns might have been the result of having closed the gates too early in the season, and that gates should be left open on receding tides until well into June. Another possible explanation was that the Petitcodiac salmon stock had not evolved to move through lakes (because the watershed contains few natural lakes), and might be permanently delayed in the impoundment.

A potential for system-wide salmon returns of 5,000 adult fish/yr was accepted as a conservative estimate of production.

The gaspereau fishery had "severely declined" and this was attributed to poor passage through the causeway. Total Petitcodiac landings were 11-17 tonnes during the 1960s, 0-16 tonnes in the 1970s, and 0-4 tonnes in the 1980s. It would be possible to design a fishway to pass the gaspereau, but a separate means of downstream passage of juveniles would be required in late summer.

The Petitcodiac's spawning population of shad was "depleted by poor fish passage". A downturn in the estuarine fishery (based on fish from many rivers, which did not spawn in the Petitcodiac) was thought to be "due to other factors related to the closing of the causeway". The factors responsible were linked to changes in sedimentation and flushing. Deposition of sediment in the estuarine region from the causeway to Shepody Bay had caused the water in the lower reaches of the river where the fishery was conducted to become more shallow. At the same time, turbidity decreased due to reduced tidal mixing. According to Dadswell *et al*. (1983), light intensity was the cue for swimming depth of shad. It was suggested that the increased light penetration and decreased depth of the fishing grounds in the lower Petitcodiac estuary after causeway construction forced the shad into deeper water where they were less available to the fishery. The infilling of the river in the region where the fishermen operated also affected the duration around high tide when the water would be of sufficient depth to fish. Fishing in deeper water would risk damage to nets from dogfish. "The [commercial] shad fishery in the Petitcodiac River in the vicinity of the confluence of the Memramcook River is currently severely depressed." The potential value of the freshwater fishery for shad that could take place each June with a restored local spawning run was estimated to be 2% of the value of the potential annual salmon fishery.

Rainbow smelt "are very weak swimmers, and are excluded from upstream migration by most barriers which require active fish passage facilities". There was a recreational dip net fishery, but no commercial fishery before causeway construction. DNRE's angling records for 1975 indicated the continued existence of a small fishery in the order of 5,000 smelt. In the same year, the Nepisiguit River (an unregulated river of similar drainage area) had an angling catch of 48,500 smelt. It was estimated that the Petitcodiac River could support a fishery for ~43,500 smelt.

It was arbitrarily assumed that the value of sea trout angling opportunities was equivalent to shad, each species being valued at 2% of salmon.

The possibility of changes to lobster and scallop landings was discussed. Decreased suspended sediment in the water had decreased the deposition of sediment in some portions of the Inner Bay of Fundy. Some people had interpreted increases in scallop and lobster landings as being due to the presence of the causeway which might have decreased suspended sediment or improved benthic conditions. It was noted that DFO disputed this interpretation.

The study estimated that 6.5×10^6 m^3 of sediment would be deposited upstream of the causeway following a permanent opening of the gates. Of this, 2.5×10^6 m^3 would be "new" sediment entering from coastal waters, and the remainder would be sediment scoured from the river bottom downstream of the causeway. Therefore, removal of the gates would result in net deposition upstream of the causeway, not into the Bay of Fundy.

Complete removal of the causeway and construction of a bridge would result in scouring of accumulated sediment from the headpond and estuary. A volume of 13.8×10^6 m^3 of sediment would be transported downstream. "There is great uncertainty as to the ultimate destination of this material. Some may be deposited in the marine sediments. Whether this would have an effect on the fisheries for scallops and lobsters is unknown."

The option of separating the headpond from the river would result in a net downstream transport of 10 x 10^6 m^3 of sediment.

Reasons for poor operation of the fishway were summarized:

- Lack of flow in the fishway – flow was uncontrolled and varied with height of the headpond, and fishway flow was the only maintenance flow available to the lower river with gates closed
- Operation of the causeway gates had released large volumes of water simulated a "freshet" condition and delayed fish in the lower estuary; moderate release would stimulate fish to approach the facility.
- Extreme turbidity and lack of directed attraction flow of sufficient magnitude over the entire tidal cycle prevented salmon from finding the fishway
- The vertical slot design was not appropriate for shad and gaspereau.

Mitigative actions which had been attempted over the years to improve fish passage included:

- Moderation of discharge from the headpond starting in 1970
- Incorporation of surface release ports in conjunction with a stoplog structure in gate 5
- Scheduling gate openings to facilitate downstream smolt migration in spring.

"These actions have not been successful in curtailing the continued decline in anadromous fish populations".

It was suggested that a new pool and weir fishway with 33 instead of 21 pools would pass salmon and gaspereau upstream if the structure were gated and increased attraction water were directed to the outlet. This kind of structure might be able to pass 70-90% of the run. However, this would have no effect on downstream passage.

It was calculated that the stocking program followed by DFO in "recent years", ~100,000 fall fingerlings/year, could result in re-establishment of full river capacity of salmon within 3 salmon generations or 12 years. The annual cost of stocking would be ~$72,000/yr for 12 yr.

Sewage discharges from Moncton, Riverview and Dieppe were ~100,000 m^3/day. The biological oxygen demand of the raw sewage was ~100 mg/L and suspended solids were ~75 mg/L. The design BOD and suspended solids removal rate of the new sewage treatment plant (to come into service in 1994) were up to 70%. In August, 1978, BOD below the causeway ranged from <1 mg/L (high tide) to 72 mg/L (low tide). The minimum dissolved oxygen concentrations were 2.1 mg/L (=32% saturation) (low tide) and 2.6 mg/L (=39% saturation) (high tide). Suspended solids contribution from sewage discharges were not considered significant because of the extremely high suspended sediment levels in the estuary.

Coliform bacterial levels in the headpond from 1985 to 1990 ranged from 0 to "too numerous to count". Most samples contained <200 cells/mL (guideline for recreational use of water). "The coliform bacteria in the headpond were not monitored on a regular basis. Therefore, a reliable evaluation of water quality in the headpond in terms of coliform bacteria level could not be established."

"While the headpond is considered to be a recreational area, some recreational activities, such as swimming, are not recommended. This is not because of poor water quality, but because of the high turbidity of the water, and the associated poor visibility. In the past, the headpond has never been closed for water quality reasons."

Water quality in the headpond between Turtle Creek and the causeway was rated "poor" by the N.B. Department of the Environment from 1975-1979. "Poor water quality indicates that the water is unsuitable for swimming or cold water fisheries due to excessive contamination." The criteria for this ranking included total phosphate concentration >0.10 mg/L, total organic carbon concentration >15 mg/L, minimum dissolved oxygen concentration <5 mg/L and/or fecal coliform counts >200 cells/100 mL.

Opening the gates would result in almost complete mixing of salt and fresh water near the causeway with a transition from brackish to fresh water between Salisbury and Turtle Creek. The downstream salinity below the causeway opening was assumed to be 25‰. Average salinities above the causeway would range from 18 to 23‰ for scenarios with 1 to 5 gates open, or 24‰ for the bridge scenario. Water quality in terms of BOD values, dissolved oxygen levels, and coliform bacteria counts would be expected to improve upstream of the causeway, as a result of the gate openings. During rising tides, well-oxygenated brackish water would enter the former headpond, wastewater contribution from the greater Moncton area would be highly diluted, and BOD values passing the causeway would be low. During falling tides, the upper part of the estuary would be flushed, and dominated by freshwater flows with good water quality. Areas downstream of the causeway would experience slight improvements in water quality, as a result of the increased tidal prism and the increased dilution capacity.

Amiro, P.G., R. E. Cutting, B. M. Jessop, T. L. Marshall and S. F. O'Neil. 1992. Status of Atlantic salmon stocks of Scotia-Fundy Region, 1991. Canadian Atlantic Fisheries Scientific Advisory Committee Research Document 92/21: 22 p.

Atlantic salmon stocks in the Inner Bay of Fundy Rivers were so low that concerns were expressed that these populations might have attained irrecoverable levels. The recreational fishery and all harvests of Atlantic salmon in the inner Bay of Fundy were closed in 1991.

A return of seven salmon to the Petitcodiac River fishway was equal to the counts in 1990 and these two records represented the lowest numbers of returning Atlantic salmon reported since the fishway trap records were started in 1983.

Amiro, P.G., R.E. Cutting, T.L. Marshall and S.F. O'Neil. 1993. Status of Atlantic salmon stocks of Scotia-Fundy region, 1992. Department of Fisheries and Oceans Atlantic Fisheries Research Document 93/13: 25 p.

Counts of salmon returning to the Petitcodiac River in 1992 were not presented, because the use of the by-pass notch (stop-log structure) by fish would render the fishway counts inconsistent with previous years.

Amiro, P. G. and E. M. Jefferson. 1996. Status of Atlantic salmon in Salmon Fishing areas 22 and 23 for 1995, with emphasis on inner Bay of Fundy stocks. Department of Fisheries and Oceans Atlantic Fisheries Research Document 96/134: 36 p.

No Atlantic salmon were reported at the trap in the Petitcodiac causeway fishway during 1995. Salmon may have passed upstream undetected, through an opening in the stop-log structure in the gate during high tides.

All harvest and hook-and-release salmon fisheries in the inner Bay of Fundy had been closed since 1991.

On September 21 1995, five electrofishing spot checks were conducted in the Petitcodiac River. The total catch was two age 1 hatchery parr, found in the main stem of the Petitcodiac at the Trans Canada Highway.

On October 10 1995, cage-reared salmon of Big Salmon River stock were stocked in the Pollett River (16 females, 13 males) and Little River (24 females, 14 males). The fish weighed an average of 4.99 kg. Based on an average egg production of 1,543 eggs/kg, the stocked fish may have deposited 230,987 eggs, or 3.4% of the conservation egg deposition. The conservation requirement for the 2,815,000 m^2 of habitat in the Petitcodiac River (Semple 1984) was estimated at 1,688 grilse and 101 multi-sea-winter salmon.

Amiro, P.G., and E.M. Jefferson. 1997. Status of Atlantic salmon in Salmon Fishing Areas 22 and 23 for 1996, with emphasis on inner Bay of Fundy stocks. Department of Fisheries and Oceans Atlantic Fisheries Research Document 97/26: 34 p.

No salmon were reported at the fishway trap in 1996. No adult or juvenile salmon were released into the Petitcodiac system in 1996.

Eight sites were electrofished on September 9-12 1996. No parr of any age were found in two sites on the main stem of the Petitcodiac (where 2 age 1 hatchery parr were found in 1995). Three of the four sites fished in the Little River contained age 0 parr (this river received adult salmon of Big Salmon River stock in 1995).

Andrews, C. W. 1943. Smolt marking on the North River, Petitcodiac, N. B. Fisheries Research Board of Canada, Manuscript reports of the biological stations 335; Atlantic salmon and trout investigations, 1943; 28(1): 9 p.

A smolt counting fence was operated from May 12 to July 31 1943, ~366 m (~400 yd) above the mouth of the North River. Only downstream passage was provided. Weather conditions, water temperatures, water levels and catches of various fish species were recorded daily. Smolts were marked by removing their adipose fin.

Most (99%) of the 3,087 smolts recorded at the fence were captured from May 12 to June 15 when temperatures ranged between 7.2 and 15.5ºC (45-60°F). After June 15, water temperatures ranged from 9.4 to 31.7ºC (49-89°F) and water heights decreased from 46 to 10 cm (18 to 4 in). Fewer fish descended the river and occasionally, some of the salmon caught were already dead. On July 13, when the water temperature was 31.7ºC (89ºF), 11 parr which entered the trap at 1630h were all dead by 1700h.

The average length of the smolts was 14 cm.

Other species captured in the trap totalled 1,025 suckers, 888 minnows, 100 gaspereau, 40 eels, 73 trout, 6 chub and 51 sea lampreys. Daily counts are reported.

Further examinations of the Anagance River and Holmes Brook (tributary to Anagance River) revealed that wherever suitable river bed and shelter were found, young salmon were also present. It was suggested that the Petitcodiac system could be improved as habitat for young salmon by providing artificial shelters such as fallen trees and brushwood.

Location	Date	Age 0	Age 1
Anagance R. - near mouth	Aug. 3 1943	none	none
Anagance R. - 823 m (900 yd) above mouth	Aug. 3 1943	several	>14
Holmes Brook - from mouth to km 2.4 (mile 1.5)	Aug. 3 1943	"well populated" with young salmon. Several redds.	
Holmes Brook - from bridge at Petitcodiac village to 137 m (150 yd) upstream (at night, with light)	Aug. 6 1943	8-10	>25

Andrews, C.W. 1944. Report on salmon trap operation, Pollett River, 1944. Fisheries Research Board of Canada, Manuscript reports of the biological stations 379; Atlantic salmon and trout investigations, 1944; 30(3): 12 p.

A counting fence for descending salmon smolts was operated ~183 m (~200 yd) below the Sanatorium dam from May 21 to August 15 1944. In total, 663 smolts and 51 parr were captured. Smolts were caught from May 21 to July 1, with a single smolt caught on July 14. The run peaked on May 29 with 149 smolts, dropped off to almost nothing, then 152 smolts were caught on June 26. The peaks in the run corresponded to increases in water depth and during each of these peaks the maximum number of smolts descended either during or immediately following a rainstorm. About 25% of the total number of smolts descended during daytime. Parr were caught from June 14 to June 29.

Smolts were marked by removing the adipose fin and the right pelvic fin. Length measurements and scales were obtained for a subsample of the fish. "…the handling involved in removing two fins, measuring as well as removing some scales sometimes left the smolt in a weak condition which however it soon overcame."

Scales and measurements were also taken from some of the smolts caught by anglers between the dam and the trap. Anglers caught about 250 smolts in this area.

Temperatures ranged from 2.8ºC (37ºF) (May 19) to 27.8ºC (82ºF) (June 29, July 9, August 5, August 15).

Sanatorium Lake was formed by building a dam across a wide meadow through which the Pollett River flowed. The lake was ~457 m (~500 yd) in both length and width. It was ~3 m (10 ft) deep at the inflow and 3.7 m (12 ft) at the eastern end, but most of the lake was only ~1 m (3 ft) deep. The dam was 46 m (152 ft) long with a concrete bridge above. A wooden apron, 46 x 11 m (152 ft by 36 ft), conducted the water from the dam to a pool just below the dam. The apron was attached about 0.8 m (2.5 ft) below the top of the dam. The slope of the apron was about 30° and its lower edge was flush with the water in the pool below except when the river was low, when the fall was 15-25 cm (6-10 in). The part of the dam over which the water flowed downstream was built of concrete.

The pool immediately below the dam was formed by the water falling over the dam before the construction of the apron. The pool was 49 m (160 ft) long and 12 m (40 ft) wide. It was 2.3 m (7.5 ft) deep at the east end and 1 m (3 ft) deep at the west end. Smolts were seen in the pool, from the time the trap began operating (May 21) until July 19. Anglers caught about 250 smolts in the pool from May 21 to June 25. One smolt was angled in the pool on July 4 and another on July 6. It was observed that smolts and parr "drifted" out of the pool for a short distance at night and returned again with the coming of daylight. This was confirmed by the events of July 19-20. The lake was drained, starting at noon on July 19, in order to clear beaver brush at the dam. Smolts and parr swam out of the pool that evening, but by midnight very little water was flowing from the pool. In the morning, 6 smolts and 7 parr were found dead among the stones between the pool and a point ~5 m (15 yd) downstream. "These salmon were undoubtedly unable to get back to the pool with the approach of daylight because of the lack of water."

During July 20-22, no water was flowing over the dam because the water was diverted through a tunnel which rejoined the river ~229 m (250 yd) below the dam. A stretch of river between the pool and a point ~137 m (150 yd) below the trap (a total distance of about 229 m (250 yd)) was virtually dry. About 200 parr and a few smolts gathered in the shallow pool of the river bed at this time. The river just above the lake, and another area 3.2 km (2 miles) below the trap were examined for parr, but only 3 parr were found at the downstream site, and none upstream. It was suggested that the area adjacent to the trap provided more protection from predatory birds because of traffic across the bridge and activity at the trap.

Given that the pool below the dam seemed to play an important role in slowing the downstream smolt migration, it was suggested that the effect of the lake above the dam should be investigated. It was determined in 1944 that only a "couple dozen" smolts could be accounted for as taken by anglers in the lake. Some smolts were observed jumping in the lake between May 21 and June 30. The water was too deep for direct visual observations.

Andrews, C. W. 1944. Lethal temperatures and sensitivity to light of some freshwater fish at high temperatures. Fisheries Research Board of Canada, Manuscript reports of the biological stations 379; Atlantic salmon and trout investigations, 1944; 30(4): 9 p.

Lethal temperatures were investigated for white perch, American eel and white sucker. Experiments were carried out at the Sanatorium dam using a galvanized tank measuring 91.4 x 61 x 15.2 cm (3 x 2 x 0.5 ft) with a capacity of 0.1 m^3 (3 ft^3). Temperature was adjusted by heating water in a 18 L (4 gal) tank, and siphoning the heated water into the experimental tank so as to increase the temperature at a rate of1 ºC every 5 min. Small (6-7 cm) American eels had a higher lethal temperature (36-37ºC) than white perch (33.2-33.7ºC) and sucker (32.8-35.5ºC) except for the smallest suckers, which had a lethal temperature of 37.2ºC.

The effect of size on temperature tolerance was tested using suckers of 1 to 30.5 cm. The largest suckers had the lowest lethal temperatures, 32.8-33.0 ºC, while the smallest suckers had the highest lethal temperature, 37.2ºC.

The response of suckers of various sizes to light during high temperatures was tested using the same tank. The tank was separated into two compartments with a board, and one compartment was covered with tar paper. The fish could pass between compartments through an opening of 7.6 x 20.3 cm (3 x 8 in). Before increasing the temperature of the water in the tank it was found that small suckers were sensitive to light; the 1-4 cm suckers immediately left the covered compartment and swam to the light compartment. Alternating the cover to the other side caused the suckers to continue to move to the light compartment. This continued with an increase in temperature up to a certain point after which the suckers either stayed in one compartment continually or swam rapidly from one compartment to the other disregarding the light or dark chamber. The temperature at which this behaviour occurred was taken to be the temperature at which the suckers were no longer sensitive to light. The behaviour of large suckers under similar conditions was the opposite with regard to light. Large suckers moved from the light to the dark compartment, up to a certain temperature. The loss of sensitivity to light occurred at lower temperatures (27-28ºC) for large suckers (20-36 cm) than for small suckers (31-32ºC, 1-2 cm). After being placed in cool water (22ºC) for 30 min-2 hr, suckers recovered their sensitivity to light.

The depth distribution of suckers was similarly affected by temperature. At 23ºC, 1 cm suckers remained near the surface, 2-4 cm suckers were 2-4 in below the surface, 4-7 cm suckers were 4-10 in below the surface, and larger suckers remained at the bottom of the tank. When the temperature was raised beyond a certain point [temperature not specified in the paper], the suckers no longer occupied any one depth or layer of water but swam from the surface to the bottom almost continually.

Andrews, C. W. 1945. Report on smolt trap operation, Pollett River, 1945. Fisheries Research Board of Canada, Manuscript reports of the biological stations 381; Atlantic salmon and trout investigations, 1945; 32(4): 9 p.

A smolt counting fence on the Pollett River (just below the Sanatorium dam) was operated from May 29 to June 27, 1945. Installation of the fence had been delayed by high freshets and "the constant descent of heavy brush and stray saw logs". It was assumed that the early part of the smolt run was not intercepted, since 29 smolts were captured on the first day of operation. Operations were concluded following damage to the fence by another freshet on June 28. On average the water level in 1945 was twice as high as in 1944. The minimum water level in 1945 was rarely lower than the maximum level in 1944.

In total, 174 smolts, 7 parr, 2,281 suckers, 379 gaspereau, 241 lampreys, 6 trout and 33 eels moved downstream through the counting fence. More than 96% of the smolts that were counted at the fence descended before June 10. During this period the average maximum daily temperature was 11ºC (51.6ºF). Smolts caught in the trap were marked by clipping the adipose and right pelvic fins.

Seven lampreys entered the trap on or before June 12, but the main descent took place from June 13 to June 27, when an average of 16.7 lampreys/day entered the trap. Lampreys were frequently observed clinging to the apron of the dam, especially in the late afternoons and evenings.

Two families of mergansers were observed in the trap area. One family of eight entered the trap on June 26.

A pool immediately below the Sanatorium dam and the headpond created by the dam were heavily fished by anglers during May and June of 1945 but no smolts were captured. A single "post-smolt" was captured there on August 15. During May, June and July of 1944, 250 smolts had been angled in the same area. The difference in catch in the two years was attributed to the effect of this pool on smolt movements under different water conditions. In the relatively low water conditions of 1944, the pool had the effect of delaying the downstream movement of smolts. Only 1 smolt descended through the fence after July 1, but smolts and parr could be seen in the pool until July 19. Examination of the river bed at night with a light showed that smolts and parr drifted or swam out of the pool and downstream for a short distance. They were not present in the area between the pool and the fence during the day, and it was concluded that they returned to the pool with the approach of daylight. This probably occurred at river flow rates of 0.03-0.06 m^3/sec (1-2 ft/sec). When water discharge from the pool was reduced to a certain (unspecified) level, resulting in lower water depths in the area, the salmon did not leave the pool. Under the higher flow conditions occasionally observed in 1944, and almost continuously present in 1945, smolt "did not stay in the pool for any length of time".

Parr were observed jumping in the pool in late June-July, usually in the late afternoon and evening. They were also observed trying to ascend the east end of the apron of the Sanatorium dam but most of them were not able to reach the lake above the dam. In most cases, the parr only ascended 4.6-4.9 m (15-16 ft), nearly halfway up the apron, before they were swept back into the pool. The water flowing over the apron was less than 2.4 cm (1 in) in depth, scarcely enough to cover the parr. Residents of the area reported that adult salmon had been observed to ascend the apron in the fall but that they were unable to reach the reservoir above. Elvers, on the other hand, were observed to successfully ascend the apron and enter the lake, with hundreds of elvers visible on the apron in both 1944 and 1945.

Andrews, C.W. 1947. Report of Pollett River smolt trap operations, 1947. Fisheries Research Board of Canada, Manuscript report of the biological stations 365: 7 p.

Salmon smolts were trapped at a counting fence below the Sanatorium dam from May 17 to June 3 1947 (when the trap was carried away by high water). In total, 4,282 smolts were trapped, of which 36 were found dead in the trap. Living smolts were released following removal of the adipose and right pelvic fins. Scale samples and length measurements were obtained for 1,274 smolts. The median length was 166 mm.

The peak of the run occurred on May 26, when 1,867 smolts were captured. Before May 26, schools of smolts had been observed in the Sanatorium lake. On May 26, it rained from 0800h to 1300h. In the morning, smolts were clearly visible in the trap and 300 were removed. At noon, there were no smolts in the trap. By 1400h the water level had increased by 23 cm (9 in) from the 0900 h measurement, and had become so turbid that the fish could not be seen except when they came to the surface. Between 1400h and 1800h, 1,500 smolts were removed from the trap. Another 67 smolts were removed between 1900h and 2000h, after which few or no smolts remained. "That the greater part of the catch trapped in daylight descended when the water became turbid is noteworthy." It was speculated that a combination of the increase in water height and turbidity contributed to the large movement of smolts. The turbidity might have diminished the light to conditions similar to twilight and night when the smolts usually descended.

A second freshet, on June 3, did not result in a large smolt run. This was the last day of operation, and only 69 smolts were taken, suggesting that the run was coming to an end. Temperature ranged from 8.3ºC (47ºF) (June 3) to 18.6ºC (65.5ºF) (May 24) during the operation of the trap.

Few, if any, smolts were taken by anglers either before or during the period of trap operation. In 1944, 25% of the recorded smolt run was taken by anglers at the dam.

Thirty-three previously marked smolts (0.8% of the total) were caught a second time. These must have found their way up through the fence.

Other fish caught included 903 suckers, 239 gaspereau, 90 eels, 5 trout, 4 lampreys and 24 chubs (*Semotilus atromaculatus*).

The trap and fence were located about 183 m (200 yd) below the Sanatorium dam as in previous years. The trap placement was modified in 1947, being located toward the west bank rather than in the middle of the river as before. The advantages of the new trap site were: (1) it trapped smolts that might have accumulated in the lake before the setting of the trap, although some probably left the lake before the trap was set and others probably remained even after trap removal, (2) there was less possibility of trapping "natural" smolts than there would be if the trap had been located further downstream. Adult salmon from the sea had been seen near the trap site, but could not ascend the lake dam to spawn. They probably spawned below the dam and therefore below the trap site, although some underyearlings had been seen near the spill pool between the dam and the trap site. The disadvantage of the site was the fast current, which increased to "torrent" proportions in time of heavy freshets. This current was caused by a bottom gradient of about 12° between the spill pool and the trap. The strength of the current, combined with debris brought down by the freshets, had swept the trap away on two occasions: June 30 1944 and June 3 1947. On the latter occasion, the water height in the trap rose by 87.6 cm (34.5 in) compared to the previous day. At Moore Bridge, about 4.8 km (3 miles) upriver, the water height rose from just under 0.6 m (2 ft) at noon on June 3 to over 1.8 m (6 ft) early on June 4.

Anonymous. 1998. Environmental quality monitoring. Pages 17-22 *in* Environmental Monitoring Working Group. 1998. Environmental monitoring of the Petitcodiac River system, 1997: Trial opening of the Petitcodiac River causeway gates. December 1998. 280 p.

Water quality data are presented for the Petitcodiac River at Petitcodiac (old TransCanada Highway) (1971-1994), at Salisbury (1970-1974), and at the control gates (1970-1978), and in Turtle Creek at the inlet to the Turtle Creek reservoir (1965-1978). High values of specific conductance (45.3-27,500 µS/cm), sodium (Na) (2.8-5,100 mg/L) and chlorine (Cl) (2.9-10,000 mg/L) near the gates indicated salt water intrusion into the headpond. Values of total organic carbon (TOC), nitrate+nitrite, and total phosphorus were also high near the gates. All measures of conductivity and nutrients were lower at the Petitcodiac site than at the gates, and lowest at the Salisbury and Turtle Creek sites. Phosphorus appeared to be the limiting nutrient at freshwater stations whereas nitrogen was limiting near the causeway gates.

Sampling from 1100h to 1345h on October 1 1997 at the Gunningsville Bridge recorded an increase in conductance from 1,350 µS/cm at low tide to 38,800 µS/cm with the incoming tide. The arrival of the tide reduced dissolved oxygen levels from 11.8 to 8.4 mg/L and also reduced turbidity and total organic carbon levels. Nitrogen, phosphorus and fecal coliform bacteria initially increased with the incoming tide, then decreased, presumably due to effluent from the waste treatment plant which was subsequently diluted by a larger volume of incoming tidal water. Fecal coliform counts ranged from 3,500 cells/100 mL at low tide to a maximum of 22,800 cells/100 mL. All samples were screened using Microtox toxicity testing and all were negative, indicating that the water samples were not toxic. The sampling was repeated on October 30 with very similar results.

Preliminary analysis of physical, chemical and bacteriological water quality from the headpond was carried out between the causeway and the railroad bridge below Salisbury. Water chemistry was comparable to historical data, but data are not presented in this report. Fecal coliform counts ranged from undetectable to >300 cells/100 mL. Samples with counts in excess of the recreational contact guideline of 200 cells/100 mL were present in 3 of the 5 months sampled. All fecal coliform counts were below the recreational boating guidelines of 5,000 cells/mL.

Toxicity of the wastewater from the Greater Moncton Sewage Commission Plant was tested on November 2 1995 using a fish toxicity test. There was no mortality of rainbow trout held for 96 hours in a 100% effluent sample; therefore, the effluent was not considered a deleterious substance under the Fisheries Act.

Wastewater samples collected on October 11 1994 and November 22 1995 had total nitrogen values of 9.4-24 mg/L, and total phosphorus of 0.9-2.8 mg/L. The sampling conducted in 1997 from the Gunningsville Bridge detected nitrate+nitrite at 0.16-1.7 mg/L and total phosphorus at 0.67-3.08 mg/L. The ranges of nutrients in the Petitcodiac River near Petitcodiac from 1971-1994 were the highest values from the freshwater areas sampled, at 0.008-0.320 mg/L of total nitrogen and 0.01-1.0 mg/L of nitrate+nitrite.

Fecal coliform counts from the treatment plant effluent on October 11 1994 were 1 x 10^6 cells/100 mL. Dilution factors of 240 on the outgoing tide, and 33 on the first flood of tide were estimated, assuming an effluent volume of 36,000 m^3/day. Biological oxygen demand of the effluent in 1997 (monthly averages) ranged from 4,007-8,019 kg/day, and total suspended solids were 2,283-6,705 kg/day.

Anonymous. 1998. Landfills and landfill leachate. Pages 192-196 *in* Environmental Monitoring Working Group. 1998. Environmental monitoring of the Petitcodiac River system, 1997: Trial opening of the Petitcodiac River causeway gates. December 1998. 280 p.

Two landfill sites, (6920-0501) located between the causeway and Jonathan Creek, and (6925-0501) located east of the Gunningsville bridge, together extend 2-3 km along the river bank below the causeway. The consultant report on the closure of landfill (6925-0501) estimated 140,000 m^3/yr of leachate production based on precipitation, evaporation and direct surface runoff, which would translate to a daily runoff of 580 m^3, occurring over an 8-month period. At an average discharge of 27.9 m^3/sec (freshwater flow only), the dilution factor would be 4,200. In addition to the freshwater dilution factor, tidal flow would dilute the leachate by a factor of 2,000 on the initial flood tide, increasing to a factor of 14,800 several hours later.

Samples collected from leachate seeps consistently exceeded Guidelines for Freshwater Aquatic Life (FAL) with respect to concentrations of ammonia, iron, copper, zinc, aluminum and lead. It was noted that FAL are not leachate guidelines, and that dilution by the expected factor of 4,200 would result in meeting the FAL guidelines. The landfill closure had reduced the volume of leachate, and many of the leachate test wells had very little leachate present in summer. The peat tank filter had effectively removed metals and organics from leachate, and concentrations of heavy metals and biological oxygen demand were lowered at its outlet.

Samples collected downstream and upstream of the landfill in the Petitcodiac River in May, July and October 1997 met the FAL guidelines with the exception of iron, copper and aluminum. Concentrations of zinc exceeded guidelines on one occasion.

Samples from boreholes adjacent to the landfill exceeded Canadian Drinking Water Quality guidelines for iron, manganese, colour, turbidity, sodium, chloride, barium and/or sulphate.

PCBs were detected in 1 of the 4 groundwater samples (0.134 ppb), and in 4 of the 8 seeps (surface water samples) (≤0.152 ppb). PCBs were not detected in samples from the river. The Freshwater Aquatic Life criterion for PCBs is 0.001 ppb; dilution of the samples by a factor of 150 would be necessary to comply with the guidelines.

Anonymous. 1998. Water samples collected March 3, 1997 by LPPA. Page 191 *in* Environmental Monitoring Working Group. 1998. Environmental monitoring of the Petitcodiac River system, 1997: Trial opening of the Petitcodiac River causeway gates. December 1998. 280 p.

Water samples collected on March 3 1997 through the ice at 5 sites from the Salisbury bridge to the causeway, and from open water below the gates and at the Gunningsville bridge, were analysed. Ranges of values were:

	Above gates (n=5)	Below gates (n=2)
Total coliform bacteria (cells/100 mL)	96-300	300
Fecal coliform bacteria (cells/100 mL)	40-160	280-560
Suspended solids (mg/L)	5.6-20.4	225-443
Total phosphorus (mg/L)	0.0256-0.083	0.0837-0.172
Total nitrogen	0.41-0.59	0.60-0.67
PH	7.30-7.40	7.30-7.5
Colour (apparent)	5-25	95-150
Specific conductance (μS/cm)	173-233	287-508
Total organic carbon (mg/L)	1.4-1.9	1.8-2.1
Sulphate (mg/L)	16.70-21.35	18.10
Aluminum (mg/L)	0.083-0.440	3.600-4.400
Iron (mg/L)	0.170-0.710	5.700-7.200
Zinc (mg/L)	0.010	0.030-0.050
Cadmium (mg/L)	0.001	0.001
Lead (mg/L)	0.002	0.006-0.009

Bacteria levels in samples collected above the gates were considered to reflect the influence of sewage lagoon discharge and livestock, while those in samples below the gates were influenced by effluent from the wastewater treatment plant. The high concentrations of suspended solids in samples below the gates were due to suspended marine silts. Total phosphorus concentrations at below-gate sites were typical of marine waters. High specific conductance and colour at those sites were due to high concentrations of silt, chloride and sodium. Higher concentrations of metals resulted from the high silt concentrations and the tendency of metals to adhere to silt particles.

Anonymous. 1998. Lake Petitcodiac recreational water sampling – 1997. Page 252 *in* Environmental Monitoring Working Group. 1998. Environmental monitoring of the Petitcodiac River system, 1997: Trial opening of the Petitcodiac River causeway gates. December 1998. 280 p.

Fecal coliform bacteria were monitored in the headpond in July and August. Concentrations of fecal coliform bacteria "are significant but below the Canadian Water Guidelines of 200 [cells] per 100 mL". Values ranged from undetectable to 120 cells/mL. It was noted that Environment Canada personnel became host to leeches during launching of boats, and that Dept. of Fisheries and Oceans staff contracted swimmers itch (*Schistosoma dermatitis*). "Although the waters in Lake Petitcodiac are safe for recreational activities, they are far from ideal for swimming."

Anonymous. 1999. City of Moncton landfill – 1998 monitoring results. Pages 41-69 *in* Environmental Monitoring Working Group. Environmental monitoring of the Petitcodiac River system, 1998: Petitcodiac River Trial Gate Opening Project. 325 p.

Landfill site (6920-0501), located between the causeway and Jonathan Creek, was monitored by collection of surface water from collection seeps, at the peat filtration tank, and from a perimeter drainage ditch; groundwater samples; water samples from the Petitcodiac River and Jonathan Creek; and air and gas samples.

"As has been the trend", seep samples contained concentrations of ammonia, iron, copper and zinc in excess of the guidelines for Freshwater Aquatic Life (FAL). "The FAL guidelines for ambient waters are not directly applicable to the end of pipe samples collected from the seeps but do provide a convenient benchmark." Employing a dilution factor of 4,200, the impact of the leachate on the receiving waters would be well within the guidelines. The peat filter reduced the levels of the above contaminants, and reduced biological oxygen demand from 48 to 13 mg/L.

A perimeter drain, installed as part of the 1998ºClosure program, contained leachate with high concentrations of iron, ammonia, and zinc similar to other seep points. This drain discharges into Jonathan Creek.

Concentrations of contaminants in samples taken in the Petitcodiac River on April 13 and August 28 did not exceed FAL guidelines. Iron concentrations in Jonathan Creek before (August) and after (October, November) installation of the perimeter drain all exceeded the FAL guideline.

Iron, manganese, colour, turbidity, sodium, chloride and/or sulphate in groundwater exceeded Canadian Drinking Water Quality guidelines.

All regular sampling points plus soil samples were tested for PCBs, but these were either not present or below detection limits in April, June and October. In August, PCBs were detected in shallow groundwater and seep samples. Concentrations were very close to the laboratory's limit of detection. The maximum value of 0.06 μg/L was considerably lower than results recorded in 1997, and was below the guideline of 0.1 μg/L for contaminated sites. The value exceeded the FAL guideline of 0.001 μg/L, but would be reduced below this level by a dilution factor of 4,200.

Anonymous. 1999. Report on 1998 monitoring by Department of Transportation. Pages 324-325 *in* Environmental Monitoring Working Group. 1999. Environmental monitoring of the Petitcodiac River system, 1998: Petitcodiac River Trial Gate Opening project. September 1999. 325 p. & Appendix to the above report (as a separate volume). 55 folio pages.

Shoreline surveys indicated the riprap shoreline upstream and downstream of the causeway to be stable. Some bank erosion occurred between the downstream end of the riprap and the Gunningsville Bridge, at a time since the 1997 survey.

Aerial photography to monitor river channel changes between Fox Creek and Turtle Creek was done in December 1998.

Channel bathymetry at the Gunningsville Bridge was monitored 20 times between January 30 and December 17. Survey results are plotted on 5 drawings in the Appendix, on which the seasonal infilling and flushing of the channel may be followed.

Bathymetry surveys of the river between Hopewell Cape and the causeway were made in 1998 at sites which had been surveyed in 1991. A few examples are included in the Appendix.

The Appendix also includes a bathymetry survey of the river at the level of Outhouse Point, which corresponds to 1979-1997 data.

A "random sounding" of the channel area immediately above the dam was done in July and September 1998 (see Appendix).

Aerial photos of the encroachment of the Moncton landfill dumpsite and other infilling of the river were compared to 1945 photos, and included in the Appendix.

Arsenault, J.T. 1998. Heavy metal data – sediments and bivalves – Petitcodiac River. Pages 31-34 *in* Environmental Monitoring Working Group. 1998. Environmental monitoring of the Petitcodiac River system, 1997: Trial opening of the Petitcodiac River causeway gates. December 1998. 280 p.

Sediment samples from the Gunningsville Bridge area in September 1997, and freshwater mussels from the headpond, Pollett River and North River (July-October 1997) were analysed for five metals of environmental concern: cadmium, copper, lead, mercury and zinc. In addition, the sediment samples were analysed for aluminum, chromium, cobalt, iron, manganese and nickel.

Concentrations of cadmium, copper, lead, mercury and zinc were all below the Lowest Apparent Effects Threshold guidelines listed in the Sediment Quality Guidelines for the Protection of Aquatic Life. There were no guidelines listed for the four remaining metals (aluminum, cobalt, iron and manganese).

Ashfield, D., D.K. MacPhail, P. Mandell and G.J. Farmer. 1984. Chemical characteristics of selected rivers in Nova Scotia and New Brunswick during 1983. Canadian Data Report of Fisheries and Aquatic Sciences 489: 18 p.

Water samples were collected in the Petitcodiac River near Salisbury, and in Turtle Creek, Coverdale, Pollett, Anagance and North Rivers on July 6 and December 5 1983. Most analyses were carried out for all sites. Calcium, magnesium, chloride, sulphate and aluminum were measured only at the Petitcodiac River site.

	Range of values observed	
	July 6 1983	December 5 1983
pH	6.65-7.48	6.11-7.29
Total alkalinity (mg/L)	14.8-50.8	6.6-34.6
Total hardness (mg/L)	17.4-154.4	11.8-105.1
Specific conductance (μS/cm)	60.2-510.0	38.4-394.3
Apparent colour (relative units)	25-65	15-55
Ca (mg/L)	12.9	10.3
Mg (mg/L)	1.9	1.4
Cl (mg/L)	21.8	10.0
SO_4 (mg/L)	20.0	13.8
Al (μg/L)	120	150

Aubé, I. 2000. Ichthyoplankton and zooplankton communities of a dammed estuary, the Petitcodiac Reservoir, New Brunswick. Honours Thesis, B.Sc. program, Dalhousie University, Halifax, NS.

Results of plankton monitoring in the headpond, below Upper Coverdale,from 1997 through 1999 were discussed. The reservoir was meso-eutrophic to eutrophic, well-mixed, warm and turbid. Low numbers of both ichthyoplankton and zooplankton were present. Larval rainbow smelt and gaspereau were the only diadromous ichthyoplankton, with spawning grounds located in the main Petitcodiac River or tributaries above the sampling stations, and in Turtle Creek. Larval *Morone* sp., probably white perch, were also present in 1999. Cladocerans were dominated by *Daphnia catawba* and *Bosmina* sp. Copepods were dominated by *Eurytemora affinis*. Rotifers were the most abundant taxonomic group. The presence of a number of typically brackish calanoids, mysids and a decapod zoea indicated occasional intrusions of brackish water into the reservoir; but these species were present up to 14 km above the causeway. The plankton community is indicative of a disturbed ecosystem, and the organisms which seem to be best adapted to the environment are taxa such as rotifers and bosminids, which are not the optimal prey organisms of fish.

Aubé, I., A. Locke and G. Klassen. 1999. Ichthyoplankton and invertebrate zooplankton communities and water quality of the Petitcodiac reservoir during the ice-free season, 1998. Pages 148-176 *in* Environmental Monitoring Working Group. 1999. Environmental monitoring of the Petitcodiac River system, 1998: Petitcodiac River Trial Gate Opening project. September 1999. 325 p.

Plankton collections at four stations in the headpond between May 13-October 16 1998ºConfirmed the conclusions of the 1997 study (Locke and Klassen 1998). The only ichthyoplankton utilizing the reservoir were larvae of gaspereau and rainbow smelt, which were present in low numbers (≤6.6 smelt/m^3 and 1.4 gaspereau/m^3). Both taxa probably spawned above the reservoir, and there was some evidence of smelt having spawned in Turtle Creek. The abundance of prey available to larval and juvenile fishes was low in the reservoir. The invertebrate plankton community was numerically dominated by rotifers and immature copepods, which provided poor quality forage for young fishes. Community composition was typical of a disturbed ecosystem.

As in 1997, the physical and chemical data characterized the headpond as a mainly freshwater, warm, turbid system. The salinity in the headpond in 1998 was mostly fresh water, but a maximum salinity of 2 PSU was recorded. Temperatures ranged from 10-28ºC. Surface and bottom temperatures reached 19-20 ºC by mid-June, and ranged from 22-28ºC in July and August. The reservoir was vertically well mixed throughout the ice-free season, and there was therefore no deep-water thermal refuge. Secchi depth varied from 0.4-2.5 m (mean = 1.15 m).

Rotifers were up to five or six orders of magnitude more abundant than the other planktonic organisms in the samples. The next most abundant organisms were immature copepods. Most of the mature copepods were the estuarine species *Eurytemora affinis*. The estuarine/marine calanoid *Centropages typicus* and marine mysids were also present. These estuarine taxa were found up to 14 km upstream of the causeway. Freshwater cladocerans were less abundant than either rotifers or copepods; the dominant taxa were *Daphnia* and *Bosmina* species.

Bailey, H.S. and G.D. Howell. 1983. Survey of toxic organic constituents in the Atlantic region's aquatic environment (1979/81). Environment Canada Inland Waters Directorate, Water Quality Branch. IWD-AR-WQB-83-48. 60 p.

The Petitcodiac headpond was sampled under the power lines about 850 m above the causeway in 1981. Polychlorinated biphenyl concentration in the sediments was below the detection limit of 0.005 mg/kg. Total polyaromatic hydrocarbon concentration was 0.102 mg/m^3.

Bailey, L.W. 1911. The fresh water diatoms and diatomaceous earths of New Brunswick. Bulletin of the Natural History Society of New Brunswick 29 (vol. 6, part 3): 291-320.

The following diatoms were recorded from the sediments of Pollett Lake [now known as Mechanics Lake] in Mechanics Settlement:
Navicula rhomboides, N. ovalis, N. binodis, N. trinodis, N. dilatata Schm. At., *N. brebissonii* Kg., *N. cuspidata* Kg., *N. (Pinnularia) major* W. Sm., *N. (P.) viridis* W. S.,*N. (P.) nobilis, N.(P.) dactylus, Stauroneis phoenicenteron* Ehr., *Surirella splendida* Ehr., *S. biseriata* W.S., *Epithemia, Gomphonema acuminatum* Ehr., *G. capitatum, G. constrictum* Ehr., *Nitschia spectabilis* Ralfs., *N. linearis?, Himantidium gracile, H. arcus, H. undulatum, Cocconema cistula, C. lanceolatum* Ehr., *Cymbella gastroides* Ktz., *C. cupidata* Ehr., *Cyclotella striata* Grun, *C. compta* Kg., *Eunotia major* Rab., *E. pectinalis* Kg., *E. pectinalis var. stricta, E. diadema, E. traodon, Synedra* sp? sigmoid.

It was noted that all were freshwater forms, although varieties of *N. ovalis* also occur in brackish waters. They were all existing forms, although the sample was taken from the lake sediments and living diatoms had not been sampled. The lake bottom deposits represented one of only four locations of "tripolite" or "infusorial earth" recorded in the province.

Beaulieu, G. T. 1970. Report on the Petitcodiac River Causeway. Department of Fisheries and Forestry of Canada, Fisheries Service, Halifax, NS. Manuscript Report No. 70-11: 19 p.

The annual run of Atlantic salmon to the Petitcodiac River was estimated as 2,000-3,000 fish prior to completion of the causeway in 1968. Subsequently, sport angling numbers of Atlantic salmon decreased markedly on the Petitcodiac River. Unsuitable hydraulic conditions resulting from the causeway were believed to have been the major cause of the reduced numbers of fish. Both upstream and downstream migration were affected by the presence of the causeway, but upstream migration is the particular concern in this report.

Migrating Atlantic salmon and other diadromous fish species require a flow of fresh water to stimulate upstream movement, but conditions at the causeway were not suitable. Gate operations at the causeway consisted of the gates being opened to discharge the excess water in the shortest possible time whenever the elevation of the reservoir was too high or in anticipation of floods. With the gates closed and the tide out, the only freshwater flow came through the fishway. This flow was insufficient to attract fish to the river from the estuary, and to provide suitable depths of water for passage upriver. Huntsman's work on the St. John River showed that migrating salmon hold and stop moving upstream when a strong freshet occurs, and that upstream migration resumes while the river is returning to normal flow from the freshet. Although the method of releasing water from the Petitcodiac reservoir in some respects approximated a freshet under high flow, it did not subside in the same manner. Most freshets taper off and their discharges gradually decrease allowing fish to migrate upstream. In the present operation, the gates released a freshet-type flow, which suddenly stopped when the gates were closed.

Even after successfully ascending the fishway, salmon were subject to adverse effects of the gate operations. Salmon probably acclimatized themselves to fresh water in the immediate area of the gates, because the reverse flow through the fishway at high tide created a mix of salt and fresh water in this part of the reservoir. However, strong water currents (>7.6 m/sec) (25 ft/sec) resulting from gates being opened caused salmon in the immediate vicinity to be swept back to the downstream side of the gates. In 196

9, seven marked salmon, which had previously ascended the fishway, were recaptured at the fishway trap, 12 days on average after their first ascent.

Evaluation of the fishway over the 1968 and 1969 seasons indicated that Atlantic salmon did not have any trouble negotiating passage to the reservoir through the fishway once they had arrived at the causeway and located the fishway. Fishway ascents were strongly influenced by tide. Few fish entered the fishway trap at low tide and 64% entered the trap within 3 hr of high tide. No fish entered the trap when the causeway gates were open, and the highest fishway use was recorded on days when relatively little water was being released from the reservoir.

It was recommended that gate operations be modified in order to aid Atlantic salmon in entering the Petitcodiac River from the estuary. Accumulated water should be released from the reservoir gradually over the entire period of low tide, rather than all at once. Salmon enter the Petitcodiac just ahead or just abreast of the incoming tide provided there is sufficient attraction for them to enter the river. Fully opening the gate nearest the fishway when the tide was within 0.3 m (1 ft) of the reservoir (theoretical velocity of 2.4 m/sec (8 ft/sec)) and keeping the gate open until the tide and reservoir levels were equal, should result in considerable attraction flow. It was recommended that experiments with these regulated releases be conducted in August, with fully controlled discharges during the expected salmon migration months of September-November.

Belliveau, P.E. and H.S. Bailey. 1983. Survey of toxic organic constituents in the Atlantic region's aquatic environment (1979/81). Environment Canada Inland Waters Directorate, Water Quality Branch. IWD-AR-WQB-83-40. 60 p.

The Petitcodiac headpond was sampled under the power lines about 850 m above the causeway in 1981. Arsenic concentration in the water averaged 0.00053 mg/L (N=3). Cadmium concentration in the sediment averaged 0.033 mg/kg (N=3). Lead concentration in sediment averaged 9.4 mg/kg.

Blackwood, C.M. 1969. Letter from C.M. Blackwood (Acting Regional Director, Department of Fisheries) to J.B. MacAulay. June 11 1969.

Fish movements through the causeway were monitored from September 17 to December 18 1968. A "partial check" of fish movements counted 103 salmon, along with tomcods, eels, silversides, white perch, flounder, killifish, striped bass, suckers and shrimp. There was no estimate of the numbers of fish which did not use the fishway but moved upstream through the open spill gates. "Cursory checks" by Fisheries staff detected more salmon on the spawning grounds upriver than were counted through the fishway.

Bray, D.I., D.P. DeMerchant and D.L. Sullivan. 1982. Some hydrotechnical problems related to the construction of a causeway in the estuary of the Petitcodiac River, New Brunswick. Canadian Journal of Civil Engineering 9: 296-307.

"An estuary that is in a state of equilibrium is an example of a natural system that is delicately adjusted to its physical, chemical, and biological environment. If some boundary condition is changed then the estuarine system will adjust to a new state of equilibrium." This paper describes "some of the practical problems" that resulted from construction of the causeway.

Typical high tides at Moncton ranged from geodetic elevations of 4.5 to 8.0 m with a mean high tide elevation of 6.1 m. The typical tidal cycle at Moncton was significantly modified from the sinusoidal tidal cycle found near the mouth of the estuary and the Bay of Fundy, as a result of the shallowing of the estuary (the bottom of the sine wave was cut off at low tide, and was replaced by a flat line representing the river flow component of the tidal cycle). Silt and clay-sized materials on the banks and tidal flats of the estuary could be placed into suspension and redistributed if the characteristic shear stress distribution was modified. The median sizes of these materials typically ranged from 0.015 to 0.030 mm. The bed of the low-water channel consisted of a layer of fine sand.

Unlike rivers, estuaries respond to certain types of engineering works that decrease the cross section (dykes, dams) with "widespread and often irreversible consequences" including reductions in discharge as a consequence of loss of volume of the tidal prism. The volume of the tidal prism (at mean high tide elevation of 6.10 m) that was lost to the Petitcodiac estuary due to the closure at the causeway was estimated as 21×10^6 m^3.

An estimated 10×10^6 m^3 of sediment had accumulated in the 4.7 km of the estuary below the causeway from 1968 to 1971. Several approaches to modelling the ultimate extent of silting were discussed. In 1981, the width at the Gunningsville Bridge was 250 m, about 32% wider than the ultimate width of 190 m estimated by McCrea (1975). An alternative model suggested that the channel section near Gunningsville Bridge had nearly adjusted to the new regime of tidal and river flows by 1981, although this was "based on a scanty data base".

The meander geometry of the estuary for ~6 km below the causeway was adjusting to the new tidal regime. With the smaller tidal discharges, the meander wave length of the channel had become shorter. This was likely to result in erosion at banks that were not subject to erosion before the causeway. Variations in the channel plan form in 1945-1978 were illustrated.

The bed of the new estuarine channel below the causeway was controlled by the sill of the control structure at elevation –1.52 m. During periods of low flow in summer, the bed level rose to an elevation of 4 m, but during periods of high flow, the bottom elevation was limited by a bedrock control just downstream of the causeway. The seasonal changes in the bed level in the estuary downstream of the causeway were expected to diminish "as the characteristic discharge from the control structure becomes small in comparison with the characteristic tidal discharge at a particular cross section."

Increased siltation had occurred in the reservoir within 4 km of the causeway since the construction of the causeway. Some of the material was deposited during closure of the causeway and during the first few months of operation of the control structure when the gates remained open. This accumulation did not, however, account for more recently observed deposits. Relatively small amounts of sediment transport were due to river flow and bank erosion. It was concluded that increased sedimentation in the reservoir area just upstream of the control structure was due to net upstream transport of sediment through the fishway and at times through gates which might be left open during the tidal cycle for maintenance. A photograph illustrated the occurrence of reverse flow through the fishway at high tides. Variation of the suspended sediment concentrations in the fishway, and associated reservoir and tidal elevations were measured on August 8 1979. The net upstream transport of suspended sediment via the fishway on this tidal cycle was estimated as 430 tonnes. The equivalent volume of sediment introduced to the reservoir during the tidal cycle was calculated as 380 m^3. After this sediment entered the reservoir, there was virtually no downstream transport and therefore no means of removal of this sediment from the reservoir.

Before formation of the reservoir, wave action was seldom sustained long enough to cause appreciable beach formation along the banks of the natural estuary. After reservoir formation, the water surface was maintained at elevation ~6.1 m during much of the ice-free portion of the year. The maintenance of a relatively constant elevation promoted wave-induced erosion. Based on wind data, it was estimated that significant wave heights of 0.30 m occurred during ~200 hr/yr at one shoreline site, and ~60 hr/yr at another. Both sites had an effective fetch of 1200 km and were located in the lower 6 km of reservoir. The tops of the wave-cut beaches in these areas were ~0.45 m above the normal reservoir elevation. At higher reservoir elevations, the beach in areas adjacent to steep banks would ultimately advance ~5 units for each unit of increase in water level.

The effect of removing all 5 gates in the sluiceway was approximated using a “relatively simple” model. For mean river flow of 25 m^3/sec and high tide elevation of 5.8 m, the maximum reservoir level would be about 0.6 m lower than the high tide level during the time immediately following gate removal. The reservoir would almost drain to the level of the downstream bedrock control during the ebb tide. Subsequently, a net transport of sediment upstream through the control structure would occur. Eventually, an upstream tidal prism would develop with a volume of about 60% of the pre-causeway volume. The channel downstream of the causeway would increase in width to approximately double the channel width before removing the gates.

Browne, K.W. 1977. Jonathan Creek - Jones Lake water quality study 1975-1976. New Brunswick Department of the Environment Report T-77-05: 21 p.

Water quality was sampled at 2 stations in May and August 1975 and ≤12 stations in May, June, July, August and November 1976, located from the headwaters of Rabbit Brook to the downstream end of Jones Lake. Water samples were analysed for colour, total hardness, total alkalinity, total inorganic and organic carbon, nitrate+nitrite, total Kjeldahl nitrogen, total inorganic phosphate, total phosphate, dissolved oxygen, pH, specific conductance, and fecal and total coliform bacteria. In 1975, bottom fauna were sampled with a Surber sampler.

Bacterial samples indicated that Rabbit Brook, a tributary of Jonathan Creek, received non-point source and domestic waste runoff. The major source of contamination in 1975-1976 was untreated waste from Crystal Springs subdivision, and this was described as a “serious health hazard”. Treatment of this waste commenced in November 1976. The main stem of Jonathan Creek from the headwaters to the Moncton city limits was not contaminated, but water quality deteriorated downstream due to inflow of domestic waste from many sources. Fecal coliform counts were “exceptionally high” in Jones Lake. The waters of Rabbit Brook, Jonathan Creek within the city limits, and of Jones Lake were classified as unacceptable for body contact recreational use.

Phosphate, carbon and nitrate+nitrite values were high throughout the study. Specific conductance was high compared to most streams in the province, but “typical for waters draining the Lutes Mountain area”. Dissolved oxygen was close to saturation.

Just below the confluence of Rabbit Brook and Jonathan Creek, the benthic community contained “a healthy mixture of clean-water types among the 20 different taxa”. The diversity index at this station was 17.66. In Jones Lake, only 9 taxa were present, 89% of the individuals were *Tubifex*, and the diversity index was only 1.96.

Butler, R.L. 1963. Petitcodiac River report. Re: Proposed causway[sic] to cross at Moncton. Unpublished report, Canada Dept. of Fisheries. December 19 1963. 3 p.

Species of fish ascending the river included salmon, shad, sturgeon, smelt, trout, striped bass, alewives, eels and tomcod.

Salmon runs were "quite extensive" and supported good angling in the Petitcodiac, Little and Pollett rivers in the previous two years. Butler estimated the run at >10,000 fish but did not provide any supporting information for this estimate.

Shad entered "in large numbers" in May and June, and Butler believed this to be the only stream at the head of Chignecto Bay where shad spawned.

Smelts entered "in large numbers" late in April and early May to spawn. The absence of a commercial smelt fishery was due to the extreme tidal conditions and the area being full of drift ice during winter when the commercial fishery occurs.

A small run of sturgeon occurred, especially in May-June. A few were caught while drift-netting for salmon and shad. The average annual catch was 227 kg (500 lb).

There were small runs of alewives and tomcod.

The Petitcodiac was a "fairly good angling stream" for trout, and the trout taken were "generally good size".

There was formerly good angling for striped bass. This had decreased to almost nothing but then improved in 1961 and 1962. The fish were small, but "quite plentiful".

The commercial fishery for salmon and shad in Shepody Bay and the Petitcodiac estuary was described as "only a small Fishery as Fisheries go, although it means considerable in some years when work in the area is scarce". The average catches and values over the past 6 years were: 2,061 kg (4,540 lb) of salmon worth $2,184; 11,891 kg (26,192 lb) of shad worth $2,594; a few sturgeon. In peak years, the catches of shad exceeded 27,240 kg (60,000 lb) and of salmon exceeded 4,540 kg (10,000 lb). Most of the salmon entering the Petitcodiac to spawn did so after the seasonal closure of commercial fishing. The fishing fleet consisted of small fishermen owning their own boats: 8 power boats (7.6-11 m, 25-36 ft), 3 outboards and 10 rowboats (3.7-4.6 m, 12-15 ft). Some fished with only 1-2 nets, approx. 92 m (50 fathoms) in length.

Large numbers of dogfish in Shepody Bay in the previous few years made it unprofitable to fish for salmon and shad there. Before the dogfish became plentiful, fishing had been good in this bay.

Butler, R.L. 1963. Turtle Creek report: Re: Water supply for Moncton. Unpublished report, Canada Dept. of Fisheries. December 19 1963. 1 p.

Species of fish ascending Turtle Creek included salmon, trout, tomcod and eels.

The salmon were described as a "moderate run" – Butler estimated 2,000-3,000, but with no supporting documentation. Fish generally arrived late in this river, from mid-October until late in December. He had seen 50-70 salmon in the pool at Jonah bridge, ~16 km (10 miles) above the tide. There was no fall angling for salmon, as the fish came in after the angling season closed. There was some spring angling but most anglers fished the Little and Petitcodiac rivers, "which are larger streams and have more fish".

Turtle Creek was a good trout stream, and was heavily fished. The fish were generally small, but some "good sized" (30.5-40.6 cm, 12-16 in) trout had been caught downstream from the area where most of the angling was done.

Butler, R.L. 1969. 1968 Petitcodiac River estuary Causeway, Dam, Fishway. Unpublished report to Regional Director, Department of Fisheries. January 21 1969. 4 p.

Poor runs of fish into the Petitcodiac River and tributaries were noted in 1968. The salmon run was "far below" the previous year. The shad had a "poor run" although the water levels during their stay in fresh water were good. Fisheries officers had noted that the run of shad had declined over the previous 4 or 5 years. Smelts were present in the Salisbury area in their usual numbers in late April, but at the time of the run the gates were open. The gaspereau run was lower in numbers than usual, and Butler speculated that most of the gaspereau stayed in the lake waters formed by the causeway. The tomcod run was in and out early in the year, before the completion of the causeway and gates on February 10 1968. Even after completion of the structure, the five gates remained open until May 3 1968.

During the time from February 10 to May 3, the smelt run was in and out and the shad and alewife runs had started before the gates were closed.

After the closing of the gates, water levels above the causeway were kept very low while work was done on the causeway rock fill until late July. With the very dry and hot weather, it took "considerable time" to build up enough water above the causeway for "best operation" of the fishway. Until this time, water did enter the fishway, but mostly as reverse flow. Butler believed that a few fish did enter, but that more were turned away and only passed upstream when the gates were opened.

Several salmon died on the mud flats below the causeway during July-October, especially during "the high run of the tides". Salmon deaths had been recorded previously in July and August in years when the fresh water was low and warm, but before the causeway this usually occurred on the mud flats in the Salisbury-Boundary Creek area. The very low water levels in all the streams due to very dry, warm weather until late October adversely affected all fish migrations into fresh water.

After the upstream water level reached the desired level and the counting trap in the fishway was completed in mid-October, some salmon were counted through the fishway, but "considerably fewer fish than would ordinarily be entering the river". Butler was not sure of the number of salmon counted through by November but estimated 100 salmon and grilse. Most remained in the headpond until the water levels in the tributaries increased to a point where fish were able to travel to the headwaters. This was probably a poor year to test the success of the fishway. The salmon run was late (late October) in all local rivers, except the Upper Salmon River (Alma), because of the low water levels. Many salmon were seen in the Petitcodiac River below the causeway, below the end of October. After this time, it became more difficult to monitor the salmon. In late October, the water became high and dark and remained so for most of the time until freeze up in December. It was not possible to see into the pools in the lower sections of the river. The fishery guardian on the Coverdale River, which was somewhat clearer, reported seeing more fish in his area of patrol than were recorded at the fishway. Spawning and/or redds were noted in Coverdale River headwaters and in lower reaches of Holmes Brook. The Pollett River had "a very disappointing run", with only a very few salmon, which were seen early in the season below the Sanatorium dam. Repairs to the fishway in the Sanatorium dam were completed in October. A counting trap operated by the Fish Culture group detected no fish using this fishway in the fall. No fish were seen in the Pollett River in the pool below the Forest Glen dam.

"There is no doubt that this structure [the causeway] will have a detrimental effect on the Fishery of the area, Commercial and Sport." Butler hoped that salmon would adjust to using the fishway at the causeway over the years, because other streams below the structure "are much smaller and not suitable for a large run of salmon". The estuary was rapidly filling with mud in the vicinity of Moncton, with slower development of mud flats down to Stoney Creek and below. The river channel was getting narrower. This had already changed the driftnet fishery in the summer of 1968, decreasing the time and distance that could be fished by driftnet between Stoney Creek and the mouth of the estuary.

Caissie, D. 1998. Hydrology of the Petitcodiac River basin. Pages 40-51 *in* Environmental Monitoring Working Group. 1998. Environmental monitoring of the Petitcodiac River system, 1997: Trial opening of the Petitcodiac River causeway gates. December 1998. 280 p.

Information on monthly flow rates, flood frequency, low flow frequency, and duration of river ice are presented graphically. The drainage basin of the Petitcodiac at the causeway includes 1,360 km^2. Median flow was 11.9 m^3/sec. Daily discharge ranged from 0.354 m^3/s to 729 m^3/s.

Caissie, D. 1999. Water temperature of the Petitcodiac River at Salisbury. Pages 133-134 *in* Environmental Monitoring Working Group. 1999. Environmental monitoring of the Petitcodiac River system, 1998: Petitcodiac River Trial Gate Opening project. September 1999. 325 p.

Water temperature of the Petitcodiac River at the Salisbury bridge (route 112) was monitored from May 27 to November 11 1998. Maximum daily mean water temperature was reached on July 17 at 27ºC. Mean daily water temperatures exceeded 25ºC for a number of days in 1998, e.g., 7 days between July 16 and 23, and August 9-10. The maximum recorded water temperature was >30 ºC on July 17 and 18.

Caissie, D. 2000. Hydrology of the Petitcodiac River basin in New Brunswick. Canadian Technical Report of Fisheries and Aquatic Sciences 2301: 26 p.

To estimate freshwater discharge at the causeway, data from the upstream hydrometric station near Petitcodiac were prorated for the total basin using a factor of 3.5 (ratio of drainage basins). Mean annual freshwater flow at the causeway was calculated as 27.3 m^3/sec. The mean annual runoff was calculated at ~634 mm in a region receiving an average of 1030 mm of precipitation annually. Thus, 62% of the precipitation in the Petitcodiac River area became water in rivers; 38% was lost to evapotranspiration. This proportion was similar to the situation in other New Brunswick rivers. Water withdrawal by the city of Moncton at Turtle Creek accounted for ~13 mm of runoff/yr.

Median flow (discharge of the river 50% of the time) was calculated as 11.9 m^3/sec (or 44% of the mean annual flow). The range of discharge was 0.36 (August-September)-730 (April 1962) m^3/sec. Mean monthly flows ranged from a high of 85.2 m^3/sec in April to a low of 7.1 m^3/sec in September. Low winter monthly flows, which occurred in January and February, were ~18 m^3/sec, i.e., more than twice the summer low flows.

On average, 292 days of the year (80% of the time), discharge was <37.2 m^3/sec; 10% of the time, discharge was <2.28 m^3/sec; 5% of the time, discharge was <1.60 m^3/sec.

The maximum monthly water discharge recorded at 730 m^3/sec in April 1962 was probably close to a 100-year flood. The estimated 100-year, 10-year and 2-year flood events were estimated as 655, 457 and 293 m^3/sec, respectively. The estimated 100-year flood was lower than the value of 950 m^3/sec calculated by Bray *et al*. (1982), because with the extra years of data available to Caissie, the high flow of 1962 was less important in the analysis. The three highest annual floods since records began to be kept in 1961 all occurred in the 1960s (729 m^3/sec in 1962, 472 m^3/sec in 1967, 433 m^3/sec in 1963). The most recent high flow event (ranked as number 5) occurred in 1987 (400 m^3/sec). The 50-year flood for the Petitcodiac River is approximately twice the magnitude of the 2-year flood, and the 100-year flood would be 2.2 times the magnitude of the 2-year flood.

The 2-year low flow was estimated at 1.5 m^3/sec, and the 5-year low flow was 0.92 or 0.97 m^3/sec. The lowest daily discharges occurred in the 1960s (0.35 m^3/sec in 1966, 0.63 m^3/sec). The most recent low flow event, third in rank, occurred in 1995 (0.67 m^3/sec).

Ice conditions in the vicinity of the hydrometric station near Petitcodiac ranged in duration from 92 days in 1980-81 to 171 days in 1971-72. The mean duration of ice cover was 124 days. Freeze-up generally occurred between November 6 and December 30 (mean, November 27), and ice-out ranged from March 8 to April 28 (mean, April 3).

Chaput, G. 1998. Summary of fish sampling in the Petitcodiac River system, July to September 1997. Pages 52-60 *in* Environmental Monitoring Working Group. 1998. Environmental monitoring of the Petitcodiac River system, 1997: Trial opening of the Petitcodiac River causeway gates. December 1998. 280 p.

Gill nets, a small mesh boxnet and electrofishing were used to sample the fish populations below and above the Petitcodiac causeway.

Fish sampled below the causeway on July 29-31 1997 consisted of American eels (30-50 cm total length, TL), blueback herring (17-21.5 cm fork length, FL) and alewife (13.4-19 cm FL).

Fish caught in the headpond from August 11 to 15 consisted of chubs, white perch, smallmouth bass, brown bullhead, chain pickerel, eels, alewife and blueback herring. Young-of-the-year gaspereau as well as a broad size range of both gaspereau species were captured. White suckers were the most common species in the gill nets. Brown bullhead and white perch were abundant. The largest eel was 63 cm TL and the single chain pickerel was 50 cm FL.

Electrofishing was conducted at 10 sites in the four major tributaries of the Petitcodiac River (Coverdale River, Pollett River, North River and Anagance River). Speckled trout, slimy sculpin, American eel, sea lamprey, white sucker and minnows were recorded. Salmon parr were present only in the Coverdale (all three sites) and Pollett Rivers.

Temperature profiles obtained with a recorder installed above the Gunningsville Bridge were plotted. Water temperature variations of 5-7ºC within a few hours were not uncommon in July and August.

A temperature and salinity profile was recorded below the gates near high tide (1000h), July 30. The water column was well mixed with a temperature of 18ºC and salinities mainly ~9-10‰. At low tide (1415h, July 30) the temperature was ~22ºC and the water was essentially fresh at 0.6‰ salinity.

Chiasson, A. 1994. A flow control model for the Petitcodiac gates. 7 p.

<No abstract.>

Chiasson, A. 1998. Effect of riparian zone management on brook trout (*Salvelinus fontinalis*): the Hayward and Holmes Brook watershed study. Report for the 1997 extended year of study. Submitted to the Fundy Model Forest. Unpublished report. Département de biologie, Université de Moncton. May 12, 1998. 13 p.

Six sites on Hayward and Holmes Brooks were fished (2 each of control, 30 m buffer zone and 60 m buffer zone) to determine the effect of riparian buffer zones on forestry impacts on brook trout. Numbers of fish captured were too low to provide population estimates using maximum likelihood techniques. All age classes of brook trout declined, suggesting density-independent mortality. Patterns of decline were not consistent within treatments.

Habitat measurements indicated that almost all sites showed a decrease in volume of pools, runs, and riffles following road construction in 1995. Of all habitat types, pools appeared to show the greatest decrease in volume. Substrate composition in pools changed after 1994, with disappearance of the large cobble fraction (an important habitat for invertebrates). Sand became the dominant substrate at all sites.

Cox, E. L. 1945. A study of artificial cover for young salmon. Fisheries Research Board of Canada, Manuscript reports of the biological stations 382; Atlantic salmon and trout investigations, 1945; 33(9): 14p.

An experimental site on the North River ~4.8 km (3 miles) from the village of Petitcodiac was used in a study of the use of artificial cover to improve salmon habitat. An experimental section of river was established with upstream and downstream control sections, each 183 m (200 yd) in length. The upper control stretch extended downstream from the mouth of Salt Springs Brook. The experimental section began just below "the lower fence of the cattle lane crossing the river" at Frank Hughes farm. The downstream control section ended just above the mouth of a small unnamed brook.

Detailed habitat data were collected, including depths of stream, nature of banks (gradual or vertical slope), description of vegetation along the banks, stream bed type (sand, pebble, cobble, gravel), and rate of current flow in different parts of the river. The report includes detailed maps showing depth contours, type of bank, vegetation on banks and stream bed habitat. Current velocity was measured every 18 m (20 yd).

Preliminary fish surveys were conducted and water >61 cm (24 in) depth was seined. White suckers, chubs (*Couesius*, *Semotilus*), killifish (*Fundulus*) and dace (*Rhinichthys*) were ubiquitous in all sections. Small eels were frequent from m 82 to 220 (yd 90 to 240), measured downstream from the mouth of Salt Springs Brook. Large suckers and many minnows were found in the Stump Pool (m 316 to 325, yd 345 to 355). The northern redbelly dace was only found along the left bank from m 142 to 151 (yd 155 to 165), and was the only minnow present in this area. Stocked and native salmon fry were found from m 183 to 366 (yd 200 to 400), the experimental section. The stocked fry were planted by Elson just before this experiment began. No native parr were observed during the experiment.

One hundred and fifty "homes for parr" were constructed with stones and fox wire and placed in the experimental section. Brush cover (small spruce and fir trees, and willow bushes) or heavy logs were placed in the stream close to the bank and tied to bushes along the banks in the same section. One hundred and fifty salmon parr were brought from the South Branch Brook, a tributary of the Kennebecasis River. Three groups of 50 parr were each marked differently, and one group was introduced to each of the three stream sections.

Seining surveys conducted 10 days after stocking of the marked parr revealed that no salmon were found in the control sections. Three parr were found in the experimental section. Some "homes for parr" and brush cover served as shelter for the salmon parr, a few suckers and an eel. Many of the house structures were overturned and swept downstream due to an increase in water levels during the 10 days after placement of artificial cover and stocking of fish. Subsequently, Elson found two more of the marked parr in the North River [smolt] trap ~549 m (600 yd) upstream from the experimental area.

Cox, E. L. 1946. Cover experiments for stream improvement (July-August 1946). Fisheries Research Board of Canada, Manuscript reports of the biological stations 391; Atlantic salmon and trout investigations, 1946; 35(15): 13 p.

The effectiveness of artificial cover (spruce trees wired onto stakes) for salmon parr habitat improvement was evaluated experimentally in the same stretch of North River that Cox used for his 1945 experiment. Three sections in the North River, each ~188 m (205 yd) in length, were designated as the upstream control, experimental section or the downstream control. The Salt Springs Pool was located in the upstream control section and the Old Swimming Hole pool was located below the downstream control section.

A preliminary assessment of fish present in the rapids was conducted using hand seines. In total, 759 m (830 yd) of the North River were surveyed for stream depths, nature of banks (gradual or vertical slope), description of vegetation along the banks, stream bed type (sand, pebble, cobble, gravel), and mapped. Artificial cover was provided in three areas of relatively rapid water, one site of slow moving shallow water and one site having the deepest water in the experimental section. Stakes were driven into the stream bed and spruce trees were tied to the stakes to provide the desired artificial cover. One hundred and fifty parr (50 per section) from the Kennebecasis River, N. B., were marked differently for their introduction in different sections of the river.

The brush cover was evidently attractive to young salmon and other fish species. At least twice as many marked fish were found in areas containing artificial cover than in either of the control sections. At least twice as many planted fish remained in this section and fish moving downstream showed a greater tendency to remain in the experimental section than elsewhere. The pool in the experimental section was almost empty of fish at the beginning of the experiment, but in the presence of cover it contained several hundred white suckers, many of them large, two large eels and many minnows. Three large eels were also taken from the brush barrier across the stream. Some "homes for parr" which remained from the 1945 experiment also provided habitat for eels.

The importance of protecting shoreline shrubbery as a source of cover as well as to prevent bank erosion was noted. Parts of the stream bank were covered in early summer by a dense growth of willow. Two weeks after cattle were allowed to graze along the stream, the foliage had been completely removed from the willows.

The ability of the stone and fox wire "homes for parr" from the 1945 experiment to withstand winter ice conditions was evaluated. Some were capable of providing cover in 1946 but most were completely buried in gravel. Bank cover that was constructed in 1945 was also mostly absent in 1946.

Three stone and fox wire groynes (16, 4.3 and 4.6 m in length, respectively) (51, 14 and 15 ft) were installed in the stream in August. Height was 30-41 cm (12-16 in) and width was 51-76 cm (20-30 in). The largest groyne was intended to clear gravel from a pool, which had partially filled in the winter of 1945-46. The smaller groynes were constructed in order to determine the minimum size of groyne necessary for effective digging.

Cutting, R.E., T.L. Marshall, S.F. O'Neil and P.G. Amiro. 1994. Status of Atlantic salmon stocks of Scotia-Fundy region, 1993. Department of Fisheries and Oceans Atlantic Fisheries Research Document 94/22: 34 p.

Observations at the fishway and in up-river holding pools indicated that few Atlantic salmon entered the Petitcodiac River in 1993. "These observations are consistent with the uncertainties associated with fish passage at the dam and with the downturn in inner Bay of Fundy salmon returns." Fishway counts were not considered quantitative because fish used the by-pass notch (stop-log system) in the gate.

Cyr, F., M.C. Mehra and V.N. Mallet. 1987. Leaching of chemical contaminants from a municipal landfill site. 8 p.

<No abstract.>

Dadswell, M.J., G.D. Melvin and P.J. Williams. 1983. Effect of turbidity on the temporal and spatial utilization of the inner Bay of Fundy by American shad (*Alosa sapidissima*) (Pisces: Clupeidae) and its relationship to local fisheries. Canadian Journal of Fisheries and Aquatic Sciences 40 (Supplement 1): 322-330.

Since 1750, there has been a unique fishery for American shad in shallow, turbid, mega-tidal embayments of the inner Bay of Fundy during summer and fall. All other shad fisheries in North America are concentrated on spawning rivers or their estuaries and exploit adult, spawning shad during a short spring season. The inner Bay of Fundy fishery occurs in shallow oceanic water, and non-spawning shad are captured during an extended season of five months. Along the rest of the Atlantic coast, shad are available to fishermen in shallow water only during the spawning season and are captured only in 50-200 m depths at other times.

The shad fishery was so important to the economy of the inner Bay of Fundy that a Special Act of the Nova Scotia Legislature was passed in 1840, one of the first fishery management regulations in Canada. In the 1870s, collection of fisheries statistics commenced. Between 1870 and 1900, annual shad landings for the inner Bay of Fundy were $1.0\text{-}2.0 \times 10^5$ kg/yr and constituted 2/3 of total Canadian shad landings. After 1900, landings declined drastically as a result of markedly decreased shad abundance and have remained at low levels up to the present, although abundance now appears to be somewhat restored and landings reflect low effort.

Some of the experimental work described in the paper was conducted in Cumberland Basin, but will be discussed here because of its relevance to Shepody Bay and the Petitcodiac estuary. Relatively few shad arrived in Cumberland Basin before June 1. Shad present during May were mostly returning to local rivers for spawning. Up to 30% of the catches made at this time were ripe adults. Spawning runs in rivers tributary to the Bay of Fundy usually commenced the first week of May, and spawning activity peaked during the last week of May or during June. Large catches of juvenile, resting and spent adult shad began during the first week of June when the temperature of Cumberland Basin rose above 10ºC.

Same-year returns of tagged shad from within the Bay of Fundy indicated counterclockwise movement of shad from Cumberland Basin to Shepody Bay and then out to the Gulf of Maine via the northern Bay of Fundy shore. In addition, fishermen's catch reports indicate that the peak of the shad run occurred in Minas Basin during the last week of June, in Cumberland Basin during the first to second week of July, and in Shepody Bay during mid-July, but "fall-run" shad were not encountered off Saint John harbour until the last week of July and the peak of the run off Grand Manan was during the last two weeks of September. Shad recaptures in Shepody Bay usually occurred two weeks after tagging in Cumberland Basin.

Mean swimming depth of shad in the turbid Cumberland Basin was much shallower than in clear water but in the same light intensity range. Light is important to shad for schooling behaviour and vertical migration. Turbidity, by reducing light penetration, may play an important role in the utilization of the shallow inner Bay of Fundy by shad. These turbid waters are also highly productive for zooplankton. Because shad is a filter-feeding planktivore, high turbidity does not interfere with feeding, and may provide a competitive advantage over sight-oriented planktivores. Turbidity has also been a contributing factor to successful fishery exploitation of the shad in this area, by reducing visibility of nets and thus increasing catch rates.

Department of Fisheries of Canada. 1968. Fisheries river basin study, Petitcodiac River, New Brunswick. Dept. of Fisheries of Canada, Ottawa. September, 1968. Atlantic Provinces Water Resources Study, Paper 13: 7 p.

Seven species of anadromous fish (Atlantic salmon, speckled trout, striped bass, shad, alewives, smelt and sturgeon) were exploited by sportsmen and commercial fishermen in the Petitcodiac basin. The catadromous American eel was also abundant.

The annual run of salmon to the Petitcodiac was estimated at 2,000-3,000 returning fish. The angling season closed on September 15 except in the Pollett River where it closed on September 30. A considerable portion of the run was believed to return after these dates. Black salmon angling was popular in May, especially in Coverdale River. Speckled trout, including some sea-run specimens, were present in all branches of the river, and were "the subject of a considerable angling fishery, especially in May". Local abundance of striped bass fluctuated widely. Shad spawned in the main river as well as in the lower 5-6 km (3-4 miles) of all the larger tributaries. During May and June, "there is an active and increasing interest in angling for shad between Salisbury and Moncton".

In 1950, the Pollett River had ≥5 dams without fish passage along its course. After 1950, several dams in the lower reach of the Pollett River were either opened for fish passage or provided with a fishway.

"Serious questions regarding conservation of anadromous fish runs to the Petitcodiac were raised in 1960 when a causeway was first proposed for the main river near Moncton. This structure is now nearing completion (1968) and is being provided with a fishway, but fisheries biologists are concerned about the possible effects of the new environmental conditions on those fish seeking freshwater for spawning purposes. The causeway is located approximately 24 km (15 miles) below present head of tide at Salisbury, and it will effectively stop any upstream tidal movements when it is built. Because of this, there will be a rather abrupt transition from saline to fresh water which could affect both the upstream and downstream movements of fish, resulting in delays. Other possible hazards include higher water temperatures and increased pollution in the headpond, salt water stagnation and elimination of striped bass spawning grounds."

In 1964, a municipal water supply dam was built in Turtle Creek, ~6.4 km (4 miles) above the mouth. The annual run of salmon to this creek ranged from 100 to 500 fish. It was estimated that salmon rearing area in this creek would be reduced by 50%. Since the City of Moncton acquired all riparian rights on both banks above the dam with the intention of prohibiting angling, it was allowed to proceed with dam development without providing fish passage. Juvenile salmon have continued to be reared in Turtle Creek above the dam through annual stocking by the Department of Fisheries.

Deoxygenating pollutants in the form of untreated domestic sewage and creamery wastes were present in the main river, mainly contributed by the City of Moncton and Village of Petitcodiac. A serious fish kill occurred in August 1966 when approximately 100 salmon were found dead in the river at Salisbury near head of tide. It was postulated that low freshwater flows retarded upstream movement of fish, which then remained in brackish water where heavy accumulations of silt occurred together with low oxygen levels and high temperatures.

"The only foreseeable change in the regulatory management of fisheries in the Petitcodiac River basin involves the possibility of extending the present angling season so that more fall-run salmon might be exploited by sportsmen. However, it is unlikely that such a change will be effected in the near future because of the new environmental conditions being created by construction of Moncton causeway which could adversely affect fish stocks."

Desplanque, C. 1971. Petitcodiac River dam study, Westmorland and Albert counties, N.B.

<No abstract>

Desplanque, C. and D.I. Bray. 1986. Winter ice regime in the tidal estuaries of the northeastern portion of the Bay of Fundy, New Brunswick. Canadian Journal of Civil Engineering 13: 130-139.

The winter ice regime of the Petitcodiac and several nearby estuaries was discussed with respect to potential ice-related problems of engineering works in estuaries with a large tidal range. The Petitcodiac was described as a well-mixed estuary, meaning that the volume of the tidal prism was relatively large compared with the volume of the estuary at the mean tide elevation.

The tidal cycle in the upper Bay of Fundy was described as consisting of a diurnal cycle with a period of 0.517 d (12 h 25 min) and tidal range of ~11 m, a spring/neap cycle with period of 14.77 d and tidal range of 13.5 m, perigee/apogee cycle with period of 27.55 d and tidal range of 14.5 m, 207 d cycle with tidal range of 15.5 m, and Saros cycle with period of 18.03 yr and tidal range of 16.0 m. The Saros cycle had last peaked in 1976.

Intertidal mud flats made up 80% of the plan area of the Petitcodiac River and 95% of the plan area of the Memramcook River from Fort Folly Point to the causeways. Most of the sediment in these mud flats consisted of sizes <65 μm, with median size ~10 μm.

Zones of ice formation were described based on hydrological characteristics of the river and estuary. Zone 1, above the causeway, was dominated by river-related processes and allowed formation of sheet ice. Zone 2, from the causeway downstream about 1/3 of the way to Fort Folly Point, was approximately delineated at the upper end by the high water level at spring tide, and at the lower end by the high water level at neap tide. In this zone, the channel was appreciably constricted by the formation of shorefast ice, forming a vertical ice wall. The volume of the winter tidal prism was significantly reduced in this zone in comparison with the summer tidal prism. In most winters, the lower end of zone 3 was probably near Fort Folly Point (the low water level at spring tide). This zone was characterized by "vast intertidal mud flats", on which drift ice became stranded. Zone 4, which could include Shepody and Chignecto bays, was the primary zone of ice production. Water was generally "not too deep", salinity was ~10-25‰, and it was possible to lower the temperature of a large mass of water to the freezing point.

It was possible for ice walls of 5 m height to form in zone 2 of the Petitcodiac River. Maximum height could be attained if freezing temperatures occurred between neap high water and spring high water near perigee of the 207 d cycle. Occurrence of the extreme conditions required for the buildup of ice walls could be predicted from the tidal cycle. Under these conditions, the walls on both sides of the estuary converged in the upstream direction, and almost touched near the upper end of the estuary. This reduced the tidal flow from the volume in the tidal prism to the point where freshwater runoff took over as the main channel-forming agent. The reduced cross-sectional area could lead to flooding if freshwater ice moving downstream at spring break-up blocked the narrow gap between the ice walls. Severe flooding could result if this sequence of events coincided with the spring freshet. The ice walls could persist until April.

Doe, K. 1998. Significance of levels of Polycyclic Aromatic Hydrocarbons and Polychlorinated Biphenyls found in sediments, and bivalve tissues from the Petitcodiac River system. Pages 35-38 *in* Environmental Monitoring Working Group. 1998. Environmental monitoring of the Petitcodiac River system, 1997: Trial opening of the Petitcodiac River causeway gates. December 1998. 280 p.

Concentrations of PCB's in sediment samples from the Gunningsville Bridge area in September 1997 (<7 ng/g) were all < the No Effect level for freshwater sediments of 10 ng/g and the Environmental Canada recommended interim sediment quality guidelines (21.5 ng/g in marine sediment, 34.1 ng/g for freshwater sediments). [ng/g=parts per billion]

Total PAH levels in the sediments were 143-182 ng/g, > an order of magnitude below the Lowest Effect Level for freshwater sediments of 2000 ng/g. Levels of 13 individual PAH's did not exceed Environment Canada's interim marine sediment quality guidelines.

PCB's were not detectable in tissues of freshwater mussels collected from the headpond, North River and Pollett River. The detection limit of the method used ranged from 112-140 ng/g dry weight of total Arochlors. According to the US Mussel Watch project, a "high" concentration is defined as 470 ng/g. The Canadian guideline for maximum tissue levels in edible shellfish is 2,000 ng/g, and the US Food and Drug Administration public health limit is 10,000 ng/g.

Total PAH's in the mussel tissue samples were 87.4-145 ng/g (dry weight). "High" concentrations as defined by the US Mussel Watch are 1020 ng/g.

Doe, K., J. Doull, A. Hanson and P. Jackman. 1999. Results of analytical and toxicological testing of water and sediment samples from the Petitcodiac River and headpond: Summer 1998 samples. Page 1-20 *in* Environmental Monitoring Working Group. Environmental monitoring of the Petitcodiac River system, 1998: Petitcodiac River Trial Gate Opening Project. 325 p.

Water samples collected on July 16 1998 just above the causeway, near the mouth of Turtle Creek, and just below Boundary Creek were found to be non-toxic according to Microtox testing.

Sediment samples were collected on June 2 1998 from the headpond between the causeway and Boundary Creek. Samples were collected as surface scrapes. These were also found to be non-toxic according to Microtox and amphipod bioassay results.

Total PCB concentrations in the sediment samples were below detection limits of 22-27 ng/g, and were therefore below interim freshwater sediment quality guidelines (34.1 ng/g). Total PAHs ranged 39-213 ng/g, more than an order of magnitude below the Ontario guideline for Lowest Effect Level of 2,000 ng/g. The levels of the toxic metals cadmium, lead, mercury, zinc, nickel and chromium in sediments were well below guidelines. The concentration of manganese exceeded Ontario guidelines for lowest effects levels, but southeastern New Brunswick soils are known to contain high levels of manganese.

Dominy, C. L. 1970. Petitcodiac River causeway - Fishway evaluation studies. Dept. of Fisheries and Forestry of Canada, Fisheries Service, Resource Development Branch, Halifax, NS. Manuscript Report 70-3: 16 p.

"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." Atlantic salmon, speckled trout, striped bass, alewife, American shad, rainbow smelt, sturgeon [species unspecified] and American eel used the Petitcodiac River. According to Elson, eels used 25%-50% of the fish-producing capacity of the river. The fishway evaluation, however, focussed on salmon.

Estimated annual salmon runs ranged between 2,000 and 3,000 fish before construction of the causeway. A few salmon entered the river in mid-June but the majority entered in September and the run peaked in October-November prior to the construction of the causeway. Eighteen percent of returning salmon were grilse. Annual sport catch was 82-670 salmon. The angling season for black salmon started on May 15 (June 1 for Pollett River) and the bright salmon season ended on October 15 (September 30 for Pollett River).

The fishway trap was operated from September 4 to December 11 1969. The first salmon entered the trap on September 8, abundance peaked on November 4 when 17 were counted, and the last fish was recorded on December 8. In total, 131 salmon were recorded. Highest daily trap counts (>5 salmon/day) were recorded when relatively little water (gates(s) open <150 minutes) was released from the gates. No fish moved into the trap when the control gates were open. Few fish moved into the fishway trap at low tide and 64% of all fish moved into the trap when the tidal stage was within 3 hr of high tide. The majority of salmon moved into the fishway between 1800h and 0800h.

Seven salmon, 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 (range 1-43 days).

The only downstream route available to these salmon was through the open control gates. These data indicate that water velocities through open gates were strong enough to force salmon back downstream, but also that the fishway was successful in passing fish upstream. Ultrasonic transmitter tags were inserted in the stomach of 13 salmon trapped in the fishway in 1968 and 11 salmon in 1969. The salmon were carried across the causeway and placed in the water on the downstream side. Shore-based tracking equipment was used to monitor passage of any of these fish through the open causeway control gates. No salmon were tracked through the control gates. Those that did return all used the fishway. Visual observations in 1968 had, however, noted four salmon moving upstream through the gates. The proportion of the Petitcodiac salmon run which passes upstream through the control gates without using the fishway has not been determined.

Preliminary measurements of water velocities at the control gates indicated that unless the gates were opened to coincide with the falling tide, or just before high tide, velocities were too high (>7.6 m/sec) (25 ft/sec) to allow fish passage. The difference in the height of water in the reservoir and that in the estuary below the causeway must be <0.6 m (2 ft) to permit passage through the control gates. A "reasonable attraction flow" for salmon was estimated to be 14.2-28.4 m^3/sec (500-1,000 cfs) (compared to approximately 340.8 m^3/sec (12,000 cfs) measured at one gate fully open). These smaller-volume releases of water should commence about 6 hr before the arrival of each high tide.

Petitcodiac River salmon may "suffer great delays in the estuary below the causeway" and "some fish may never find their way upstream". Angling records indicated that no bright salmon were caught in either 1968 or 1969. Fishway records indicated that very few fish ascended into the river before the angling season closed on October 15; the causeway appears to have caused conditions which cause the run to be delayed in the estuary. Angling statistics for 1965 to 1969 inclusive were:

Year	1965	1966	1967	1968	1969
Black salmon	288	149	645	275	21
Bright salmon	41	163	495	0	0

The low catch of 21 black salmon in 1969 was a further indication of a small run of bright salmon in 1968.

Of the 131 salmon counted at the fishway in 1969, 24% were grilse and virgin salmon. The proportion of females in this group was 39%. Repeat spawners were 67% of the total run. Approximately 58% of the returning adults had left the river as age 2 smolts and the remainder were age 3 smolts. About two-thirds of the repeat spawners of age 3-sea winters had spawned only once before, at age 1-sea winter and the remainder had spawned at both ages 1- and 2-sea winters.

A spear-head floating salmon trap was operated on the south side of the reservoir 732-823 m (800-900 yd) above the causeway from September 4 to October 27, at which time it was moved to 274 m (300 yd) above the causeway and operated to November 24. No data were presented for this trap.

A gill net with 3.8 cm (1.5 in) stretched mesh was used on July 9 and 10 in the reservoir within 823 m (900 yd) of the causeway, and captured a total of 20 salmon smolts (1 smolt/hr of fishing effort). These smolts were all aged 2 and had mean length of 141.7 mm and mean weight of 26.8 g.

Juvenile salmon and other stream-dwelling fish were sampled in the freshwater reaches of the river in July 1969 by electrofishing without barrier nets at 12 sites. The majority of juvenile salmon were found in the Little River, but juveniles were also present in the Pollett, North and Petitcodiac rivers. Abundance of fry was "uncommonly low", supporting the other indicators of poor spawning escapement in 1968. Age 1 parr ("small parr") were the most abundant life stage except in the main Petitcodiac River where only age 2 parr were captured. No age 3 parr were found. Juvenile size was smallest in the Little River samples. Electrofishing above the former sawmill dam at the village of Pollett River confirmed that this dam was impassable to salmon.

Dunfield, R. 1985. The Atlantic salmon in the history of North America. Canadian Special Publication of Fisheries and Aquatic Sciences 80: 181 p.

British officers who were in charge of expelling the French inhabitants from Petitcodiac in the 1750s "could not fail but notice the extent to which the people of these communities relied on the local fisheries" (pg. 40). In the 1800s, there was no regular commercial fishing base or "singularly important" fishing station between the mouth of the Saint John River and the Petitcodiac estuary, although most of the inhabitants along the shore fished at the mouths of the streams (pg. 130). Although “great numbers of salmon” had previously frequented both the Petitcodiac River and its tributaries, their numbers began to decline about 1830, likely because of weirs, set nets, and local overfishing (pg. 131).

Dunfield, R. 1991. Notes on the fisheries resources of the Petitcodiac River basin. Canada Dept. of Fisheries and Oceans, Halifax, NS. Unpublished manuscript. 12 p.

By 1780, most of the Petitcodiac River valley below the head of tide (Salisbury) was settled. Historical records show that the species of commercial interest in the system, including Shepody Bay, were salmon, shad, smelt, eel, trout, gaspereau, striped bass, tomcod, sturgeon, herring and cod. By the end of the first quarter of the 19th century, various stocks of river fish were reported to be declining due to overfishing.

Historical records show that salmon frequented most, if not all, of the tributaries of Shepody Bay and the Petitcodiac River system. They were mentioned specifically in the Little River at least to Sherman Brook, Anagance Brook, North River, Turtle Creek, and Pollett River to Gordon Falls. Salmon were heavily fished on the Petitcodiac system from the earliest times of settlement. Annual salmon catches of 68,100 kg (150,000 lb), ~30,000 fish, have been reported. Salmon were taken by spearing in the freshwater river, and in nets, seines and weirs from Shepody Bay to above Moncton.

The intensity of the salmon and shad fishery was such that in 1826 the Provincial Legislature passed an act “to prevent the destruction of the breed of Salmon and Shad in the River Petticodiac [sic] and its Branches”. The act limited fishing to three days a week, closed the salmon season on August 20 each year, and disallowed the setting of weirs, seines or set nets above Moncton. This act was intended to remain in effect for five years but was extended for a further ten years, to April 1 1841. Evidently these measures did not stop the decline of salmon, since Moses Perley expressed the opinion in the late 1840s that nothing short of a complete closure of the spear fishery would prevent extirpation of the Petitcodiac salmon. The shad drift-net operations, which began around 1840, probably did not contribute greatly to the decline in salmon, since the nets were generally of insufficient strength to hold salmon. The freshwater reaches of the Petitcodiac were closed to salmon fishing in 1869 for conservation reasons, but they were “constantly and severely poached”, and by this time the shad drift nets had been improved so as to hold salmon efficiently. Recovery of the salmon population was also hindered by development of the lumber industry, which was accompanied by dams and sawdust pollution. The fishery officer’s report of 1878 suggested that “There appears to be no hope of restoring the Pollett and Coverdale Rivers to migrating fish”. Nevertheless, commercial salmon catch statistics indicated catches of 2,270 to 15,890 kg (5,000 to 35,000 lb) from 1875 until the late 1920s or early 1930s, after which catches rarely exceeded 4,086 kg (9,000 lb) and averaged only 1,589 kg (3,500 lb) annually. By the 1950s, the commercial catch of salmon was derived entirely from the drift net fishery, and in 1967 the shad drifting season was shortened to correspond with the salmon season. At this time there were approximately 30 boats licensed for salmon and/or shad. The salmon fishery closed in 1972, but bycatch of salmon in the shad nets was allowed until 1983.

The Petitcodiac was one of the more important shad producing rivers in the Maritimes. Until the mid-1800s the traditional fishing methods in Shepody Bay were weirs and standing (set) nets. Driftnet fishing for shad commenced around 1840, with more than 20 boats involved within 2-3 yr. By 1850, almost 200 shad boats were fishing Shepody Bay and the lower Petitcodiac estuary. Approximately 50 of these drift-netted from Cape Demoiselle to Stoney Creek, above which few shad were caught. Average catches from July to mid-September were 363,200 kg (800,000 lb). By 1972, there were 30 boats operating from Dover to Shepody Bay, taking 11,350 kg (25,000 lb) annually between 1971 and 1975.

The history of the gaspereau fishery is not well documented. The Albert County yield of gaspereau was reported as 635,600 kg (1,400,000 lb) in 1869; 572,040 kg (1,260,000 lb) in 1870; but only 9,080 kg (20,000 lb) in 1871. Only 772 kg (1,700 lb) were reported landed in 1946. Gaspereau were reported to have frequented the Anagance River and the lower reaches of the Pollett River. There may also have been some spawning grounds in the North River.

Commercial fishing records for smelts show that in 1879, 162,986 kg (359,000 lb) were taken in the entire Petitcodiac fishery. The only entry for 1951 through 1991 shows that 1 tonne was landed in 1974.

Commercial catches of striped bass amounted to 545 kg (1,200 lb) in 1870, 1,907 kg (4,200 lb) in 1872, 454 kg (1,000 lb) in 1913, and 4,540 kg (10,000 lb) in 1914. Semple (1980) reported a small angling fishery in 1979, but no commercial fishery.

Historical records suggest that significant runs of sea-run brook trout occurred. For example, a catch of 6,129 kg (13,500 lb) was reported for the Petitcodiac estuary in 1879, and similar catches were being made in 1913 and 1914.

In the late 1860s, as many as 36,320 kg (80,000 lb) of eels were taken annually in the commercial fishery. Catches of 4,540 kg (10,000 lb) were still being made annually in the early 1910s, but commercial interest had waned by the 1930s. Semple (1980) reported no recognized fishery in 1979.

Catches of sturgeon were 2,633 kg (5,800 lb) in 1913, 2,724 kg (6,000 lb) in 1914, and 1,498 kg (3,300 lb) in 1929. Occasional catches of around 1 tonne were reported until the 1980s, at which time catches of 0-8 tonnes were reported.

Elson, P. F. 1941. Experimental planting of salmon fingerlings in North River, tributary of the Petitcodiac River, N. B. Fisheries Research Board of Canada, Manuscript reports of the biological stations 212; Atlantic salmon and trout investigations, 1941; 22(3): 21 p.

In late August and early September of 1941, experimental plantings of hatchery-reared Atlantic salmon underyearlings began in the North River, which at that time did not support any salmon. Fingerlings were obtained from the South Esk hatchery (Miramichi River stock) in New Brunswick and from the Collingwood hatchery (River Phillip stock) in Nova Scotia.

Approximately 215,000 salmon fingerlings were planted in the North River system from its headwaters near Trites Road (below Stiles Village) down to the mouth. The main North River was planted throughout its entire length wherever conditions were suitable (water depth <0.6 m (2 ft), sufficient food and stones for cover, preferably located near rapids). The only areas not planted were a relatively inaccessible stretch west of longitude 65° 00′ W, an adjacent stretch of deep water extending ~3.2 km (2 miles) above North River bridge, and a stretch of deep water ~1.2 km (0.75 miles) long below Lewis Mountain Brook.

Most of the tributaries were not extensively planted. Tributaries in the headwater portion of the North River above Indian Mountain Road were “quite thoroughly” planted. Below Indian Mountain Road, tributaries were planted only near their mouths, with the exception of additional plantings to parts of Lewis Mountain Brook and Walker Brook, and plantings throughout Bennett Brook.

Details of stream and streamside habitat (width, depth, bottom, shoreline vegetation) and exact areas of planting are provided in this report.

Elson, P. F. 1942. Experimental planting of Atlantic salmon fingerlings in the Pollett River, tributary of the Petitcodiac River, New Brunswick, 1942. Fisheries Research Board of Canada, Manuscript report of the biological stations 327; Atlantic salmon and trout investigations, 1942; 25(8): 11 p.

On August 18-21, 1942, a total of 16,298 salmon fingerlings of River Philip stock were planted in the Pollett River between the dam at Elgin and the Sanatorium dam. An additional 1,200 fingerlings were distributed ~4 km (2.5 miles) below the Sanatorium dam.

Estimates of the number of parr that could be supported by each stretch to be stocked were: Barchard Brook – 8.8 parr/100 m (8 parr/100 yd), Lee Brook – 17.5 parr/100 m (16 parr/100 yd), the combination of the two below their junction – 26.3 parr/100 m (24 parr/100 yd), Gowland Mountain Brook – 5.5 parr/100 m (5 parr/100 yd), Mapleton Brook – 8.8 parr/100 m (8 parr/100 yd), Pollett River – 82.1 parr/100 m (75 parr/100 yd). The methodology by which these estimates were obtained is not documented. Details of the habitat are presented.

Elson, P. F. 1943. Experimental planting of Atlantic salmon fingerlings in the North River, tributary of the Petitcodiac River, N. B., 1943. Fisheries Research Board of Canada, Manuscript reports of the biological stations 336; Atlantic salmon and trout investigations, 1943; 29 (12): 17 p.

The 1941 stocking of 215,207 fingerlings in the North River yielded a descent of 3,087 smolts in 1943, for a survival rate of ~1.5%. This "rather small yield" was expected to be augmented by descent of some age 3 smolts in 1944, since age 2 parr had been observed in all but the lower 5.6 km (3.5 miles) of river in the summer of 1943. "It is quite unlikely that such an addition will bring the total yield from the planting to more than 2 or at the most 3%". High mortalities were attributed to unusually high temperatures in the summer of 1942.

Having experimented with what was believed to be a maximal rate of stocking in 1941, it was decided to try a "minimal" planting in 1943. The North River was therefore stocked at a rate similar to that used in the Pollett River in 1942 and 1943. It was assumed that both rivers were capable of supporting 68.6 parr/100 m of stream length, or 825 parr/km (75 parr/100 yd, or 1320 parr/mile). The assumption of equal habitat quality in the two rivers was probably not correct, since it was observed that "the bed of the North is silted up with clay and sand in many places so that it provides neither the cover nor the food-rearing capabilities of the Pollett".

In total, 42,033 Atlantic salmon fingerlings were planted in nine different sections of the North River from Sept. 2-14 1943. Fingerlings, averaging 3.88 cm in length (range 2.7 to 6.1 cm), were were of River Philip stock from the Cobequid hatchery.

Spot-planting was the new approach used to stock fingerling salmon in smaller tributaries of the North River, as an alternative to the thorough planting of salmon that was carried out in 1941. No stretch of river longer than 1.6 km (1 mile) was left unstocked, provided that there was suitable habitat for salmon. Except in the smallest tributaries, fingerlings were distributed at a target rate of 825 fingerlings/km (1,320 fingerlings/mile). In comparison, the 1941 stocking of the North River was at a rate of ~5,000 fingerlings/km (8,000 fingerlings/mile).

At the end of planting, ~3,000 excess fingerlings were released over a 0.4 km (0.25 mile) stretch of rapids in the main Petitcodiac River, just above the point where the highway and railroad crossed about 1.6 km (1 mile) below River Glade.

Maps showing locations of the plantings of Atlantic salmon and details (time of day, exact area and number of fish released) of the planting operations are included in this report. Habitat conditions are summarized for most sites.

Elson, P. F. 1943. Experimental planting of Atlantic salmon fingerlings in the Pollett River, tributary of the Petitcodiac River, N. B., 1943. Fisheries Research Board of Canada, Manuscript reports of the biological stations 336; Atlantic salmon and trout investigations, 1943; 29 (13): 9 p.

In 1943, a total of 16,482 River Philip stock salmon fingerlings from the Cobequid hatchery were stocked in the Pollett River system from August 19-23. Of these, 12,568 fingerlings were stocked in the main river above the Sanatorium dam and 3,914 fingerlings in the tributaries of the Pollett River. Specifically, 290 fingerlings were distributed in Barchard Brook, 536 in Lee Brook, 215 at the junction of Barchard Brook and Lee Brook, 120 in Gowland Mountain Brook, 380 in Mapleton Brook, 655 in Gladstone Brook, 1053 in Salmon Hole Creek, and 665 in Babcock Brook.

The experiment was a repetition of that conducted in the Pollett River in 1942, with identical planting techniques and fingerling distribution. Unusually high temperature and low water conditions shortly after the 1942 stocking had resulted in high mortality of fishes stocked to the main Pollett River. Survival rates from the 1942 stocking were better in the cooler tributaries, reinforcing the assumption that high temperatures caused the mortalities. Conditions following the 1943 stocking were cooler than in 1942, with higher water levels.

Salmon were slightly smaller (average 3.23 cm, range 2.6 to 4.8 cm, N=40) in 1943 than those stocked in the same river in 1942.

At the conclusion of stocking, 1,300 "excess" fingerlings were released over a 0.4 km (0.25 mile) stretch around the bridge 4 km (2.5 miles) below the Sanatorium dam.

Elson, P. F. 1944. Experimental planting of Atlantic salmon underyearlings in the middle Pollett River. Fisheries Research Board of Canada, Manuscript reports of the biological stations 380; Atlantic salmon and trout investigations, 1944; 31(6): 19 p.

Underyearling salmon were stocked in the middle Pollett River between the Sanatorium and Elgin for the third consecutive year. Since there was almost no survival of salmon fingerlings stocked in the main river during the previous two years, stocking of salmon was concentrated in the tributary brooks where survival was greater (1-8%). Survival had been somewhat better from the 1942 stocking (low water and high temperatures) than from the 1943 stocking (lower temperatures but high water following stocking). The reason for the poor survival rates of both cohorts was not known. Possibilities included the above-mentioned adverse physical conditions or else predation. Elson noted that "mergansers work the middle Pollett rather thoroughly".

Salmon stocked in the middle Pollett River from August 22-28 were from Miramichi River stock. Average length of fingerlings was 4.1 cm (N=177) and the range in length was 3.1-5.4 cm. Average length was almost 1 cm longer than the fish stocked in 1943.

The same number of fish was stocked in 1944 as in 1942 and 1943, but stocking was concentrated in the tributaries. Longer stretches were stocked than previously, in order to keep planting density within the limits expected to be encountered naturally. Five km (3 miles) of Babcock Brook, the largest tributary of the Pollett River, were stocked with 4,000 fish. The upper portion of this brook is sandy or rocky and was considered to be trout rather than salmon habitat. Therefore, stocking was concentrated only in the lower part of Babcock Brook. Salmon Hole Creek, Gladstone Brook, Lee Brook, Barchard Brook and Mapleton Brook [note – some of these names have changed] were stocked with 3000, 2500, 3000, 1000 and 500 underyearling salmon respectively. A total of 2,500 salmon was stocked in the main river along different sections spanning from above the Sanatorium to below Salmon Hole Creek.

A detailed map showing locations where salmon were stocked is included in this report, as well as records of habitat, bottom type, and shoreline vegetation.

Elson, P. F. 1945. Atlantic salmon planted in the North River, Petitcodiac, N. B. Fisheries Research Board of Canada, Manuscript reports of the biological stations 381; Atlantic salmon and trout investigations, 1945; 32(5): 15 p.

A total of 15,387 Atlantic salmon underyearlings (River Philip stock from the Cobequid hatchery in Nova Scotia) were stocked in the upper 2/3 of the North River on September 4-11, 1945. Average length of 402 salmon was 4.0 ± SD 0.6 cm. The rate of stocking was 825 fish/km (1,320 fish/mile). Maps showing locations stocked with Atlantic salmon and details (time of day, exact area and number of fish released) of stocking operations are included in this report.

Previous stocking experiments had involved "heavy" stocking of about 200,000 fish in 1941 and "sparse" stocking of 42,000 fish in 1943. About 1/3 of the young salmon became smolts at age 3. A yield of about 1.5% of planted fingerlings as age 2 smolts and 0.7% as age 3 smolts was obtained from the initial stocking of the North River in 1941. Unfavourable conditions for smolt trapping in 1945 prevented a comprehensive evaluation of the 1943 stocking, but such analysis as was possible indicated that the results were similar to the 1941 stocking.

Previous work suggested that most of the smolt production came from the upper part of the North River, including the tributaries, with a very small contribution from the lower 11.3 km (7 miles) of the main river below Wheaton Settlement Bridge. It was therefore decided that stocking in 1945 should be restricted to the area above Wheaton Settlement Bridge. Successful natural spawning had occurred in Bennett Brook in 1943 and 1944, and in Walker Brook in 1944, and therefore these brooks were removed from the 1945 planting schedule. After stocking had commenced in 1945, it was found that some successful spawning had occurred as far up as Pacific Junction in 1944, but this was "of limited extent".

The lengths of naturally spawned underyearlings taken in the North River above the Pacific Junction road bridge (Sept. 4), below this bridge (Sept. 5), in Walker Brook (Sept. 6) and in Bennett Brook (Sept. 18) were recorded. The mean length of 60 fish was 6.71 ± SD 6.4 cm.

Elson, P. F. 1945. Experimental planting of Atlantic salmon underyearlings in the middle Pollett River. Fisheries Research Board of Canada, Manuscript reports of the biological stations; 381; Atlantic salmon and trout investigations, 1945; 32(6): 12 p.

Young of the year salmon were stocked in the middle Pollett River (between Elgin and the Sanatorium) on August 17-23 1945. Fish originated from the Cobequid hatchery (84,500 fish of River Philip stock) and the South Esk hatchery (164,000 fish of Miramichi River stock). Average length of 473 River Philip fish was 3.35 ± SD 0.037 cm. Trough-reared Miramichi River fish (122,700 fish in total) were 3.59 cm in length (N=338, SD=0.039 cm) and pond-reared Miramichi River fish (41,300 in total) were 3.93 cm (N=229, SD=0.049 cm). Overall, the mean length was 3.67 cm, and lengths ranged from 2.6 cm to 5.2 cm.

No fish were stocked into tributaries of the Pollett River. The intensity of stocking was considered to be comparable to the 1941 planting of the North River. Maps showing locations of stocking and number of salmon stocked at each station are included.

Elson, P. F. 1945. Dispersal of Atlantic salmon underyearlings after planting. Fisheries Research Board of Canada, Manuscript reports of the biological stations 382; Atlantic salmon and trout investigations, 1945; 33(8): 8 p.

Starting in August 1945, one week after the stocking of the middle Pollett River, surveys were done with a small one-man hand seine to determine the extent of the dispersal of stocked underyearling salmon. Salmon had been stocked at 6 different stations along a 16 km (10 mile) stretch from Elgin to the Jordan Memorial Sanatorium.

Underyearling salmon were found to have spread 0.4-0.8 km (0.25-0.5 mile) upstream of Moore Bridge and Blakney Station, respectively, and 0.6 km (3/8 mile) downstream of Moore Bridge in one week. Two weeks after stocking, there was some indication that more fish had moved downstream. A survey at the Forest Glen stocking site after three weeks showed that salmon had dispersed throughout the 1.2 km (0.75 mile) stretch of river between this site and the upper limit of the one-week dispersal at the Moore bridge site. After ten weeks (October 30) an area just above the Sanatorium reservoir (2.4-3.2 km (1.5-2 miles) below the lowest stocking site) was sampled with gill net and seine, but only suckers and minnows were found.

Two underyearling salmon taken at Moore Bridge on October 31 measured 6.2 and 6.4 cm respectively. In the 10 weeks since stocking, these fish had grown about 2.5 cm from their mean length of 3.4 cm (SD 0.4 cm) when stocked.

Elson, P. F. 1946. Experimental planting of Atlantic salmon underyearlings in the middle Pollett River - 1946. Fisheries Research Board of Canada, Manuscript reports of the biological stations 391; Atlantic salmon and trout investigations, 1946; 35(13): 8 p.

Atlantic salmon underyearlings were stocked in the middle Pollett River for the fifth consecutive year. Salmon stocked on August 20-21 1946 were of Miramichi River stock from the South Esk hatchery. Mean length of 171 salmon was 3.6 cm and scale examination of 12 fish revealed a mean of 5 circuli per scale. The procedure used for scale examination is described.

Stocking of salmon was restricted to the tributaries and to sections of the tributaries which were easily accessible by truck. Consequently, stretches of 3.2 km (2 miles) or more of stream were left unstocked. Barchard Brook (5,760 fish stocked), Lee Brook (8,640), Gladstone Brook (7,680), Salmon Hole Creek (13,440) and Babcock Brook (12,480) were stocked with underyearling salmon, totalling 48,000 fish planted in the tributaries. Maps showing exact locations and numbers of salmon stocked at these sites are included in this report.

Elson, P. F. 1946. Dispersal and growth of planted salmon underyearlings in tributaries of the middle Pollett River, 1946. Fisheries Research Board of Canada, Manuscript reports of the biological stations 391; Atlantic salmon and trout investigations, 1946; 35(14): 7 p.

Tributaries of the Pollett River where salmon underyearlings had been recently stocked were seined to determine the dispersal of the young salmon. Results were similar to those found in the 1945 seining survey.

In 2.5 weeks, fish had moved ≤0.8 km (0.5 mile) downstream of the area where they were planted in Gladstone Brook. The stocked salmon were not found beyond a point which was "commanded" by two 15-20 cm (6-8 in) trout in a pool through which any descending fish would have to pass. Meanwhile, fish stocked at Kay's Bridge in Salmon Hole Creek were taken ≤274 m (300 yd) above the stocking site. On the same date, the lower planting site in Salmon Hole Creek, Bannister's Bridge, yielded no parr at the stocking site and "some distance" downstream, perhaps due to the abundant trout population in the lower part of the creek. In Babcock Brook, the stocked fish had dispersed 0.5 km (0.3 mile) downstream in 17 days. There appeared to be considerable post-stocking mortality at this site and again this was attributed to trout predation.

After seven weeks, the salmon fry had dispersed upstream 549 m (600 yd) from the stocking at Babcock Bridge. The young salmon moving upstream survived passing through a pool that was found to contain several large trout. Twenty specimens captured on October 10 averaged 5.61 cm in length, an increase of 57% relative to the length at stocking (Sept. 20-21) of 3.57 cm. Analysis of variance was carried out to demonstrate that larger salmon underyearlings moved further upstream above the original planting site than smaller salmon.

Elson, P.F. 1950. Increasing salmon stocks by control of mergansers and kingfishers. Pages 12-15 *in* Fisheries Research Board of Canada. Progress Reports of the Atlantic Coast Stations No. 51. October, 1950.

In the Pollett River, where 90% of the smolts descended at age 2, protection from birds over the entire pre-smolt period resulted in a 4.7-fold increase in smolt production. Figure 1 shows the timing of the smolt descent in 1947 and 1949.

The plantings of hatchery-reared underyearlings in the first 5 years of experimentation on the Pollett River ranged from 16,000 fingerlings dispersed over a total of 8 km (5 miles) to 250,000 fingerlings spread over 6 areas totalling 1 km (0.6 miles). The highest rate of survival was from a sparse planting (1,000 age 2 and 3 smolts, 6% survival) but the greatest production was from a heavy planting (4,800 age 2 and 3 smolts, 2% survival). Greater survival was recorded in the tributaries than in the main river. However, greatest yield from the tributaries was 2,000 smolts (4% survival). In each of these years, 3-4 broods of mergansers (30-40 ducks) and a similar number of kingfishers were reared on the stream.

In 1947, bird control was instituted, and the most productive (heavy) planting of underyearlings (270,000) was repeated. Age 2 smolts from this planting descended in spring of 1949. Of the total of 19,925 smolts which descended, 19,100 were found to be age 2. Seining during the summer of 1949 showed that ~5,000 age 2 parr remained in the river. "Since available information indicates that little loss of fish of this size occurs in the absence of bird predation", it was expected that this would bring the final smolt yield in 1950 to a total of about 24,000 (9% survival).

Catches of fish species seined from 7 sections of the Pollett River were:

Year	Distance seined, m (yd)	American eel	White sucker	*Couesius* (Chub)	*Rhinichthys* (Dace)	Salmon parr	Other	Total
1947	343 (375)	5	242	1,301	160	85	10	1,818
1948	347 (380)	22	568	2,639	486	396	22	4,133
1949	347 (380)	42	391	2,645	1,117	550	3	4,748
Ratio of 1947: 1948: 1949		1:4:8	1:2:2	1:2:2	1:3:7	1:4:6		2:5:5

Elson, P.F. 1951. Increasing salmon production by bird control. Pages 88-91 *in* Needler, A.W.H. Fisheries Research Board of Canada. Report of the Atlantic Biological Station for 1951.

Production from the plantings of underyearling salmon in the Pollett River from 1942 to 1946 was estimated under a wide range of conditions (dispersal, numbers, main Pollett River vs. tributaries). The production from the plantings was determined by seining parr and by trapping and counting the descending smolts. In 3 of the 5 years in which smolts were to be counted, the counting weir broke down at times of flood. For these years, estimates were reached through consideration of age groupings (1) in preceding parr populations, (2) in succeeding smolt runs, and (3) by comparison of the numbers of parr found in the river in various years. About 85% of smolts descended at age 2 and the rest at age 3. These were the salmon plantings without bird control:

Planting				Smolt crop		
Year	Number	Dispersal (m^2/fish) (yd^2/fish)	Location	Year	Number counted	Estimated yield
1942	16,000	7.1 (8.5)	Pollett	1944	900	1,000
1943	16,000	7.1 (8.5)	Pollett	1945	174	2,000
1944	16,000	2 (2.5)	Tributaries	1946	333	2,000
1945	249,000	0.07 (0.085)	Pollett	1947	4,282	4,300
1946	48,000	0.08 (0.097)	Tributaries	1948	360	1,800

Bird control was introduced after the 1947 smolts had descended. Three successive years of planted underyearlings were protected from birds throughout their entire freshwater life.

Year (n)	Number of fingerlings planted (year n)	Estimated parr, from seining (year n+1)	Counted smolts (year n+2)
1947	273,000	25,000	19,925
1948	235,000	35,000	13,190
1949	243,000	35,000	20,348

Smolt yield with bird protection was eight times better than unprotected yield. Protection was accomplished by year-round patrols on a semi-weekly basis. “A high proportion” of birds were shot or trapped and many others were frightened off.

The maximum demonstrated capacity of the Pollett River up to 1951 was about 70,000 parr. More than half of these could be taken by mergansers.

Elson, P.F. 1951. Salmon planting experiments on the Pollett River. Pages 90-91 *in* Needler, A.W.H. Fisheries Research Board of Canada. Report of the Atlantic Biological Station for 1951.

The experimental design (fingerling density) and outcome (smolt production) of the upper Pollett River experiment on effects of dispersal at planting were:

	1948 planting	1949 planting	1950 planting
Upper section	4.6 fingerlings/m (5/yd) 947 smolts	455 fingerlings/m (500/yd) 1,410 smolts	46 fingerlings/yd (50/yd) no data
Middle section	455 fingerlings/m (500/yd) 628 smolts	46 fingerlings/m (50/yd) 1,129 smolts	4.6 fingerlings/m (5/yd) no data
Lower section	46 fingerlings/m (50/yd) 1,097 smolts	4.6 fingerlings/m (5/yd) 1,475 smolts	455 fingerlings/m (500/yd) no data

Plans for a heavy planting of the middle Pollett River in 1951 were postponed because (1) a few mature salmon gained access to the area in 1950, and (2) insufficient fingerlings were available for a heavy planting.

In 1950, 15 adult salmon ascended the Denil fish ladder at the Sanatorium dam. Only 1 of the 15 had been marked as a Pollett smolt, a survivor of the 20,000 smolts descending in 1949. When heavy November floods damaged the pound where these fish were being held, 10 escaped, at least 4 of which entered the experimental area above. A few resulting fry were found in 1951.

Although there were reported to be many salmon below the dam in 1951, only one had ascended the ladder by October 25. "The ladder has, however, been shown to function well and minor improvements are planned."

"It has become obvious that numbers of salmon are removed illegally from the river below the dam, so that the value of the fish pass for recording returns of marked fish is limited."

Elson, P.F. 1951. Estimation of fish populations and salmon smolt production in the Pollett. Pages 92-95 *in* Needler, A.W.H. Fisheries Research Board of Canada. Report of the Atlantic Biological Station for 1951.

The first population studies on the river were considered to have obtained "minimum" counts for the areas seined. These involved selecting several "representative" areas and attempting, by repeated seining, to catch all the fish in an area closed off by barrier nets. "…the method appeared to give a fairly good idea of fish present, but contained no inherent means of testing reliability. It became obvious that the efficiency of removal depended on such factors as character of the stream and experience of the operators."

Seining was then carried out to determine proportions of marked fish, which had been liberated within a known area contained within barrier nets. This initially done on selected areas, which were chosen to be similar to those used in the first method, so that results could be compared. Both of these methods "were open to the criticism that the sections might not actually be representative". In 1951, an attempt was made to remove personal bias in selection of areas to be sampled. The stream was considered in sections about 27 m (30 yd) long, a little less than 8% of the total length was eliminated from consideration as being too deep to seine, and the balance was stratified into 6 sections (proceeding upstream, on the basis of relatively uniform character in each area). From these sections, 10 sample areas were picked by chance, the number of areas per section being proportional to the total length of the section.

The results of "minimum count seining" were applied to the entire experimental area on a basis of stream length, to estimate the total production from known plantings. For this purpose it was assumed that only 80% of the parr present were caught, except in 1950 when electrofishing was done immediately following the seining. The 80% figure was derived from tests on marked fish.

Estimates of several fish species from 1948 to 1951, and total parr in the middle Pollett River in 1951 are presented. "It would appear that most species of fish have maintained populations of a relatively stable order of size during the past four years".

Elson, P.F. 1951. Magnitude of smolt runs measured by sampling. Pages 95-97 *in* Needler, A.W.H. Fisheries Research Board of Canada. Report of the Atlantic Biological Station for 1951.

A mark-recapture method of estimating smolt runs in the Pollett River is discussed. Two "partial weirs" were used. Late in the season of 1950, the lower trap, which was installed "a short distance" above the fence across the entire stream, ceased to take many fish because of unusually low water. The upper "marking" trap continued to fish well. Such a condition would result in a low estimate for the late-running fish. It was noted that "because of lack of attention to the traps the test is not a good measure of the best results which may be expected from sample trapping." Because fish marked and released at the upper trap did not descend immediately, estimates based only on daily catches were not as accurate as those based on cumulative catches.

Elson, P.F. 1952. Assessment of young salmon production in the Pollett River. Pages 97-99 *in* Needler, A.W.H. Fisheries Research Board of Canada report of the Atlantic Biological Station for 1952.

Methods used for counting young salmon in the Pollett River included direct measurement of the smolt run, mark-recapture experiments, and seining.

Counting fences were used for complete enumeration (direct measurement) on relatively small rivers (maximum discharge <114 m^3/sec (4,000 ft^3/sec) in most years). These were often not installed early enough, or operated effectively, on most rivers.

Mark-recapture estimates were compared to complete counts for smolts on the middle Pollett River. Smolts were marked at an upstream trap and recaptured at a trap about 1.6 km (1 mile) downstream.

Year	Total count at fence	Fence count during mark-recapture experiment	Mark-recapture estimate	% difference of estimate from count
1950	15,862	14,370	10,365	-39%
1951	25,164	18,842	21,255	+11%
1952	26,297	25,899	40,500	+36%

The first seining studies in the stream "were made by attempting to remove all, or nearly all, or the fish in representative sample areas". Fish caught in the previous five years in the same 7 sampling areas (total length, 358.4 m (392 yd)) using the same methods each year were tabulated:

Year	Suckers	*Couesius* (Chub)	Dace	Eels	Salmon parr	Salmon smolt, following year
1948	568	2,639	486	--	396	19,925
1949	391	2,645	1,117	1,678	550	13,190
1950	629	1,633	935	1,043	633	20,348
1951	326	1,270	1,335	--	933	22,852
1952	604	1,704	783	1,759	105	--

There was no temporal trend in abundance of "coarse" fish. The large eel populations were found by electrofishing. The apparent upward trend for parr "is of questionable significance. Some of it reflects accumulating experience of the seining crew."

Seining to estimate populations within an area by recovery of a proportion of a known number of marked fish was tested in the middle Pollett River.

	Stream length, m (yd)	Estimated number of parr in year		
		1950	1951	1952
Total seining, 7 selected areas	356 (390)	633	933	105
Sample seining, 6 selected areas	137 (150)	226		
	160 (175)		631	
	210 (230)			52
Sample seining, 10 chance areas	274 (300)	-	1,059	75

These catches were extrapolated to give estimates of salmon parr numbers in the entire middle Pollett River, assuming that (1) "total seining" accounted for 80% of the fish present, and (2) stream length was 17,400 m (19,000 yd). Estimates were expressed to the nearest 5,000 parr in 1950 and 1951 and to the nearest 1,000 parr in 1952.

	Estimated number of parr in year		
	1950	1951	1952
Total seining	35,000	55,000	5,000
Sample seining, selected areas	30,000	70,000	4,000
Sample seining, chance areas	-	65,000	4,000

There was relatively good agreement between the resulting estimates. It was concluded that "total seining" would be the preferred method if it could be done "with a consistent degree of effectiveness", because it "is best adapted to handling all kinds of fish". "Sample seining" was a "more generally satisfactory method for such fish as parr" because it was possible to determine the reliability of the estimate and this method was faster "when fish are very scarce".

Elson, P.F. 1952. Experimental planting of fingerlings for best smolt production. Pages 99-101 *in* Needler, A.W.H. Fisheries Research Board of Canada report of the Atlantic Biological Station for 1952.

The effect of dispersal (at stocking) of salmon underyearlings was studied by planting salmon in the upper Pollett River. Three similar stretches of river were seeded in 1949-51 with 4,000 fingerlings each, at rates of 4.6, 46 and 455 fingerlings/m (5,50 and 500 fingerlings/yd) of stream length. The last crop of age 2 smolts was counted in 1952, and the experiment would be completed with the smolt run of 1953. The "three principal smolt runs" [presumably, only age 2 smolts?] were summarized:

Number of fingerlings/m (no./yd)	Number of smolts from section			
	Upper	Middle	Lower	Total
4.6 (5)	947	841	1,475	3,263
46 (50)	1,194	1,129	1,097	3,420
455 (500)	1,410	628	1,380	3,418
	3,551	2,598	3,952	10,101

The principal causes in variation in the 9 smolt crops were associated with good vs. bad years (1948 – 2,672 smolts, 1949 – 4,014 smolts, 1950 – 3,415 smolts) and with the particular section planted. The middle section gave consistently low returns. The distinguishing mark for this section (both pelvic fins removed) was sometimes obliterated by regeneration of one or other of the fins. High rates of production of smolts from planted fingerlings (~28%) were associated with this experiment, possibly due to relatively low numbers of eels.

The above experiment determined that wide, medium or low dispersal did not affect smolt yields, so later experiments on "best smolt production" used intermediate dispersal "which involved little more effort than the small amount of dispersal". These experiment involved planting 65,000-925,000 fingerlings in the middle Pollett River between 1950 and 1953, and would be completed with the smolt counts of 1955-1956.

In 1950, a Denil-type fish ladder was installed by the Department of Fisheries at the dam barring the middle Pollett to salmon. Fish were counted at a trap at the upper end of the ladder. Salmon counts for the first three years of operation were:

Year	Total salmon	Unmarked	Marked as Pollett smolts
1950	15	14	1
1951	5	5	0
1952 (to Nov. 6)	22	19	3
Total	42	38	4

The capture of Pollett River marked smolts in weirs operated for herring and salmon on the south shore of the head of the Bay of Fundy, 2-3 months after the smolt run, demonstrated that some marked smolts survived the descent through the trap and estuary. In 1952, ~1% of the Pollett smolt run was recaptured at Minas Channel, and these post-smolts were ~20% of the total post-smolts caught. "Why do the Pollett smolts not contribute more to local fisheries and to Pollett spawning stocks?"

Elson, P.F. 1952. Variation in increased production of salmon parr and smolts with bird control. Pages 102-103 *in* Needler, A.W.H. Fisheries Research Board of Canada report of the Atlantic Biological Station for 1952.

The 1952 results on the bird control experiments on the Pollett River were similar to those described earlier. The average yearly smolt production was about 9 times as good with control as without.

	With bird control	No bird control
Smolt crop years	1949-1952	1944-1948
Mean annual crop	19,000 smolts	2,200 smolts
Standard error	±2,000	±600

There was considerable variation among the four smolt crops with bird control, although the poorest crop with protection was still 3 times as good as the best without. Percent production rates (i.e., survival rates between stages) in the four years with bird control were:

	Survival rate (%) in year of planting					
	1947	1948	1949	1950	Mean	Standard error
Fingerling to parr	9	15	14	22	15	±3
Fingerling to smolt	7	6	8	9	8	±0.6
Total parr to smolt	80	38	58	42	55	±10
Parr>10cm to smolt	100	46	68	51	66	±12

About 85% of the Pollett River smolts were age 2, and most of the rest were age 3. Survival rates to smolt would differ for salmon having different life histories. Survival rates from fingerling to parr and from large parr (>10 cm) to smolt each could be twice as large in some years than others. This could result in a four-fold difference in yield of smolts in some years.

Elson, P.F. 1953. Smolt production from hatchery plantings and natural spawnings of varied densities. Pages 111-116 *in* Needler, A.W.H. Fisheries Research Board of Canada report of the Atlantic Biological Station for 1953.

"While within recent decades the Petitcodiac and its tributaries have not been important producers of salmon, it is said that a little over one hundred years ago the abundant stocks were a decided attraction to the first settlers. The Pollett is the largest tributary of the system and even now appears well adapted to rearing the salmon which have persisted, in reduced numbers, in all branches of the Petitcodiac. It was selected as an experimental stream for studying productivity in terms of smolt yield because of this apparent suitability and because of its general accessibility as compared with most salmon streams. A lack of organized and legitimate interest in its salmon, resulting from their recent scarcity, meant that experimental control of stocks could, when required, be undertaken without serious interference with local values."

Experiments on the Pollett River were divided into 5 phases:

- 1942-1949: Determining planting procedure for getting best smolt production under existing conditions. Plantings of 16,000-250,000 underyearlings resulted in 1,000-4,300 smolts (mean 2,000 smolts). This yield was thought to be low for the capacity of the river and to be limited by bird predators.
- 1947-1952: Assessing effects of controlling bird predation. Plantings of 250,000 underyearlings resulted in an average yield of 19,000 smolts. Other fish species numbers also increased, but not as much as salmon.
- 1948-1953: Assess effect of dispersal at planting. This experiment was carried out in three plots in the upper Pollett, separated by 3.2 km (2 miles). Most of the variation in yield was related to annual effects (1948 – 3,279 smolts, 1949 – 5,111 smolts, 1950 – 2,458 smolts) and with plot location/type of mark, the middle plot (both pelvic fins removed) giving lowest yields. The likelihood that dispersal at planting was connected with the variations in yield was "negligible". The overall survival rate from fingerlings to smolts was 30%. The only protective measure was removal of merganser broods. Other possible factors in the high survival were the "relative dearth" of eels above Gordon Falls and "a lack of excessively heavy planting for the total rearing area available to the fish".
- 1950-1956: Determine optimal productivity using hatchery stock and bird control. This experiment was in progress. No stocking of the area was done in 1951 because of the inadvertent escape of a few adults into the area.
- 1953-1960: Determine maximum productivity using natural spawning. Determine minimal number of spawners for optimal productivity. Determine effects of other fish on production of salmon smolts.

In 1952, counts of eggs carried were made for 47 females entering the trap at the downstream edge of the middle Pollett. Females would have supplied ~300,000 eggs, although none were allowed to spawn. At the time of writing, it was expected that the adult run would be as large in 1953 as in 1952. Enough females and males had already been admitted to the lower 5.6 km (3.5 miles) (up to Forest Glen dam) to stock that part with a number of eggs similar to the number of fingerlings used in the medium planting. As more fish entered the trap they were to be transported overland to the section between Forest Glen and Elgin in order to obtain a similar density of eggs. Any extra fish were to be divided between the two areas.

The combined middle and upper Pollett included 3 parts similar in general physical character but separated from each other by the dam at Forest Glen and the barrier falls at Elgin. The falls at Elgin resulted in differences in the abundance of other species. The two lower sections had large numbers of suckers, minnows and eels, but above the falls there were no suckers, only one minnow, and few eels.

Elson, P.F. 1953. Growth and migration of Pollett River salmon. Pages 146-148 *in* Needler, A.W.H. Fisheries Research Board of Canada. Report of the Atlantic Biological Station for 1953.

Marked post-smolts from the planting experiments in the Petitcodiac River were found in the Halls Harbour weirs in Minas Channel as early as 1945. In 1951, 23 Pollett River post-smolts were recovered (25,187 smolts were marked). In 1952, 204 of the 26,297 marked fish were recovered. In 1953, 9 of the 3,639 marked fish were recovered. Marked fish from Maine rivers were also found at this location.

After two years in the river, Pollett River smolts averaged 15.9 ± SD 1.1 cm total length. After an additional 2.5 months at sea, the post-smolts averaged 29.7 ± 1.4 cm, and the first sea-winter band was starting to form on the scales. By the time these fish had spent 1.5 years at sea, they averaged 62.9 ± 3.7 cm and 4.7 ± 0.7 lb.

Only 7 of the >80,000 smolts marked and liberated from the Pollett since 1949 had been retaken in the Pollett as mature fish.

Year	Adult salmon entering experimental area of Pollett R.		
	Marked as Pollett smolts	Unmarked	Total
1950	1	14	15
1951	0	5	5
1952	3	137	140
1953 (to Nov. 4)	3	41	44
Totals	7	197	204

The marked returnees were similar in size and growth characteristics to the unmarked fish, according to scale examinations. The first part of scale patterns of both groups of fish were similar to those of the Pollett post-smolts taken at Hall Harbour. The unmarked adults could have originated from the lower Pollett or other parts of the Petitcodiac system, but were unlikely to have originated from the Maine rivers due to differences in growth patterns on the scales.

Most of the Petitcodiac and Pollett salmon runs were concentrated in the late autumn. A few fish entered each year as early as July and even late June, depending on height of water in the river among other factors. By far the largest part of the run entered after mid-October or even mid-November, and these runs appeared to be partly related to spring tides.

Year	No. of salmon entering experimental area of Pollett R.		
	July & Aug.	Sept. & Oct.	Nov.
1952	11	6	123
1953	9	30	7 (to Nov. 4)

Elson, P.F. 1954. Seeding requirements for best production of Atlantic salmon smolts. Pages 130-135 *in* Hart, J.L. Fisheries Research Board of Canada. Report of the Atlantic Biological Station for 1954.

The heavy and medium plantings of underyearlings in the middle Pollett River during the experiments of 1950-1952 resulted in similar parr and smolt crops among years, with yearling parr almost 3 times as numerous as smolts. "It is assumed that these two plantings show the full capacity of the area to rear parr and smolts." Underyearlings planted at a rate of 72/100 m^2 (60/100 yd^2) produced a yearling parr population of 19-20 parr/100 m^2 (16-17 parr/100 yd^2). More fingerlings resulted in "unnecessary waste"; fewer fingerlings resulted in proportionately smaller numbers of parr. The light planting rate resulted in ¼ to 1/3 as many parr and it was assumed that the smolt crop would be about ½ that of the two heavier plantings, because at this lower density the parr-to-smolt mortality rate would be lower. The maximum smolt production of 6-7 smolts/100 m^2 (5-6 smolts/100 yd^2) could be obtained from considerably fewer parr than the maximum parr capacity. The requirements for the Pollett were suggested to be: planting underyearlings at a rate of 36 /100 m^2 (30/100 yd^2) to obtain yearling parr at 8-10/100 m^2 (7-8/100 yd^2) and smolts at 6-7/100 m^2 (5-6/100 yd^2). For the 16 km (10 miles) of the middle Pollett, the total numbers of fish would be about 130,000 fingerlings, 30,000-35,000 parr and 20,000-25,000 smolts.

As a rearing stream, the Pollett "appears to be of about average or even a little better than average value, since its combination of fertility and relatively warm water results in rapid growth and early smolt transformation. Its demonstrated capacity for holding parr of a size required to make smolts in the following year is somewhat larger than the density observed on the Northwest Miramichi".

On the basis of observations made in the Petitcodiac system, the period of adjustment for young hatchery salmon to their new environment "would appear to be not over about two months after planting, when planting is in late summer".

On the Pollett River, the mean weight of adults was 2.2 kg (4.75 lb) and the mean egg content of 47 females examined in 1952 was 3,745 eggs. Thus the egg/kg of female ratio was ~1,762 eggs/kg (800 eggs/lb). In 1953, the entire run of 43 females was placed in the middle Pollett to spawn. "Disregarding possible losses to predators, including poachers, of which there is no record but which may have been quite large", this represents a potential deposition of ~160,000 eggs, or a rate of 44 eggs/100 m^2 (37/100 yd^2). In 1954, late summer fingerlings were somewhat erratic in distribution, but were found over the area at 2.4 fingerlings/100 m^2 (2/100 yd^2), a survival from undeposited egg to fingerling stage of about 5%. To get 17 fingerlings/100 m^2 (14 fingerlings/100 yd^2) required for 8 pre-smolt parr/100 m^2 (7 pre-smolt parr/100 yd^2) would thus need egg deposition at a rate of about 299 eggs/100 m^2 (250 eggs/100 yd^2), i.e., the Pollett should have 7 times as many females as entered in 1953, about 19 female salmon or 40 kg of female salmon/km of stream (30 female salmon or 143 lb/mile).

Elson, P.F. 1956. More salmon by controlling mergansers. Pages 161-164 *in* Hart, J.L. Fisheries Research Board of Canada, Biological Station, St. Andrews, N.B. Investigators summaries, 1955-56. (Summary No. 64)

Salmon underyearlings were planted in a 16 km (10 mile) stretch of the Pollett in August of each year from 1942 to 1950. In the first five experiments, 16,000-250,000 hatchery-reared fingerlings were used. These were variously distributed as sparse plantings in the main river, or in principal tributaries, and heavy plantings in the main river or in tributaries. In the year following each planting, parr were so scarce as to be difficult to find. Fish of other species were also present only in very small numbers. The one exception to this was a population estimated at 12,000 salmon parr in the summer following the heaviest planting. These parr, however, were greatly diminished within a few months.

Intensive control of mergansers and kingfishers resulted in an increase in average smolt output to at least four times the unprotected output. Most other species of fish increased to about double their original numbers. There was no evidence that eel abundance was affected by bird control.

Analysis of merganser and kingfisher diets indicated a preference for salmon. The relationship of merganser predation and parr fit Ricker's type C predator-prey situation and therefore predation set a limit to salmon stocks. Parr abundance <7 parr/100m^2 (6 parr/100 yd^2) was associated with a "basic level" of merganser activity, but merganser activity increased directly with parr more abundant than this. Changes in abundance of "coarse fish" did not seem to have any effect on activity. Activity of kingfishers was more or less constant from year to year, consistent with Ricker's type A predator, and offered no serious limit to salmon stocks at the concentrations of kingfishers and salmon observed at the Pollett River.

Mergansers visiting the area, even when parr were scarce, were capable of taking many more salmon than the Pollett could rear. Kingfishers were not abundant enough to take more than about 25% of the parr.

Control measures reduced predation by 90%. In order to obtain close to maximum smolt production, predation by mergansers in relatively productive streams should not exceed the equivalent of 1 merganser/20 ha (1 merganser/50 acres) of stream throughout an 8-month open-water season. This is equivalent to 1 merganser/8 km (1 merganser/5 miles) of stream, 23-27 m (25-30 yd) wide. For less productive salmon streams, the maximum should be 1 merganser/16 km (1 merganser/10 miles). "In practice, this level of merganser activity is likely to be that remaining with complete local brood elimination, and visits by flying migrants kept under close control."

Elson, P.F. 1956. Using hatchery stock for best production of Atlantic salmon smolts. Pages 164-172 *in* Hart, J.L. Fisheries Research Board of Canada, Biological Station, St. Andrews, N.B. Investigators summaries, 1955-56. (Summary No. 65)

For the 16 km (10 mile) experimental stretch on the Pollett River, an expectation of 20,000 smolts per year from 250,000 underyearlings was established using hatchery stocking. This "moderately fertile stream" was capable of producing up to 6-7 smolts/100 m^2 (5-6 smolts/100 yd^2), based on stocking 38-48 hatchery underyearlings/100 m^2 (32-40 hatchery underyearlings/100 yd^2), when most of the smolts were 2 years old and they were protected from fish-eating birds.

Survival rates from age 1 parr to age 2 smolts in the Pollett were similar to those for age 1 parr to age 2 parr in the Miramichi. Production of smolts was similar in both the Pollett and Miramichi Rivers, around 1-2 smolts/100 m^2 (1-2 smolts/100 yd^2), without bird control. When fish were this scarce, mergansers appeared to find prolonged foraging unprofitable.

Plantings of 4,000 underyearling salmon were made at three sites just above the experimental area on the Pollett River, in order to determine the amount of scattering required at individual sites. The sites were 3 km (2 miles) apart. In 1948, 1949 and 1950, underyearlings were dispersed at 60 fish/100 m^2 (50 fish/100 yd^2), 599 fish/100 m^2 (500 fish/100 yd^2) or 5,985 fish/100 m^2 (5,000 fish/100 yd^2). The different degrees of dispersal had no significant effect on the number of smolts resulting from the stocking, based on analysis of variance. Differences in survival were significantly associated with year effects. The annual merganser kill at the experimental 16 km (10 mile) stretch downriver (assumed to be an annual index of merganser abundance) was significantly negatively correlated with the survival of smolts, thus it is likely that mergansers limited smolt production in the scattering experiment. However, the plantings were made at the approximate rate suggested earlier, i.e., 1,250 fingerlings/km (2,000 fingerlings/mile) of stream 9 m (10 yd) wide, and smolt production was around 4 smolts/100 m^2 (3 smolts/100 yd^2), about 30% better than the prediction for this type of stream with no bird control. It was concluded that there was no need to scatter fish any more than 5,985 fish/100 m^2 (5,000 fish/100 yd^2) at the planting sites.

In the dispersal experiments, age 1 parr were rather uniformly distributed for about 1.6 km (1 mile) upstream and downstream from the planting sites. Some had spread several km (miles) beyond these limits. In bird control experiments, there was good dispersal for 0.8 km (0.5 mile) upstream and 1.6 km (1 mile) downstream within 2 months. One year later, the intervening area appeared to be relatively uniformly populated. It was recommended that planting sites be <3 km (2 miles) apart.

The best age for planting was investigated by following the survival to smolt of plantings of underyearling and yearling fish in the Petitcodiac system. Yearlings were widely dispersed in streams where predation by birds was almost non-existent. Survival to smolt was ~10%. However, 16% survival was attained from underyearling stocking on the Pollett with bird control. In the presence of fish-eating birds, newly planted yearlings would "doubtless" be more vulnerable than fish which had already lived for a year in the stream. It was concluded that there would be no advantage from rearing salmon to yearling age in hatcheries before planting them.

In all the experimental plantings, fingerlings were released in relatively shallow water, usually in rapids. In the Pollett plantings, eels took many fingerlings within a few hours of planting, when plantings were in areas of large cobble and rocks with abundant eels. Pools containing larger trout were also considered hazardous to released fingerlings.

Observations during the Pollett experiments led to the suspicion that eels sometimes limited survival between fry and parr stages. The limit set by eels was well above the limit imposed by mergansers, i.e., eels would only limit survival in the absence of mergansers. Above Gordon Falls, an area relatively free from eels, survival to the smolt stage averaged 30%, with a maximum survival of 45%. In the lower, main experimental area, with an abundant eel population, the comparable survival rate was 15%. Above Gordon Falls, there were 70% fewer eels of salmon-eating size, compared to below the falls. The average abundance of eels in the Pollett River and several tributaries of the St. John River was 18 eels/100 m^2 (15 eels/100 yd^2).

Elson, P.F. 1956. Adult salmon required to maintain stocks. Pages 173-176 *in* Hart, J.L. Fisheries Research Board of Canada, Biological Station, St. Andrews, N.B. Investigators summaries, 1955-56. (Summary No. 66)

Experiments with hatchery underyearlings showed that the Pollett River could produce 6-7 age 2 smolts/100 m^2 (5-6 age 2 smolts/100 yd^2) of stream bottom, from stocking of 10-12 yearling parr/100 m^2 (8-10 yearling parr/100 yd^2). "Probably when young salmon have lived in a stream for a year or more, it makes very little difference to their value for producing smolts whether they came from hatchery or native spawned stocks."

Known numbers of adult salmon were stocked into the 16 km (10 mile) experimental section of the Pollett River. The total weight of adult female salmon entering the river was known, but not the magnitude of removals. There was little angling, but salmon were removed "by other means". It was assumed that poaching on the Pollett was probably of the same order of magnitude as angling on most other rivers, and therefore was a reasonable estimate of "normal losses". Female Pollett River salmon carried about 1,762 eggs/kg (800 eggs/lb). Survival from "potential egg deposition" through underyearling and age 1 parr was monitored. At an average 5% survival rate from egg to age 1 parr, potential egg deposition of 239 eggs/100 m^2 (200 eggs/100 yd^2) would be required in order to get the 12 age 1 parr/100 m^2 (10 age 1 ("large") parr/100 yd^2) needed for maximum smolt production. This translated to 20 kg of female salmon/km of stream/9 m wide – probably 9 grilse or 2.5 larger salmon (44 lb of female salmon/mile of stream 10 yd wide - probably 15 grilse or 4 larger salmon). The average weight of the Pollett salmon was 2.16 kg/fish (4.75 lb/fish).

Elson, P.F. 1957. The importance of size for the change from parr to smolt, in Atlantic salmon. Canadian Fish Culturist 21: 1-6.

Scales from several thousand salmon smolts from the Pollett River were aged. Ninety to 95% of the smolts emigrated to sea at age 2, and almost all the rest at age 3. Radii for the years of river life were measured for 250 samples from the 1950 smolt run. For the 14 age 3 smolts measured, the calculated mean length and standard deviation at the end of the second winter was 10.7 ± 0.8 cm. For 22 age 2 smolts from the same migration, the calculated mean length at the end of the second winter was 14.0 ± 1.7 cm.

Examination of scales from Pollett River parr collected monthly through most of a year indicated that usually about ¼ of the growth for the year occurred during the laying down of the winter band, between about mid-August and the following May. In consequence, most fish which were about 11 cm long by the time the winter band was completed were probably well under 10 cm long in the preceding August. Those which were ≥ 14 cm in May must have been ≥11-12 cm long in the preceding August. This size distribution supported the hypothesis that parr ≥10 cm by late summer become smolts in the following spring.

Elson, P. F. 1957. Number of salmon needed to maintain stocks. Canadian Fish Culturist 21: 19-23.

Previous experiments indicated that stocking salmon fry at a rate of 42 fry/100 m^2 (35 fry/100 yd^2) in the Pollett River should result in 8 large (>10 cm) parr and 6-7 age 2 smolts/100 m^2 (10 large parr and 5-6 age 2 smolts/100 yd^2) over the subsequent two years. It was assumed that survival of stocked fry in the first year was lower than survival of wild fry, but that second-year survival from parr to smolt was similar to wild fish. The question addressed in this paper is how many adults should spawn in the wild in order to produce 12 parr/100 m^2 (10 parr/100 yd^2)?

Studies were conducted in 1953-1955 to determine how many underyearlings, parr and smolts were produced by known numbers of adult salmon entering a 16 km x 23 m (10 mile x 25 yd) stretch of the Pollett River. Most of the salmon entering the Pollett River were grilse weighing on average 2.2 kg (4.75 lb). Female Pollett River salmon carried 1,762 eggs/kg (800 eggs/lb) Between 95 and 141 kg (210-310 lb) of adult female salmon entered the experimental stretch in each of the three years. Potential egg deposition was 46.2-86 eggs/100 m^2 (38.6-71.7 eggs/100 yd^2). Survival of eggs to underyearlings (summer) was 6-8%. Survival of underyearlings to large parr (mainly age 1, but 5-15% could have been age 2) was 54-100%. Survival of eggs to large parr was 4-6%. At an average survival rate of 5%, potential egg deposition at a rate of about 239 eggs/100 m^2 (200 eggs/100 yd^2) would produce the target value of 12 large parr/100 m2 (10 large parr/100 yd^2). This translated into about 20 kg (44 lb) of female salmon, approximately 3 female grilse or 1 large female salmon in each km of stream, 9 m wide (10 female grilse or 4 large female salmon, in each mile of stream, 10 yd wide). This was a general rate for the stream as a whole, not just the nursery areas or spawning beds. In 1956, the average potential egg deposition in the same area was 302 eggs/100 m^2 (252 eggs/100 yd^2), thus the results of this spawning (not yet known at the time of writing) would be a test of the hypothesis.

Relative to rivers such as the Miramichi, the Pollett River survival rates may have been quite low. Eels, which were 10 to 20 times as abundant in the Pollett as in the Miramichi, preyed on both salmon eggs and alevins still in the redds, as well as on older stages.

Elson, P. F. 1957. Using hatchery-reared Atlantic salmon to best advantage. Canadian Fish Culturist 21: 7-17.

Experiments on bird control to increase the smolt yield of hatchery-reared fish were conducted on a 16 km (10 mile) stretch of the Pollett River. Underyearling salmon were planted in 1942 (15,000 salmon), 1943 (15,000) and 1945 (250,000) with no bird control and in 1947 (275,000), 1948 (235,000), 1949 (245,000) and 1950 (245,000) with bird control. Smolt production was about 1 smolt/100 m^2 (1 smolt/100 yd^2) of stream with mergansers, but 6-7 smolts/100 m^2 (5-6 smolts/100 yd^2) with bird control. Without bird control, enough mergansers visited the area to eat more parr than the river could support, but with control only about 25% of the parr could be eaten.

The Pollett River was considered to be typical of Maritime streams in its abundance of mergansers. It was suggested that merganser abundance should not exceed one bird for every 16-24 km (10-15 miles) length and 9 m (10 yd) width of stream. Kingfishers could not remove enough young salmon to seriously affect the smolt output but probably should not exceed 1 kingfisher per km and 9 m width of stream (2 kingfishers per mile and 10 yards width of stream).

The smolt-producing capacity of the Pollett River was similar to that of Miramichi streams and the Port Daniel River in Gaspé. Survival rates of underyearlings to age 1 parr ranged from 8-27% and from age 1 parr to age 2 smolts was 34-51% for hatchery-stocked fish and 80% for naturally spawned fish. (Natural spawning had occurred from the effects of a freshet, which brought a few adult salmon past a closed fishway into the experimental area.) Approximately 90% of the Pollett River smolts were age 2.

Maximum recommended rates of stocking for a two-year smolt population were 4,375 fingerlings per km of stream 9 m wide (7,000 fingerlings per mile of stream 10 yards wide) (in fertile streams with <0.3 mergansers/10 km x 9 m (1 merganser/10 miles x 10 yd)) or 1,563 fingerlings/1 km x 9 m (2,500 fingerlings/1 mile x 10 yd) (barren streams, or fertile streams with mergansers more abundant). These values were considered to be maxima, and "planting 1,000 or so less should give nearly all the smolts the stream could raise. But planting many more is almost certain to result in waste of all the excess either through predation or starvation."

The optimal dispersion at stocking was studied in 1948, 1949 and 1950 on a section of the Pollett River above Gordon Falls, 16 km (10 miles) above the area used for the studies of smolt production. Three dispersion rates (60, 599, and 5,985 underyearlings/100 m^2) (50, 500 and 5,000 underyearlings/100 yd^2) of 4,000 underyearlings were tested at each of three planting sites located 3 km (2 miles) apart. The fish planted in each section were marked by removal of certain fins. Results were evaluated by counting smolts from each planting as they passed through the smolt trap 24 km (15 miles) downriver. There was little difference in the number of smolts produced in each treatment.

Young salmon dispersed from the stocking sites to produce a fairly uniform distribution for about 0.8 km (0.5 miles) upstream and 1.6 km (1 mile) downstream over 1-2 months after stocking. A year after stocking they were fairly well scattered over 1.6 km (1 mile) both upstream and downstream. It was recommended that stocking sites should not be >3.2 km (2 miles) apart.

Experiments were conducted in Holmes Brook and Bennett Brook to determine the most appropriate size at which young salmon should be stocked, taking in consideration both predation and competition. Yearling salmon were stocked, and their survival was compared to the underyearling stockings, which were the standard procedure. Both streams were ~8 km long and 1.8-4.6 m wide (5 miles long and 2-5 yards wide), and had small populations of native salmon (~2.4 salmon/100 m^2) (2 salmon/100 yd^2). In Holmes Brook, more than half the native salmon migrated as age 3 smolts, the rest as age 2 smolts. Almost all Bennett Brook smolts were age 2. Other fish present in both streams were eels, horned dace (*Semotilus atromaculatus*), lake Northern chub (*Couesius plumbeus*), black-nosed dace (*Rhinichthys atratulus*) and brook trout (*Salvelinus fontinalis*), the latter fished by local anglers. Occasional kingfishers visited the streams but mergansers were rare. Hatchery yearlings (mean length 10 cm) were distinctively marked before stocking. Parr were stocked into both brooks in 1945 but only Bennett Brook in 1946. Survival rates to age 2 smolts varied from 2% to 30% with mean of 13% (SE=3%, N=13). Typical survival rates of the yearlings were considered to be in the range of 5 to 20%, "not materially better than the 15% survival rate that can be obtained from underyearlings".

Some of the yearling fish planted in Bennett Brook in July 1946, 16% of which appeared to be smolts, apparently reverted to parr behaviour. None of these fish was taken in the smolt counting fence below, in the year of planting. Several were recognized as stocked fish, living near their original stocking sites during the summer. The failure of these fish to go to sea was attributed to the late stocking date.

The effect of predation on stocking was noted with an example from the Pollett River, where eels ≥30.5 cm (1 ft) in length were found to take many fingerlings within a few hours of planting. Gordon Falls was a partial barrier to eels, since only about 1/3 as many eels "of the sizes that eat salmon" were found above the falls as below. Above Gordon Falls, the average survival rate of underyearlings to smolt (sparse populations) was 30% (maximum 45%) but below Gordon Falls was only 15%. Eels were considered to be much more abundant in streams flowing into the Bay of Fundy, including the Pollett, than in Gulf of St. Lawrence watersheds.

Returns to the Pollett River of mature salmon derived from stocks collected in other rivers but planted as underyearlings in the Pollett have been "almost negligible". At the time of writing, an experiment was being conducted to evaluate the returns of 800 marked smolts of Pollett stock, reared to the usual underyearling stage in a hatchery, then planted back into the Pollett River.

Elson, P.F. 1957. Need merganser control be continued indefinitely? Pages 130-132 *in* J.L. Hart. Fisheries Research Board of Canada, Biological Station, St. Andrews, N.B. Annual report and investigators' summaries, 1956. Covering the period November 1, 1955, to March 31, 1957. (Summary No. 59).

Merganser kill on the Pollett River had decreased steadily over the previous 4 years, believed to reflect either a decrease in the number of mergansers, lower parr abundance, or both. It was not considered to be a direct result of control operations. During June-November 1956, mergansers were scarce relative to previous years. Parr, which resulted from a sparse natural spawning, were also scarce. In late September, 100,000 underyearling salmon were planted in the area. The fish were 7 cm long, about twice as long as those used in previous plantings. In contrast to much smaller underyearlings, these fish could be eaten "in considerable numbers" by mergansers. During January-March 1957, merganser incidence in the area was "heavy". Merganser (numbers killed from January 1 to March 8) and parr abundance (of length >7 cm) in the middle Pollett River (16 km stretch) was summarized for 4 years. For the first 3 years, parr abundance was based on seining results from the preceding August. For 1957, it was based on seining results plus an assumption of 25% survival of the planted fish (survival rate assumption was based on the earlier experiments with smaller fish).

Year	No. mergansers killed	Ice cover	No. parr/100 m^2 (no./100 yd^2)
1954	12	Normal	14.4 (12)
1955	14	Little	4.8 (4)
1956	1	Normal	2.4 (2)
1957	26	Normal	10.8 (9)

Elson, P.F. 1957. Growth, size and smolt development in young Atlantic salmon. Pages 133-135 *in* J.L. Hart. Fisheries Research Board of Canada, Biological Station, St. Andrews, N.B. Annual report and investigators' summaries, 1956. Covering the period November 1, 1955, to March 31, 1957. (Summary No. 60).

The scales of about 200 Pollett River smolts, derived from hatchery plantings, were examined for age and growth characteristics by comparing scale radii in the parr years with the scale radius: smolt length ratio for individual smolts. Most Pollett smolts were age 2, and the rest were age 3. For age 2 and 3 smolts, parr which exceeded "by a comfortable margin" a total length of 10 cm at the end of one summer became smolts the following spring. For the Pollett River, with relatively warm water and fast growth, the age 2 smolts exceeded this standard in their second autumn by nearly 3 cm. The age 3 smolts "barely attained" 10 cm in the second autumn, but were 5-6 cm longer by their third autumn. Therefore, they were larger smolts than the age 2 group.

Individuals which grew rapidly in one year did not necessarily continue rapid growth in subsequent years. In the age 2 smolts, there was a trend for an inverse relationship between growth rate in the first year and growth rate in the second year. Age 2 Pollett smolts which were largest as yearlings actually made less growth in their second year than did the average Pollett age 3 smolts in their second year. It was suggested that growth was determined by environment rather than heredity.

Elson, P.F. 1957. Adult salmon required for full smolt production. Pages 139-141 *in* J.L. Hart. Fisheries Research Board of Canada, Biological Station, St. Andrews, N.B. Annual report and investigators' summaries, 1956. Covering the period November 1, 1955, to March 31, 1957. (Summary No. 62).

The fourth natural spawning of adult salmon in the middle Pollett River occurred in 1956. The numbers of mature fish naturally available had been low, and in 1954-1956 these native fish had been augmented "to a considerable extent" with adults netted in other Petitcodiac tributaries and transported to the experimental section. All returning Pollett salmon were also transported from the trap at the Sanatorium dam to various parts of the experimental section. Based on observations of redds, most or all of the fish had spawned in the general area of release. "The results appear to be acceptable as an experiment on natural spawning with variable numbers of adults." Throughout the first three years the numbers were fairly low, but in 1956 sufficient salmon were imported from other tributaries to produce a "moderately heavy" spawning.

The experimental area was separated by a dam, normally insurmountable to salmon, into a lower 5 km (3 mile) section and an upper 11 km (7 mile) section. There was no indication of extensive downstream movement past the dam, or into the weir maintained at the lower end of the experimental section during any of the spawning seasons. Hence, the two sections of river were reasonably independent for each spawning-to-fry observation. Using the 1953-1955 spawning data, it was tentatively calculated that potential egg deposition at the rate of 239 eggs/100 m^2 (200 eggs/100 yd^2) should result in the maximum rate of 6-7 smolts/100 m^2 (5-6 smolts/100 yd^2).

Elson, P.F. 1957. Reinforcing native populations with hatchery stock. Pages 141-143 *in* J.L. Hart. Fisheries Research Board of Canada, Biological Station, St. Andrews, N.B. Annual report and investigators' summaries, 1956. Covering the period November 1, 1955, to March 31, 1957. (Summary No. 63).

A third "very light" spawning in the middle Pollett experimental area resulted in "inadequate" native stock, i.e., numbers insufficient to produce maximum smolt production. After assessing the native population in early August, it was decided to plant 100,000 fingerlings in order to produce 15,000 smolts. These were allocated to 6 planting sites in accordance with the local abundance of native underyearlings.

The fish planted in 1956 were 7.2 ± 0.9 cm in length, compared to 3.6 ± 0.5 cm average length of the previous plantings. The native stocks averaged 6.9 ± 0.7 cm at the time of planting. The adipose fin was removed from 1/11 of the hatchery fish, 10 days before planting.

Planting was done September 21-22. In previous years, the latest planting had been September 12. Eels, which in the past had been shown to eat considerable numbers of fry immediately after planting, were relatively inactive. Of 78 eels >20 cm long, taken by electrofishing on planting sites within 24 hr of planting, 6 contained 1 salmon fry each. In other years, eels had contained 10, 20 or even 40 fry each. The reduced predation was probably due to a combination of the large size of the planted fish and the relative lateness of the season.

To follow the dispersal and survival of the planted fish, 7 stations were electrofished each week, from about 0.8 km (0.5 mile) below the uppermost planting and 0.8 km (0.5 mile) above the next planting which was 4 km (2.5 miles) downstream. In 7 weeks, the fish were evenly dispersed to 1.6 km (1 mile) below the upper planting. At this point, the density indicated by "somewhat ineffective seining" was 12 underyearlings/100 m^2 (10 underyearlings/100 m^2), about double the number of native underyearlings present in the same area in July. At the same time, up to 1.6 km (1 mile) above the next planting, the observed density was 6 underyearlings/100 m^2 (5 underyearlings/100 yd^2), about 2.5 times the July density.

Fish were planted in the upper 3.6 km (2.25 miles) at a rate of 26 fish/100 m^2 (22 fish/100 yd^2). One week later they were found at 14 fish/100 m^2 (12 fish/100 m^2), and after 7 weeks at 8 fish/100 m^2 (7 fish/100 m^2). From earlier observations it was thought that most post-planting mortality would have occurred by this time. The apparent survival rate was ~30%.

None of the fish marked at the hatchery were identified among the 472 underyearlings captured by electrofishing.

Elson, P.F. 1958. The development of practical merganser control. Pages 147-152 *in* J.L. Hart. Fisheries Research Board of Canada, Biological Station, St. Andrews, N.B. Annual report and investigators' summaries, 1957-58. (Summary No. 69).

The results of merganser control experiments on the Pollett, St. Mary's and Miramichi rivers were compared. Unlike the other rivers, the number of mergansers removed annually in the Pollett did not decline over the decade of merganser control, probably because the Pollett watershed was not sprayed with DDT. With local broods no longer being reared, mergansers found in the Pollett in the autumn were probably migratory birds from other rivers. There was considered to be a "strong and direct" relationship between parr populations and merganser incidence on the Pollett River (partial correlation coefficient of 0.512, significance between 0.1 and 0.2).

Year	No. of mergansers removed		No. of parr/100 m^2 (no./100 yd^2)
	Total	Sept.-Dec.	
1948	18	7	6 (5)
1949	81	54	11 (9)
1950	40	11	10 (8)
1951	69	41	14 (12)
1952	76	21	2 (2)
1953	55	42	14 (12)
1954	51	21	5 (4)
1955	51	9	2 (2)
1956	52	14	17 (14)
1957	68	8	18 (15)

Elson, P.F. 1958. The use of hatchery stocks to remedy specific deficiencies. Pages 152-156 *in* J.L. Hart. Fisheries Research Board of Canada, Biological Station, St. Andrews, N.B. Annual report and investigators' summaries, 1957-58. (Summary No. 70).

In July 1956, the average density of underyearling salmon in the Pollett River was 5 underyearlings/100 m^2 (4 underyearlings/100 yd^2). This was not expected to produce the maximum rate of 6 smolts/100 m^2 (5 smolts/100 yd^2), which required parr densities of 10-12 parr/100 m^2 (8-10 parr/100 yd^2). Previous studies had indicated that 10 age 2 pre-smolt parr could be produced from 15 native August underyearlings or 30-35 hatchery underyearlings, 3-4 cm long, planted in late August. This translated to 150,000 hatchery fry for the 16 km (10 miles) of river.

It was decided to plant 100,000 underyearlings "in order to get good reinforcement while still being able to observe optimum survival rates". The adipose fin was removed from 9% of the planted fish. The fish were 7.2 ± 0.9 cm long instead of 3-4 cm. The native fish were smaller, 6.9 ± 0.7 cm. The planting was done on September 20-21, a month later than the previous experiments. Water temperatures were 10 C (50ºF), about –12.2ºC (10ºF) lower than in the previous experiments. This caused restricted activity of the salmon and "greatly restricted" activity of the predatory eels. An "intensive study" of the food of eels at planting sites immediately after release of these salmon showed that eels had eaten only a small fraction of the salmon that eels took from previous plantings. This was probably due to both the low temperatures and the size of the salmon. Electrofishing until mid-November showed good dispersal of the fish from planting sites, and the survival rate over 2 months was ≥ 30%.

The overall mean density of planting was 28 underyearlings/100 m^2 (23 underyearlings/100 yd^2), and by July 1957 the mean density of the stocked fish (based on marked individuals) was 16 parr/100 m^2

(13 parr/100 yd^2). The survival rate was 55-60%, more than double the rate used to calculate requirements. In addition, some of these stocked fish descended in 1957 as age 1 smolts.

An experiment on the dispersal of planted yearling parr was begun in the upper Pollett River on September 11 1957. This followed a 3-year design similar to the study of dispersal of underyearlings which had been previously conducted. It was noted that the underyearling experiment had showed very little difference in smolt production due to dispersal, and that the yearling experiment would not be continued for the full 3 years unless "important differences" were observed in the first year. The first year of the experiment involved planting of age 1 parr as follows:

Location	Fins removed	Mean length ± SD (cm)	N	No. planted	Stream length planted, m (yd)
Coleman Corner	Right pelvic	13.8 ± 2.3	122	978	1.8 (2)
Steeve's Clearing	Both pelvics	13.3 ± 1.8	209	991	18.3 (20)
Sproule Bridge	Left pelvic	12.5 ± 2.0	200	1,000	183 (200)

The smolt run of 1957 confirmed earlier indications that planting large underyearlings could result in early smolt production. Of the 99,000 underyearlings planted in the Pollett in 1956, about 0.75%, or 750 fish, exceeded the 10 cm size limit believed to be the critical size for smoltification the following spring. About 68 of these large underyearlings were adipose fin clipped. The following spring, 59 age 1 smolts with this mark were recorded. Preliminary scale inspection indicated that nearly all of these smolts were ≥ 10 cm at the end of the first year of growth when they were planted. As smolts, they averaged 13 cm in length, ~3 cm shorter than the usual age 2 Pollett River smolts. Thus, the run accounted for ~85% of the large underyearlings planted, implying both an excellent winter survival rate and an equally successful rate of smolt production from appropriately sized planted stock.

Comparison of autumn vs. spring planting for smolt migration in the year of planting was also carried out, using large yearling salmon from the St. John hatchery (minimum length of 11.5 cm in mid-May). Fish with the right pelvic fin removed were planted 19.3 km (12 miles) above the counting weir on May 22 1957, and with the left pelvic fin removed were planted in the same place on September 11 1957.

	Spring	Autumn
No. planted	4,998	3,891
Mean length ± SD	12.5 ± 1.1 cm	16.4 ± 1.6 cm
N of length sample	102	95
No. migrating	2,066	0
Mean length ± SD	13.8 ± 0.9 cm	
N of length sample	2,066	
Period of migration	May 23-June 23 1957	

Preliminary scale examination of the fish planted in the Pollett in May indicated that about 2,250 of the 4,998 planted fish were ≥10 cm long in the preceding autumn. Most of the resulting smolts were also in this category. Thus, 90% of the fish fulfilling the 10 cm autumn size requirement descended as smolts the following spring, most within 1-2 weeks of planting. (Those which remained a month "showed excellent growth after liberation", apparently due to an abundant source of insects as food.) None of the autumn-planted fish descended before winter, although they were much larger at planting than the subset planted in the spring. It was recommended that smolt plantings should be made no later than June 1.

Elson, P.F. 1958. Adequacy of salmon stocks. Pages 157-160 *in* J.L. Hart. Fisheries Research Board of Canada, Biological Station, St. Andrews, N.B. Annual report and investigators' summaries, 1957-58. (Summary No. 71).

In 1957, cool weather delayed the spring growth of young Pollett River salmon. Fry were so small at the time of seining that they were not captured as thoroughly as in most years, and abundance was probably underestimated. In late 1956, a "moderately heavy" planting of hatchery yearlings was made. These fish were as large as the native stock, and much more numerous. Their survival rate to 1957 was double the expected rate, and the survival of the native stocks was less than anticipated. The resulting parr crop was 20% higher than the largest on record. "This situation may well have contributed some extra mortality to both native and planted stocks."

The average production from potential eggs to underyearlings was 5%, including the low 1957 counts. The average production from underyearlings to parr was about 60%, including the 1957 parr, which may have been "unduly depressed". The average production rate of parr to smolts was 50%. The observed values of smolt production were almost as high when preceded by 7 parr/100 m^2 (6 parr/100 yd^2) as from heavier parr densities. Combining the above information, the "optimum rate" of production from potential egg deposition to smolts was in the range of 1.5-3% for this part of the Pollett River. The optimum rate of smolt production was ~6 smolts/100 m^2 (~5 smolts/100 yd^2), and this would be obtained from potential egg production of 239-419 eggs/100 m^2 (200-350 eggs/100 yd^2). "Quite possibly eggs at any heavier rate than 200 [239 eggs/100 m^2] would be unnecessary in most years."

Elson, P.F. 1959. Use of hatchery and native salmon stocks for best production of smolts. Pages 143-147 *in* J.L. Hart. Fisheries Research Board of Canada, Biological Station, St. Andrews, N.B. Annual report and investigators' summaries, 1958-59. (Summary No. 77).

Field work to study the number of hatchery underyearling salmon required for the best smolt production in the Pollett River was completed in 1957. The target rate of smolt production was 6 smolts/100 m^2 (5 smolts/100 yd^2) of river bottom. This required planting underyearlings at a rate of ~42 underyearlings/100 m^2 (35 underyearlings/100 yd^2). In 1958, the final year-class of native underyearlings for the study of the amount of spawning needed for best smolt production was assessed. About 10 parr/100 m^2 (8 parr/100 yd^2) were required, and at the observed survival rate of 65%, this would necessitate a population of 14 underyearlings/100 m^2 (12 underyearlings/100 yd^2). In terms of potential egg deposition, this would require 299 eggs/100 m^2 (250 eggs/100 yd^2). Thus, about 35 hatchery underyearlings were deemed equivalent to 250 eggs brought to the river by wild adult salmon.

In 1956, the native fingerling population in the Pollett River was estimated as 8 fish/100 m^2 (7 fish/100 yd^2). This was expected to produce just under 3.6 smolts/100 m^2 (3 smolts/100 yd^2). Supplemental planting was tested in order to achieve the maximum capacity of the stream, which was set at 7 smolts/100 m^2 (6 smolts/100 yd^2). With the optimum hatchery underyearling-to-smolt survival rate calculated as 15%, a planting of ~30 fry/100 m^2 (25 fry/100 yd^2) was indicated. In practice, 27.5 fry/100 m^2 (23 fry/100 yd^2) were planted in late September. The mean length was 7.2 ± 0.9 cm, somewhat larger than the native underyearlings (6.9 ± 0.7 cm). Survival rate of the planted stock to the following smolt run was 19%, apparently exceeding that of the native stock (14% from July underyearlings). The rates of production were 5.3 hatchery and 1.2 wild smolts/100 m^2 (4.4 hatchery and 1.0 wild smolts/100 yd^2). Production from this hatchery planting was greater than anticipated, but appeared to have been at the expense of native stock already present. It was concluded that smolt rearing capacity had been overestimated in designing the experiment.

Of the marked smolts which migrated from the Pollett River from 1949 to 1956, about 110,000 were of hatchery origin, mostly planted as underyearlings, and about 15,000 were native spawned fish. The return rate of hatchery-reared stock from non-Petitcodiac genetic sources was 0.02% to the Pollett River, none recorded from other rivers, and 0.5% taken in distant commercial fisheries. For native stock in the same stream, 4% returned to the river of egg origin, and none were recorded in other rivers or in the commercial fishery.

Elson, P.F. 1961. Proposed Moncton causeway-aboideau in relation to anadromous fish of the Petitcodiac system. Unpublished report, Fisheries Research Board of Canada. January 31 1961. 9 p.

The migratory fishes which would be affected by such a structure included salmon, possibly speckled trout, shad, alewives, smelt, striped bass, possibly sturgeon, and eel.

Salmon had the greatest economic significance. Shad were almost equally important "until recently" and were still locally important as a food fish. The use of the other species was more limited.

In 1874 the Chignecto area yielded 2% of the total Maritimes catch of salmon, or about 75,818 kg (167,000 lb). The Petitcodiac was the principal rearing stream of the area, illustrating its potential value. The present contribution to the salmon fishery was about 0.1% of the Maritimes commercial catch.

From 1953-1959, the average recorded angling catch was 180 fish/yr. In the same period, Elson was capturing an average of 250 salmon/yr in the Pollett River, and about 250 fish/yr in the main Petitcodiac and Coverdale rivers. "Our operations always appear to have left good numbers of parent stock in these other streams." He guessed that he did not see more than 25% of the local salmon stock. This suggested that the annual run into the system would average over 2,000 fish. About 200 to 300 more would be taken in commercial fisheries. Thus, the annual run of salmon was probably ~2,000-3,000 fish. In some years production would be ~ 1/3 of this, and in other years possibly double. In Elson's opinion, these numbers would be higher "with more complete management".

Fresh salmon were known to enter the Pollett as early as June 16. A few entered in July and August each year with suitable water conditions. The main run began in September and peaked in October. "Good numbers come in November and occasional fish in December, even after ice formation". There was limited angling in summer; most angling occurred from September to mid-October. There was "quite a bit" of kelt angling, especially in the Coverdale River, in May. The smolt run occurred mostly in the last half of May.

There was a "considerable" trout fishery, especially in May. All branches supported trout, and large trout were taken in the main Petitcodiac in May. Some of these may have been sea trout, although Elson was uncertain whether they had actually been to sea or had grown large in the rich, lower freshwater reaches. He had caught 1.6 kg (3.5 lb) trout in salmon weirs. During the summer, trout mostly disappeared from the warm lower reaches of the larger streams.

"In most of the last half century residents along the Petitcodiac seem to have been as conscious of the shad runs as of salmon". Shad spawned in the main river up to the village of Petitcodiac. Elson was "not aware that they use the tributaries much", although they sometimes ascended the lower 5-6 km (3-4 miles) of most. There was a "modest shad fishery" below Moncton, both by drift nets and by stake nets fished from wagons at low tide. The fishery was "very much higher" in the first quarter of the 20th century than in the 1960s. Within the previous 15 yr, there had been increasing interest in angling for shad between Salisbury and Moncton. In the previous 5 yr, this interest in shad angling had been "quite active". Angling occurred during the spawning run in May and into June, and Elson believed the fishery had considerable recreational potential.

The spring smelt run extended ~8 km (5 miles) above the head of tide at Salisbury. Local residents dip-netted the spawning run. Elson noted the possibility that these smelt were important forage fish for other species.

Gaspereau had been recorded in the Pollett River traps, but spawned largely in the Anagance River, which had considerable stillwater area. He was not aware that they were much used locally, and there was no commercial fishery.

There was a limited angling fishery for striped bass in the summer and early fall. Local abundance had "characteristic unpredictability". Elson had seen 10 cm (4 in) young of striped bass in July, in the North River above Petitcodiac.

Occasional sturgeon were taken by commercial fishermen below Moncton. A local fishery officer told Elson he had seen several sturgeon in the lower freshwater reaches.

Eels were abundant in all Petitcodiac tributaries. They had little or no direct fishery, but used ¼ to ½ of the fish-producing capacity of the waters.

Elson considered the Petitcodiac estuary to be unique among Maritime estuaries "in that it has a massive exchange of a relatively large body of salt water under extremely turbulent conditions at each tidal cycle". In summer, salinity above Moncton probably was at least 28.5‰, except under freshet conditions. At Salisbury, 24 km (15 miles) upstream, salinity varied from ~0.26 ‰-11.00‰.

The low summer outflow of the Pollett River, which represented ~20% of the catchment basin above the proposed causeway, was estimated at 0.9-1.4 m^3/sec (30-50 cfs). Average total low water summer outflow would therefore be ~5.7 m^3/sec (200 cfs) or about 0.2 x 10^6 m^3 (8 x 10^6 $ft^{3)}$ per 12-hr tidal cycle. The MMRA plans showed storage capacity of 14 x 10^6 m^3 (500 x 10^6 ft^3) for a reservoir geodetic level of 0 m (0.0 ft) upstream of the proposed causeway, and about 27 x 10^6 m^3 (950 x 10^6 ft^3) at a level of +6 m (+20 ft). Thus, the ratio of salt water to fresh water at the causeway would be between 500:8 and 950:8. Thus, most of the freshwater flow would be lost at each tidal cycle, and only the freshwater flow during the last part of ebb tide and on the early rise before bore formation would have much potential for attracting fish into the river.

The bore also probably served to disrupt fish orientation in the river, through turbidity and turbulence. Small fish such as smelts and possibly salmon smolts were seen "tossed" in the wave of the bore and preyed upon by numerous gulls during the bore's passage. Large fish such as salmon and shad were sometimes left stranded on the mudflats with the recession of the tide, which Elson attributed at least in part to ineffective orientation with respect to the water movements. The bore also prevented stabilization of the silt bottom through growth of rooted aquatics. Elson thought it unlikely that this upper part of the estuary contributed to natural production of aquatic organisms, functioning mainly as a "rather violent transport area between fresh waters and the more stable sea environment" commencing near Pre-d'en-Haut.

"A causeway at Moncton which incorporates a dam cannot but bring about profound changes in the upper estuary. The nature of such changes will depend partly on whether any salt water is allowed above the dam." The possibility of stagnant salt water zones, similar to those occurring in the anoxic waters above the causeway of North River, PEI, was noted.

Temperatures in the reservoir were expected to be high. All the large Petitcodiac tributaries "get warm" during hot days from mid-June to September, up to 26.7-32ºC (80-90ºF). They generally cooled by –15 to -12.2ºC (5-10ºF) at night. The impoundment would be expected to have temperatures of ≥21ºC (70ºF) and probably approach 26.7ºC (80ºF) from the end of June throughout much of August. Temperature in the reservoir "could greatly affect movements of fish".

With elimination of the scouring effect of the bore, the bottom of the reservoir would probably become stabilized, and was expected to allow establishment of "a rich, bottom-rooted flora". *Potomageton,* already established in the system, and water-lilies would probably be important. An anchored alga of the *Cladophora* group grew abundantly in the North and main Petitcodiac rivers, "often blanketing the bottom during much of the summer. In the river it thrives best in flowing water, but may contribute to the flora of an impoundment." Bennett Brook had a high concentration of calcium sulfate and supported a dense growth of *Enteromorpha intestinalis* during summer low water; masses of *Enteromorpha* might develop in a lower reservoir, especially if salt water was added periodically.

Fishes present in the system, and which might be expected to thrive in such a reservoir, included suckers, *Couesius*, *Fundulus*, *Notemigonus* and eels. Eels were the only large predaceous fish, other than salmonids, already established in the system as more or less permanent residents. Gaspereau might have "relatively great" increases in available spawning areas. Striped bass might use such a reservoir "to a greater extent than they now use the lower fresh waters and upper estuary". Another species which "will almost certainly benefit" was the lamprey. Ammocoete larvae, already abundant in the pond of the Sanatorium, and in quieter areas of all lowland tributaries, were "almost certain to find the mud bottom of the new reservoir a favourable habitat".

"As with any impoundment, the proposed Moncton causeway is likely to affect both the downstream movement of smolts and kelts and the upstream movement of mature adult salmon." Delays experienced by smolts descending the 3 m (10 ft) Sanatorium dam on the Pollett River typically ranged from <1 day to "a couple of weeks", depending on water conditions. It was noted that smolts tend to prefer the upper 1.5-3 m (5-10 ft) of water, and that a sudden increase in current and turbulence, as at a dam spill, is an immediate stimulus to upstream orientation and movement, and appears to delay passage over dams. A channel draining the surface layers of water was recommended as a means to facilitate seaward movement of smolts at the causeway. Such a channel should extend several feet below the surface of the water (possibly 1-1.8 m) (3-6 ft) "to avoid drawing only the warmest surface water, which the smolts may avoid, in the last part of June". The opening of the channel should have a gradually rising floor (about 15° incline to the horizontal) to force gradual rather than abrupt acceleration of water flow. It had been observed that a dam with an upstream face sloping at 15° passed salmon smolts without "conspicuous delay", but that a sloping face of 30° resulted in "noticeable delay". Delay of smolts in a lake above the causeway would "almost surely result in heavy losses to predators" and perhaps even more loss to heat stress.

At the time of writing, the tidal bore travelled from Pre-d'en-Haut to Boundary Creek. Adult salmon travelled in and out with the tide, but few continued on to fresh water during the summer. Elimination of half the length of the bore might provide a better chance of upstream movement if the freshwater discharge could be made more effective. If the fresh water were to be mixed with "great amounts" of salt water by being discharged from deep gates, it would be relatively ineffective. Surface releases of fresh water might extend the attraction flow over a longer part of the tidal period than was the case in 1961.

Elson, P.F. 1962. Natural survival rates of Atlantic salmon. Pages 148-151 *in* J.L. Hart. Fisheries Research Board of Canada. Biological Station, St. Andrews, N.B. Annual report and investigators' summaries 1961-1962. (Summary No. 67).

Survival rates for Atlantic salmon in the Pollett River were summarized as:

Stage	Mean ± SD (%)
Eggs to fry	4.3 ± 0.9
Small parr to large parr	76.6 ± 4.7
Large parr to smolts	50.1 ± 4.7

The combined survival rates of the Pollett and Miramichi rivers would yield 4-5 adult fish for each pair of 4.5 kg (10 lb) spawners, an overall production rate of 2:1.

Annual variations in survival rates were discussed. From inspection of the data, it was concluded that "it would be rare to have more than 2 good or 2 bad years during the course of a normal 5- or 6-year life span". "Granted average survival conditions, even the low yield of adults is capable of returning stocks to normal in a generation or so."

Elson, P. F. 1962. Predator-prey relationships between fish-eating birds and Atlantic salmon. Bulletin of the Fisheries Research Board of Canada 133. 87p.

Although not at the time of writing noted as a salmon river, the Petitcodiac once had a good supply of the fish, and still had the physical attributes necessary for producing salmon. Public concern over apparently declining stocks in the Maritimes was noted by Perley (1852). Perley wrote of the great numbers of salmon once found in the Petitcodiac, and their depletion, which he attributed to overfishing. Conservation measures, such as provision of fishways at dams, were undertaken by 1870. In 1874, the catch from the Chignecto region was 68,100 kg (150,000 lb), about 2% of the catch in the entire Maritime region south of Cape Gaspé. Within a few years the Chignecto catch diminished by >90%. Despite conservation efforts the fishery never again approached its earlier magnitude. Even so, in 1943 some native young salmon were found in all suitable reaches of the Petitcodiac not blocked by dams.

A few grilse and larger salmon typically entered the Petitcodiac and its tributaries from mid-June onward, but most spawners entered fresh water in October and November. Petitcodiac salmon spawned in October, November and occasionally into December. Alevins emerged from the redds in late May-early June. Over 80% of these fish spent 2 years as parr, and practically all the rest spent 3 years. Parr which reached a length of 10 cm towards the end of August generally smolted the following spring. Smolts, which descended to salt water in the latter half of May and early June, had a total length of 16 cm and weighed 0.045 kg on average. Post-smolts marked in Petitcodiac tributaries were taken in weirs operated for herring and salmon along the Nova Scotia shore of the Bay of Fundy, between Hall Harbour and Morden, in July and August. They had grown to about 30 cm in length and 0.45 kg in weight. Mature salmon returning to the Petitcodiac to spawn were mainly grilse, having spent one year at sea. They were about 65 cm long and weighed approximately 2.1 kg (4.7 lb), just under the legal 2.3 kg (5 lb) limit then in place for the New Brunswick commercial salmon fishery. At the time of writing, there was still a commercial fishery for salmon from the Petitcodiac in Chignecto Bay and Shepody Bay. Stocked salmon from Miramichi River and River Philip genetic background, which were marked in the Pollett River as descending smolts, had contributed more to Gulf of St. Lawrence, eastern Newfoundland and Labrador fisheries as 2-sea-winter salmon than to local fisheries or local spawning stocks at any age. There was no evidence that this was the case for the native stock.

The abundant supply of salmon for food was reportedly one of the attractions of the Pollett River area for early settlers. Compared with most New Brunswick salmon streams, the watershed of the Pollett was relatively fertile. Gordon Falls, 4.5 to 6 m high depending on amount of discharge, had apparently always been a barrier to upward movement of salmon. There had been a dam at Forest Glen (also known as the village of Pollett River) for at least 150 years. During much of this time it had no fishway and constituted a barrier to salmon. A dam at Elgin, 0.8 km (0.5 mile) below Gordon Falls, barred salmon from holding pools in the lower half mile of the gorge "for many years" but was no longer effective in the 1940s. A 2-m falls, located 0.4 km (0.25 mile) above the site of the Elgin dam, formed a barrier to upstream movement of immature salmon. An earth and concrete dam was built at the Jordan Memorial Sanatorium about 1910. There was no provision for fish to pass it after the mid 1930s when the associated fish pass was destroyed. A Denil-type fish pass was installed in 1950, with a trap to control upward movement of salmon.

Experiments on planting young salmon were begun on the Pollett in 1942. As a starting point, it was estimated after detailed inspection of the territory that the experimental area, from the Sanatorium Dam to Gordon Falls (about 16 km), could support about 16,000 yearling and older parr. Initial stocking used about 16,000 underyearlings with the objective of obtaining the highest smolt production for the costs of stocking. Later, heavier plantings were used to measure total capacity of the area to produce smolts.

A summary of experimental plantings of salmon fry is presented. Production of salmon smolts from five years (1942-1946) of plantings was studied under natural conditions (i.e., no predatory bird control). A mean smolt production of 3,000 and 1,000 smolts/yr were calculated for the 16 km (10 mile) experimental area in the main Pollett River and its tributaries respectively. Mergansers and kingfishers were suspected to be the limiting factors, controlling smolt production by preying upon young salmon. Four annual stocking experiments (1947-1950) were tried with control of mergansers and kingfishers. The average smolt production increased by a factor of 4-5 to 20,000 smolts/yr following predatory bird control. Increasing numbers of suckers and minnows showed that they also benefited from bird control. The abundance of eels also increased significantly, perhaps by 6-8 times. Merganser predation was found to be the major limitation to smolt production in the Pollett River. A limit of 1 merganser/20 ha (1 merganser/50 acres) of water of the Pollett River was estimated to produce maximum smolt production. Predation pressure by kingfishers on young salmon was not as extensive and limiting as that of mergansers. A density >1 kingfisher/0.8 ha (1 kingfisher/2 acres) of water would require some control to prevent reduction of the salmon population.

Salmon production rates in the Pollett were compared with other systems and were similar to those in the Miramichi. The Pollett was considered to be a moderately productive salmon stream.

Details of merganser and kingfisher predation, abundance, and behaviour are summarized.

Elson, P.F. 1964. Post-smolt Atlantic salmon in the Bay of Fundy. Pages E-20 to E-23 *in* J.L. Hart. 1964. Fisheries Research Board of Canada, Biological Station, St. Andrews, N.B. Annual report and investigators' summaries, 1963-64. (Summary No. E-7).

Recaptures of marked post-smolts from the Pollett River in eastern Bay of Fundy weirs for 1963 were summarized. In June and July of 1963, 15,484 smolts were marked in the Pollett River during their descent to sea. In total, 11 of the post-smolts, or 0.07% of the marked fish, were intercepted at the weirs, which were located along the Kings County, NS, shore.

Elson, P.F. 1964. Pollett River salmon studies. Pages E-23 to E-26 *in* J.L. Hart. 1964. Fisheries Research Board of Canada, Biological Station, St. Andrews, N.B. Annual report and investigators' summaries, 1963-64. (Summary No. E-8).

The last two smolt runs to be measured in the Pollett River project were derived from a combination of plantings of hatchery underyearlings and small numbers of spawners carried above the impassable Gordon Falls. "Seedings were designed to be ample to fill the smolt-producing capacity of this upper part of the river".

Earlier studies had indicated that overwintering conditions for pre-smolt parr might be better in the upper Pollett River than in the middle Pollett below the falls, where the earlier experiments were done. Sample censuses of pre-smolt parr in the upper Pollett River in 1962, from 130,000 underyearlings planted in 1961, but no spawning in 1960, found 11 parr/100 m^2 (9 parr/100 yd^2). This was considered to be "good but not outstanding by standards developed on the middle Pollett". There were 5 parr/100 m^2 (4 parr/100 m^2) in the middle Pollett from limited spawning there. The combined parr population of the upper and middle Pollett should have produced a total run of 20,000-30,000 smolts, by the standards developed for the middle Pollett. Trap installation in 1963 was delayed until June 1, by which time 75% of the smolt run would already have descended, according to the timing in most years between 1944-1962. Water conditions would have favoured a high proportion of smolt descent in the last week of May, 1963. The counted run of 14,975 smolts was believed to represent a total run of 30,000-45,000 smolts, with ½-2/3 of these having come from the upper Pollett.

The 1963 parr population of the upper Pollett was derived from a low number of imported adults, which resulted in 2.4 underyearlings/100 m^2 (2 underyearlings/100 yd^2) in 1962, and an autumn 1962 planting of 100,000 hatchery underyearlings. Electrofishing indicated 26 parr/100 m^2 (22 parr/100 yd^2) in the upper river in 1963. There were 4-5 parr/100 m^2 (3-4 parr/100 yd^2) in the middle Pollett. The value for the upper river was 50% higher than the highest value ever observed in the middle Pollett.

Planting of hatchery stock above Gordon Falls began in 1960. Spawners were transported from below Gordon Falls to 5-6 km (3-4 miles) above the falls, starting in 1961. In 1961, these fish were released "at a place of convenient accessibility which happened to be in the middle of a 2-mile [3 km] shallow, rapid reach. Many of the fish moved downstream at once. In the next 2 years some fish were liberated in rapids, others near deep pools. Subsequent dispersal was judged by counting redds the same autumn." There was better upstream dispersal of spawners when they were released in pools rather than rapids, but wider overall distribution from releases in shallow rapids.

Year	Release site	No. released		No. of redds	
		Total	Females	Above Falls	Below Falls
1961	Rapids	121	84	8	20
1962	Pool	109	80	37	11
1963	Rapids	72	44	31	N/A
	Pool	25	15		

An experiment was conducted on the effect of "mild artificial freshets on enhancing runs" at the Sanatorium dam. "Short flash floods" were simulated by installing and removing 30 cm (12 in) planks on the crest of the cement dam on 4 nights. Only 10 fish had entered the trap by September 18. From September 19 to October 9, 25 fish entered the trap. Twenty-two of these arrived on the 4 nights of the artificial freshets.

Smolt marking and adult returns were summarized for smolt years 1949-1962 in the Pollett River. Smolts were marked at the Sanatorium dam trap. Adult returns were evaluated at the Sanatorium dam fishway (since 1950) and by seining the Pollett below the dam as well as in the main Petitcodiac and "a lower tributary" from 1954 to 1962. Origin was expressed as (hatchery stock)/(hatchery stock + introduced spawners). This was based on assessment of native fingerlings or parr before planting. There was a higher percentage of marked fish in the adult count when smolts were derived mainly from natural spawning in the river. It was tentatively concluded that native fish gave better returns than hatchery stock, even when the latter were introduced at an early age. However, it was also concluded that hatchery stock could be used to build up a stock of fish over a few generations.

Year of smolt migration (Y)	Origin (% hatchery)	No. smolts marked in year Y	Adults in year Y+1	
			Total	% marked
1949	100	19,925	15	6.7
1950	100	15,862	5	0
1951	100	25,187	140	2.9
1952	100	26,297	77	12.8
1953	0	3,639	121	4.9
1954	100	23,751	89	1.1
1955	0	8,837	462	2.6
1956	0	4,965	753	4.5
1957	0	7,091	136	12.5
1958	75	31,639	28	21.4
1959	25	20,738	207	43.4
1960	25	21,704	109	28.4
1961	100	4,098	96	33.3
1962	100	8,687	97	45.3

Elson, P. F. 1975. Atlantic salmon rivers, smolt production and optimal spawning: an overview of natural production. International Atlantic Salmon Foundation Special Publication Series 6: 96-119.

Many of Elson's experiments on salmon production in the Pollett River were summarized here and some previously unpublished data were presented. The Petitcodiac River was described as having lost its renown as a good salmon producer about 125 yr ago. Concern about salmon production in the Miramichi River began about the same time - the application of some of the results of the Pollett River experimentation to the Miramichi salmon population, e.g., merganser control, was noted. Smolt production estimates in the experimental study conducted on the Pollett River were very similar to those obtained in studies of the Northwest Miramichi River.

Average abundance of young salmon and other freshwater fish (eels, minnows) were graphed for different combinations of current, depth and substrate in the Pollett River. Data were obtained by electrofishing at 20 sites in a 16 km (10 mile) stretch of river over 6 yr. Salmon fry and parr, and eels, were more abundant in depths <25 cm (10 in) whereas the reverse was true of minnows. Parr and eels were more abundant in rapids than in flats and pools. Fry were ~ equally abundant in rapids as in flats and pools. Minnows were much more abundant in flats and pools. Fry and minnows were more abundant over gravel stream beds but parr and eel abundances were less strongly associated with substrate type.

Survival rates and production of smolts from fry stocking experiments in the Pollett River were reviewed. The Pollett River had abundant salmon in the early days of settlement but by the 1930s they were restricted to the lower 8 km of river by impassable dams. A 16 km section above the dams but below an impassable natural falls was selected in 1942 for experiments. Parr were surveyed by extensive seining and smolts were evaluated at a counting fence downstream. Successive experiments included:

- 1942, 1943: objective was high survival rate from underyearling to smolt stage: 16,000 underyearlings were planted in the main stem
- 1944, 1946: stocking the tributaries - very limited capacity for producing smolts
- 1945: objective was maximum smolt output regardless of survival rate: 15 times as many, or ~0.25 x 10^6 underyearlings were stocked
- 1947-1950: stocking rate comparable to 1945 but with control of birds
- 1951: no stocking was done, since there was an accidental escapement of adult salmon (6 males and 9 females) into the area the previous year
- 1952: nearly 1 million underyearlings were stocked
- 1953: 65,000 underyearlings were stocked
- 1953-1960: natural spawning of 21-964 female salmon
- 1956: supplementary stocking of 99,000 hatchery underyearlings

Survival rates to parr and smolts for each of these underyearling stockings were summarized. Underyearling dispersal from the stocking sites was ~1.6 km (1 mile) downstream and 0.8 km (0.5 mile) upstream About 88% of the smolts were age 2, with the remainder being age 3. Without predator control, the highest survival rate from stocking was obtained from sparse stocking, ~4.8 underyearlings/100 m^2 (4 underyearlings/100 yd^2). Overall production was ~0.2 to 0.6 smolts/100 m^2 (0.2 to 0.5 smolts/100 yd^2). Stocking of 68 underyearlings/100 m^2 (57 underyearlings/100 yd^2) produced 1.4 smolts/100 m^2 (1.2 smolts/100 yd^2) but survival rate was only 2%. It was extrapolated that planting at a rate of 12-24 underyearlings/100 m^2 (10-20 underyearlings/100 yd^2) would probably give about as many smolts as the heavy planting, with survival rates comparable to those from the sparse planting. Bird predation, especially by mergansers, is described as Ricker's "type C", in which the predators remove all prey individuals in excess of a certain minimum number. When prey abundance is reduced to this level, the predator transfers its activities elsewhere. With merganser control, the smolt production of 68 underyearlings/100 m^2 (57 underyearlings/100 yd^2) was increased to 5.5 smolts/100 m^2 (4.6 smolts/100 yd^2). Survival rate from underyearling to smolt was ~8%. Kingfishers were also controlled but probably had only a small effect compared to mergansers. Stocking of 255 underyearlings/100 m^2 (213 underyearlings/100 yd^2) in 1952 produced 6.6 smolts/100 m^2 (5.5 smolts/100 yd^2), not much more than the 6.3 smolts/100 m^2 (5.3 smolts/100 yd^2) obtained from the 68 underyearlings/100 m^2 (57 underyearlings/100 yd^2) stocked in 1950. Hence, the maximum production of the Pollett River, described as a "rather good stream" was considered to be 6-7 smolts/100 m^2 (5-6 smolts/100 yd^2). It was noted that smolt production was only 4 smolts/100 m^2 (3 smolts/100 yd^2) from the 1953 stocking, despite "ample seeding" (although in the next paragraph he called the 1953 stocking a "rather sparse planting"). In any case, the survival rate at 5 underyearlings/100 m^2 (4 underyearlings/100 yd^2) without predator control was similar to the survival rate at 18 underyearlings/100 m^2 (15 underyearlings/100 yd^2) with predator control. An asymptote of smolt numbers/unit area, approximately 6 smolts/100 m^2 (5 smolts/100 yd^2), occurred at just under 48 underyearlings stocked/100 m^2 (40 underyearlings stocked/100 yd^2). This translated to ~11 parr/100 m^2 (9 parr/100 yd^2). Without merganser control the maximum number of smolts was ~20-25% of this production rate.

The number of adult spawners required to attain the smolt production described above was discussed using data from the Pollett and other rivers. Spawning intensity in this study was defined in terms of "potential egg production", or the estimated number of eggs brought into a stream by female salmon, making no allowance for females which might be removed from the stream before having opportunity to spawn. Since there had been no salmon in the experimental section of the Pollett for many years, there was minimal interest in angling. Most of the salmon entered too late in the season (October and November) to support much angling. "But there was a vigorous tradition of poaching". An assumption was made, based on local opinion, that up to 25% of the adult fish might be removed before they could spawn. Electrofishing was conducted in the previously established sample areas to evaluate juvenile production from known numbers of females spawning in 1953-1960. Smolt production of 4-6 smolts/100 m^2 (3-5 smolts/100 yd^2) was achieved in three of four years when potential egg production exceeded 239 eggs/100 m^2 (200 eggs/100 yd^2). Very dense parr populations (the level being somewhere in excess of 7-12 parr/100 m^2) (6-12 parr/100 yd^2) reduced underyearling survival in the following year. Natural spawning was supplemented with hatchery stocking in 1956 on the assumption that 1 native underyearling equated to 3 hatchery underyearlings in terms of smolt production (i.e., that the survival of hatchery fry was only 1/3 that of wild fry). The parr resulting from this stocking appeared not to have impinged as much on the wild fry produced the following year as was observed in other years for the wild parr-wild fry interaction, perhaps because of behavioural differences between wild and hatchery-stocked parr.

The relative values of wild underyearlings versus late-summer releases of hatchery underyearlings were discussed. Mean survival of hatchery-reared underyearlings (stocked at 68 underyearlings/100 m^2 (57 underyearlings/100 yd^2)) to the smolt stage was 8%, and the best survival was 12%. Mean survival of wild underyearlings to smolt was 38%. Naturally spawned underyearlings were therefore determined to have a survival value to age 2 smolt which was 3-5 times that of hatchery underyearlings planted in late summer or early autumn.

Elson, P.F. and C.J. Kerswill. 1955. Studies on Canadian Atlantic salmon. Transactions of the 20th North American Wildlife Conference, March 14-16 1955: 415-426.

Pollett River studies were used as examples of "some of the interesting developments" in Canadian Atlantic salmon research.

Salmon marked as smolts in the Pollett River had been taken in relatively large numbers around Newfoundland, especially along the east coast. Many Pollett River salmon were taken in the drift-net fishery off the Miramichi estuary, and in trap nets extending up to the head of tide in the Miramichi. In fresh water, marked adults were recaptured only in the river of origin. In total, there had been 132 recaptures by October 1953 out of 25,197 salmon marked as descending smolts in the Pollett River in 1951. The breakdown by recapture location was: Newfoundland shore nets, 79/132 (60%); Miramichi drift nets, 17/132 (13%); Miramichi shore nets, 12/132 (9%); Nova Scotia outer coast shore nets, 19/132 (14%); Bay of Fundy shore nets, 5/132 (4%).

Bird control experiments on the Pollett River were also discussed. When there were 30-40 mergansers reared locally and twice as many seasonal invaders, smolt production from 16,000 planted fingerlings was ≤2,000 smolts/yr. When 15 times as many fingerlings were planted, annual production was "scarcely doubled". The mean production from three plantings of 16,000, one of 48,000 and one of 249,000 fingerlings was 2,400 smolts/yr. But when mergansers and kingfishers were controlled by semi-weekly patrols, average production from 4 plantings of about 250,000 fingerlings each increased to 19,000 smolts (i.e., an 8-fold increase). Mergansers were found to do much more damage than kingfishers.

The amount of hatchery stocking required for best smolt production was studied on the Pollett River, "after establishing bird control as a necessary adjunct of good production". The maximum rate of smolt production was 6 smolts/100 m^2 (5 smolts/100 yd^2). The recommended stocking rate was 36 fingerlings/100 m^2 (30 fingerlings/100 yd^2), which translated to 9.6 yearling parr/100 m^2 (8 yearling parr/100 yd^2). Smolt production was not increased with heavier stocking, although it had been possible to increase yearling parr densities to 19 parr/100 m^2 (16 parr/100 yd^2).

The number of adults required to maintain stocks at the highest levels was estimated on the Pollett River to be about 42 kg of female salmon/km of stream with summer stream width of 69 m (150 lb/mile, width ~75 yd). This translated to approximately 359 eggs/100 m^2 (300 eggs/100 yd^2) of stream bottom.

Environment Canada. 1979. Water quality data, New Brunswick, 1961-1977. Inland Waters Directorate, Water Quality Branch, Ottawa, ON. 280 p.

Samples were collected from the Petitcodiac River at the control gates of the causeway (May 4 1970 – October 28 1977), at the highway 112 bridge in Salisbury (May 4 1970 – September 26 1974), at the highway 2 bridge north of Petitcodiac (gauging station) (May 16 1972 – June 6 1973), and from Turtle Creek at the inlet to the reservoir (December 13 1965 – October 27 1977). Values of up to 72 water quality parameters are summarized.

Environment Canada. 1989. Atlantic Region federal-provincial toxic chemical survey of municipal drinking water sources. Data summary report, Province of New Brunswick 1985-1988. Environment Canada, Inland Waters Directorate, Water Quality Branch, Moncton, NB. IWD-AR-WQB-89-155. 316 p.

The municipal water source at Turtle Creek was sampled on June 7 1985, October 11 1985, September 11 and 25 1986, and October 10 1986. Data for 104 chemicals or water quality measures are summarized.

Environment New Brunswick. 1980. Water quality data, Petitcodiac River (1975-1979). Data report number D-8001. Environmental Services Branch, New Brunswick Department of the Environment, Fredericton, N. B. March, 1980. 176 p.

Water quality data are presented for 30 stations in the freshwater Petitcodiac River system sampled between 1975 and 1979. A variable number of samples was obtained for 5 sites in the Petitcodiac River between the causeway and Petitcodiac, 3 sites in the North River from Petitcodiac to Blakeney Brook, 4 sites in the Pollett River between Kay Settlement and Church's Corner, 5 sites in the Coverdale River between the mouth and Pleasant Vale, 3 sites in Turtle Creek from the mouth to Stuart Mountain, 2 sites in Jonathan Creek from Jones Lake to Berry Mills, 5 sites in Halls Creek from Highways 11 and 126 to the TransCanada highway, 2 sites in Humphreys Brook from Lewisville Road to the TransCanada highway, and 1 site in Fox Creek at St. Anselme. Temperature, pH, conductivity, dissolved oxygen measurements, alkalinity, colour, hardness, phosphate, nitrate+nitrite, total Kjeldahl nitrogen, inorganic and organic carbon, and total and fecal coliform data were measured. Calcium, lead, zinc, copper, cadmium and mercury were analysed at a subset of sites which was resampled in 1979. This report provides the raw data for the discussion in Environment New Brunswick's (1980) Technical Report T-8007.

Environment New Brunswick. 1980. Water quality of the Petitcodiac River (1975-1979). Technical report number T-8007. Environmental Services Branch, New Brunswick Department of the Environment, Fredericton, N. B. September, 1980. 23 p.

Water quality was monitored at 30 stations in the Petitcodiac watershed in 1975 (see Environment New Brunswick, 1980, Data Report D-8001 for details). Because much of the watershed was found to have good water quality, the number of stations was reduced for surveys in 1976 and 1977. Several stations were sampled again in 1979. In addition to the water chemistry and coliform samples tabulated in the Data Report, benthic invertebrates were collected using a Serber sampler in June-July 1975.

The water quality of most of the upper Petitcodiac River watershed was graded as 'good to excellent', but water quality deteriorated to 'poor' in the Moncton area due to domestic waste discharge. The 'excellent' grading represented a "virtually pristine state". 'Good' areas had elevated levels of organic material, nutrients or fecal coliform bacteria but were still considered suitable for water-based recreation or support of a cold-water fishery. 'Poor' quality water was unsuitable for swimming or cold water fisheries due to excessive contamination.

The water quality of the headwaters of the Pollett River was graded excellent. Downstream, the river received a small loading of organics and nutrients but remained in good condition. A slight increase in nutrients was probably due to release of treated waste from the Jordan Sanatorium. The benthic invertebrate community near Kay Settlement was the most diverse among the areas sampled. The dominance of organisms intolerant of organic loading and requiring well-aerated water indicated an area of continuously high water quality.

The Coverdale River received very little waste because of limited human activities in its headwaters, and was graded excellent for most of its length. Near the mouth, bank erosion and agricultural activities occurred along with increased phosphate concentrations and "an occasional high fecal coliform count". Benthic invertebrates requiring well-oxygenated water and low nutrient concentrations were sampled near the mouth (although in low numbers). This suggested that the measured degradation of water quality near the mouth of the river was minimal and of short duration.

Water quality in most of Turtle Creek was excellent but high nutrient and coliform concentrations were measured downstream of the drinking water reservoir. Water quality was downgraded to good at a point between the two covered bridges (near the mouth and at Turtle Creek). As in the other tributaries, this change was attributed to agricultural activity.

Although upper portions of the North River drained farmland, the water quality was considered good. Small concentrations of nutrients and organic matter were measured at the most upstream station (near Blakeney Brook). Benthic invertebrates at this station and near Wheaton Settlement showed no signs of stress. Although the water became more turbid, few other changes in water quality occurred downstream in the main Petitcodiac except in the headpond. Dissolved oxygen declined, and phosphates, organic matter and fecal coliform bacteria increased sharply. Below Allison, the water quality was considered 'poor'. "The water at this point would be considered unsuitable for most uses." The deterioration in water quality was attributed to loading from storm sewers and domestic waste from the city of Moncton. Increased conductivity and hardness at two causeway sites also indicated intrusion of estuarine water. This probably contributed further to the decline in water quality, because much of the city's sewage was discharged untreated to the estuary.

Jonathan Creek, Halls Creek, and Humphreys Brook had very poor water quality and were considered a health hazard primarily because of the discharge of untreated and treated domestic waste from Moncton and its surrounding areas. Jonathan Creek near Berry Mills was a "somewhat degraded environment" based on the invertebrate community. At the head of Jones Lake, a stressed biological community was found. The abundance of the annelid *Tubifex* suggested low heavy metal concentrations at this site, but in 1979 the zinc concentration exceeded "the safe level for aquatic life".

Halls Creek received domestic waste throughout much of its length and was described as one of the most polluted watercourses in the province. Based on the invertebrate community, water quality deteriorated rapidly between Mapleton Road and the Université de Moncton. The area near the university was "grossly organically polluted. In this condition, it would have to be considered a health hazard in addition to being unsightly."

Poor water quality was identified in Humphreys Brook, for the same reasons as Halls Creek.

Fox Creek was also contaminated by sewage, probably due to the presence of estuarine water carrying Moncton city sewage.

Water quality data presented in detail in the 1980 Data Report were summarized in appendices. Detailed benthic invertebrates data were listed. The report also listed sewage treatment plants in the watershed in 1979.

Environment New Brunswick. 1980. Effects of sewage treatment in the Greater Moncton area on the Petitcodiac River. Environment New Brunswick, Environmental Services Branch, Fredericton, NB. Technical Report T-8002. 25 p.

The City of Moncton had no sewage treatment in 1978. Physico-chemical data were collected as input to a model to predict water quality under various management strategies. Fisheries resources and their water quality requirements were also considered. Lateral and vertical salinity profiles were measured along the length of the estuary (to ~33 km below the causeway, near Beaumont) in late June and early July 1978. Biochemical oxygen demand and dissolved oxygen were measured in August 1978. A model was developed by Montreal Engineering to predict dissolved oxygen levels under various degrees of sewage treatment. The present report includes Montreal Engineering's results (which are cited in a report to Environment New Brunswick) and incorporates further sampling and analysis.

Salinities at high tide (August 22 1978) were 29.9‰ just below the causeway and 31.0‰ at the Gunningsville Bridge. Salinities gradually increased to ~32‰ at Beaumont. The causeway station could not be sampled at low tide due to lack of water, but salinity at the Gunningsville Bridge was 14.0‰. Salinities increased sharply from 14.1‰ to 23.9‰ at the right-angled bend in the river just below Halls Creek. Salinities then gradually increased to approximately 32‰ at Beaumont.

Under low river flow conditions such as those present in August 1978, primary sewage treatment would be expected to increase the lowest observed dissolved oxygen concentration at high tide from 2.6 mg/L to 4.0 mg/L (39% of saturation). Secondary and tertiary treatment would result in minimum dissolved oxygen concentration of 6.3 mg/L (94% of saturation) and 6.6 mg/L (99% of saturation) respectively.

The brook trout population annually produced an estimated catch of 95,000 fish for 28,000 angler days in the early 1970s, according to New Brunswick Department of Natural Resources data (W. Hooper). It was believed that the catch consisted primarily of locally reared fish. With the possible exception of gaspereau, the other anadromous species were much reduced from their former numbers. Striped bass, shad and smelt runs were nearly non-existent. The significant numbers of shad harvested commercially near the mouth of the river were believed to be produced in other river systems.

The fishway had been ineffective in maintaining anadromous fish stocks, due to a combination of excess leakage through the control gates and siltation (W. Watt, pers. comm.). Leakage attracted fish to the greater flow at the gates rather than to the fishway. The lower reservoir levels caused by leakage along with high river bed levels caused by siltation downstream of the causeway resulted in a low exit velocity from the fishway, insufficient to attract migrating fish. Additionally, reverse flow of silt-laden salt water through the gates deposited excessive silt above the causeway, which at times blocked the passage of fish travelling through the fishway.

New Brunswick Department of Natural Resources estimated the productive capacity of the watershed to equal an annual salmon smolt production of 115,000-190,000 fish. At return rates of 3-8%, this would translate into an annual run of 3,450-15,000 adult salmon. It was suggested that an average run of 4,000 adult salmon "would be a reasonable estimate" (T. Pettigrew). There were no estimates of the productive capacity of the watershed for other species.

The above estimates assumed that water quality in the estuary was suitable for fish passage, but this was not always the case. The 1978 data indicated that in late summer a "parcel" of water with low (<5 ppm) dissolved oxygen moved up and down the estuary with the tide. This was presumably due to the discharge of untreated sewage in the Moncton area. However, a dissolved oxygen concentration of ≥5.0 mg/L or greater was recommended in order to improve water quality to levels which would permit the migration of anadromous fish. A minimum flow of 15 m^3/sec or greater could maintain the dissolved oxygen at 5.0 mg/L at higher temperatures. At lower temperatures, less flow would be needed to achieve a suitable level of water quality.

The discharge of untreated wastes at Moncton was probably a major contributor of bacteria also. Approximately 14,800 ha (37,000 acres) of the Petitcodiac Estuary extending from Moncton to a line between Mary's Point and Cape Maringouin were closed to shellfish harvesting due to fecal coliform contamination as indicated by a 1968 survey. No recent surveys of the extent or production of shellfish beds had been done in the area although it was believed that the resource was almost nonexistent near Moncton due to the large amount of erosion and siltation. It was stated that the New Brunswick Department of Fisheries did not consider the Petitcodiac River-Shepody Bay region to be a priority area for shellfish.

Treatment of sewage, therefore, would be more for the benefit of anadromous fishes than to protect the shellfish resource. "There do not appear to be any other resources in the Moncton area which would be affected by sewage treatment". Dissolved oxygen was the major concern and a concentration ≥ 5 mg/L was recommended. Conservative estimates of the temperatures, flows, and proportion of the time when the flow required to attain 5 mg/L of DO had been achieved, during the months when salmon were expected to migrate were:

Month	Mean temperature(C)	Flow in m^3/sec to achieve 5 mg/L DO	% of time flow was exceeded
August	20	15	10
September	19	11	15
October	18	9	50
November	16	7	80
December	14	0	100

Three alternatives were proposed to maintain the desired dissolved oxygen level for fish passage:
- discharge of untreated sewage at least 7.5 km below the causeway,
- primary treatment to permit discharge of waste farther upstream
- or secondary treatment to permit discharge of waste as far upstream as the causeway.

Environment New Brunswick. 1988. Possible sources of pollution to the Petitcodiac Lake.

<No abstract.>

Environmental Monitoring Working Group. 1998. Environmental Monitoring Plan, November 1997. Pages iv-xii *in* Environmental Monitoring Working Group. 1998. Environmental monitoring of the Petitcodiac River system, 1997: Trial opening of the Petitcodiac River causeway gates. December 1998. 280 p.

Current operating procedure at the causeway gates was for gates normally to be closed, but opened for variable lengths of time to manage headpond water level, ice and silt. Gate 5, next to the fishway, was fitted with stoplogs and was open ~ April 1 to November 30, except when the level of the tide exceeded that of the headpond. The top stoplog had a spill notch to enhance fish passage.

The trial opening was scheduled for 7 months in 1998, beginning as soon as possible after the spring freshet (probably May) and excluding periods of flood or ice floe management. It would involve the full opening of one gate at low tide and its subsequent closure to "clip" the rising tide such that the headpond level would not exceed 2.5 m. The gate would be reopened once the falling tide receded below the headpond level.

Aquatic monitoring to be conducted before and during the trial would include: surveying riverbed cross-sections, aerial photography of shoreline changes, suspended sediment concentrations, measuring contaminants in sediments, water quality (dissolved oxygen, suspended solids, nutrients, fecal coliform bacteria, metals, limited toxicity testing), fish, lobster and scallop fisheries, benthic invertebrates, macrophytes (submergent and emergent vegetation), freshwater mussels, contaminants in various biota.

After the trial, anticipated monitoring would include, at a minimum, aerial photography of shorelines, and monitoring of contaminant levels in biota.

Anticipated gaps in monitoring included possible dump leachate in Jonathan Creek, reproduction of lobster in Shepody Bay, sediment quality of shorebird areas and availability of the amphipod *Corophium*, recreational fishing and boating on the headpond, ice formation, erodability studies of the mud, tidal cycle and bore monitoring.

Fisheries and Oceans Canada and Environment Canada. 1998. Canadian Environmental Assessment Act screening report. Proposal by the New Brunswick Department of Transportation for the Petitcodiac River Trial Gate Opening project. May 19, 1998. 68p.

At the time of report preparation, i.e. pre-trial, the five sluice gates at the Petitcodiac River causeway were being operated to meet the following objectives: prevent tidal inflow into the headpond, maintain average headpond elevation of 6 m, control headpond flooding, operate fishway from April 1 to November 30, operate gate #5 sluiceway with special stoplogs from April 1 to November (provide attraction water near the fishway by opening gate #5 when tide levels fall below the headpond level, allow overflow at a special spill section in the upper stoplog), flush silt accumulation near the gates, control potential ice jams, control shoreline erosion.

The proposed trial gate opening was intended to investigate uncertainties in ADI Ltd. (1996) related to river bank and structures stability, and erosion protection requirements. Environmental and other data that might be useful in making further decisions regarding the causeway/gates would also be collected. During the trial, the gates would be operated so as to maintain a target elevation of 2.5 m in the headpond, and maximize opportunities for fish passage. Guidelines for operations were outlined in the event of risk to public safety or stability of the gate structure or causeway, extreme weather conditions, increased sedimentation preventing freshwater flows and fish passage, erosion causing physical damage and timing of incoming tides limiting fish passage opportunities. These included provisions for suspension of the trial in response to risk to public safety, extreme weather, siltation and/or high freshwater flows which would compromise the ability to control upstream water levels. A minimum fish passage opportunity of 0.5 hr on each incoming tide was requested.

The trial was scheduled to begin in May 1998, following the removal of silt from the channel above and below the causeway, using the spring freshet for flushing. The proposal followed the approach of Scenario 1, Approach B, described in ADI (1996). The expected project completion date was December 31 1998.

Issues and concerns identified by the public were listed and cross-referenced to pre-trial environmental assessments and other documentation. Literature on the aquatic environment was summarized for two “zones of influence” (1 – the area where physical change from the project would be most likely, extending from the mouth of Turtle Creek, to the bend at Outhouse Point, 2 – the anticipated limits of any detectable environmental effects, encompassing the entire Petitcodiac watershed from Shepody Bay to the headwaters of the tributaries). The summaries included: hydrology, fish, fish habitat, headpond vegetation, benthic invertebrates, zooplankton, aquatic birds, erosion and sedimentation, water and sediment quality. The present or former occurrence of endangered or protected species in the watershed (bald eagle, dwarf wedgemussel) was discussed. Recreational, commercial and aboriginal fisheries data for the watershed were also summarized.

Expected effects of the trial gate opening on the aquatic environment and biota were outlined. The plan for monitoring before, during and after the trial was presented.

Fitzpatrick, D. 1994. Socioeconomic impact assessment of opening tidal gates at the Petitcodiac River causeway: Social survey. 14 p.

<No abstract.>

Ganong, W.F. 1898. Notes on the natural history and physiography of New Brunswick. 7. On halophytic colonies in the interior of New Brunswick. Bulletin of the Natural History Society of New Brunswick 16: 50-51.

A colony of “sea-shore plants” at the Salt Springs, 4.8 km (3 miles) east of Sussex, was described. It was noted that another salt spring was located at Bennett’s Brook near Petitcodiac. No species list was given for the Bennett’s Brook salt spring.

Ganong, W.F. 1913. Notes on the natural history and physiography of New Brunswick. 127. On the stability of the New Brunswick coast. Bulletin of the Natural History Society of New Brunswick 30(vol. 6 part 5): 450-451.

According to residents of the Petitcodiac, the head of tide had moved over 1.6 km (1 mile) up the river “within historic times”.

Godfrey, H. 1951. A report on the eel investigation for 1950-51. Fisheries Research Board of Canada, Manuscript reports of the biological stations 439. 38p.

The American eel [called *Anguilla bostoniensis* in this report, but now known as *A. rostrata*] was found in New Brunswick streams in “unsuspected abundance” following the introduction of electrofishing in 1949. At the time it constituted “only a very minor fishery” but there was concern over its role as a predator and competitor of other fish.

Eels were found in 25 streams of the Petitcodiac system where electrofishing was conducted. The density of all eels in a portion of the upper Bennett Brook was 244 eels/100 m^2 (204 eels/100 yd^2). The density of eels ≥ 90 mm in length in the lowermost 572 m (625 yd) of Nigus Brook was 134 eels/100 m^2 (112 eels/100 yd^2). Smaller eels were not counted in Nigus Brook but were described as “numerous”. Collections from other rivers in the system were believed to represent only about 67% of the eels present, and to be biased in favour of large eels. Numbers were not adjusted to account for this belief, and ranged from 96-429 eels/100 m^2 (80-358 eels/100 yd^2) in the Coverdale River, 314-345 eels/100 m^2 (262-288 eels/100 yd^2) in Turtle Creek, and 181-632 eels/100 m^2 (151-528 eels/100 yd^2) in the Pollett River. Eels were thought to be absent from the upper parts of Mitton Brook, a tributary of the Coverdale River, and scarce in Lee Brook, Salmon Hole Creek and an unnamed tributary of the Pollett River because of colder temperatures in these streams.

Size-frequency histograms were presented for the various streams. Mean lengths were:

River	Mean length (mm)	N
Bennett Brook	159.0	173
Nigus Brook	168.0	1373
Turtle Creek	179.7	527
Coverdale River	162.4	603
Pollett River	198.2	1442

Comparing the Pollett River with the lowest section of its tributary, Nigus Brook, the smaller stream had relatively more small eels (length < ~16 cm) and fewer larger eels. Although the largest eels were taken in the Pollett River, very few eels with a total length greater than 35 cm were taken anywhere. Despite the larger size of the eels in the Pollett River, it had the lowest estimated weight of eels per unit area, because it had fewer eels on average.

The diet of eels in some Petitcodiac streams were mainly composed of immature stages of mayfly nymphs (Ephemerida), stone-fly nymphs (Plecoptera), true flies (Diptera), caddis worms (Trichoptera) and common earthworms (*Lumbricus*). Trout and salmon remains were also found but in fewer than 5% of eel stomachs. Two eels of 15 cm length were found to have eaten salmon fry, and this was also the size of the smallest eel that Elson had previously described to be feeding on fry. Eels taken in the smolt traps in the Petitcodiac River almost invariably had one or several of these fish in their stomachs.

Predation upon eels by mergansers and kingfishers was "with occasional exceptions, of minor importance" (according to White). No data were collected on predation by fishes on eels.

Elvers were reported to be migrating into the river in late May, but were not observed by the writer until early June. Elvers <10 cm in length were taken up to 24-32 km (15-20 miles) above tidal waters. There was a great deal of variation in the size of elvers in the run, and the period during which they entered the river extended over several months.

An upstream movement of small eels (15-25 cm) was witnessed in the Pollett River in mid-August. Numerous small eels were swimming upstream at various depths across the width of the river during a hot summer afternoon.

Downstream migrations of both silver and yellow (including many small and far from mature) eels have been recorded on many New Brunswick streams in fall. A trap was installed on the Anagance River at Petitcodiac to capture seaward-migrating silver eels from Sept. 19-Nov. 17 1949. The wings of the net were only 46 cm (18 in) high. Catches were as follows:

Species	Numbers	Size (mm)	Timing	Comments
American eel	Total = 79 Mean=1.5/day Max.=11/day	Range=153-550 mm Mean=260 mm	Sept. 19-Nov. 17	10 were silver, starting on Sept. 19.
Sea lamprey	Total=1,509 Mean=60.4/day during the run Max.=321/day		Oct. 12-Nov. 5	All silver. Migrated only at night. Swam within 15-20 cm (6-8 in) of surface in midstream, always headed downstream.
Salmon parr	Total=72 Max.=11/day	Range=87-187mm Mean=122 mm	Oct. 15-Nov. 17	All ripe males. One-third were age 2, rest were age 1.
Brook trout	Total=10			2 ripe males, 2 ripe females
Minnows	small numbers			Several species.
Suckers	many			

Experiments with removal of eels or branding of eels determined that few of the marked eels had left a 46 m (50 yd) long area and that there had been very little movement into a 91 m (100 yd) stretch from which all eels had been removed. Experiments were conducted from Aug. 23 to Nov. 2 1949.

Experiments were conducted on the susceptibility of salmon eggs to damage from electrofishing, using eggs from a salmon trapped in Holmes Brook. Eggs were found to be killed by severe electric shock but were "somewhat protected" when buried in gravel.

An experiment to determine the effects of eel predation on salmon eggs in artificial redds was described but results were not yet available.

Godfrey, H. 1951. The effects of eels on salmon production. Pages 101-103 *in* Needler, A.W.H. Fisheries Research Board of Canada. Report of the Atlantic Biological Station for 1951. (Summary No. 64).

An experiment to determine effects of eel predation on salmon fry was begun in Nigus Brook in the autumn of 1950. Fertilized salmon eggs were planted in artificial redds in two sections of the stream, one of which had the eels removed. Fry traps were placed around each redd to count the emerging young. The experiment was inconclusive, since most of the eggs died in early stages of development due to smothering with silt.

The predation rate of eels on planted fry was to have been examined in the Coverdale River. Five sections, 27.4 x 38.4 m (90 ft x 42 ft), were screened off, and eels were removed from two sections by electrofishing. After this, the electrofisher broke down and the experiment was terminated. Data on the eels from the first two sections are not presented in the report.

Godfrey, H. 1952. The eel as a predator on natural stocks of young salmon. Pages 112-113 *in* Needler, A.W.H. Fisheries Research Board of Canada. Report of the Atlantic Biological Station for 1952. (Summary No. 71).

The densities of eels sampled with an electrofisher were:

River	Width, m (yd)	No. of eels/100 m (no./100 yd)	No. of eels/m^2 (no./yd^2)
Bennett Brook	0.9 (1)	187 (204)	2.4 (2.04)
Nigus Brook	1.8 (2)	201 (220)	1.3 (1.10)
Turtle Creek	9.1 (10)	251 (275)	0.3 (0.262)
Coverdale R.	15.5 (17)	184 (201)	0.1 (0.121)
Pollett R.	21.0 (23)	269 (294)	0.2 (0.133)

Gray, R. W. and J. D. Cameron. 1980. Juvenile Atlantic salmon stocking in several Nova Scotia and Southern New Brunswick salmon streams, 1971-79. Canadian Data Report of Fisheries and Aquatic Sciences 202: 47p.

Juvenile Atlantic salmon stocking in the Petitcodiac system is summarized in Table 52, Figure 9 and Appendix H. Age 1 parr and age 0 fry of Big Salmon River genetic origin were stocked in 1973 and 1975, respectively. Eleven sites on the Pollett River and five sites on the Petitcodiac River between Salisbury and Petitcodiac were stocked. Details of release location (latitude and longitude), age (parr or fry), release dates, number released and identification marks of young salmon were summarized. A map showing spawning and nursery areas in the watershed, and the location of dams and falls is also provided.

Greater Moncton Pest Control Commission. 1998. Mosquito control program: 1997 annual report. Pages 172-190 *in* Environmental Monitoring Working Group. 1998. Environmental monitoring of the Petitcodiac River system, 1997: Trial opening of the Petitcodiac River causeway gates. December 1998. 280p.

Only the text of the report is included in this monitoring volume, with no tables or figures.

Mosquito monitoring and control (Vectobac spray) was carried out from early May to the end of August. High larval densities were encountered through May and June, and were particularly high in the Outhouse Point Marsh and the marsh within the outer dyked area in St. Anselme. These marshes had developed into highly productive areas within the past year and were expected to remain productive in coming years, possibly into August and September due to tidal flooding.

Several potential breeding areas for mosquitoes were identified above the causeway.

Greater Moncton Pest Control Commission. 1999. Mosquito control program: 1998 annual report. Pages 197-205 *in* Environmental Monitoring Working Group. 1999. Environmental monitoring of the Petitcodiac River system, 1998: Petitcodiac River Trial Gate Opening project. September 1999. 325 p.

As in the previous year, only the summary of this document is presented in the monitoring report.

Mosquito control was carried out from April 22-August 21 1998. High larvae densities were encountered during the last week of April and led to early applications of BT.

Data were collected on potential new marsh area that might result from an opening of the gates. "…we were able to monitor wet areas which could rapidly become mosquito breeding grounds. The first few years following the opening of the gates may not provide vast areas of breeding, however, the following years the potential breeding area may increase significantly."

H.G. Acres and Co. 1946. Report on tidal power, Petitcodiac and Memramcook estuaries, province of New Brunswick, 1945. Dept. of Mines and Resources Canada, Surveys and Engineering Branch. Ottawa.
Part 1 - Text. 60 p.
Part 2 - Plans. 71 plates.

This two-part report describes a plan to develop the Petitcodiac and Memramcook estuaries for tidal power. At Hopewell Cape, the estuary of the Petitcodiac River experienced a tidal range of 6.4-15.8 m (21-52 ft), which was considered to be an excellent opportunity for tidal power development. The unique feature of the site was the presence of two tidal estuaries side by side (Petitcodiac and Memramcook) and thus there was an opportunity to produce continuous power. This two-basin scheme was "without any known precedent". Much of the document discusses the engineering aspects of the proposed development, but there is also some information relevant to the river conditions at that time.

The Petitcodiac River was a navigable stream at certain stages of the tide. Tankers and ocean-going steamships "of limited tonnage" docked regularly at Hillsborough and Moncton. The practice was for vessels to anchor off Hopewell Cape, and to await a favourable tide before proceeding further upriver. The survey crew considered the river to have "many stretches of fast water and treacherous bottom".

The Memramcook River was also navigable at "certain upper ranges of tide", but shipping was limited to fishing boats "of the motor-boat and small sail-boat class".

A survey was made of the marsh lands adjacent to both rivers and maps are provided in the second volume of the report.

All sewage from Moncton and its suburbs was discharged directly into the Petitcodiac River or Halls Creek. All sewage was "successfully and swiftly" carried downriver twice daily on the ebb tide, and all sewer outlets and low-lying sewer sections were completely flushed twice daily at the higher stages of the incoming tides. Elevations of some main sewer outlets were listed.

The idea of producing power from the tidal waters of the Petitcodiac and Memramcook Rivers had been originally proposed in the early 1920s. A number of test holes were drilled in the area in 1924 and 1927.

Silt was measured at 1.5 m (5 ft) depth intervals from the surface to 7.6 m (25 ft) in the Petitcodiac River. The density of water without silt was 1.022 g/mL at 18.5ºC. Silt concentrations ranged from 0.132 to 0.220 g/L.

Hanson, A. and H. Dupuis. 1998. Foreword. Pages i-iii *in* Environmental Monitoring Working Group. 1998. Environmental monitoring of the Petitcodiac River system, 1997: Trial opening of the Petitcodiac River causeway gates. December 1998. 280 p.

The Petitcodiac River causeway was completed in 1968 as a joint venture between the Province of New Brunswick and the Maritime Marshlands Rehabilitation Administration (federal Department of Agriculture). The MMRA's design met all regulatory requirements of the time. It soon became apparent that the fishway was not performing adequately and a number of renovations to the fishway and adjustments to gate operations have been made over the years. Fish stocks have continued to decline and some approach extirpation or extinction.

A study report released in February 1996, funded by the Environmental Trust Fund, presented options to improve fish passage and partially restore the natural ecosystem of the Petitcodiac River.

In December 1996, the provincial Departments of Transportation and Environment, and the federal Department of Fisheries and Oceans and Environment Canada signed a Memorandum of Understanding (MOU). This MOU provided a co-operative agreement between the agencies for a limited gate trial. This trial opening was a prerequisite to identifying a long-term solution to fish passage and other ecosystem issues.

The trial gate opening was scheduled for a 7-month period beginning in the spring of 1998. In 1997, erosion control works were put in place on the embankments near the causeway. Maintenance work was also in progress on the concrete piers supporting the road near the control gates, and necessitated a drawdown of the headpond in early June.

Collection of background data on the watershed began in the spring of 1997. This report presents data on numerous aspects of the ecology of the Petitcodiac River system.

Hanson, A. and H. Dupuis. 1999. Foreword. Pages iii-vii *in* Environmental Monitoring Working Group. Environmental Monitoring of the Petitcodiac River system, 1998: Petitcodiac River Trial Gate Opening Project. September 1999. 325 p.

Background information essentially repeats their 1998 foreword, up to events in spring of 1998. It had been expected that the pre-trial mud flushing phase would commence in April 1998, following normal spring ice, mud and floodwater management. This mud-flushing would establish the physical conditions required to begin the trial itself: sufficiently low river flows and a river channel conducive to maintaining the headpond water level below elevation 2.5 m above Mean Sea Level throughout a full tidal cycle. During the mud-flushing, the headpond water level would fluctuate considerably but no tidal salt water would be allowed upstream of the causeway. Upon commencement of the trial, one or more gates would be fully opened at low tide and subsequently closed to "clip" the rising tide such that the water level in the river channel upstream of the causeway did not exceed a maximum elevation of 2.5 m. The gate(s) would then be reopened once the falling tide had receded below the "headpond" elevation, thereby allowing the "headpond" to drain. Maintaining the headpond level below 2.5 m would ensure that silt-laden salt water remained confined to the historical river channel in the headpond.

The Trial Gate Opening did not proceed as planned in 1998. A legal challenge to the project delayed the initiation of pre-trial mud flushing until May 31 1998. Prevailing low freshwater flows made it impossible to cut the upstream mud plug and establish the conditions required for the initiation of the trial. The water level in the headpond decreased from 6.20 m on May 31 to 2.55 m on June 10-12. The flushing exercise was terminated on June 19 1998, as the water level could not be maintained below 2.7 m. The water level in the headpond had returned to normal operating levels by late June.

Data included in this report are described as a "progress report".

Hanson, J.M. and A. Locke. 1998. Petitcodiac Headpond monitoring activities, 1997 and 1998: Benthic invertebrate, aquatic macrophyte, and freshwater mussel communities of Petitcodiac Headpond, Status of endangered and threatened species of freshwater mussels in the Petitcodiac watershed. Pages 61-73 *in* Environmental Monitoring Working Group. 1998. Environmental monitoring of the Petitcodiac River system, 1997: Trial opening of the Petitcodiac River causeway gates. December 1998. 280 p.

Submersed macrophytes were collected at 8 locations in the headpond during the first week of August 1997. Semi-quantitative mapping of submersed and emergent species in the tributaries, and of emergent species in the headpond, was also completed. Much of the shoreline upstream of Turtle Creek was ringed with substantial beds of emergent vegetation. *Typha latifolia* and *Juncus* spp. (mainly *J. effusus*) were the dominant emergent forms in the headpond. These often occurred with broad-leaved arrow-leaf (*Sagittaria latifolia*) in the more sheltered areas. The yellow water lily (*Nuphar variegatum*) was found in calm areas in small creeks.

One small but well-established colony of purple loosestrife (*Lythrum salicaria*) was found in the headpond (at the mouth of Michael's Creek). Another colony was found in a ditch draining into the Petitcodiac River downstream from the town of Petitcodiac. This invading species was predicted to spread throughout the headpond if freshwater conditions continue.

Pondweeds (*Potamogeton*) were the most common submerged macrophyte (38% of total biomass) followed by *Naias flexilis* (19% of total biomass). On average, submerged macrophyte blotted wet weight was 76.6 g/m^2.

Benthic invertebrates were sampled at 11 locations in the headpond. About 50% of the biomass in both the littoral (depth $\leq$ 2.5 m) and sublittoral zones consisted of oligochaetes. Total biomass was low, averaging 41.6 g/m^2 (littoral) and 23.1 g/m^2 (sublittoral). The littoral community was dominated by oligochaetes and molluscs (sphaerid clams and snails) (together, 87% of total biomass) with low numbers of amphipods, chironomids, and a sparse insect fauna (<10% of biomass). In the sublittoral zone, oligochaetes and molluscs represented 72% of the biomass, with 22% from aquatic insects. A number of groups typically found in lakes and reservoirs were very rare or absent.

Freshwater mussels were sampled at 11 locations in the headpond. The eastern floater, *Pyganodon* (formerly *Anodonta*) *cataracta*, was widespread, but averaged only 6.7 live shells/m^2 (littoral) and 3.0 live shells/m^2 (sublittoral). Empty shells in which the nacre remained shiny provided an index of same-year mortalities and represented 18% (sublittoral) - 24% (littoral) of total numbers. Age structure clearly reflected the disturbance history of the headpond; no animals older than age 9 were present, indicating that the headpond was recolonized in 1988 following exposure to salt water. Low numbers of animals older than age 7 suggested continued disturbances during drawdowns in 1989 and 1990. This species lives up to 15 years in undisturbed habitats. The relatively short drawdown of the headpond in 1997 did not prevent breeding, and age 0 mussels were present in densities on the order of 33 individuals/m^2.
The eastern elliptio, *Elliptio complanata,* was also present in the headpond, but only 10 were collected in total.

A survey of the tributaries was begun in order to cover all known sites where an endangered (dwarf wedgemussel, *Alasmidonta heterodon*), a threatened (brook floater, *Alasmidonta varicosa*) and two special concern (triangle floater, *Alasmidonta undulata*; eastern pearl mussel, *Margaritifera margaritifera*) freshwater mussel species were found in the 1950s and 1960s. A preliminary survey of 13 sites suggested that the dwarf wedgemussel had been extirpated from the Petitcodiac River, the only location where it had previously been found in Canada. Both floater species were still present in the watershed, despite severe degradation of former habitat in the North River. The eastern pearl mussel was common through much of the watershed, except in Turtle Creek (this species uses Atlantic salmon as a host for a parasitic larval stage). Newfoundland floater, *Pyganodon fragilis*, had been reported from the watershed in 1984, but was not found in 1997.

Hanson, J.M. and A. Locke. 2000. The status of the dwarf wedgemussel, *Alasmidonta heterodon* (Lea 1830), in Canada. The Canadian Field Naturalist 114(2): 8 p. (to be published in April 2000).

The only recorded Canadian location for the dwarf wedgemussel was the Petitcodiac River drainage. The species was last collected in 1960, at which time it was classified as being common. It was not detected in extensive surveys of the watershed, conducted in 1984 and 1997-98. The species was classified as "extirpated in Canada" by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in April 1999. This paper is based on the status report submitted to COSEWIC.

In the U.S.A., the dwarf wedgemussel had been extirpated from all but 20 of its 70 known locations and is listed as an endangered species. It was believed to be in decline in all but one of the remaining American locations.

Freshwater mussels produce a parasitic larval stage (glochidia) which requires attachment to a fish host for a short stage in its life cycle, and the dependence of dwarf wedgemussel glochidia on anadromous fish hosts has been a major factor in the decline of the species. Impoundment of rivers had been implicated in losses of the dwarf wedgemussel throughout its range due to dams blocking movements of host fish species. Other forms of habitat degradation were unlikely to have been factors in the extirpation of the dwarf wedgemussel in Canadian waters. The 1960 survey had recorded the presence of dwarf wedgemussels in the North River upstream of highway 112, and in the main Petitcodiac River near River Glade. Although these sites were severely degraded by excess nutrients and silt from agricultural sources in 1997-98, this had not been the case in 1984. Nevertheless, dwarf wedgemussels were not found in these areas by 1984. Extensive areas of suitable habitat (small streams to medium-size rivers; slow to moderate current; fine sediments, sand and gravel; well-oxygenated; stream-side vegetation seems to be required) currently exist in the Petitcodiac, Little and Anagance rivers and contain other mussel species which usually co-occur with the dwarf wedgemussel. It is likely that eradication of anadromous fish runs by the causeway is the cause of the extirpation of the dwarf wedgemussel.

The fish hosts for wild dwarf wedgemussels are unknown. Of the several species which have been demonstrated to serve as hosts in the laboratory, only Atlantic salmon ever occurred in the Petitcodiac watershed. The authors suggested that American shad was the likely candidate as the host of the Petitcodiac population of dwarf wedgemussels. The former spawning and rearing sites of shad corresponded closely to the former collection sites of the mussel. The shad was the only species known both to have occurred at the dwarf wedgemussel collection sites and to have been immediately eliminated from the system by the causeway.

The Petitcodiac location of the dwarf wedgemussel was its only Canadian occurrence and represented the extreme northern edge of the species' range. It was one of only two locations where the species was considered to be common (the other was the Connecticut River system). "Populations at the edge of the range of a species often contain unique genetic adaptations and, for this reason if for no other, are an important component of biological diversity and are worth protecting. Whatever unique adaptations allowed the Dwarf Wedgemussel to form a large population in the Petitcodiac River System were lost with the extirpation of this species from Canadian waters."

"Large stretches of suitable habitat remain in the Little, Petitcodiac, North and Anagance rivers. Successful re-introduction (from U.S. populations) is unlikely until the native anadromous fish populations (in particular American shad and Atlantic salmon) are re-established in the watershed. This would require removal of the blockage caused by the Petitcodiac causeway. Even with the causeway in place, small numbers of shad and salmon attempt (usually unsuccessfully) to migrate into the river. Part of the former range of the Dwarf Wedgemussel would require substantial rehabilitation to reverse the effects of destructive agricultural practices."

Hanson, J.M. and S.M. Richardson. 1999. Petitcodiac headpond monitoring activities in 1998: Macroinvertebrates, macrophytes and freshwater mussels. Pages 135-147 *in* Environmental Monitoring Working Group. 1999. Environmental monitoring of the Petitcodiac River system, 1998: Petitcodiac River Trial Gate Opening project. September 1999. 325 p.

Surveys of aquatic macrophytes and benthic invertebrates were carried out in the headpond in August 1998 following methods and survey designs established in 1997. These organisms were expected to respond to differences in the drawdowns of the headpond that occurred in both 1997 and 1998:

Description of drawdown:	1997	1998
Dates	May 31 - June 6	May 31 – June 18
Duration (days)	7	19
Degree-days	62	258.9
Ave. (range) mean daily temperature	8.8ºC (6.6-15.6)	13.6 (8.5-21.6)
Ave. (range) maximum daily temperature	13.5 (9.5-22.3)	18.9 (10.7-25.7)
Ave. (range) minimum daily temperature	3.2 (0.2-8.8)	8.3 (2.7-17.9)
Total precipitation (mm)	13.3	55.1

The biomass of macrophytes in 1998 (4.99 g/m^2 blotted wet weight) was much lower than in 1997 (13.64 g/m^2). The dominant submergent taxon was *Najas flexilis*, followed by pondweeds. *Najas* is a typical plant of disturbed systems because it colonizes quickly. The emergent *Typha latifolia* decreased, but *Juncus effusus* increased significantly. Drying of the sediments may have killed newly germinated *Typha*, which require saturated soil. The low biomass of emergent vegetation reported did not represent the large stands of emergent vegetation found along much of the shoreline, but represented colonization by these emergent species into shallow waters formerly covered by submerged species.

Littoral zone macroinvertebrate biomass (8.65 g/m^2 wet weight) was only 1/3 of that recorded in 1997 (35.25 g/m^2). As in 1997, the community was dominated by oligochaetes, followed by molluscs (sphaerid clams and gastropods). Insects represented a relatively small proportion of the total and were mostly composed of chironomids. Amphipods accounted for only 1.0% of total biomass. Several insect taxa normally prominent in lakes were all but absent.

Sublittoral zone biomass followed a similar trend (6.55 g/m^2 in 1998, 20.04 g/m^2 in 1997). Taxonomic composition was similar to 1997, with dominance by oligochaetes, insects and molluscs.

The average density of freshwater mussels in the littoral zone of the headpond decreased significantly from 1997 to 1998, while density increased significantly in the sublittoral zone. This indicated that some animals were able to move into the sublittoral zone as water levels declined in 1998, but that many of those trapped in the littoral zone died. The late timing of the drawdowns resulted in greater mortality than would have occurred in cooler, wetter weather.

Five species of freshwater mussels were found in the Petitcodiac watershed in 1997. The eastern pearl mussel (*Margaritifera margaritifera*), eastern floater (*Pyganodon cataracta*), and eastern elliptio (*Elliptio complanata*) were abundant in the appropriate habitats throughout the watershed except in the North River where most sites were devoid of freshwater mussels (largely due to severe habitat degradation). The endangered dwarf wedgemussel (*Alasmidonta heterodon*), which had been common in the watershed in 1960, was not found at any sites surveyed in 1984, 1997 or 1998. Based on a conservation status report (Hanson and Locke 1999) submitted to the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), the dwarf wedgemussel was declared extirpated in Canada. This was probably caused by construction of the causeway and subsequent exclusion of diadromous fish species required for the wedgemussel to complete its life cycle. The brook floater (*Alasmidonta varicosa*) was common in a few locations in the lower reaches of the Little River and in a few locations of the Petitcodiac River downstream of the town of Petitcodiac. Since the Petitcodiac River watershed is the only known location of this species in New Brunswick, this very limited population is a cause for concern. The triangle wedge mussel (*Alasmidonta undulata*) was very rare in the watershed and may disappear because only isolated individuals were found and they may be too far apart for successful reproduction.

The longer drawdown in 1998 exposed the macrophyte, benthic invertebrate and mussel populations to more extreme environmental conditions than they experienced in 1997. In particular, the high air temperatures and lack of precipitation in the latter part of the 1998 drawdown undoubtedly allowed substantial drying of the sediments. Large numbers of dead amphipods were associated with dried macrophytes on the dry lake-bed. The benthic community was already disturbed prior to the drawdowns by normal operating procedures, since drawdowns to depths ≤1 m have been frequent events in this headpond.

Harvey, J. 1997. Death watch on the Petitcodiac. Atlantic Salmon Journal, Summer 1997: 36-43.

According to Moses Perley, fishermen landed more than 2,000 barrels of shad (approximately 120,000 fish) each year from about 150 small boats in the lower Petitcodiac River. The shad fishing grounds extended from Stoney Creek to Grindstone Island. Between 1870 and 1900, commercial catches of shad in the upper Bay of Fundy peaked at 0.9-2.7 x 10^6 kg/yr (2-6 million lb/year) representing 2/3 of Canadian shad landings. Populations and catches then plummeted and by the 1920s the export trade had disappeared. The decline was eventually linked to the destruction of spawning stocks on American shad rivers by hydroelectric dams and pollution. By the 1940s, a fleet of 8-9 boats each netted about 5,000 shad and 300 salmon/yr in the lower Petitcodiac system. When river restoration projects in the USA began to show results in the 1980s, shad started to increase once again in the upper Bay, but only in Cumberland Basin, not in Shepody Bay or the Petitcodiac.

In 1965, anglers landed more salmon on the Petitcodiac and its tributaries than on the Restigouche. Only anglers on the Miramichi and the St. John landed more. Elson apparently estimated salmon runs at 8,000 to 10,000 fish in 1966.

By spring of 1969, the effects of the causeway were apparent. The fishway did not allow smelts, gaspereau and shad to pass. Declines occurred in commercial and recreational salmon fisheries, salmon juvenile counts from electrofishing surveys, commercial catches of gaspereau and shad, and recreational fishing for smelts and striped bass.

The causeway dam is 1 km in length, built to span a river of that width. Today the river at the causeway is 0.08 km wide at high tide, a reduction of 92%. At low tide, the water flow is reduced to a 1 m channel. At Bore Park, the river used to span 1.6 km. Today the channel is 0.12 km at high tide. Perhaps 400 ha (1000 acres) of mud flat, much of which is now vegetated and turned to marsh, have accumulated in the river channel at Moncton.

The causeway gate opening in 1988 resulted in a “small revival” of the sea trout fishery upriver. Shad fishermen apparently had improved catches. The tidal bore was partly restored.

The last year that salmon were captured in the fishway trap was 1993. Six adult salmon were transported to the fish hatchery in Saint John for spawning. In total, 5,000 fry were hatched; due to a chemical spill all but 1,500 fry died. Fry were eventually stocked to the river where they were expected to run to sea as smolts in 1997.

Hicklin, P.W., R.D. Elliot and B. Harrington. 1998. The current status of Semipalmated Sandpipers in the Bay of Fundy. Pages 6-16 *in* Environmental Monitoring Working Group. 1998. Environmental monitoring of the Petitcodiac River system, 1997: Trial opening of the Petitcodiac River causeway gates. December 1998. 280p.

This report primarily addresses the status of sandpipers but in so doing includes information about *Corophium volutator* (the amphipod which is eaten by the sandpipers) on mud flats near the mouth of the Petitcodiac estuary, in Shepody Bay.

Amphipod densities in two locations (Grande Anse at Dorchester Cape, and Daniel’s Flats, near Shepody) increased in 1997 compared to earlier years:

Grande Anse:

Year	Mean no./m^2±SD	Range no./m^2	Frequency (# sites)
1978	5,162 ± 3,476	150 - 9,900	12/12
1994	204 ± 958	0 - 4,700	2/12
1997	13,400 ± 19,000	0 - 54,000	7/13

In 1997, the first five stations of the transect (uppermost 500 m) had the highest densities, averaging 34,400 ± 14,408 animals/m^2. Five of the 7 stations in the lower 600 m stretch had no *Corophium* and the maximum abundance was much lower (range 0-3,000 animals/m^2). Mean density for the entire transect in 1997 was 2.5 times higher than that recorded in 1978, and 6.5 times higher for the uppermost 500 m alone. The major difference between years was in the distribution of the amphipod; in 1978 they were most abundant near the middle of the mudflat, whereas in 1997 they were concentrated in the uppermost 500 m.
Daniel's Flats:

Year	Mean no./m^2±SD	Range no./m^2	Frequency (# sites)
1978	2,567 ± 2,738		17/17
1997	55,030 ± 51,090	1,000-220,000	

New Horton mudflat (Mary's Point) was also sampled, but quantitative results were not presented in this report.

Hudson Engineering Ltd. 1998. Petitcodiac River Basin snow and ice measurement project, February-March 1998. Prepared for New Brunswick Department of the Environment. vii+182 p.
The table of contents for the above report is presented along with the executive summary in: **Hudson Engineering Ltd. 1998. Petitcodiac River Basin snow and ice measurement project, February-March 1998. Pages 242-251 *in* Environmental Monitoring Working Group. 1998. Environmental monitoring of the Petitcodiac River system, 1997: Trial opening of the Petitcodiac River causeway gates. December 1998. 280 p.**

The average ice thickness on the headpond during the week of February 23 1998 ranged from 0.61-0.69 m. Ice thickness on the tributary rivers was: Little R., 0.52 m; Pollett R., 0.58 m; North R., 0.60 m.

By March 2 1998, the Little and Pollett Rivers were ice-free.

During the week of March 16 1998, ice thickness in the headpond ranged 0.37-0.41 m. All tributaries were ice-free.

Air reconnaissance on March 14 showed that the river was ice-free from a point 6 km above the causeway. The remains of a minor jam were observed at the mouth of the Anagance River. Some minor jams were observed on the lower reaches of the North River. The Pollett River, Little River and Turtle Creek were all free of ice.

Downstream surveillance on March 2, 9, 14 and 16 indicated little or no ice movement in the Petitcodiac River. Most of the ice cakes observed were grounded along the river banks and tributary streams, and may have been deposited during high tides in January and February. There was no sheet ice along the banks of the river.

Huntsman, A.G. 1931. The Maritime salmon of Canada. Biological Board of Canada Bulletin 21: 99 p.

Catch statistics of Atlantic salmon from Albert, southern Westmorland and southern Cumberland county from the provincial border to Cape Chignecto were pooled together as 'Chignecto salmon'. Chignecto salmon catches from 1872 to 1930 showed a generally decreasing trend. A peak catch of 758,180 kg (1,670,000 lb) occurred in 1874. Catches from 1918 to 1927 "almost disappeared" and ranged from 4,540 to 24,062 kg (10,000-53,000 lb). Huntsman attributed the depletion of salmon in this area to the settled nature of the country and "extreme overfishing". The lack of periodicity in the catch, in contrast to Huntsman's expectation of a four-year cycle to correspond with the life history of the Petitcodiac salmon, was attributed to an absence of competition for food in the freshwater environment, i.e., low juvenile densities resulting from low levels of spawning escapement. "There would seem to be no hope for the future unless the fishing can be controlled" (p. 15-18).

"Depletion...is particularly evident in rivers emptying into the Bay of Fundy, having progressed to total extinction in some cases. The Chignecto system (Petitcodiac river) affords an example where it has stopped just short of extinction" (p. 98).

Huntsman, A. G. 1941. Report on selection of a stream for a practical experiment in planting young salmon. Fisheries Research Board of Canada, Manuscript reports or the biological stations 212; Atlantic salmon and trout investigations, 1941; 22(4): 18 p.

The Petitcodiac was once noteworthy for its salmon (Perley 1852) but trends in catch records since that time indicated that the Petitcodiac salmon stock had been depleted. The reason for the depletion was not explicitly stated in this manuscript but Huntsman appears to be implying that overfishing was involved. The driftnet fishery for shad and salmon was carried out from Dover through Shepody Bay to Herring Cove, just west of Alma. The salmon component of this fishery was dependent on the Petitcodiac stock, and surveys conducted in 1931 had determined that it was discrete from other salmon fisheries. Tagging of Apple R., Annapolis R., and St. John R. salmon showed some movement of fish between them, but no movement to the Petitcodiac outflow.

There was suitable habitat for salmon in the main Petitcodiac and all tributaries. Headwater areas were more appropriate for trout, but the intermediate parts of the rivers contained good salmon habitat with "extensive beds and banks of clean gravel and running through flat intervale land in valleys". The lower parts of the rivers were somewhat sluggish, with gravel bottoms choked with silt from farms; Huntsman believed that these areas were formerly productive for salmon, but currently unsuitable due to siltation. Huntsman considered the estuary of the Petitcodiac to be very much like that of the most famous British salmon river, the Wye of Monmouthshire - great tidal amplitude, muddy water, and "slimy" banks.

Thirty sites in the Petitcodiac River were seined in 1936 and 1941, but only five contained young salmon. Salmon were believed to ascend only Turtle Creek, Coverdale River, and Pollett River.

No young salmon were found in the lower part of Turtle Creek, and few in the upper part. None were found above a dam on the east branch at Steeves Mills.

Young salmon were found in Coverdale River only in the upper parts, the main portion being without suitable spawning beds.

No young salmon were found in the Pollett River. The lower part of the river was considered "rather unsuitable" for spawning, and impassable barriers for spawning fish were present at km 6.8 (mile 4.25, Sanatorium dam) and km 24 (mile 15, Gordon Falls). However, the possibility of natural spawning below the Sanatorium dam was not ruled out. The Pollett River had the reputation of being the best salmon stream in the system at one time and Huntsman believed that there might still be some natural spawning below the Sanatorium dam.

Both salmon and shad had been prevented from spawning above River Glade by a dam prior to 1935, but a spawning run of shad had returned to the area following a washout of the dam in the winter of 1934-1935. However, salmon had not returned to the area by 1941. Huntsman verified this by finding young shad but not salmon during seining. The area blocked prior to 1935 therefore included the Anagance and North Rivers and part of the main Petitcodiac.

Angling for trout throughout the river system was described as "intense". This angling typically started at the end of May and continued until the middle of August.

Huntsman, A.G. 1941. Salmon planting on the Petitcodiac. Fisheries Research Board of Canada, Manuscript reports of the biological stations 212; Atlantic salmon and trout investigations, 1941; 22(5): 28 p.

"Although there are salmon in the river, there is now little that can be called a fishery." About 91 kg (200 lb) of salmon was taken annually in drift nets operated between Dover and Herring Cove, near Alma. Some weir fishing also took place along the coast. During summer, salmon were sometimes left stranded by the falling tide on the flats of the upper part of the estuary. There was also some angling above the head of tide, but this was not considered to be extensive.

Huntsman refers to the "considerable fishery" that Perley reported in "olden days". Perley (1852) stated that "Great numbers of salmon, generally of small size, frequented this river" and attributed the diminution of numbers which had occurred even by 1850 to overfishing. Huntsman believed that the extensive fishery mentioned by Perley took place in the freshwater portion of the main Petitcodiac River from Salisbury to Petitcodiac. In 1941, an 87-year-old resident of Salisbury told Huntsman that in his youth the salmon went up the river at least to Salisbury and perhaps up the North River. The implication is that by 1941 this was no longer the case.

Huntsman considered the salmon catch in Chignecto Bay to be representative of trends in Petitcodiac salmon. There was a general decline from a catch of ~45,400 kg (1,000 cwt) in Chignecto Bay in the 1870s to ~4,540 kg (100 cwt) in the 1920s. In general, the catch along "the coast" (by this, presumably Huntsman is referring to the Bay of Fundy) had not declined over the same period. From this, Huntsman inferred a "steady, slow depletion" of the Petitcodiac stock. Average catches in the years 1932 to 1938 were:

June – 0 kg (0 cwt)
July – 350 kg (7.7 cwt)
August – 1,135 kg (25 cwt)
September – 558 kg (12.3 cwt)
October – 14 kg (0.3 cwt)

The salmon caught were practically all grilse and previously spawned fish. A weir operator at Hopewell Cape and a driftnet fisherman from Cumberland Basin both stated that the salmon did not appear until July.

Trout angling in the whole river system was described as "very intense".

Scale samples and capture data were obtained for 36 salmon in 1931 and 49 salmon in 1941, mainly sampled in the shad fishery. The average length was 60.5 cm (range 47-78.7 cm) (23.8 in, range 18.5-31 in.) and average weight was 2.5 kg (range 1.4-5.4 kg) (5.5 lb, range 3-12 lb). The weir operator at Hopewell Cape confirmed that the small size was not the result of selection by the shad gillnets; the fish taken in his weir ranged from 1.1 to 4.5 kg (2.5-10 lb) in weight.

The river age of 81% of the sampled fish was 2 years, and the remainder were 3-river-year fish. Almost 98% of the fish were either spawning for the first time at age 1-sea-winter (grilse), or were repeat spawners who had spawned for the first time at age 1-sea-winter. In total, 63% were maiden spawners, 29% had spawned once before, 7% had spawned twice before, and 1% had spawned three times before.

The Petitcodiac fish not only spawned initially as grilse, but as far as size was concerned they remained grilse throughout subsequent sojourns at sea. The one that had spawned three times and was presumably preparing for a fourth spawning was only 68.6 cm (27 in) long and weighed 2.4 kg (5.25 lb).

The proportion of fish that had previously spawned was considered unusually high. About 1/3 of the fish were repeat spawners. Mortality rates were estimated as 50% from first to second spawning, 75% from second to third, and 83% from third to fourth spawning.

In the summer, 1941, survey of the watershed, young salmon were found only in Turtle Creek and Coverdale River, which entered the estuary below the head of tide (near Salisbury). There were no young salmon found in any of the tributaries entering the main river above the head of tide.

Previous plantings of salmon in the Petitcodiac system predated the summer of 1941. An undisclosed number had been planted a short distance above the head of tide at the Salmon Pool, where a small brook enters the main Petitcodiac River. The success of this planting was unknown but Huntsman implied that the habitat was probably not suitable for young salmon.

The information initially given to Huntsman was that salmon ascended only the Pollett River and had not ascended the main river above the mouth of the Pollett at River Glade despite the opportunity furnished by a dam washout in the winter of 1934-35. Huntsman subsequently concluded that this information was incorrect; it was unlikely that successful reproduction was occurring in the Pollett River because of blockage by dams and furthermore salmon ascended the main river and even the lower part of the North River. He detected evidence of the bottom of the North River having been worked by salmon in the first 1.6 km (mile) above the mouth, and was told locally that many salmon occurred in the river. However, he found no gravelly areas free from fine silt, and no young salmon, and concluded that conditions were not conducive to development of salmon eggs although he did not rule out the possibility of spawning. He concluded that it was “very doubtful whether salmon are being produced in the Pollett River or in the main river and its branches above the mouth of the Pollett”.

Small trout were found throughout the upper waters of the North River, and large trout were said to occur in the lower waters. Eels and minnows (*Semotilus*) occurred nearly everywhere. *Fundulus* (killifish) and *Gasterosteus* (sticklebacks) were found in the lower and less rapid parts of the river. Shad were said to ascend the river for several miles and “doubtless spawn in it”. A gaspereau had been caught “very far up” the river. Suckers were distributed throughout the river and large ones were present “in considerable numbers in the deeper pools”.

The Anagance River was considered to be less suitable for salmon than the North River.

The main Petitcodiac River above Salisbury was considered to have “definite possibilities” for smolt production, but was considered to be more important “for the spawning of the shad and the rearing of their young”.

The Pollett River between River Glade and Elgin was judged to have good conditions for young salmon, “but no very suitable spawning grounds were seen, there being considerable sediment”. Near Elgin, streams were found which were considered excellent for both spawning and rearing of the young. However, the Sanatorium dam, 7.2 km (4.5 miles) up from the mouth, presented an impassable barrier to spawning salmon, and additional dams were present at km 13.3 (mile 8.25) (Forest Glen) and km 23.4 (mile 14.75) (Elgin). Gordon Falls, at km 25 (mile 15.5), was also considered impassable. The part of the river considered the best for salmon was above the falls.

The Little River was tidal for a short distance above its mouth, but overall was considered to be the “outstanding salmon producer of the Petitcodiac system”. This was due to the high quality of the habitat in the upper part of the system, which was found to be “well populated” with young salmon and was also suitable for spawning. The lower freshwater area lacked suitable bottom for spawning and hatching, and contained no young salmon.

Turtle Creek was less suitable for salmon than Little River, but did contain young salmon. The eastern branch was dammed and excluded spawning adults.

The tidal portion of the river extended regularly to Salisbury and, on high tides, to a mile or more above the Salisbury bridge. Huntsman considered the transition zone between the tidal and freshwater river just above Salisbury to have definite possibilities for salmon rearing.

Huntsman, A. G. 1942. Salmon planting in the Petitcodiac, 1942. Fisheries Research Board of Canada, Manuscript report of the biological stations 328; Atlantic salmon and trout investigations, 1942; 26(10): 25 p.

This manuscript mainly discussed the seining surveys conducted in the Petitcodiac system up to 1942 to detect juvenile salmon. For the 1942 results, details of other species present at the sites and of the habitats were also provided.

On July 29 1937, Huntsman had examined the Petitcodiac in two locations: a short distance below Petitcodiac village and a short distance below River Glade. An impassable dam at River Glade had washed out that spring. The shad had “at once taken advantage of the opportunity” and had been observed in June up near Petitcodiac. Their young were seined at both Petitcodiac and River Glade. No young salmon were found but they could not by that time have taken advantage of the elimination of the dam. On July 23 1941, Huntsman made short examinations of the North River at a number of accessible points from Pacific Junction to Petitcodiac village and also of the Anagance River and one of its tributaries at two points. Again he found no young salmon. Later examination of the North River in the course of stocking it in 1941, and more thorough examination in 1942 revealed no underyearlings. One underyearling, which could have come only from natural spawning in 1941, was found at the very mouth of the river.

In 1942, 2,318 and 559 smolts descended the Petitcodiac and Pollett Rivers respectively. So far as determined, these were all age 2, and would therefore have been the product of wild spawning rather than of the 1941 stocking of underyearlings.

The survival of the planted salmon was mainly in the intermediate part of the North River. The salmon planted in 1941 were absent from most of the headwaters, which Huntsman refers to as trout waters. An 8 km (5 mile) stretch of pools and rapids had a “very good” population of yearling salmon. The middle part of the river, about 13 km (8 miles) long, described as a long stretch of still waters with some slight rapids, had “fair numbers” of salmon left in the “more suitable places”. The lower part of the river, about 11 km (7 miles) long, described as the “broad, shallow rapid portion”, had been planted with more than half the salmon but was practically devoid of salmon and had few fish of any kind. Bennett Brook had a “fair population” of salmon.

Some tributaries of the North River, including Walker and Lewis Mountain Brooks, were found to be completely dry in the summer of 1942, which was considered to be an extremely dry summer. In the second week of June, the temperature of the Petitcodiac River rose to nearly 32ºC (90ºF). Young salmon were reported to be dying “in millions” at the Fawcett bridge and Huntsman assumed this condition was probably general throughout the lower 11 km (7 mile) stretch of the North River. The river was low at that time and water levels were even lower during the rest of the summer. Any salmon that descended into this area of the river “will surely have perished”. Thorough examination in late August found no young salmon.

In the low water and warm temperature conditions present in 1942, Huntsman considered that predation by eels, trout, mergansers and kingfishers might have been higher than usual. There is some discussion of the relationship of the young salmon to biotic and abiotic factors in the river. It was noted that a beaver dam on Turtle Creek, observed in 1941, seemed to have prevented access of salmon to the spawning grounds above.

The planted fish showed growth as good as or better than that of the native fish in other tributaries of the Petitcodiac. As yearlings in August or early September they were 8-13 cm long. Naturally produced yearlings in Nigus Brook or Anagance River and its tributaries were “no larger”. Further growth the next spring resulted in smolts of 13-20 cm at the Petitcodiac trap.

No age 2 salmon were found in the other tributaries of the Petitcodiac, and no age 3 smolts (some of the largest were only age 2) were taken in the Petitcodiac trap. Huntsman therefore predicted that the salmon planted in the North River in 1941 would all become smolts in 1943.

Stocking in the Pollett River from August 18-21 1942 was briefly mentioned. The Pollett River between the Elgin dam and the Sanatorium dam was stocked with about 16,000 underyearling salmon. Stocking intensity was about 10% that in the North River.

Results of seining surveys:

Location	Date	Age 0	Age 1
North R. - several, Pacific Junction to Petitcodiac	July 23 1941	none	none
Anagance R. and one tributary	July 23 1941	none	none
Petitcodiac R. – River Glade bridge	Aug. 7 1942	none	none
Nigus Brook	Aug. 7 1942	many	many
Holmes Brook – km 0.8 and 2.8 (miles 0.5 and 1.75)	Aug. 20 or 21 1942	many	many
Anagance R. – km 0 to 1.2 (mile 0 to mile 0.75)	Aug. 20 or 21 1942	fair	fair
Hayward Brook - near highway	Aug. 20 or 21 1942	fair	fair
North R. - just above mouth	Aug. 6 1942	none	present
North R. - below Salisbury-Fredericton road	Aug. 6 1942	none	present
Bennett Brook - just above mouth	Aug. 6 1942	none	present
North R. - for 61 m (200 ft) above bridge at Trites Rd.	Sept. 2 1942	none	none
North R. - for 183 m (200 yd) below bridge at Trites Rd.	Sept. 2 1942	none	1
North R. tributary - Kelly’s Lane, 1.6 km (1 mile) below Trites Rd.	Sept. 2 1942	none	1

Location	Date	Age 0	Age 1
North R. – 0.2 km (0.12 mile) below Kelly’s Lane	Sept. 2 1942	none	1
North R. tributary – 0.8 km (0.5 mile) above Indian Mountain Rd.	Sept. 2 1942	none	1
North R. - between Indian Mountain Rd. and 0.8 km (0.5 mile) above	Sept. 2 1942	none	≥22
North R. - below Indian Mountain Rd.	Sept. 2 1942	none	≥23
North R. - below Pacific Junction Rd. for 3.2 km (2 miles)	Sept. 2 1942	none	47
North R. - from 2 to 4 km (1.25 to 2.5 miles) above Salisbury-Fredericton Rd.	Sept. 2 1942	none	5
North R. - from Salisbury-Fredericton Rd., up 0.8 km (0.5 mile)	Aug. 31 and Sept. 12 1942	none	7
North R. - from Salisbury-Fredericton Rd., down 640 m (several 100 yd)	Aug. 31 and Sept. 12 1942	none	1
North R. – 0.8 km (0.5 mile) below Salisbury-Fredericton Rd.	Aug. 7 1942	none	>6
North R. – 0.8 km (0.5 mile) below Salisbury-Fredericton Rd. (680 paces, total)	Aug. 31 1942	none	20
North R. - upper bridge to Lewis Mountain (above mouth of brook) - for 150 paces below	Sept. 4 1942	none	7
North R. - lower bridge to Lewis Mountain - for 299 paces above, up to beaver dam	Sept. 4 1942	none	9
North R. - lower bridge to Lewis Mountain - for 300 paces below	Sept. 4 1942	none	26
Lewis Mountain Brook - for 170 paces up from road bridge - river was dry	Sept. 4 1942	none	none
North R. - just above Wheaton Settlement bridge	Sept. 4 1942	none	none
North R. - several hundred paces above and below mouth of Walker Brook	Sept. 4 1942	none	none
Walker Brook - for 130 paces from mouth	Sept. 3 1942	none	none
North R. - at Fawcett Mill, and up for 250 paces	Sept. 3 1942	none	none
North R. - for 274 m (300 yd) down from Fawcett bridge	Sept. 12 1942	none	2
North R. tributary just below Fawcett bridge on east side	Sept. 12 1942	none	3
North R. – 1.9 km (1.2 miles) above Intervale bridge, for >300 paces	Sept. 12 1942	none	none
North R. - between Salt Springs Br. and Bennett Br.	Sept. 3 1942	none	2
Bennett Brook – km 0.4 (mile 0.25)	Aug. 6 1942	none	>6
Bennett Brook - from mouth, up 250 paces	Sept. 3 1942	none	4
Bennett Brook - above mouth of Gordon Brook	Sept. 3 1942	none	5
Bennett Brook - between bridges south of Kinnear Settlement	Sept. 3 1942	none	17
Bennett Brook - at Mannhurst bridge	Sept. 3 1942	none	29
Salt Springs Brook - at mouth, lower bridge, middle bridge (km 4.8) (mile 3)	Sept. 3 1942	none	none
North R. - just above mouth	Aug. 6 1942	none	6
North R. - just above mouth, for 630 paces	Aug. 21 1942	none	1

Huntsman, A.G. 1943. Report for 1942 on the Atlantic salmon and trout investigations. Pages 29-30 *in* Cameron, A.T. Annual report of the Fisheries Research Board of Canada for the year 1942.

The North River, which was without salmon, was planted with ~200,000 underyearling salmon in 1941. In 1942, the surviving yearlings were found to be as large as, or larger than, native yearlings in other tributaries of the Petitcodiac system. Their survival varied considerably with location in the river. The summer was "most exceptionally dry" as well as having a heat wave in the second week of June, which killed large numbers of salmon and other fish in the open, broad and shallow lower part of the river.

Huntsman, A.G. 1944. Report for 1943 on the Atlantic salmon and trout investigations. Pages 34-35 *in* Cameron, A.T. Annual report of the Fisheries Research Board of Canada for the year 1943.

Two source streams of the Petitcodiac River had been planted and the young had to face the dry, hot season of 1942, which killed nearly the whole fish population of the Petitcodiac River proper. From the cohort of ~200,000 underyearlings planted in the North River in 1941, 3,075 smolts were counted just above the river mouth during their descent in 1943. Later examination of the river failed to show either underyearlings or yearlings, which would have been evidence of natural spawning that might render planting unnecessary. It did detect the presence of age 2 parr in areas where yearlings were abundant in 1942.

In 1942, 16,000 underyearlings were planted in the middle part of the Pollett River, which was inaccessible to natural spawning. In 1943, surviving yearlings were found only in parts of the system with steep slope, i.e., in tributary brooks. This corresponded with previous observations in the North River.

Huntsman, A.G. 1944. Relation of beaver to salmon. Fisheries Research Board of Canada, Manuscript reports of the biological stations 379; Atlantic salmon and trout investigations, 1944; 30(1): 8 p.

On July 22 1941, it was observed that beavers had repaired a break in a man-made dam 3 km (2 miles) up the east branch of Turtle Creek and had apparently prevented the ascent of spawning salmon in 1940. The dam had apparently been built "by persons desirous of improving the trout fishing". It was unlikely that the dam, in its original condition, had prevented salmon migration. Seining below Steeves Mills, 3 km (2 miles) further upstream, gave no underyearling salmon, but only a yearling, suggesting that ascent of spawning fish was blocked in 1940. Both underyearlings and yearlings were found downstream of the dam.

When the North River was planted with young salmon later that year, a beaver dam was observed about 16 km (10 miles) above the mouth. Since fish planting extended to 40 km (25 miles) above the mouth, there was some concern about possible blockage of the smolt descent. The dam was opened on May 29 1943 to ensure smolt passage. The dam was not repaired, and there was no evidence that any smolts failed to descend. A new beaver dam was found 19 km (12 miles) above the mouth of the North River in early summer of 1944, but whether this had interfered with descent of age 3 smolts from the 1941 planting was unknown.

In autumn of 1943, there was evidence of beavers at various points of the Anagance River and tributaries, in which the salmon were spawning naturally. In early summer of 1944, a beaver dam not far above the mouth of Hayward Brook, which was populated with native young salmon, had prevented the descent of smolts, which were seen in the pool above the dam.

In the fall of 1943, beaver dams were found about 5 km (3 miles) up Holmes Brook, "which had been selected for study as a stream with a good stock of native salmon". This brook was trapped for descending smolts in the spring of 1944, and it was presumed that the dams had not interfered with the smolt run. On September 24 1944, young salmon were investigated upstream of a point where the power lines crossed the brook, about 3 km (2 miles) above the mouth. The water increased in turbidity near the dams, which were 7 in number and placed at "rather short intervals". The 4 lower dams had been built since the visit late in 1943, and the 3 upper dams had been abandoned. The pools above the upper dams were low and with clear water, and "quite a number of salmon of trout could be seen". All but one of the 8 salmon that were taken were smolts averaging 16.3 cm long (range 16-16.75 cm). In contrast, 8 marked Petitcodiac smolts, which had descended to the sea around June 1 and were recaptured in weirs in Minas Channel before mid-August, had been twice the length (average 32.5 cm, range 24-35.5 cm) and at least 8 times the weight of those that had not been able to descend. Five smolts in good condition, taken in the Pollett River in 1942, ranged in length from 16 to 16.75 cm and weighed on average 45 g (1.6 oz). The average weight of the Minas Channel post-smolts was 411 g (range 269-680 g) (14.5 oz, range 9.5-24 oz.). Despite their small size, the "post-smolts" trapped above the beaver dam appeared to be in excellent condition. The absence of small fish in the pools was probably due to having been eaten by the larger salmon and trout, since small fish were common both up and down stream. The depth, murkiness and extent of pools above the 2nd-4th dams that were in use did not allow for observations of fish. The first of the new dams was low and the pool above was short, and seemed to have been made quite recently. The pool contained fish much the same as the pools below the dams. Fish above all the dams, in addition to salmon and trout, were sticklebacks, *Couesius*, *Rhinichthys* and suckers. Salmon parr were found all along the stream as far up as it was examined, about 1 km (0.75 mile) above the dams. Ages 0 to 3 (from eggs deposited from 1940 to 1943) were represented, but no yearlings (1942 spawning) were found above the dams (numbers and sizes are included in the manuscript). The presence of underyearlings indicated that salmon surmounted the three dams that were observed in 1943. Salmon may not have passed the dams in 1942. Normally, salmon did not enter Holmes Brook before September, and spawning occurred near the end of October. The summer and autumn of 1942 were very dry, and the rainfall for August-October was much lower than in 1941 and 1943.

A salmon kelt was taken at the beaver dams on Holmes Brook in the spring of 1944. It was suggested that the dams had prevented the seaward migration of this fish.

On August 10 1944, Salmon Hole Creek [now known as Colpitts Brook], a tributary of the Pollett River, contained salmon and had a dam just above the mouth, made partly by man and partly by beavers. Whether this had prevented descent of any age 2 smolts was not known.

Huntsman, A. G. 1945. Assessing stream populations of young salmon. Fisheries Research Board of Canada, Manuscript reports of the biological stations 381; Atlantic salmon and trout investigations, 1945; 32(1): 10 p.

A mark-recapture method using a one-man seine for assessment of the population of young salmon was tested in three brooks of the Petitcodiac system (Nigus, Milton and Holmes).

Nigus Brook (tributary of Petitcodiac R.), August 11 1945: Underyearling salmon were so abundant in the area closed off for the test that they were not assessed. The size of the underyearlings was 5-6 cm. The smallest yearling salmon was 8.7 cm. No attempt was made to determine the ages of fish from the scales, but it was assumed that all were yearlings with the possible exception of one 18-cm parr, which might have age 2. The numbers in the various size classes were:

Size (cm)	9	10	11	12	13	14	15	16	17	18
No.	1	4	8	4	3	1	1	0	0	1

The kind of seining routinely used for population estimation (one sweep, open site) captured 1/3 to 1/2 of the fish present in the repeatedly seined, closed (with barrier nets) site. It was determined that 24 parr were present in the stretch, although the area enclosed was not stated.

Milton Brook (tributary of Little R.), August 13 1945: A 41 m (45 yd) stretch a short distance from the mouth and just above the remains of an old dam was seined. Details of habitat were provided. The salmon captured ranged in length from 7.1 to 12.3 cm, and the mark-recapture estimate of abundance was 33 salmon. Trout were also collected, but only those presumed to be yearlings or older were measured. It was subsequently determined that underyearling trout were probably not reliably separated from the older fish. None smaller than 8.3 cm were measured, and the largest trout was 18 cm long. The mark-recapture method estimated that 117 small (<8.5 cm) and 34 large (8.5-18 cm) trout were present. Each standard seining sweep collected somewhat less than half the total number of salmon, close to 1/3 of the larger trout, and from 1/4 to 1/3 of the smaller trout.

Holmes Brook (tributary of Anagance R.), August 20 1945: A 128 m (140 yd) stretch near Petitcodiac village was seined. Yearling salmon, 9.1-14.9 cm in length, were collected. Approximately 1/6 to 1/4 of the estimated total of 29 salmon was collected in standard seining of 1 hour duration.

It was concluded that the standard seining that had been used to estimate young salmon population abundance following stocking operations in the Petitcodiac caught 1/3 to 1/2 of the population when the fish were readily seined. Seining in areas with obstacles (e.g., logs) or cover (alders overhanging from banks) resulted in a lower success rate.

Huntsman, A.G. 1945. Report for 1944 on the Atlantic salmon and trout investigations. Pages 28-29 *in* Cameron, A.T. Annual report of the Fisheries Research Board of Canada for the year 1944.

About 200,000 underyearlings planted in 1941 in the North River, "which was not producing salmon naturally", had produced 3,075 age 2 smolts in 1943 and 1,950 age 3 smolts in 1944. Some 40,000 underyearlings were planted in the North River in 1943. "So far as can be estimated from the abundance of the yearlings in characteristic portions of the river, the numbers of two-year-old and three-year-old smolts to descend in the next two years will be many more than one-fifth those from the first planting."

Young salmon did not survive equally well in all parts of a stream. The "common picture" was: "Few in the small upper parts, doubtless owing to little room; many in intermediate parts with swift water and good pools and cover; and few or none in broad, open, shallow lower parts, possibly for lack of cover."

Salmon in the Petitcodiac system did not descend as smolts in the spring after the water got very low, "as from the pool below the Sanatorium dam, even though there was a current of sufficient depth to carry them down if they would." With low water, they also did not descend from above certain beaver dams, "remaining there from June until at least as late as October".

The North River, "without native salmon", was expected to have a grilse run from the underyearlings planted in 1941 and marked as smolts in 1943, but only 2 marked fish ascended it in 1944, together with 28 unmarked and "presumably foreign grilse".

The lateness (relative to other rivers) of the typical Petitcodiac salmon run was attributed to the "estuarial conditions". The salmon were described as "having to traverse a long, shallow estuary in which the river water is quickly dissipated in the sea water as churned by very heavy tidal movements". The implication was that (in contrast to the Cheticamp River, which was described as having a much earlier run) a steady discharge of river water sufficient to "guide the fish in" was not available.

There was little evidence of use of salmon marked as descending smolts in the North River in 1943. "While the water of the Petitcodiac river is usually too warm for successful angling for the entering adult salmon until very late in the season, angling for the descending smolts, weighing [42.5 g] an ounce and a half each, is quite successful. There is evidence that about a quarter of the run may be taken from a single, good pool, which is one way of using the fish, even though this may be, as has been believed, undesirable because they are so small."

Huntsman, A.G. 1946. Heat stroke in Canadian Maritime stream fishes. Journal of the Fisheries Research Board of Canada 6: 476-482.

Many fishes died in the Petitcodiac system as a result of warm temperatures experienced in early June of 1942. Temperatures, as measured at fish counting traps in the Petitcodiac and Pollett Rivers just above the confluence of the two rivers, began to rise on June 6, and peaked on June 13. Minimum daily temperatures reached 23.6ºC in the Petitcodiac and 25.4ºC in the Pollett, and maximum temperatures were 31.1 and 31.4ºC, respectively. Fish were not acclimated to these temperatures; the highest temperatures recorded up to that time had been 23ºC (73.3ºF) on May 25 and 23.2ºC (73.7ºF) on June 2 in the Petitcodiac and 22.6ºC (72.7ºF) on June 2 in the Pollett. Air temperatures exceeded 32.2ºC on June 13. The sky was relatively free from clouds, at least from June 9 to 12, which would tend to increase the heating of the water. The rivers were low, but not exceptionally so. Rainfall at the village of Petitcodiac was 3.4 cm (1.34 in) in May and 3.6 cm (1.40 in) in June of 1942, whereas average monthly rainfall was 6.4-8.9 cm (2.5-3.5 in).

In the Petitcodiac River, 2,517 dead shad were counted between June 12 and June 17, the majority on June 13. These were "large, spawning shad, in the river from the sea at that time of year". Most of the deaths occurred in an 8 km (5 mile) stretch of river at the head of tide, upwards from Boundary Creek, i.e., "in the lowest part free from sea water influence with existing neap tides".

Young salmon were reported as dying in large numbers in the North River at Fawcett Hill and the Coverdale River about 3 km (2 miles) from Salisbury on June 14. Dead parr and smolts were found in and near traps which were operated in the Pollett and Petitcodiac Rivers just above River Glade, from June 12 to 16.

Other fish found dead in smaller numbers during this period included white suckers, gaspereau (alewife), trout, American eels, and two kinds of minnows (*Couesius plumbeus* and *Semotilus atromaculatus*). Salmon parr, suckers and *Couesius* entered the Pollett trap in large numbers during this period.

The fish fauna of the Petitcodiac River was examined at a number of locations in August 1942 and compared to the tributary spring-fed brooks, where temperatures would not have been as high. In comparison with the tributaries, and with data collected for the Petitcodiac River on July 29 1937, "the fish population of the Petitcodiac had been practically wiped out except in some parts with deep water." Additional contributing factors to the "relatively barren" conditions were considered to be the exceptionally low water conditions which persisted until late autumn, and the possibility that water "may have become very warm after the period of observation". Low water and high temperatures may have made fish more vulnerable to predation.

That the Petitcodiac and Pollett were "somewhat prone to have fish die from heat stroke" was inferred from historical occurrences, such as the stranding of salmon on flats or in tidal pools. At 1700 h on September 2 1942, some of these pools were 28.3ºC at the bottom. Adult salmon were reported to have died in the Pollett River for ≥1.6 km (1 mile) up from the mouth in August 1928, when the weather was very dry and warm. At that time, 150 dead salmon were counted in a 3 km (2 mile) stretch above the head of tide in the Petitcodiac, below the mouth of the Pollett. Meteorological records for Moncton indicated that July and August 1928 were very dry and maximum air temperatures exceeded 26.7ºC (80ºF) daily from August 13 to 19 and were >33.3ºC (92ºF) on three successive days. Minimum daily temperatures were 14.4-20.6ºC (58-69ºF). These conditions were warmer than those recorded in June 1942.

Fish deaths were observed or reported in the lower parts of the Petitcodiac, Pollett, Coverdale and North Rivers, but not in the upper parts of those rivers nor in any parts of the Anagance River or in any of the brooks of the system. The places where deaths occurred had apparently reached the highest temperatures, according to "limited observations". Features common to these sites were (1) steady and moderate declivity, giving heavy currents during high water and almost continuous rapids with but slight flow during low water, (2) evenness of bed of stream through the filling up of holes with material carried down, (3) breadth and openness as a result of the clearing action of the freshets, and (4) long travel of waters under these conditions, that is, a considerable length for this part of the river. A "striking" contrast was seen between one of the streams where fish died and a neighbouring short tributary with no deaths and a large population of fish.

Huntsman commented, "It is extraordinary that the shad should be found to die from heat stroke at spawning time in streams almost at the northern limit of their range, where the streams are on the verge on not being warm enough for spawning …The shad spawn in the lower parts of the streams, which become warmest."

Huntsman, A.G. 1946. Report for 1945 on the Atlantic salmon and trout investigations. Pages 32-33 *in* Cameron, A.T. Annual report of the Fisheries Research Board of Canada for the year 1945.

"Sea conditions that determine later growth, survival and catchability vary much and are for the Petitcodiac with its tidal bore quite peculiar".

Smolt counts were incomplete because of excessive rain in 1945, but calculations from the partial counts indicated that the North River produced as many age 2 smolts from ~40,000 underyearlings planted in 1943 as it had in 1943ºFrom >200,000 planted in 1941. This indicated that only a "somewhat sparse" planting was required. The new planting for 1945 was only 16,000 underyearlings, in order to test this idea.

"Small holding capacity in a large stream such as the lower part of the North River" was believed to be due to lack of cover. An experiment indicated that marked fish moved away from the place of stocking only when the place lacked cover.

"Attempts to produce the most smolts per dollar spent in planting the middle part of the Pollett river, now inaccessible to spawners, continue to show the river itself almost a complete failure. The tributary brooks do quite well, but plantings made in three successive years are giving evidence that even with sparse planting there is good survival only every other year in the cooler streams where growth is slow, apparently because one year's lot eliminates the next. In such, it seems worthwhile to plant only every other year. That this is a natural condition of rather wide occurrence is suggested by the fact that the salmon catch shows rather frequent ups and downs every two years or so".

North River salmon marked as smolts were "reported widely" in the sea, in Minas Channel and Cumberland Basin as well as in the Petitcodiac estuary. In contrast, Pollett River fish were not reported from the sea, and Holmes Brook fish were reported only from the estuary. North River fish appeared in the estuary early and then disappeared, very few entering the river, and more going to Holmes Brook than to their home stream "as occurred in 1944". Fish originating from Holmes Brook returned "in fair numbers" and all returned to the home stream.

About ¼ of the smolts produced in 1944 from planting in the Pollett River were taken illegally by anglers, but the remainder of the marked fish did not seem either to have been taken in the sea by fishermen or to have returned to the river. High water in 1945 resulted in anglers catching no smolts, but only trout, during the smolt run. "The North River smolts of 1944 were taken widely in the sea by weirs and nets to the extent of at least 0.77%, but of the few that returned none were reported caught by anglers, who on the Petitcodiac succeed in taking only a few salmon late in the season, evidently because of the high temperature of the water during the summer."

Huntsman, A.G. 1947. Report for 1946 on the Atlantic salmon and trout investigations. Pages 30-31 *in* Dymond, J.R. Annual report of the Fisheries Research Board of Canada for the year 1946.

An "outstanding" feature of the studies on salmon in the Petitcodiac system had been the "failure of survival in the lower open parts of the streams, swept clear of obstructions, where greatest production was expected." As a test of this conclusion, 250,000 underyearlings were planted in the middle Pollett River in the 16 km (10 mile) stretch between the Sanatorium and Elgin, in 1945. As late as September of 1946, the large numbers of yearlings found seemed to contradict the conclusion, but in October the large local populations apparently disappeared. This was believed to be the result of "merganser depredations". An incidental result was the discovery that with such heavy planting the fish spread out even into the tributaries, where more of them may have survived than in the main stream where they were planted.

Holmes Brook was to be used as a "control" to determine the variation in natural production of salmon. The count of smolts descending the stream was 1,162 smolts in 1944, 457 smolts in 1945 (incomplete because of floods, but estimated as less than half the 1944 number), and 460 smolts in 1946. In part, the decrease in numbers was linked to activities of beavers. Beaver dams on the upper part of the stream had prevented ascent of adults and descent of smolts in some years, while "activities of the beavers have vitiated the stream downward from the dams." Huntsman considered that this did not completely explain the change in numbers of salmon.

Of 5 lots of distinctively marked yearling salmon planted in Bennett and Holmes Brooks in 1945, as many as 25% descended as smolts in 1946. The highest percentage was in Holmes Brook, supposedly well populated with native fish. Also, more came from the upper lots "in spite of the additional hazard of their having to descend (with low water, as it happened) a greater distance to the traps".

In 1946, a year of continuous low water, adult salmon failed to ascend to upper spawning streams even at spawning. Up to the time that the streams froze and the traps were removed in December, no salmon had entered traps on Holmes and Bennett Brooks and the North River. Although spawning usually occurred in late October and early November, "it is possible" that salmon that were known to enter the Petitcodiac River very late in the year might spawn even in December, although low temperature made this unlikely.

Petitcodiac fish marked as smolts were taken in Minas Channel at Hall's Harbour.

Huntsman, A.G. 1948. Report for 1947 on Atlantic salmon investigations. Pages 37-38 *in* Reed, G.B. Annual report of the Fisheries Research Board of Canada for the year 1947. (Appendix II).

Marked Atlantic salmon from the Petitcodiac system were caught as post-smolts near Hall's Harbour in Minas channel.

Huntsman, A. G., H. C. White, C. W. Andrews and P. F. Elson. 1945. Failure of smolt counts through heavy freshets. Fisheries Research Board of Canada, Manuscript reports of the biological stations 381; Atlantic salmon and trout investigations, 1945; 32(2): 18 p.

In 1945, high water prior to the smolt run and heavy freshets during the run prevented the collection of accurate numbers of descending smolts. Some traps could not be installed before the run started and others were washed out in May or June. This was the first year since 1942 that reasonably complete counts of smolts could not be obtained.

Records were obtained from the Meteorological Division of the Department of Transport in order to determine whether such freshets were a common occurrence. Data had been collected at Petitcodiac village for 12 years, and at Moncton and Sussex for 48 years. In April-June 1945, 39.5 cm (15.54 in) of rain fell at Petitcodiac, the previous record having been 27 cm (10.60 in) in 1937, with a twelve-year average of 21.5 cm (8.45 in). In all three locations, the April-June1945 rainfall was 50-60% more than the previous record.

Modifications in operations and construction were suggested for the counting fences being operated at Holmes Brook, the Pollett River, Bennett Brook and the North River. Some information on habitat and river conditions is included.

Hurley, D.A. (summarized by C.J. Kerswill). 1954. Observations on eels in relation to Atlantic salmon. Pages 135-137 *in* Hart, J.L. Fisheries Research Board of Canada. Report of the Atlantic Biological Station for 1954. (Appendix No. 65).

Field observations and feeding experiments on eels were carried out from May 17 to August 30 1954. Eels were collected in the Pollett River from the lower end of the experimental section to the headwaters. Gordon Falls, at the lower end of the upper Pollett, had been thought to be impassable to any fishes including eels. On August 2, small eels were observed successfully negotiating the falls by ascending the rocky ledges behind the falling water in the damp moss and algae.

A sample of 63 eels from the 191 taken on July 21 by electrofishing during regular parr assessment on the middle Pollett ranged in length from 105 to 480 mm (mean, 231 mm).

Stomach analyses on collection of eels (150-500 mm long) from the Pollett and Kennebecasis Rivers showed a preponderance of insects, including nymphs of Plecoptera, Ephemeroptera, Trichoptera and Anisoptera, and larvae of Coleoptera. Fish occurred in only 12% of the stomachs which contained food. These included *Lota lota* [must have been in the Kennebecasis samples], *Salvelinus fontinalis* and unidentifiable remains. A few stomachs contained earthworms.

Preliminary experiments were conducted on feeding in the Pollett River and at Birch Cove near St. Andrews. Eels confined with salmon fry, *Rhinichthys* and *Couesius* preferred them in that order, but the salmon specimens were slightly smaller than the others. The average rate of feeding in July on these species by confined eels (280-520 mm) averaged ~1 fish (45-60 mm)/eel/24 hr. Later experiments with eels (283-471 mm) confined with salmon underyearlings (52 ± 4 mm), *Rhinichthys* (51 ± 7 mm) and *Fundulus* (67 ± 8 mm) indicated a preference for *Rhinichthys* over salmon. *Fundulus* were considerably less preferred, possibly because of their larger size.

Ide, F. 1945. Analysis of samples of bottom organisms taken in September 1945 from three stations along the upper Rawdon river flowing from Beaverbank lake to Kinsac Long Lake and from Holmes Brook, Petitcodiac River, N. B. Fisheries Research Board of Canada, Manuscript reports of the biological stations 382; Atlantic salmon and trout investigations, 1945; 33(7): 4 p.

A diverse benthic fauna, characteristic of the upper reaches of streams, was sampled in Holmes Brook, a small tributary of the Petitcodiac River, in September 1945. The method of sample collection was not specified, but apparently involved visual inspection of 212 cm^2 of stones collected from the bottom of the stream. There was no mention of other substrates being sampled. Organisms were identified, counted and weighed.

Total density of benthic insects was 12,650 organisms/m^2. The volume of insects sampled was 29.20 cm^3/m^2, and the volume of algae and other debris was 155 cm^3/m^2. Only the more abundant groups of organisms are tabulated in this report. These included:

- insects which strain food from the water
  - Trichoptera (caddisflies)
    - Hychropsychidae (515 organisms/1000 cm^2)
    - Philopstamidae (85 organisms/1000 cm^2)
- insects associated with vegetation
  - Trichoptera (caddisflies)
    - Leptoceridae (present)
    - Hydroptilidae (present)
  - Ephemeroptera (mayflies)
    - *Baetis* spp. (14 organisms/1000 cm^2)
    - *Ephemerella* spp. (118 organisms/1000 cm^2)
  - Coleoptera (beetles)
    - Elmidae (9 organisms/1000 cm^2)
  - Diptera (true flies)
    - Chironomidae (midges) (376 organisms/1000 cm^2)
    - Tipulidae (craneflies) (42 organisms/1000 cm^2)

Jackman, P. 1998. Petitcodiac River sediment for maintenance of amphipod culture. Page 31 *in* Environmental Monitoring Working Group. 1998. Environmental monitoring of the Petitcodiac River system, 1997: Trial opening of the Petitcodiac River causeway gates. December 1998. 280 p.

Sediment collected on November 4 1997 from the Gunningsville Bridge area was used to maintain a culture of the amphipod *Leptocheirus plumulosus*, which was used as a test organism for toxicity tests. Large increases in amphipod numbers were noted after 6-8 weeks. Population numbers and age variations found on termination of the cultures in Petitcodiac sediment were approximately the same as those in clean sediment from Sequim Bay, Washington. Environment Canada has subsequently been using the Petitcodiac sediment as a clean sediment for maintaining cultures of this organism for use in testing other sediments.

Jackman, P. and K.G. Doe. 1998. Results of toxicological testing of water and sediment samples from the Petitcodiac River and headpond. Pages 23-30 *in* Environmental Monitoring Working Group. 1998. Environmental monitoring of the Petitcodiac River system, 1997: Trial opening of the Petitcodiac River causeway gates. December 1998. 280 p.

Water samples collected from the Petitcodiac River on July 15-16 1997, and from the river and headpond on October 30 and November 3 1997, were analysed for toxicity to the bacterium *Vibrio fischeri* according to a standard Microtox test. Sediment and suspended sediment samples collected on September 3 1997 were analysed for both Microtox and toxicity to an estuarine infaunal amphipod, *Eohaustorius* *estuarius* (a laboratory population, not indigenous to the Petitcodiac). None of the samples was considered toxic. Survival of the amphipod in the test sediments was 96-100%.

Jansen, H. 1990. Fish passage – Moncton causeway. Memo to H.H. Scarth. Fisheries and Oceans Canada, Halifax, NS. May 17 1990. 2 p.

A delayed closure of the causeway beyond June 15 had been suggested as a means of extending the shad fishery in the Belliveau Village area. There was no evidence that this would work in the short term to increase the catches.

Information on the Belliveau Village shad fishery from 1985 to 1989 was summarized. In 1985 and 1986, moderate catches of 22.7-45.4 kg/drift (50-100 lb/drift) were obtained. Catches on June 17 1987 were 340.5 kg/drift (750 lb/drift) but decreased a week later. The gates were operated in these three years as they had been since the installation of the causeway.

In 1988, the gates were open from April 15 to June 7 and from September 26 to October 31, and tidal water was permitted to enter upstream. The shad catch at Belliveau Village was 908 kg/drift (2000 lb/drift) from June 20 to 27. By July 11 to 17 the catch was 15.9 kg/drift (35 lb/drift).

In 1989, the gates were opened at low tide from May 3 to June 9, and tidal water was not permitted to enter the headpond. The shad catch at Belliveau Village was 272.4 kg/drift (600 lb/drift) from June 12 to 15. By June 15-18, the catch was 15.9 kg/drift (35 lb/drift).

It was suggested that the seasonal decline in catch (which occurred each summer) was probably related to seasonally changing environmental conditions which caused the shad to move to a new location. For example, the data from the gauging station on the Petitcodiac River indicated that the mid-June flow was usually ¼ to ½ of the early June flow.

Jessop, B.M. 1993. The status of alewife and blueback herring stocks in Scotia-Fundy region as indicated by catch-effort statistics. Department of Fisheries and Oceans Atlantic Fisheries Research Document 93/9: 17 p.

Anadromous alewives occur in “virtually all suitably-sized and accessible rivers in Scotia-Fundy Region”. Blueback herring occur in fewer rivers and are usually less abundant than alewives where both species co-occur. Blueback herring start moving upriver about 2-3 weeks later than alewives. Both species “return with substantial fidelity to a home river” and return to sea shortly after spawning. Spawning occurs first in both species at age 3 and virtually all fish have spawned by age 6. Repeat spawners may for 35-90% of the stocks of both species.

The inability of gaspereau to overcome difficult fish passage has been known for over a century. Perley (1852) commented that “Very slight obstructions suffice to prevent the gaspereaux from ascending streams to their old haunts; the dams for mills, or for driving timber, have shut them out in numerous instances from their best spawning grounds, and the greatest injury has in this way been inflicted on the fishery.” Jessop noted that most such dams have been removed, and most remaining dams have fish passage, although downstream passage at hydroelectric dams remained a problem. The creation of large headponds has, in some cases, enhanced production of alewives.

Landings of gaspereau were summarized by Fisheries Statistical District. Landings for FSD 81 (Petitcodiac River area), FSD 79 (Shepody Bay area) and FSD 24 (Cumberland Basin area) from Table 1 are summarized below: (the dash indicates either no data or zero catch, these are not differentiated in the report)

Year	Gaspereau landings (tonnes)		
	FSD 24	FSD 79	FSD 81
1960	-	<1	11
1961	-	2	12
1962	-	2	12
1963	-	-	-
1964	-	-	-
1965	-	3	10
1966	-	3	11
1967	-	3	17
1968	-	3	11
1969	-	4	11
1970	-	5	11
1971	-	5	<1
1972	-	6	-
1974	-	8	-
1975	<1	8	-
1976	-	782	-
1977	-	10	-
1978	<1	11	-
1979	<1	-	-
1980	1	-	-
1981	1	-	-
1982	1	-	-
1983	<1	-	-
1984	-	-	-
1985	-	2	2
1986	1	-	-
1987	-	1	-
1988	-	1	-
1989	-	1	2
1990	-	5	11
1991	<1	1	1
1992	-	2	-

Jessop, B.M. 1993. The status of rainbow smelt stocks in Scotia-Fundy region as indicated by catch and license statistics. Department of Fisheries and Oceans Atlantic Fisheries Research Document 93/69: 11 p.

Rainbow smelt support small recreational and commercial fisheries in Scotia-Fundy region. Among the problems experienced by the stocks is the obstruction of access to man-made barriers such as mill dams and culverts. Smelt cannot ascend vertical drops exceeding 15-20 cm.

Sexual maturity and first spawning occur at age 2 or 3. Maximum ages are 5 to 6 years. Smelt are believed to home on a natal river.

Reported commercial fishery landings of smelt in Fisheries Statistical District 24 (Cumberland Basin) and FSD 81 (Petitcodiac area) since 1960 were very rare and in years when a catch was reported it was <1 tonne. An anomalously high reported catch of 197 t in 1967 in FSD 81 (Petitcodiac area) was believed to be in error. No landings were reported for FSD 79 (Shepody Bay area).

Kenchington, E., I. Dempsey and M. J. Lundy. 1998. Petitcodiac River causeway monitoring programme: Scallops. Pages 74-89 *in* Environmental Monitoring Working Group. 1998. Environmental monitoring of the Petitcodiac River system, 1997: Trial opening of the Petitcodiac River causeway gates. December 1998. 280p.

In the Bay of Fundy, scallop landings peaked in 1989 due to the settlement of strong year classes (1985 and 1986) throughout the Bay. Recruitment has been poor since these year classes entered the fishery and landings have steadily declined.

During telephone interviews and meetings with local fishermen in December 1997, 54% expressed some concern about the proposed trial gate opening. Concerns related to siltation, contamination, and loss of fishing grounds.

Areas of active scallop fishing were identified near Advocate Harbour and the Apple River, and a third area near Grindstone Island was identified as a possible site for scallops. A survey was conducted on January 27-28 and February 2-5 1998 and determined the spatial distribution of pre-recruit and recruit scallops in survey areas, and number of live and dead scallops by shell size categories. These data would be sufficient to detect sublethal effects on yield and growth or mortality events subsequent to the trial opening.

Kenchington, E. and M.J. Lundy. 1999. 1998-1999 Petitcodiac River causeway monitoring programme: Scallop stock surveys. Pages 71-98 *in* Environmental Monitoring Working Group. Environmental Monitoring of the Petitcodiac River system: Petitcodiac River Trial Gate Opening Project. September 1999. 325 p.

A survey of scallops was carried out in the Cape Chignecto and Apple River areas from January 10-29 1999. There were no significant differences in abundance of either live or dead animals relative to the 1998 sampling.

Kerswill, C.J. 1955. Recent developments in Atlantic salmon research. Reprinted from the Atlantic Salmon Journal, January 1955. Fisheries Research Board No. 398. 10 p.

Research projects on salmon were summarized.

Work on the Pollett River included a series of experiments on salmon stocking and on natural reproduction to get the best smolt production, and a bird control experiment which showed an 8-fold increase in smolt production.

Locations of recaptures of adult salmon, tagged as smolts in the Pollett River, were shown. By October 1953, a total of 133 marked salmon from 25,187 marked Pollett River smolts had been reported. A large number had been taken in Newfoundland commercial fisheries and elsewhere in the Maritimes. "This demonstrates the value of hatchery plantings in adding to the over-all Atlantic coast catch, even though few may return to the planted stream."

Preliminary results on planting of fingerlings suggested that 36 fingerlings/m^2 (30 fingerlings/yd^2) would give the best production of smolts. Planting more was a waste of hatchery stock, and planting fewer would not take full advantage of the potential of the stream.

Kerswill, C.J. 1954. Annual production of smolts by typical streams and their utilization as adult salmon. Pages 112-116 *in* Hart, J.L. Fisheries Research Board of Canada. Report of the Atlantic Biological Station for 1954. (Appendix No. 58).

Smolts in the Pollett River were marked by removal of adipose fins until 1952, and by removing the adipose and both ventral fins from 1953 onwards. The numbers marked were: 13,190 smolts in 1950; 25,187 smolts in 1951; 26,297 smolts in 1952; 3,639 smolts in 1953; 23,751 smolts in 1954. Salmon marked as smolts in the Pollett River were caught in commercial fisheries off the Miramichi Bay, the north shore of Quebec, Newfoundland, Labrador, Chaleur Bay, the outer coast of Nova Scotia and the Bay of

Fundy. Details of locations and years are included in the paper. None were caught by anglers in the Miramichi or in "many other rivers both in the Maritime Provinces and Newfoundland".

Kerswill, C.J. 1957. Progress of smolt-marking experiments on five salmon rivers. Pages 128-130 *in* J.L. Hart. Fisheries Research Board of Canada, Biological Station, St. Andrews, N.B. Annual report and investigators' summaries, 1956. Covering the period November 1, 1955, to March 31, 1957. (Summary No. 58).

All smolts produced in experiments on the Pollett River since 1942 had been marked.

Year	No. of marked smolts
1950	13,190
1951	25,187
1952	26,297
1953	3,639
1954	23,751
1955	8,052
1956	4,897

No recapture data were presented in this report.

Kerswill, C.J. and P.F. Elson. 1963. Outline of Atlantic salmon investigations to 1962. Pages F-3 to F-13 *in* J.L. Hart. Fisheries Research Board of Canada. Biological Station, St. Andrews, N.B. Annual report and investigators' summaries, 1962-63. (Summary No. F-2).

The Pollett River was originally selected for studies on production of Atlantic salmon smolts because it offered a variety of available salmon habitats, which were inaccessible to salmon because of dams and falls. Lack of native salmon implied that the public would not be concerned by the experiment. The stream was accessible to humans compared to comparable reaches for most Maritime salmon streams.

Planting procedure to get best production of smolts under natural conditions was studied in 1942-1949. Production in the main river was 0.2-1.3 smolts/100 m^2 (0.2-1.1 smolts/100 yd^2), with bird predation seen as the limiting factor. Production in the tributaries was 4 smolts/100 m^2 (3.3 smolts/100 yd^2), with bird predation seen as unimportant. Despite the lower rates of production in the main river, total production was ≥ all tributaries combined because of greater surface area in the main river. Suitable planting rates for August hatchery fingerlings for a situation with normal natural predation were 12-24 underyearlings/100 m^2 (10-20 underyearlings/100 yd^2).

Smolt production was measured in 1947-1953 when kingfishers and mergansers were controlled, and increased by at least 5 times. Mergansers were the limiting factor.

The capacity of the area to produce smolts from hatchery stock was determined by planting numbers 1/4 and 4 times those used in the study of bird control in 1950-1956. Maximum rate of production of about 6 smolts/100 m^2 (5 smolts/100 yd^2) required about 42 August underyearlings/100 m^2 (35 August underyearlings/100 yd^2).

Amount of dispersal at time of planting to give best survival was studied for underyearlings in 1948-1953 and yearlings in 1957-1961. There was no difference in survival rate with wide dispersal vs. no dispersal at planting when fish were planted only in sufficient numbers to seed about 1.6 km (1 mile) of stream in both directions from the planting site. Underyearling stock were found not to effectively utilize stream areas more than about 1.6 km (1 mile) from the point of liberation. Similar survival rates to smolt were observed for underyearlings remaining 1.5 yr in the stream after planting as for yearlings remaining 0.5 yr.

The first Denil-type fishway in Canada was constructed in the Pollett River in 1950 (at the Sanatorium dam). From 1950 to 1960, the number of adult salmon for optimum smolt production was studied by introducing a known number of salmon into the experimental area above the fishway. When necessary, additional adults were seined and transported to the experimental area from other Petitcodiac streams. The observed maximum capacity for smolts was the same (6 smolts/100 m^2) (5 smolts/100 yd^2) as that using hatchery underyearlings. For this, ~12.7 kg of female salmon per km of stream 9.1 m wide (45 lb of female salmon per mile of stream 10 yd wide) were required, and up to 31.8 kg (70 lb) for streams with age 3 smolts.

The entire experimental area was measured for bottom type, gradient, and depth, so that habitat types where salmon and other fish were most abundant could be determined. Shallow gravel and cobble areas, especially riffle areas of these types, provided the most suitable habitat, with coarser types favouring the larger parr. Winter conditions, especially the occurrence of frazil and anchor ice, were suspected as a contributing factor to habitat values.

Migratory behaviour of hatchery-rearing smolts was studied from 1957-1960. A size prerequisite for early migration was defined. Liberation no later than mid-June was recommended.

Planting to supplement deficient native populations was judged to be successful in increasing the smolt run, based on experiments in 1956-1964. The value of this planting in terms of returning adults was still unevaluated.

Introduction of adult salmon to new areas was studied in 1961-1962 by trucking salmon to the upper Pollett River above Gordon Falls. Liberation at a holding pool was followed by extensive upward movement of 3/4 of the fish as indicated by spawning redds. Liberation in shallow swift water was followed by extensive downward movement of about 2/3 of the fish.

Returns from introduced and native stock were compared in 1950-1964. Returns to the river have been several times greater for native stocks than for earlier planted stock.

Pollett River investigations were expected to terminate in 1964. The work of the Fisheries Research Board was described as having developed the salmon resource "to quite an extent". Interest of anglers in the Moncton area was described as "rapidly growing".

Other work included observations in 1948 on the association of fish populations with the physical characteristics of a stream. This work was shelved in favour of studies on production of stocks. Smolt behaviour at dams was studied in 1958 and 1959. The experimental area contained 2 dams, over one of which smolts passed readily and another at which they were delayed in seasons of low water. Again, the work was discontinued before major results were obtained. The distribution of post-smolts at sea was studied since 1952 across the Bay of Fundy from the Petitcodiac, in the Hall's Harbour area. Preliminary analysis of catch records suggests a mixing of stocks from the Bay of Fundy-Gulf of Maine region in this area. Lastly, censusing operations in the Pollett River obtained information on interspecific interactions, especially between young salmon and speckled trout.

Lakshminarayana, J.S.S., H.J. O'Neill, S.D. Jonnavithula, D.A. Léger and P.H. Milburn. 1992. Impact of atrazine-bearing agricultural tile drainage discharge on planktonic drift of a natural stream. Environmental Pollution 76: 201-210.

An experiment on the effect of agricultural use of the herbicide atrazine on phytoplankton and zooplankton drift populations was conducted in a first-order tributary of Salt Spring Brook near Cornhill. Atrazine concentrations in the stream samples varied from less than detection limit (0.001 µg/L) to 1.89 µg/L. Widespread agricultural use of atrazine in the watershed resulted in presence of atrazine at the control sites. The water chemistry was influenced by gypsum shale in the study basin as evidenced by high concentrations of sulfate and calcium in the water samples. Various water quality data were summarized. At one site with considerable contribution of ground water to base flow, the specific conductance was consistently >1090 µS/cm.

The plankton drift community included 103 species of phytoplankton and 10 species of zooplankton. The drift included diatoms (76 species), green algae (18), flagellates (5) and bluegreens (5). The most common phytoplankton species were *Cocconeis placentula, Cyclotella meneghiniana, Fragilaria crotonensis, F. virescens, Aulacoseria granulata, Melosira varians, Navicula pupula, Pinnularia apendiculaa, Pinnularia borealis, Surirella linearis, Surirella ovulum, Surirella tenera, Synedra nana, Synedra ulna, Tabellaria fenestrata, Tebellaria flocculosa, Spirogyra* sp., *Trachelomonas dybowskii*. The zooplankton species were rare and represented by *Amoeba, Brachinesta paludosa, Bryocamptus, Chaoborus, Colpoda, Daphnia, Limnocalanus,* Nematoda, *Paramecium* and tintinnids.

Reduced numbers of species and cells occurred downstream of the tile drainage, when stream discharge was low. The tile drainage waters affected a 20 m section of the stream, based on changes in the resident biological community. No negative impacts were evident beyond 50 m downstream of the tile drainage and stream confluence.

Lawton, P. and D.A. Robichaud. 1998. Interim report on DFO fisheries monitoring in LFA 35 relative to a proposed trial opening of the Petitcodiac River causeway. Pages 90-97 *in* Environmental Monitoring Working Group. 1998. Environmental monitoring of the Petitcodiac River system, 1997: Trial opening of the Petitcodiac River causeway gates. December 1998. 280 p.

Landings data since 1989-1990 were collated by fishing season for 5 statistical districts bordering Chignecto Bay (SDA, with principal ports of landing were: 79 – Alma, 81 – Wood Point, 24 – Apple River, Joggins, 44 – Advocate Harbour, 40 – Scotts Bay). Catches in SDA 79 and 81 had increased since 1993. Historical catch records were not presented, but could be obtained for the former system of administrative units (Lobster Districts).

At-sea fishery monitoring was available for some upper Bay of Fundy ports. The longest local data series was for vessels fishing from Alma, which had been sampled since 1979. Since that time, there had been a dramatic shift in both catch and size distribution. In 1979, catch amounted to approximately 1 lobster/trap haul (548 lobsters/512 hauls); this had increased to 10 lobsters/trap haul (2,393 lobsters/238 hauls) in 1997. The sampled size distribution had become comparable to areas in the lower Bay of Fundy, which historically had size distributions with a strong weighting of recruiting size classes.

A new trap sampling program was introduced in spring 1997. Four fishermen from Advocate, Parrsboro and Alma recorded size distribution and sex of lobsters they captured in their commercial traps in June and July. These fishermen also fished experimental juvenile lobster traps to obtain information on pre-recruits.

Lawton, P. and D.A. Robichaud. 1999. Report of 1998 DFO fisheries monitoring in Lobster Fishing Area 35 relative to a proposed trial opening of the Petitcodiac River causeway. Pages 99-110 *in* Environmental Monitoring Working Group. Environmental Monitoring of the Petitcodiac River system: Petitcodiac River Trial Gate Opening Project. September 1999. 325 p.

Landings by statistical district were presented for 1957-1998. Catches had increased from 1980 onwards, especially for STD 79 (Alma) and 44 (Advocate Harbour). Overall, lobster catches in LFA 35 were at historic high levels since landings reports began.

The latest stock status report on the Bay of Fundy lobster fishery had noted dramatic shifts in the sampled size distribution in the upper Bay of Fundy. Average size had decreased, driven by an increased representation of sub-legal lobsters and lobsters in the first molt group in the fishery. Increased numbers of pre-recruit lobsters in the past few years suggest improved recruitment conditions in the upper Bay in the 1980s.

It was noted that the commercial fishery only "samples" lobsters that settled ≥5 years before the time of trapping, and commercial landings include only lobsters that settled 8-12 years before. Thus, signals of changing recruitment are considerably time-lagged.

Lawton, P., D.A. Robichaud and A. MacIntyre. 1998. Interim report on interviews with LFA 35 lobster fishermen regarding a proposed trial opening of the Petitcodiac River causeway. Pages 98-110 *in* Environmental Monitoring Working Group. 1998. Environmental monitoring of the Petitcodiac River system, 1997: Trial opening of the Petitcodiac River causeway gates. December 1998. 280 p.

Eleven fishermen were interviewed in January 1998. They stated that the aquatic environment of Chignecto Bay had changed, and that lobster catches had increased over the previous 20 years. There had been an increase in the areal extent of lobster fishing in the upper bay, which now supports significant catches above Grindstone Island. Net erosion of sediment had occurred between Alma and Hopewell Cape, with increased deposition further up the Petitcodiac River. Before the 1960s, traps set above Cape Enrage were filled with sediment, or unrecoverable from becoming anchored to the bottom. In the present day, there was little indication of sediment in the traps, and all electronic soundings indicated hard bottom. Fishermen from Alma also indicated that water clarity had improved compared to clarity 10-15 years earlier. Lobster traps that were formerly not visible until they broke the surface were currently usually visible in 1.5 m (5 ft) of water. One fisherman reported that during May 1997, when the causeway gates were partially opened for less than a day, a large slug of brown surface water took three days to pass by Hopewell Cape and was noticed as far down as Alma.

Fishermen were also concerned that toxins would leach from the dump sites below the causeway and be accumulated by lobsters.

Several fishermen had observed species not previously seen in the upper Bay, including whales, large sharks, basking sharks and sunfish. They suggested that the water temperature in the upper Bay might have changed.

Lobster fishing had become more profitable over the past 10 years, and this was attributed by some to improvements in fishing methods and by others to the increase in hard bottom lobster habitat which had extended the fishing grounds. It was also noted that increased production had occurred throughout the Bay of Fundy, paralleling high catches from Nova Scotia and the US portion of the Gulf of Maine. All fishermen agreed that, although the lobster catches had increased, the average size of lobster had dramatically decreased. Before the early 1990s, up to half of the catch was >1.4 kg (3 lb), but now the average lobster was in the 0.5 kg (1 lb) range. A lobster of >1.4 kg (3 lb) had become rare. The minimum carapace length of berried females was believed to be decreasing, and they had recently observed berried females which were below market size.

Fishermen, especially those fishing furthest up Chignecto Bay, had noticed a dramatic increase in the number of dogfish. This created a problem with using fresh bait in traps. One fisherman said that on one occasion he hauled his trap 15 min after it was set, and found 14 dogfish in the trap. The fishermen had also noted an increased number of seals in the upper Bay.

Several fishermen, who also held scallop licenses, noted that scallops seemed to be appearing further up into Chignecto Bay, but that scallop catches were on the decline. They attributed this to overfishing.

LeBlanc, A.R., A. St-Hilaire, T. Milligan, H. Dupuis and G. Bourgeois. 1999. Monitoring of turbidity in the Petitcodiac River in 1998. Pages 111-132 *in* Environmental Monitoring Working Group. Environmental Monitoring of the Petitcodiac River system: Petitcodiac River Trial Gate Opening Project. September 1999. 325 p.

Turbidity data were collected intermittently at three sites (headpond, river near downtown Moncton, river across from Stoney Creek) between April 17 and November 20 1998. The collection of data at the downtown Moncton site experienced technical difficulties because at times sediments covered the sensor.

Turbidity at the river stations reached maximum values of 3,355 NTU (Stoney Creek) and 3,296 NTU (Moncton), varying with the tides. The maximum for each tidal cycle was usually between 2,500 and 3,300 NTU (6.7 and 10.4 g/L respectively). Suspended sediment values in downtown Moncton on September 5 1998 varied from 0 g/L to 19.6 g/L, but maximum turbidity values did not correspond to maximum suspended sediment concentration.

Turbidity in the headpond did not exceed 1,000 NTU (3.2 g/L) except on April 17 and 26-29, and June 2-8. The maximum recorded turbidity was 2,087 NTU (10.9 g/L) on June 7 at 1600h.

Locke, A. 1999. Fish communities of the Petitcodiac River reservoir and tributaries: 1998 monitoring study. Pages 177-196 *in* Environmental Monitoring Working Group. 1999. Environmental monitoring of the Petitcodiac River system, 1998: Petitcodiac River Trial Gate Opening project. September 1999. 325 p.

At least four of the anadromous species historically present in the Petitcodiac system, alewife, blueback herring, rainbow smelt and sea lamprey, spawned in both 1997 and 1998. Low abundance of larvae of the first three species could be due either to a small spawning run or to advection of the larvae out of the reservoir by currents. Lampreys spawned in the Little and Pollett Rivers and Turtle Creek.

On May 20-22 1998, a total of 21,345 Atlantic salmon smolts were released in the Pollett River near Elgin. The smolts were age 1 hatchery stock of St. John River ancestry. Downstream migration was monitored by gillnetting and visual observations of jumping smolts, and an undetermined number of smolts appeared to have successfully migrated past the gates. The N.B. Department of Transportation operated the gates during the smolt migration in order to provide at least several hours a day of open gate passage.

Electrofishing results for juvenile Atlantic salmon surveys indicated that some natural spawning took place in the Pollett River in 1997, but data on 1998 spawning were not yet available. Juvenile abundances from the spawning runs of 1996 and 1997 were very low. Summer temperatures in the reservoir in both 1997 and 1998 exceeded the upper temperature limit of salmon and could delay adults attempting to return to the system.

White sucker was the dominant fish in the reservoir. The warm, shallow, weedy, muddy conditions were extremely favourable for this species, as well as for smallmouth bass, brown bullhead, and chain pickerel. Weedy nearshore habitats of the reservoir and Turtle Creek served as a nursery area for brown bullheads and smallmouth bass.

Gaspereau also used the reservoir as a nursery area. Gillnetting of adult gaspereau indicated that only alewives were present in the reservoir in May, although blueback herring were present below the gates. By mid-June, 88% of the adult gaspereau transiting the reservoir were blueback herring. Adult gaspereau disappeared from the system shortly after spawning. Schools of small gaspereau, believed to be age 1 juveniles, were observed in the main Petitcodiac and North Rivers during the summer.

White perch, banded killifish, American eels and a few juvenile (5-6 cm, probably age 0) tomcod were also present in the reservoir in August. The tomcod were found only at the sampling site closest to the causeway and were most likely carried through the fishway by reverse flow at high tides.

Locke, A. and G. Klassen. 1998. Ichthyoplankton and invertebrate zooplankton communities, and water physico-chemistry of the Petitcodiac headpond during the ice-free season, 1997. Pages 111-123 *in* Environmental Monitoring Working Group. 1998. Environmental monitoring of the Petitcodiac River system, 1997: Trial opening of the Petitcodiac River causeway gates. December 1998. 280p.

Ichthyoplankton, zooplankton, phytoplankton, temperature, salinity, irradiance, and water transparency were sampled from May to October 1997 at three stations in the headpond (between the causeway and Allison). Sampling bracketed a major flushing event due to a drawdown for construction at the causeway from May 31 to June 8.

Salinities in the headpond were generally fresh water. Maximum surface temperatures were 24-25ºC in August. Transparency of the water, as measured by Secchi depth, was low (0.5-1.2 m). Photosynthetically active radiation was rapidly attenuated in the first 0.5-1 m of the water column. Nutrients (silica, nitrogen, phosphorous) measured on August 8 were in the meso-eutrophic range.

The only fish larvae collected in plankton surveys were rainbow smelt (*Osmerus mordax*) and gaspereau (*Alosa* sp.). Abundance was low, even before the drawdown of May 31. The distribution of yolk-sac larvae indicated that spawning of both smelt and gaspereau took place upstream of the headpond.

Larvae and juveniles of brown bullhead (*Amiurus nebulosus*) and smallmouth bass (*Micropterus dolomieui*) were observed in high abundance among the macrophytes near shore. These opportunistic species are well known for their ability to invade newly established reservoirs.

The invertebrates collected in the plankton nets were a mixture of planktonic, benthic and terrestrial taxa. The major taxonomic groups typical of the plankton of freshwater lakes (calanoid and cyclopoid copepods, cladocerans and rotifers) were all present in the headpond but in atypical proportions, low numbers, and low species diversity. Composition was highly skewed toward small species with fast reproductive rates (which, incidentally, would also be poor prey organisms for fish). Given the low densities of planktivorous larval fishes, predation was probably not the cause of the low numbers of large zooplankters. By far the dominant group was the rotifers, which were unusually abundant. Many zooplankton were probably removed from the headpond as a result of the drawdown, and the community which developed throughout the summer was the result of recolonization.

Another feature of the zooplankton community was the presence of estuarine and brackish-water species, instead of the freshwater species that were expected. There were no freshwater calanoid copepods. The estuarine copepod *Eurytemora affinis* had clearly established a viable population in the headpond.

Overall, the zooplankton was typical of a disturbed, unstable system. The community was composed mainly of opportunistic taxa, with highly skewed numerical representation. It was considered unlikely that the plankton community of the headpond would ever reach a stable condition, given the ongoing advection even in the absence of drawdowns.

Lynch, D.K. 1982. Tidal bores. Scientific American 247(4): 146-157. October, 1982.

The physics of tidal bores were discussed, and the Petitcodiac River bore was described as the "most striking" in North America [the author placed it in Nova Scotia in the text, but got it right on the map]. Precisely how many rivers had bores was not known. A list of 32 bores was presented, and it was estimated that a list currently being compiled by the author would eventually include about twice as many. Thus the worldwide total was expected to be ~64 tidal bores. Only two were mentioned for Canada (Petitcodiac River; Salmon River, Truro). The only other tidal bores listed in North America were in Alaska. A diagram shows the increase in water depth associated with the arrival of the Petitcodiac bore in Moncton.

McCrea, J.H. 1975. Study of Petitcodiac River estuary. B.Sc. (Engineering) senior report, Department of Civil Engineering, University of New Brunswick, Fredericton, NB. April, 1975. 69 p.

Data related to the "present regime" of the estuary are summarized. These included climate, geological setting, vegetation, drainage area, discharge, and ice.

Channel pattern was described from aerial photographs of the low water channel, taken in 1970. The short reach of the estuary near Moncton exhibited a pattern of confined meanders from the causeway to just below Outhouse Point, where the channel straightened out and ceased to meander. It was speculated that the change in pattern was caused by a possible change in the slope of the river bed near Outhouse Point.

Cross-sections of the estuary were used to obtain data used to calculate the tidal prism. The most recent chart, from which 24 cross-sections were measured, was Canadian Hydrographic Service Hydrographic Chart No. 4130, for which the survey work was done in 1861. The tidal prism was calculated as 4.6×10^9 m^3 (16.1×10^{10} ft^3). This estimate was believed to be accurate within 20%.

The average tidal discharge was estimated to be 21 times the freshwater discharge in the upper reach of the estuary.

Factors involved in the formation of the tidal bore were discussed. The combination of high tides in the Bay of Fundy and the change in slope at Stoney Creek formed the Petitcodiac bore.

Subsurface sediments were discussed using bore hole records from a 1964 preliminary survey for the Moncton city water line, which was to be tunnelled under the river about 3 km (2 miles) upstream of the causeway.

Suspended sediments were collected over a tidal cycle at the Gunningsville Bridge on October 12 1974. Suspended sediment increased from 3,010 ppm just before arrival of the bore to 27,500 ppm after the bore. Samples of up to 51,700 ppm suspended sediment were collected. Mean sediment content was 22,800 ppm, or ~2% by weight of the water.

By 1974, the tidal flats had built up by ~6.1 m, compared to the hydrographic chart levels. The width and location of the low water channel had also changed, mainly since the construction of the causeway. The low water channel at the Gunningsville Bridge was ~76.2 m wide. The ultimate width at the causeway would probably be determined by freshwater discharge. Before construction of the causeway, tidal waters would have determined the width of the river up to 16 km above the causeway location.

MacEachern, N. 1965. Anadromous fish affected by the proposed Moncton causeway on the Petitcodiac River. Memo to C.P. Ruggles. Fisheries Service, Department of the Environment, Canada. December 15 1965. 3 p.

"The proposed causeway on the Petitcodiac River at Moncton will affect the following runs of anadromous fish: salmon, shad, sea run trout, smelt, alewives, striped bass, eels and lampreys."

Salmon was the most economically valuable species likely to be affected. As the main run of fish did not move into the tributaries until October or November, angling was usually restricted to the main river. Some fish arrived in the main river in June and early July, and these could be angled in tributaries in years with favourable water conditions. "Black salmon" fishing was carried out in the main river and tributaries in spring.

There was no "accurate" assessment of the size of the salmon run but "a fair estimate" was made from the following information. The average commercial catch over a 6-yr period was 2,061 kg (4,540 lb) with a peak year of 4,540 kg (10,000 lb). Angling catches from 1956-1965 ranged from 18 to 206 with an average of about 100 fish. An electrofishing survey of Turtle Creek indicated a potential run of 200 to 700 adults. Trap counts of salmon at a fishway on the Pollett River combined with seining below the structure indicated average runs of 200 fish with peak years of up to 750 fish. Most of the Pollett River salmon run consisted of grilse. Seining of age 1 parr on the Coverdale River and the main Petitcodiac River by the Fisheries Research Board caught up to 200 fish. From this information, MacEachern estimated that the salmon run in an average year was about 2,000 fish, with double this amount in peak years.

Shad entered the main river to spawn during May and June. They were fished commercially below Moncton by drift net and stake nets. The average catch for a 6-yr period was 11,804 kg (26,000 lb) with a value of $2,600. The peak year during this period was >27,240 kg (60,000 lb). There was a small angling fishery on fish entering fresh water, which was expected to increase in future.

The tributary streams provide "excellent speckled trout fishing in the spring". Large trout taken on the main river were referred to as "sea trout" but MacEachern was unable to corroborate their origin.

There was no commercial fishery on the smelt run which entered in April and May, but local residents harvested a "small portion" of the run.

A small run of alewives was reported to spawn in the Anagance River. There was no local exploitation of this run.

Striped bass were angled during summer and fall. The run fluctuated from year to year, and the fish taken were small. "As the spawning season would be around June, the runs exploited by the anglers are probably on a feeding migration".

The need for fishway and fish counting facilities, and attraction water to lead fish to the fishway entrance, was noted. Facilities for fish passage would be needed from April to December. In addition to upstream facilities, provision would be needed to allow spent fish and progeny of the spawning runs to reach salt water. Salmon smolts would migrate to sea in May and part of June. Juvenile shad would move downriver during summer and fall. It would be necessary to provide a surface discharge to allow these seaward migrating fish to descend past the causeway.

The creation of an artificial lake was expected to benefit some fish and adversely affect others. It might provide additional spawning and rearing areas for gaspereau. It might improve trout angling, by deterring the sea trout from moving to salt water. Predator and coarse fish now present in the system "will tend to increase in this new environment". The pond effect might delay seaward migration of salmon smolts, which would be subjected to this additional predation in the pond.

McEachreon, J. C. T. 1991. Electrofishing spot check report-Jonathan Creek and Somers Creek (Petitcodiac River System; Westmorland County, New Brunswick). Acadia Consultants and Inspectors Ltd., Moncton, NB. Report to Department of Fisheries and Oceans, Halifax, NS. November 19 1991. 21 p.

Baseline data for the Environmental Impact Assessment of the proposed Westmorland/Albert Integrated Waste Management Facility were collected in Jonathan Creek and Somers Creek. Jonathan Creek was located in the path of a proposed access road. Somers Creek had a tributary adjacent to the sites' proposed sedimentation and leachate collection ponds.

Two stations on each creek were electrofished on September 19 1991. Barrier nets were not used. Stream habitat characteristics (temperature, depths, average velocity based on visual estimates of stream bed area covered with gravel, in-stream cover, degree of bank stabilization, pool types, % of pools present) were measured and habitat suitability ratings were assigned. Species, numbers and size of fish were recorded.

Common shiners (*Notropis corautic*) [?], bridle shiners (*Notropis loifrenatus*) [?], fallfish (*Semotilus corporalis*) [?], white suckers (*Catostomus commersoni*), blacknose dace (*Rhinichthys atratulus*) and threespine sticklebacks (*Gasterosteus aculeatus*) were recorded as common to both Jonathan and Somers Creeks. American eels (*Anguilla rostrata*) were found in Somers Creek. Brook trout (*Salvelinus fontinalis*) were found at both stations in Jonathan Creek.

Neither creek had ideal trout habitat for all life stages, although Jonathan Creek probably contained better habitat on average. Portions of Jonathan Creek contained gravel areas that might be suitable for trout spawning, but in general the creek sections examined were more suitable as rearing areas. The quality of Jonathan Creek was reduced by industrial and residential developments on the lower reaches. Beaver dams probably restricted the upstream movement of trout released at Centennial Park for recreational fishing. The Somers Creek sites were less appropriate for trout rearing, but previous observations in April-May had located some suitable feeding areas for juvenile and adult trout downstream of the sampling sites. The stream bottom below Delong Drive was dominated by silt and scored as a 0 as spawning habitat. Green algal mats were also common in that area. On Somers Creek, improper wood cutting practices and the lack of a buffer strip posed a threat to fish habitat.

The best fish habitat was in Jonathan Creek and it was recommended that protection measures be implemented in this area. In the event that the Solid Waste Provisional Commission decided on the Berry Mills Road site through which a part of Somers Creek flowed, long-term monitoring was recommended for this creek to ensure that the landfill would not contribute to fish habitat loss.

McLeod, C.L. 1972. Report on the 1970 fishway evaluation studies - Petitcodiac River Causeway. Unpublished report. Canada Department of the Environment, Resource Development Branch, Maritimes Region. February 1972. 11 p.

The fishway trap at the Petitcodiac causeway was operated from September 11 to December 4 1970. The total number of salmon counted through the fishway in 1970 was 345 fish. All salmon were marked with a Carlin disc tag, measured for length and a scale sample taken for age determination. The first fish entered the trap on September 11 and the last fish was recorded on November 24. Bimonthly counts were:

Date	Number of salmon	
	1970	1969
Up to Sept. 15	19	1
Sept. 16-30	57	14
Oct. 1-15	148	16
Oct. 16-31	84	21
Nov. 1-15	27	56
Nov. 16-30	10	22
Dec. 1-15	0	1
TOTAL	345	131

Arrangements were made with the NB Department of Highways to operate the causeway gates so as to provide better attraction water for fish moving up the estuary. The gates were fully opened for short periods at high tides, when a height differential of 0.3-0.6 m (1-2 ft) was reached between the reservoir level and the incoming tide level. The gates were not to be fully opened at low tides. This mode of operation resulted in a 60% increase in water release frequency, although the volume of water released was probably not affected.

Month	Number of water releases	
	1970	1969
Sept.	12	8
Oct.	26	9
Nov.	20	19
TOTAL	58	36

The timing of entry of fish to the fishway was more uniform in 1970 than in 1969, as expected given that the velocity and individual volumes of water spilled by the control gates were more closely regulated. Returns were equally distributed between high and low tide periods. This indicated an improvement in approach conditions to the fishway.

Tidal stage	% of returns to fishway	
	1970	1969
High tide ± 3 hr	49	66
Low tide ± 3 hr	51	34

Mean number of fish captured in the fishway during the period of high tide was significantly (P=0.01) correlated with mean volume of water released (r=0.98, df=3). This suggested that an increase in water flow was associated with an increase in the numbers of fish in the fishway. There was no significant correlation of fish numbers with water volume released for the low tide period (r=-0.33, df=3, P=0.70).

Examination of fish numbers in the fishway at four tidal periods indicated that the salmon moved into the vicinity of the causeway on the incoming tide.

	Fish captured on:			
	Incoming tide (3 hr before high tide)	High tide ± 1 hr	Outgoing tide (3 hr after high tide)	Low tide
No. of fish	17	31	34	86
% of total	10.1	18.5	20.2	51.2

Since the rising tide drowns out the flow of attraction water through the fishway, fish may tend to delay behind the causeway until the receding tide decreases its influence on fishway flows. Over 70% of the salmon moved through the fishway during the periods of ebb or low tide.

It was concluded that the revised flow patterns from changes in gate operation in 1970 “obviously improved approach and passage conditions” for fish which had already arrived at the causeway. However, there was no strong evidence that the revised flows improved attraction of fish from the estuary. The timing of fish arrivals at the causeway was not dependent on the number of days since water releases.

Experiments were carried out to further monitor fish movements through the fishway or open gates, especially to investigate possible delays. Drift netting was carried out in the river estuary from September 15 to October 30, and all 7 salmon that were captured were marked and released. Six of these were tagged with Carlin tags, and 1 with an ultrasonic transmitter inserted in the stomach. None of these fish were subsequently recovered at the causeway. Two groups of salmon were tagged at the fishway and placed downstream. Only 8 of 75 fish (10.7%) marked with Carlin tags were recaptured in the fishway. The time for them to return to the fishway ranged from 1 to 28 days. It was not possible to determine if any of the tagged fish entered the headpond via open control gates. Only 3 of 25 ultrasonically tagged fish (12%) were recaptured - 2 in the fishway and 1 tracked by sonic receivers as it moved through the open gates during one of the scheduled water releases. It was suggested that passage opportunities could be improved by timing the flow releases from the gates to coincide with the falling rather than the rising tide.

A high proportion of grilse were recorded in 1970 (95% in 1970, but only 18% in 1969). Mean fork length was 49.9 cm. Over 80% of the grilse had migrated as age 2 smolts. The remainder smolted at age 3. All of the multi-sea-winter salmon had also smolted at age 2 or 3.

Electrofishing of juvenile salmon during July 16-25 indicated that the Coverdale River was the most important spawning and rearing area. Six sites were sampled using barrier nets on the Coverdale River, and 6 sites without barrier nets on the other streams.

River (No. of sites)	No. of juveniles /100 m^2 (no./100 yd^2)					
	Fry (age 0)		Parr (age 1)		Parr (age 2)	
	1970	1969	1970	1969	1970	1969
Main stem (2)	0	Trace	0	0	0	1
Coverdale R. (6)	8.4 (7)	7.2 (6)	7	23	10	2
Pollett R. (2, 1)	0	Trace	0	2	Trace	1
North R. (2)	0	0	0	1	0	trace

Size characteristics of the 1970 juvenile population were:

	Mean fork length (mm)	Mean weight (g)
Age 0	39.0	0.7
Age 1	80.3	7.6
Age 2	100.6	14.1

McLeod, C.L. 1972. Petitcodiac River causeway evaluation - report on the 1971 study. Canada Department of the Environment, Resource Development Branch, Maritimes Region. Unpublished report, 12 p.

<No abstract.>

McLeod, C. 1973. Petitcodiac River system: An outline of potential for Atlantic salmon development in the Pollett River tributary. Unpublished manuscript. Canada Department of the Environment, Resource Development Branch, Fish Habitat Protection Section. March 1973. 17 p.

Fish passage problems on tributary rivers of the Petitcodiac system were examined. “It is obvious that to maintain the salmon population at anything resembling pre-causeway levels (estimated 1,500-3,000 fish annually) all available spawning and rearing areas within the system must be utilized.” Only the Coverdale River, Turtle Creek and Pollett River had any significant spawning and rearing areas for Atlantic salmon.

The Coverdale River historically produced a majority of salmon in the system. There were no major obstructions and salmon used the stream extensively, even the headwaters and many feeder branches. Of the total 50 km (31 miles) of river, ~40 km (25 miles) were productive salmon habitat in the early 1800s through 1940s, and ≥40 km (25 miles) in 1970 and 1973.

In the past, Turtle Creek contributed significantly to the salmon resource, but the construction of the municipal water supply dam in 1964 blocked fish access ~10 km (6 miles) above the river mouth. Of the 43 km (27 miles) of river, in >32 km (20 miles) were productive salmon habitat in the early 1800s and the 1940s, but only 3 km (2 miles) were available to salmon in 1970 and 1973.

The Pollett River, the largest tributary of the Petitcodiac system, had not been a significant salmon producing stream "for many years", due to several dams. Twenty-nine of the 58 km (18 of 36 miles) of river were available to salmon in the early 1800s but only 10 km (6 miles) in the 1940s and 1970. Twenty-nine km (18 miles) were again accessible in 1973, from the mouth of the river up to Gordon Falls, which was a barrier to the upstream movement of most fish.

For over 150 years, a dam at km 16 (mile 10), near the town of Pollett River (Forest Glen) was a total barrier to fish movement. Negotiations undertaken by the Department of Fisheries and Forestry resulted in removal of the dam in 1970. A dam which existed for many years near Elgin, ~0.8 km (0.5 mile) below the falls, was destroyed by floods in 1948. A concrete and earth dam near The Glades, providing a 1.6 km (1 mile)-long water supply lake for the Jordan Memorial Sanatorium, was located at km 10 (mile 6) and was the most serious obstacle. The dam was built without a fishway in 1910. A fishway was installed between 1930 and 1935, but soon washed away in a flood. No other provision for fish passage was provided until 1950 when the Fisheries Research Board installed a Denil-type fish pass. A flood destroyed this structure in 1970. A replacement fishway was constructed, but the entrance elevation was 0.5 m (1.66 ft) too high and very few fish were able to pass the dam. The New Brunswick Department of Public Works, owner of the dam, agreed to remove the dam in the spring of 1973.

The salmon rearing area in the Pollett River had not been surveyed, but area was estimated from Fisheries Research Board studies. In the 16 km (10 mile) experimental area between the Sanatorium Dam and Elgin, Elson calculated a total of 363,660 m^2 (435,000 yd^2) available for salmon production under normal summer low flow conditions. The 10 km (6 miles) of river below the Sanatorium dam, with similar flow patterns and bottom type, were estimated to contain 83,600-167,200 m^2 (100,000-200,000 yd^2) of productive area. On the same basis, the 16 km (10 miles) of main river and 13-14 km (8-9 miles) of headwater tributaries above Gordon Falls should contain 334,400-418,000 m^2 (400,000-500,000 yd^2) of area. Elson classed the Pollett River as a moderately productive stream capable of producing 1.2 smolt/100 m^2 (1 smolt/100 yd^2) with no predator control.

Salmon angling on the Pollett River was usually confined to pools near the mouth. The angling season was June 1-September 30 until 1967.

Counts of salmon at the Sanatorium fishway were discontinued after completion of the experimental work in 1963 and were not resumed until 1972. Although a few salmon still entered pools at the mouth of the river, none moved past the Sanatorium dam in 1972. The "recent decline" in the salmon population of the Pollett River was linked to several events, (1) the completion of the Moncton-Riverview causeway and consequent reduction and delay in migrating salmon, and (2) the incorrect rebuilding of the fishway at the Sanatorium dam. Electrofishing in 1971 and 1972 failed to locate any juvenile salmon at sites along the river, suggesting minimal success in migration of spawners past the dam.

Other species of fish in the Pollett River included speckled trout, eels, and several minnow species. Trout fishermen had "fair success" on portions of the headwater and tributary streams. A "small number" of alewives migrated up the Pollett River in the period prior to 1968. "None have been reported in the Pollett River during recent years".

Removal of dams on the Pollett in 1970 and 1973 allowed access to ≥332,775 m^2 (435,000 yd^2) of rearing area. "Because of recent environmental changes and a new obstruction on the main stem of the Petitcodiac River, the native salmon population of the Pollett River seems to be almost extinct... it does not seem likely that natural re-population of the Pollett River can succeed." Re-establishment of the run through hatchery stocking was recommended. It was further suggested that provision of a fishway at Gordon Falls would provide access to considerably more habitat.

Maritime Marshland Rehabilitation Adminstration. 1961. Petitcodiac River causeway survey report. Unpublished report. Maritime Marshland Rehabilitation Administration, Canadian Department of Agriculture, Amherst, NS. March 30 1961. 20 p.

Three sites were considered for the causeway location: Site #1 – approximately 2.8 km (1.75 miles) below the Gunningsville Bridge; Site #2 – 1.2 km (1 mile) above the Gunningsville Bridge; Site #3 – 3.2 km (2 miles) above the Gunningsville Bridge.

The City of Moncton and the New Brunswick Department of Public Works had indicated site #1 [near Bore Park] as a preferred location. Disadvantages of this location were the difficulty and cost of (1) extending sewage and storm runoff systems through the causeway in order to maintain minimum flows of 50 parts water to 1 part sewage, (2) providing a regulated canal lock and lift span for shipping to Moncton. The combined cost of these two items was $14 million.

Site #2 would have involved an extension of Commercial Street. At this site, the sewage problem would be "virtually eliminated" and alterations to existing port facilities would be minor. The disadvantages of the location were (1) its proximity to the existing bridge, which would be exposed to high velocity flows, (2) a large low-lying section of downtown Moncton would not be protected from flooding by the structure, (3) traffic congestion.

Site #3 [near the present location of the causeway] had the same advantages as site #2 with respect to sewage and shipping. Also, the Urban Renewal Survey of the City of Moncton had recommended an upper river crossing. This site would not afford any protection to the low-lying lands downriver.

The anticipated benefits of a causeway were: (1) river bank scour below the causeway would disappear or become so minor that corrective measures would be economical, (2) additional river crossing structures would become much simpler to construct, because any work above the causeway would be carried out in a controllable level "lake", and river flows below the causeway "would be greatly subdued".

It was recommended that the reservoir water level be maintained at ~+4.6 m (+15 ft) geodetic elevation. This would be ~2.1 m (7 ft) below average marsh elevation and 9.1 m (30 ft) above river bottom in the vicinity of the Gunningsville Bridge. The number of minutes per tidal cycle that the tide would be higher than the reservoir level was tabulated for various tidal amplitudes and geodetic reservoir elevations:

Reservoir geodetic elevation, m (ft)	Tide		Duration (min) that tide is higher than reservoir by:	
	Amplitude, m (ft)	% of tides >amplitude	0.3 m (1 ft)	0.6 m (2 ft)
+3 (+10.0)	4.9 (16)	90%		192.5
	6.1 (20)	50%	234.2	219.8
	7.3 (24)	10%	259.3	248.0
+4.6 (+15.0)	4.9 (16)	90%	0	0
	6.1 (20)	50%	152.4	131.5
	7.3 (24)	10%	199.4	187.6
+5.5 (+18.0)	4.9 (16)	90%	0	0
	6.1 (20)	50%	74.4	0
	7.3 (24)	10%	155.8	138.8

The feasibility of using the reservoir above the causeway as a water supply for Moncton was considered, but rejected on the grounds that the fish passage requirement stated by Canada Department of Fisheries would allow entrance of salt water. Even without the fish passage requirement, it would be difficult to waterproof the barrier sufficiently to exclude all salt water. It was suggested that a second dam (with an overflow spillway and a fish ladder) be constructed 13 km (8 miles) above the Gunningsville Bridge. Such a dam would create a storage capacity of 1.4-2 x 10^6 m^3 (50-70 x 10^6 ft^3) at a reservoir elevation of 4.6-5.2 m (15-17 ft).

Predictions were made as to future siltation. A causeway at site #1 would result in considerable narrowing of the river channel for ≥1.6 km ("a mile or more") downstream. "The zone of greatest build-up would be from the downstream toe of the causeway fill to the junction point of the excavated sluice channel. This would involve ~107 m (350 ft) of river length. This area could build almost completely to marsh level in 15 to 20 years. The sewer outlets would be practically clear of silt and new channels would be formed to carry the flows to the main river". River narrowing would occur by bank build-up of silt. The river bottom in the channel "would build up to some extent seasonally as at present." The maximum seasonal buildup in the channel bottom was expected to be 1.8 m (6 ft). A causeway at either site #1 or site #2 would result in the same situation "in their immediate vicinity. Changes farther down the river would be less significant. The combined sewer and run-off outlets would aid in keeping the river clean." It was further noted that, in the event that bank build-up was excessive on the Moncton side of the river near the existing Irving Oil Company wharf, "a minor extension with rock over the silt would permit the relocation of the wharf closer to the channel".

A list of 18 marshes, 14 of them currently protected by dykes, and the acreage that could be "reclaimed" by the building of a causeway, was tabulated. A map of the marshlands was also included.

Site	Marshland area (ha) (acres) upstream of site		
	Dyked	Not dyked	Total
1	516.8 (1,292)	369.2 (923)	886.0 (2,215)
2	455.6 (1,139)	189.2 (473)	644.8 (1,612)
3	448.4 (1,121)	138.8 (347)	587.2 (1,468)

Miles, H.S. 1894. Report on the fisheries of district no. 3 of New Brunswick, comprising the counties of Victoria, Carleton, York, Sunbury, Queen's, King's, St. John and Albert, for the year 1893, by Inspector H.S. Miles. Pages 183-185 *in* Annual Report of the Department of Marine and Fisheries. April 1 1894. 348 p.

In Albert County, there was a decrease in catch of all kinds of fish except salmon in 1893. This was attributed to sawdust and other sawmill refuse, which was dumped into the streams in contravention of the Sawdust Act. This effluent had "a very injurious effect on the feeding grounds of the fish, and thus destroying the shad fishery in the bay".

Mitchell, D. G. 1968. Report on tidal measurements in the Petitcodiac River, 1968. Marine Science Branch, Ottawa, Canada, 41p.

Soon after the construction of the Petitcodiac causeway, a study was conducted on the tidal propagation in the Petitcodiac River. Original plans for the study had been to install tide recorders from Hillsborough to Boundary Creek, but discovery of the causeway upon the arrival of the researchers in Moncton necessitated a change of plans. Recording gauges were operated at Belliveau village wharf, Dover wharf, the Irving Oil Refinery just below Halls Creek in Dieppe, and at the causeway, from July 12 or 13 to July 30, 1968.

Detailed data are presented regarding water heights. Tidal bore arrival times and the height of tides are tabulated for Dieppe and the causeway. High water times and heights were compared with those in Saint John. Hourly heights are also tabulated at Belliveau Village, Dover, Dieppe, and Moncton (at the causeway) for certain days in July 1968.

An attempt was made to measure the cross-section of the channel between Dieppe and Dover at low water. The deepest section obtained was 1.1 m (3.5 ft), ~100 m (a few hundred ft) below the Dieppe gauging site. The usual width of this section was ~91 m (300 ft) and its usual depth ranged from 0.3 to 0.5 m (1 to 1.5 ft) close to the west shore, tapering to nothing on the east shore. They encountered a swift current (2.6-3.6 m/sec) (5-7 knots) and large boulders (0.6-1.5 m) (2-5 ft) in diameter) at Mud Creek. The channel crossed the river to the east side between Mud Creek and Lower Coverdale and at the eastern end of this crossing were three rapids. After crossing the second rapids they found less than 15 cm (6 in) of water and had to haul their 3.7 m (12 ft) aluminum boat ashore at Upper Dover. They waited there for the bore to arrive before travelling back up to Dieppe.

Specific gravity measurements of 1.040 were obtained at low water from the causeway to Upper Dover. This value was thought to be due to silt rather than the salt content of the water, since some of these measurements were taken in freshwater runoff through the sluice gate at the causeway. "It was impossible to see anything submerged 5 cm (2 in) in the water". Specific gravity in the same area at high water averaged 1.011. Near Belliveau Village and Dover, an average value of 1.022 was observed at high water.

Despite reports by ship masters concerning shifts in the channel which was thought to be caused by silt deposits, it was concluded that there were no changes in the tidal range and that the previous formula used to predict the arrival of the tidal bore was still adequate.

Montreal Engineering Company, Ltd. 1969. Moncton study area. Pages 1-1 to 4-5 *in* Maritime provinces water resources study, stage 1. Volume 3, New Brunswick. Book 2. Report #4, ADB-1675-2. For Atlantic Development Board. January, 1969.

Results for the "Moncton study area" were discussed. The Petitcodiac headpond was described as a "source of potable water…even if full treatment is required." It was also described as affording "excellent opportunities for water based recreational developments". It was noted that pollution of the Petitcodiac adjacent to Moncton would intensify due to reduction in the river's flushing of effluents, a consequence of the causeway's reduction of the river's tidal action. "The same effect is causing rapid silting in the river downstream of the causeway which is causing navigational problems for ships serving Moncton."

The main species of fish found in the Petitcodiac River near Moncton were considered to be Atlantic salmon, speckled trout and striped bass. Angling catches of salmon had been increasing for the previous 16 years and the average catch/rod-day had reached 0.27 fish.

Angling records of salmon for Turtle Creek were started after construction of the water supply dam, "and since that time catches of salmon have steadily dropped." It was estimated that 100-500 salmon had entered the upper reaches of Turtle Creek for spawning before dam construction. Juvenile salmon continued to be reared in the area above the dam through continued annual stocking by the Department of Fisheries.

"The Petitcodiac River Causeway recently constructed just upstream of Moncton allows the passage of the salmon by means of a fish ladder. Natural migration of the fish should therefore be little affected by the structure although it is possible that the abrupt change from saline to freshwater and the change in water temperature might affect the movement of fish." There was concern that reduced tidal flushing might allow the level of pollution in the river to "rise to such an extent to preclude fish even reaching the causeway".

The headpond was described as a "major recreational resource…a large body of freshwater suitable for most aquatic activities." Later in the report it was suggested that this non-tidal water would be suitable for log-storage for a hypothetical future pulp and paper mill.

Wharf facilities at Moncton were used primarily by oil barges which entered from the Bay of Fundy on the high tide. They had to rest on the bottom at low tide. "It has been found that silting of the river has been very rapid since the closure of the causeway and that the available draft in the river has already been reduced by as much as [1.5 m] five feet." Silting had resulted in "formation of mud banks in the region of the city which are left uncovered at times of low tide. Effluent from the existing sewers is therefore discharged over these mud banks where it remains an unsightly and obnoxious covering until flushed by the next tide."

Sewage from the small communities upstream of the causeway, especially Salisbury and Petitcodiac, was noted as a potential problem in the headpond. "Unless this potential pollution is controlled at its source, it is possible that during times of low river flows in the summer stagnation will occur in the reservoir which would detract from its recreational value."

Municipal and industrial waste discharges to the Petitcodiac River were listed.

The main water quality problem identified in the upper Petitcodiac River was turbidity. Values at Salisbury ranged from 0.7 to 460 turbidity units. Colour ranged from 15-35 Hazen units. Colour and turbidity levels were expected to decrease in the headpond. The water was slightly alkaline. Hardness ranged from 18-83.4 ppm at Salisbury. One analysis at Petitcodiac had a total dissolved solids level >500 ppm, which was usually the limit for potable water.

A single Turtle Creek sample was alkaline, slightly corrosive, and generally low in colour, hardness, turbidity and total dissolved solids.

"Most surface waters in the area, where not affected by pollution are expected to be of reasonably good chemical quality".

Montreal Engineering Company, Ltd. 1969. Petitcodiac River basin. Pages 1-1 to 4-3 *in* Maritime provinces water resources study, stage 1. Volume 3, New Brunswick. Book 3. Report #5, ADB-1675-2. For Atlantic Development Board. January, 1969.

"Problems and opportunities in the Basin tend to be orientated toward the recently constructed Moncton causeway reservoir. The potential benefits of the reservoir for water supply and recreational use are offset by the reduction in tidal displacements which has led to increased siltation and pollution downstream of the causeway in the vicinity of Moncton. Pollution upstream of the causeway, which could negate some of the benefits, is cause for concern as is the effect of the causeway on the fisheries resource."

The Petitcodiac River basin was described as second to the Saint John River basin as the most densely populated river basin in New Brunswick.

Sport fishing in the freshwater system was estimated as 82-670 Atlantic salmon, 2,000-4,000 speckled trout, and an undetermined number of shad annually. No striped bass were recorded as having been angled after 1954. The total annual number of salmon prior to the causeway completion was estimated at 2,000-3,000.

"Speckled trout, including some sea-run specimens, are present in all branches of the river and are the subject of a considerable angling fishery, especially in May."

"Serious pollution has occurred" at Moncton. Most sewer outfalls discharged untreated domestic and industrial wastes directly into the river, mainly downstream of the causeway. Upstream of the causeway, the major sources of pollution were Salisbury and Petitcodiac. Sewage wastes from Salisbury were discharged untreated into the Petitcodiac River. At Petitcodiac, 70% of the buildings were connected to a sewer system, and wastes "undergo lagooning treatment" before discharge into the river. A dairy at Petitcodiac was reported as a major source of pollution.

"As an indication of the degree of pollution a serious fish kill took place in August 1966 when an estimated 100 salmon were found dead in the river at Salisbury near the head of the tide. Silt, high temperatures and lack of dissolved oxygen were believed to be the cause. The Moncton causeway may accentuate the pollution problem due to stagnation in the reservoir behind the causeway and especially downstream due to the reduction of estuarial tidal volumes."

A list of 14 dams on the Petitcodiac watershed indicated that only 2 had fish passage facilities (the causeway, and the Sanatorium dam). Most of the affected rivers had only one dam, but several had two. The dams were located on the main Petitcodiac (the causeway), Turtle Creek (water reservoir), North Halls Creek (2 former water reservoirs), Jonathan Creek (Jones Lake and Berry Mills), Mill Creek, Lake Brook (Mechanics Lake), Bennett Brook, Robinson Brook, Gordon Brook, Anagance River, and Pollett River (Sanatorium and Pollett River).

"Although fish passage facilities have been provided in the causeway, several questions have been raised regarding the conservation of anadromous runs in the Petitcodiac Basin, especially as efforts were made in 1950 to increase the runs by the removal of several dams in the lower reaches of most tributaries. Because of the rather abrupt transition from saline to freshwater at the causeway, upstream and downstream movements of the fish could be delayed. Other possible hazards to fish include higher water temperatures and increased pollution in the headpond, salt water stagnation and the elimination of the striped bass spawning grounds."

Murphy, O. 1993. Briefing note for the regional Director General. Canada Department of Fisheries and Oceans, Halifax, NS. December 13 1993. 3 p.

This briefing responds to concerns of the Alma Fisherman's Association regarding long-term opening of the Moncton-Riverview causeway gates. The Association was concerned that such an opening would negatively affect the lobster and scallop resources in Chignecto Bay due to sedimentation. DFO's data suggested that increasing trends in lobster and scallop landings in Chignecto Bay since construction of the causeway were due to general stock recruitment patterns throughout the Scotia-Fundy Region rather than being a consequence of the causeway. A recruitment pulse of two strong scallop year-classes in the Bay of Fundy in the 1980s occurred concurrently with the increased landings, and resulted in increased fishing effort. The predicted effect of opening one gate would be to increase sedimentation in the headpond rather than downstream, with no significant impact on the distribution or concentration of fine-grained sediment in Chignecto Bay (defined as beyond Mary's Point) in the event of free flow in the river.

Naegel, A.S., and J. Harvey. 1998. A closer look: The Petitcodiac River. Pages 29-33 *in* Harvey, J., D. Coon and J. Abouchar (eds.) Habitat lost: Taking the pulse of estuaries in the Canadian Gulf of Maine. Conservation Council of New Brunswick, Fredericton, NB.

This report presents a brief history and case study of the Petitcodiac River causeway. More than 1.1 x 10^6 m^3 (40 x 10^6 yd^3) of tidal volume had been lost since the causeway was built. The channel at the causeway had been reduced by 92% to 80 m. Wharves in the city of Moncton had been buried in mud and this effect extended downstream at least to the wharf at Pre-d'en-Haut, 24 km below the causeway.

The altered Petitcodiac system was described as having implications which reached beyond Canadian borders. As described by Dadswell *et al*. (1983), every shad from rivers along the eastern seaboard of North America eventually migrates to the upper Bay of Fundy to feed. The decline in shad landings in the upper Bay of Fundy was thus linked to degraded river habitats in the United States, where spawning stocks and their habitats had been destroyed by hydroelectric dams and pollution. By the 1980s, following river restoration programs in the USA, shad populations started to return to the upper Bay of Fundy – but only to the Cumberland Basin, not to Shepody Bay or the Petitcodiac. Shad require suitable depth and light intensity, and when either is compromised, the fish move into deeper waters, out of reach of fishermen. The authors suggest that changes in the Shepody Bay/Petitcodiac have created conditions unsuitable for shad.

The article further discusses the advocacy for and against the causeway, and events relating to the planned trial gate opening in 1997.

NATECH Environmental Services Inc. 1998. Simulation of selected gate settings with the Calibrated Petitcodiac Gate Flow Model. Report to Department of Fisheries and Oceans, Moncton, NB. April 4 1998. 77p.

The computer model used in 1996 to assess the technical feasibility of controlling headpond water levels by manipulating the gates under Option B1 (ADI Ltd., 1996) was not calibrated against measured values. This study calibrated the model for Option B1, based on data collected during the gate opening of April 18-May 2 1998. Several limitations of the model were discussed. "The results of the calibration show that for the purpose of this study, however, the model is fully capable of providing sufficiently accurate estimates of the effects of certain gate openings on the flow across the gates and on the up-stream water levels."

Headpond water levels resulting from certain tide conditions, freshwater inflows and gate settings were estimated, along with the time available for upstream fish passage. Given the objective of maintaining a headpond elevation of <2.5 m, upstream fish passage would be possible for up to 2 hr/tide during freshwater flows of <10 m^3/sec. At freshwater flows >25 m^3/sec, it would become difficult to maintain the water level <2.5 m, unless >3 gates were open. The time for fish passage would decrease at higher flows. It would be possible to achieve upstream fish passage at flows up to 100 m^3/sec, but the headpond level would rise significantly above 2.5 m.

Siltation above and below the gates would reduce the duration of upstream fish passage, especially when tides were low. At flows <10 m^3/sec, fish passage of 2-3 hr could be achieved even if siltation had elevated the channel bottom by as much as 3 m.

New Brunswick Department of the Environment. 1976. 1976 update of recreational feasibility study, Petitcodiac Lake. Environmental Services Branch, Department of the Environment. 14 p.
Also appears as: **Appendix C *in* ADI Ltd. 1979. Study of operational problems, Petitcodiac River causeway, Moncton, N.B. Report prepared for New Brunswick Department of Transportation, File 600-154. December 1979. 122 p.**

This report addresses recreational use of the headpond (considered to be of very limited potential) but also contains information on the aquatic habitat. More than 50% of the area studied had fecal coliform bacterial counts in excess of the recommended level for body contact use. The source of this contamination was mainly surface runoff of untreated waste from local residential dwellings. There may have been some salt water intrusion, although the tidal cycle at the time of the study had only a moderate tidal amplitude. All areas had high levels of suspended solids in the water. There were extensive off-shore sediment flats. Secchi depth was restricted to 10-15 cm (4-6 in) at all sites. The extensive nearshore silt flats prevented obtaining depth soundings throughout the lake.

New Brunswick Department of the Environment. 1984. Moncton planning region: Water resources review. Water Resources Branch, Department of the Environment. 261p.

The main focus of this report is drinking water, but there is also considerable information on rivers in the Petitcodiac watershed. Drainage areas of the major rivers were summarized:

River	Drainage area (km^2)
North	290.2
Anagance	144.5
Pollett	309.4
Little	297.6
Petitcodiac	2071.6

Details of drainage area, basin perimeter, meander length, basin length, and basin shape were provided for 136 watercourses in the Petitcodiac drainage.

Water chemistry data were summarized from provincial and federal departments of the Environment reports for the Petitcodiac, Pollett, Coverdale rivers, Turtle, Fox and Jonathan creeks, and Halls and Humphreys brooks. Median levels of nutrients (total organic carbon, total Kjeldahl nitrogen, nitrate+nitrite, total inorganic phosphate and total phosphate), metals (cadmium, copper, iron, lead, mercury, zinc), and other water quality parameters (total hardness, pH, dissolved oxygen, specific conductance, fecal coliforms) were presented for standard monitoring stations (years 1961-1977). Latitudes and longitudes of these stations were listed. Chemical conditions at the pumping station inlet of the Turtle Creek reservoir were also presented for August 1982.

There were 3 active hydrometric stations in the Petitcodiac basin area, regulating natural flows: Petitcodiac River near Petitcodiac, Turtle Creek at Turtle Creek, and Palmers Creek near Dorchester. Extreme maximum and minimum daily flows at these stations were summarized, and a flow profile was presented for 18-23 yr of data. A currently inactive station had been located in the Petitcodiac River near Salisbury.

Sewage treatment facilities and major industrial water users in the watershed were described.

Flooding conditions were discussed. The flood of March 31-April 4 1962 was described as the most extreme in memory, and resulted from a record rainfall of 109 mm of rain in 24 hr. Historical flooding events, beginning with the Saxby Gale in 1869, were listed.

New Brunswick Department of the Environment. 1999. Water quality of the Petitcodiac headpond, 1997-1998. Environmental Quality Branch. Technical Report T-9905. Pages 206-323 *in* Environmental Monitoring Working Group. 1999. Environmental monitoring of the Petitcodiac River system, 1998: Petitcodiac River Trial Gate Opening project. September 1999. 325 p.

Water quality surveys were conducted at 33 stations in the headpond from June 10-November 3 1997 and July 16-October 14 1998. All measurements of arsenic, cadmium, mercury, ammonia, nickel, pH and dissolved oxygen were within guidelines. Guidelines were not met for <10% of the samples for chromium, lead, suspended solids, turbidity and zinc. For the most part the excesses were small and were considered to pose only a minimal threat to aquatic life.

In total, 32 fecal coliform readings exceeded 200 cells/100 mL, of which 22 readings were <300 cells/100 mL. Twenty of the 32 were recorded in November 1997 or September 1998.

Extensive listings of the water quality data are included in this report.

New Brunswick Environment. 1998. Water quality in the Petitcodiac River head pond, 1997. Pages 197-241 97 *in* Environmental Monitoring Working Group. 1998. Environmental monitoring of the Petitcodiac River system, 1997: Trial opening of the Petitcodiac River causeway gates. December 1998. 280 p.

Data for suspended solids, aluminum, total phosphorus, fecal coliform bacteria, and conductivity were presented for sites sampled within the watershed in 1997. Data are in graph format with no explanatory text.

New Brunswick Department of Transportation. 1998. Petitcodiac River sections, 1979 to 1997. Pages 253-280 *in* Environmental Monitoring Working Group. 1998. Environmental monitoring of the Petitcodiac River system, 1997: Trial opening of the Petitcodiac River causeway gates. December 1998. 280 p.

Bathymetric cross-sections of the river and headpond are presented.

Newbould, K.A. 1989. North American Atlantic salmon tagging programs 1974-1985. Canadian Data Report of Fisheries and Aquatic Sciences 730: 260 p.

Releases of tagged fish to the Petitcodiac system from 1974 to 1985 are summarized.

Date	Location	Origin, stage	Tag type	Tag codes	No. released
May 17-18 1983	Pollett	Hatchery smolt	Blue carlin	M60000-M69999	10,000
Aug. 3-Oct. 7 1983	unspecified	Hatchery adult	Orange t-bar	1031-1037, 1303-1474	156
Sept. 16-Oct. 17 1983	unspecified	Wild adult	Yellow t-bar	1900-1956, 2300-2599	350
Jul. 13-Nov. 22 1984	unspecified	Wild adult	White carlin	17000-17234	231
May 24 1985	Pollett	Hatchery smolt	Light green carlin	AA43000-AA45999	3,000

O'Blenis, S. 1989. Possible sources of contamination to the Petitcodiac River. 13 p.

<No abstract.>

Parker, G. 1997. The Hayward Brook Project: a general description. Fundy Model Forest Technical Notes vol. 1 (no. 1): 12 p.

A five-year research project within the Fundy Model Forest at Hayward Brook, a tributary of the Anagance River, was started in 1993. The purpose of the study was to determine the ecological implications of forested buffer zones along second order streams during forest harvesting. Experiments were concentrated on cause and effects of pre-harvesting, harvesting and post-harvesting of the forest surrounding Hayward Brook and Holmes Brook, but aquatic surveys were also conducted.

Data collections included: water and suspended sediment samples; stream discharge; identification of fish habitats and monitoring of fish communities and aquatic invertebrates. Methodologies were described but no data were presented in this report.

Perley, M.H. 1852. Reports on the sea and river fisheries of New Brunswick. J. Simpson Printer, Fredericton, NB. 294 p.

Perley noted an "entire" change in both the geology of the coast and the nature of the fishery at Point Wolf. Above this point, "the shad rejoice in muddy waters, and especially delight in the extensive mud-flats of the upper part of the Bay, from which they procure the food that renders them so excessively fat and delicious". Few herring or cod were taken up the bay from this point.

The upper Bay of Fundy shad fishery extended up the bay from a small settlement called Cannon Town Beach, just to the east of Herring Cove [Fundy National Park]. West of Cape Enrage, there was no drifting for shad, "the Bay being too wide and stormy, and the water too clear". In this part of the bay, shad were taken using brush weirs. The valuable shad drift-net fishery commenced above Cape Enrage. Fishermen from the Parish of Hopewell fished between Cape Enrage and Cape Demoiselle at the entrance to the Petitcodiac River. There were 50 fishing boats in this stretch, catching about 20 barrels each annually. Above Cape Demoiselle, the fishermen of Hillsborough and Memramcook fished the Petitcodiac up to Stoney Creek, above which few shad were caught. At least 100 boats fished this stretch. All the drift-net fishermen used nets with mesh size of 11.4-12.7 cm (4.5 - 5 in), "as they want the large fat shad only". Each boat had 137-366 m (75-200 fathoms) of net, about 4.9 m (16 ft or 46 meshes) deep, and this was fished by drifting during the night. The fishing was done "between seed time and hay making, very seldom after that", for a season of about 3 months from July to mid-September. The drift-net fishery had its start around 1840. Until that time, the shad had been fished only at standing nets and standing weirs. These were criticized as being non-selective and "the most effective means of destroying shad altogether". A large part of the catch was lost from the standing nets on the ebb tide and "become a treat for the sturgeons, and dog-fishes, these being numerous and strongly attracted". Shad were also mentioned as being a particularly good sport fish.

It was clear from interviews with fishermen that the shad were using the upper Bay as a feeding rather than a spawning area. It was unusual to find roe in the fish caught there. References to "shad-worms"and shrimp eaten by the shad on the muddy flats, and to "that thick yellow oily matter which we find on the top of every barrel of shad" indicated very successful feeding, which made these shad "the best in the world". These conditions were not found elsewhere, e.g., "…the shores of the Gulf…are supposed to furnish less of the peculiar food of the shad, than the muddy rivers of the Bay of Fundy, where they are taken in such high perfection." The shad-worms were said to be "nearly as large as a man's finger".

From Grindstone Island to Enrage, sharks frequently damaged the nets. They came up the bay "in the latter part of the season", and caused an early closure of the shad fishery. Thresher sharks of 1.8-2.4 m (6-8 ft) were usually found, and at times, dogfish were abundant. One fisherman had taken a "cartload" out of a single shad net, all caught during one tide. Dogfish could also be fished on the flood tide at Grande Anse. Sharks appeared in Sackville Bay at the end of August; these presumably included thresher sharks, as one was said to be 2.7 m (9 ft) in length.

Grilse were sometimes taken in the shad nets. "Great numbers of salmon, generally of small size, formerly frequented [the Petitcodiac] river; but latterly, owing to the unmerciful and cruel manner in which this fish has been hunted and persecuted…they have greatly diminished, and are at present in a fair way of being extirpated altogether." Perley had observed "wanton destruction" of salmon in pools near the head of tide [Salisbury area] which were speared with pitchforks.

There was no mention of gaspereau in the Petitcodiac, but the following general observation was made. "Very slight obstructions suffice to prevent the gaspereaux from ascending streams to their old haunts; the dams for mills, or for driving timber, have shut them out in numerous instances from their best spawning grounds, and the greatest injury has in this way been inflicted on the fishery."

Pettigrew, T. 1977. Letter to Mr. Richard Debow, president of Moncton Fish & Game Association. New Brunswick Department of Natural Resources, Hampton, NB. December 2 1977. 5 p.

Atlantic salmon production potential was estimated for the North, Anagance, Pollett, Coverdale and main Petitcodiac rivers. Smolt production based on habitat quality was assumed to be: good habitat, 5-7 smolts/100 m^2 (4-6 smolt/100 yd^2); fair habitat, 2-5 smolts/100 m^2 (2-4 smolt/100 yd^2); poor habitat,1-2 smolts/100 m^2 (1-2 smolt/100 yd^2).

	North R.	Anagance R.	Pollett R.	Coverdale R.	Petitcodiac R. above headpond
Stream km (miles) in main stem	46.7 (29)	25.8 (16)	51.5 (32)	41.8 (26)	24.1 (15)
Estimated ave. width, m (yd)	11 (12)	9 (10)	18.3 (20)	13.7 (15)	22.9 (25)
Stream habitat, m^2 (yd^2)	512,033 (612,480)	235,418 (281,600)	941,670 (1,126,400)	573,830 (686,400)	551,760 (660,000)
Rearing habitat by quality (%):					
Good	10	10	30	30	15
Fair	20	20	40	40	25
Poor	50	50	30	30	30
Unsuitable	20	20	0	0	30
Estimated smolt production (mean, range)	11,000 (7,958-14,692)	5,000 (3,658-6,754)	35,500 (25,905-45,052)	21,500 (15,785-27,452)	13,000 (9,240-16,500)

On the basis of this table, mean annual smolt production for the entire system was predicted to be 86,000 smolts (range, 62,546-110,450 smolts). Considering that tributaries of the various rivers would also provide smolts, an estimate of 100,000 smolts/yr was considered realistic.

Based on some absolute figures chosen from the production range of each river, required spawning escapement was calculated with the following assumptions:
Smolt-to-adult survival = 5%.
Egg deposition = 239 eggs/100 m^2 (200 eggs/100 yd^2)
Average weight of fish = 4.1 kg (9 lb)
Egg production = 1652 eggs/kg (750 eggs/lb)

	North R.	Anagance R.	Pollett R.	Coverdale R.	Petitcodiac R.	Total
Smolt production	12,000	6,000	43,000	25,000	14,000	100,000
Adult returns	600	300	2,150	1,250	700	5,000
Spawners	362	168	668	584	390	2,172

Adding some fish for natural and poaching mortality, annual returns of 2,500 spawners were required to obtain the recommended spawning escapement. With a potential angler harvest of 30% of the run, approximately 1,500 fish would be available for angling. This would provide about 5,000 rod-days of recreational angling.

Pratt, J.H. 1893. Report on the fisheries of district no. 3, comprising the counties of Victoria, Carleton, York, Sunbury, Queen's, King's, St. John and Albert, for the year 1892, by Inspector J.H. Pratt. Pages 67-69 *in* Fisheries statements and inspectors' reports for the year 1892. Supplement no. 4 to the annual report of the Department of Marine and Fisheries. S.E. Dawson, Printer. Ottawa.

Shad catches were similar to the previous year (1891), but "Complaints have been received regarding the sawdust and mill refuse deposited on the flats in the waters of Albert County, and driving this fish from their usual haunts." Shad were reported to have come up the Bay of Fundy one month earlier than usual, but left the area "as soon as mill refuse began running down the river and settled on the shores". Despite the environmental problems, "there was an increased run in the Petitcodiac this year."

Prince, E.E. 1912. The shad fishery of Canada and its restoration. Pages 120-136 *in* Commission of Conservation, Canada. Sea-fisheries of eastern Canada. The Mortimer Co. (printers), Ottawa.

Forty to 60 yr earlier, the shad in the upper Bay of Fundy had been regarded as "inexhaustible", but a marked decline in the supply had been noted over the previous 25-30 yr, and they had been "alarmingly scarce" for 10-12 yr. "The only fishery yielding returns of consequence at the present time is that carried on up the rivers, in non-tidal waters, where the last remnants of the shad spawning schools ascend for breeding purposes. The fishery in the tidal waters of the bay is still carried on, but the success of the fishing depends not so much upon the shad taken, as upon the salmon which may happen to be caught in the same nets."

Causes for the "present serious condition" of the shad fishery were discussed; (1) dams and other obstructions in rivers, preventing the parent fish from ascending to their spawning grounds, (2) capture of the breeding fish when ascending the river, (3) over-fishing, (4) pollution of rivers and feeding grounds. "There is no doubt that one of the most serious causes of depletion has been the blocking of rivers by dams, which prevent the ascent of the spawning schools of shad. This fact was years ago established". Pollution was primarily due to sawdust and other forestry products, which were washed downstream in freshets. "Quantities of sawdust, before becoming water-logged and later sinking to the bottom, cover the sandy beds and fill the pools on the bay of Fundy flats which the shad frequent. When the sawdust rots, it must, in its decayed condition, be most deadly to all insect life and to the minute food upon which the shad fatten."

Raymond, R. 1944. Montée du saumon et de quelques autres poissons dans la rivière Petitcodiac, à Salisbury, 1944. Fisheries Research Board of Canada, Manuscript reports of the biological stations 380; Atlantic salmon and trout investigations, 1944; 31(5): 18 p.

A counting fence was operated in the main Petitcodiac River at Salisbury, 1 km (200 rods) above the head of tide, from July 8 to October 14 1944. The majority of the 510 salmon captured in the trap were grilse. Salmon were measured and scale sampled. Length of salmon captured averaged 58.7 cm (range 40.6-81.3 cm) (23.1 in, range 16-32 in). Mean weight was 2.3 kg (5 lb). One adipose-clipped hatchery salmon that had entered the trap on August 23 was tagged.

There was a strong correlation between the arrival of high tide and the appearance of salmon each day. Salmon first appeared in late July, when mean daily temperatures were 18.3-23.9 ºC (65-75ºF). In August, salmon were not caught for more than a week during a period of sustained high temperatures (>25.6ºC) (78ºF). The run resumed when temperatures became cooler.

Salmon released from the trap during the day appeared to be somewhat disoriented. Most took refuge under the river bank, but some took position in full sunlight in the angles formed by the fence and the river bank and remained there throughout the day unless disturbed. Salmon held under a burlap cover in the trap all day and released at nightfall seemed to immediately resume their upstream migration.

However, some moved only 1 km (200 rods) above the fence and then remained in a small pool with excellent cover for up to three weeks. Most salmon eventually assembled in Jones' Pool (Salmon Pool) on their way upstream. On September 13, this pool, with a maximum depth of 3.7-5.2 m (12-17 ft), contained 65 of the 106 salmon that had been counted through the fence by that date. Mitton's Pool was a stopping point for only a few individuals, and salmon never assembled there in summer.

Approximately half the salmon were caught at night, but before midnight. Some nights, one-third of the captures were made during the first hour of complete darkness.

Poaching of the salmon pools was considered practically impossible, due to continual surveillance by fishery officers. A fishery officer was assigned to the counting fence at night, and the fence operator was there all day.

Salmon catches of fishermen fishing in the estuary from June 26 to September 30 totalled 857 fish. Salmon were caught throughout the entire period, but catches were low until mid-July. Scale samples were obtained.

According to older residents of the area, salmon had been much more abundant 20 yr earlier. A good net haul during the night rarely captured fewer than 30-40 salmon. One individual with two assistants had speared 113 salmon in a single day. Another had specialized in salmon ice-fishing. One remembered catching so many salmon that they were used as food for foxes.

During the operation of the counting fence, 165 white suckers, 39 striped bass, 9 shad, 9 eels, and 1 perch were also captured. Of the suckers captured, 75% were caught during the last month of operation, 37% during two days (Sept. 17-18). The mean length of 142 suckers measured 32.4 cm (12.75 in). Striped bass were caught in two periods: July 9-August 7 (30 bass) and August 22-September 16 (9 bass). The intervening period when no bass were caught was the same warm-temperature period when no salmon were caught either. The average length of striped bass was 30 cm (11.8 in).

Algae presented a problem from the moment the trap was set until mid-August. High water temperatures and low water encouraged growth of algae to the point where the spaces between the slats of the fence were blocked. Algae, formerly attached to rocks on the river bottom, were also carried down by freshets. Opening of the Sanatorium dam on July 19 led to a rise in water of 40.6 cm (16 in) and the river bed "remained clean" for more than a week. The algae eventually disappeared completely in September and October.

Review committee on options for the future of the Petitcodiac River dam and causeway. 1991. Report on options for the future of the Petitcodiac River dam and causeway. May 14 1991. 27 p.

This report, prepared by a provincial inter-departmental committee at the request of the provincial government, defined options for the future of the Petitcodiac River dam and causeway, defined the issues concerning each option, and listed any studies required to evaluate each option. The committee found that there was no option that would favourably satisfy all issues. Options that would preserve the headpond would prevent the re-establishment of the pre-causeway tidal bore. Options that would remove the headpond would offer a positive outlook to the fisheries resources but would eliminate the aquatic recreation and aesthetics value of the headpond.

A brief history of the causeway dam was included. Highlights are summarized below:

- January 7 1960: Moncton City Council passed a resolution to request the provincial government to conduct a feasibility study of a causeway to cross the Petitcodiac River at Moncton
- March 30 1961: Maritime Marshland Rehabilitation Administration reported on feasibility of three sites, one of which was in the area where the structure is now located
- July 3 1961: A letter from the federal Fisheries Department expressed a requirement for a fishway in the structure.
- July 30 1963: A meeting was held with representatives of the city and province. Those present favoured a crossing at the western end of Moncton. It was pointed out at this meeting that tidal silt deposits would cause the stream bank width to decrease downstream of the causeway.
- November 1963: It was decided to construct a causeway. Maritime Marshland Rehabilitation Administration was asked to do the engineering design work. Department of Public Works asked for approval from the New Brunswick Water Authority, which contacted various provincial and federal departments for comment. The Water Authority opted for the causeway proposal believing that the

resulting freshwater headpond would provide a source of industrial water and have recreational potential. The project was approved under the Navigable Waters Protection Act on June 3 1964.

- December 14 1964: Maritime Marshland Rehabilitation Administration advised that they would cost share to $800,000, due to the expected upstream benefits to agricultural lands. The total estimated cost of the project was in the order of $3 million.
- February 8 1966: Construction began.
- March 17 1967: Federal Fisheries Department approved the fishway design.
- February 10 1968: Causeway was closed (i.e., completed).
- 1969: Federal Fisheries Dept. report recognized adverse effects on salmon and other fish species, and recommended modifying the gate operating procedures to improve salmon migration.
- December 1979: ADI Ltd. completed report on operational problems. Modifications were recommended, with an estimated capital cost of $825,000. The recommendations did not meet with the approval of Dept. of Fisheries and Oceans or Dept. of Natural Resources as these departments preferred a complete removal of the gates and if necessary part of the causeway to at least partially restore previous tidal flow.
- 1980: Provincial government decided to proceed as recommended by ADI. Discussions with DFO resulted in new operation sequence for the gates during fish migration, a special spill-through stop log was built for fish passage, and the fishway was modified.
- 1988: Provincial government decided to open the gates and allow free tidal flow to help fish migration from April 15 to June 7. After the initial release of headpond water, two gates were left open. Net infilling of the Petitcodiac River between the causeway and Turtle Creek during this period was estimated as 600,000 m^3 of silt. Free tidal flow was re-established from September 26 to October 31. Net infilling with silt reached 900,000 m^3 during the fall opening.
- May 3-June 1989 and May 15-June 15 1990: The headpond was drained with the gates remaining open at low tide and closed on the incoming tide, at the request of DFO and Dept. of Natural Resources and Energy, to facilitate fish passage. The gates were not opened during the incoming tide because of the siltation of the headpond experienced in 1988.

Issues considered in the discussion of future options were: tidal bore, fish passage, siltation and erosion, transportation, agriculture, recreation, aesthetics, water quality, economics, wildlife and costs.

The options discussed in the report were:

(1) Gates opened: This was the *status quo* option, with the gates essentially closed but operated according to the agreement with Fisheries and Oceans in the early 1980s, i.e., the gates would be operated for water level control, gate 5 would be operated with the special stop logs in place to aid fish migration, and the fishway would be maintained. No changes would be required to the facilities. This option would not improve the tidal bore and fish passage would remain minimal. In the event of this option or of options (2), (3), or (4), the future course of the river channel below the causeway and the future of the tidal bore should be studied. The headpond would be available for recreation but water quality would continue to be affected by sewage effluent from upstream communities and this should be studied for any of options (1) through (4).

(2) Operate gates to help fish passage: Gates would be operated extensively to help fish passage but so as to keep tidal silt out of the headpond. No changes would be required to facilities. It was noted that construction of a water main under the river immediately upstream of the dam required that the headpond stay drained during late spring and early summer of 1982 by opening the gates at low tide and closing them on the incoming tide. "This accidently [sic] helped smolt fish passage downstream past the dam. The result was a phenomenal return of salmon in 1983 that has not been repeated." Headpond aesthetics and boating would be compromised by this option.

(3) New fishway design: Operation of the gates would be similar to the *status quo*, but a new and improved fishway would be constructed. This appears in principle to be an ideal solution but "new concepts to significantly improve on the present fishway design are lacking".

(4) Fish trap and transport: Operation of the gates and fishway would remain at the *status quo*, but a fish trap and transport system would move fish past the causeway. This would require a feasibility study to attempt to establish a working procedure.

(5) Gates open: All or some of the gates would be raised for free flow at all times. It would be expected that this would act positively on "the revitalization of fish stocks" and on recreational and commercial

fishing. Cost-benefit studies should establish whether this would result in significant benefits. The predicted extent of erosion downstream, siltation upstream and re-establishment of the tidal bore should be studied. It might be necessary to re-establish some of the old dykes and aboiteaux upstream. The headpond would be eliminated. Capital costs would include remedial works to assure the river stayed within acceptable channel limits. This option, as well as options (6) and (7), would require registration under the Clean Environmental Act for a possible environmental impact assessment.

(6) Replace causeway with bridge: The dam and causeway would be removed to re-establish all or part of the original cross-section, and a bridge would be built to maintain the river crossing. The river would be expected to eventually revert to its pre-causeway form, but this would require study and possibly remedial works to control the river channel. The Dept. of Fisheries and Oceans, Dept. of Fisheries and Aquaculture and Dept. of Natural Resources and Energy were confident that this option would significantly benefit fish stocks. It would be necessary to re-establish dykes and aboiteaux, and the headpond would disappear. The tidal bore would be expected to re-establish itself. Water quality studies would be required upstream and downstream of the causeway site. This would be expected to be an expensive option.

(7) Separate river from headpond: A special channel would be constructed to take a portion of the river discharge around the headpond, for fish migration. The gates would be operated for flood control and the present fishway would be closed. This would be an elaborate and costly engineering work. This scenario would require similar studies as the gates closed option. Studies would be necessary to assure fish would use the proposed new by-pass channel.

The committee did not recommend a course of action to be taken, but listed the studies necessary in order to evaluate each of the options.

Richardson, S.M. 2000. Effect of drawdown duration on macrophyte and benthic invertebrate communities of a disturbed headpond. Honours Thesis, B.Sc. program, Dept. of Biology, Dalhousie University, Halifax, NS.

Three consecutive drawdown periods (1997, 1998, 1999) were studied in the Petitcodiac reservoir. The 1998 and 1999 drawdowns resulted in significant decreases (relative to 1997) in biomass and numbers of all macrophytes, benthic invertebrates, and freshwater mussels in the littoral zone, and to a lesser degree in the sublittoral zone. The most dramatic changes occurred between 1997 and 1998 when most species populations virtually collapsed. The age structure of freshwater mussels indicated that such collapses had occurred regularly in the history of the headpond. The only macrophyte to increase in biomass over the 3 years was *Polygonum lapathifolium*, which often establishes new populations during this type of environmental disturbance.

Riley, D.C. 1971. Anadromous fish passage problems associated with tidal structures. A paper presented at the Northeast Conservation Engineers, Portland 1971. Environment Canada, Resource Development Branch, Manuscript Report 71-31. Fisheries Service, Halifax, NS. 13 p.

Construction of causeway-dams across tidal river basins of the Bay of Fundy created unusual technical problems in developing suitable fish passage devices because of the unique tides encountered. The Petitcodiac River causeway and Great Village River aboiteau were discussed as examples.

The entrance to the Petitcodiac fishway was located in tidal water and was subject to substantial backwatering [reverse flow] action because of the large tidal range (up to 9.1 m, 30 ft). The backwatering “seriously impairs the fishway entrance attraction qualities that normally prevail at non-tidal locations. No additional attraction water was specified in the original design to compensate for decreased velocities through the fishway entrance port during high tide.”

The current practice of selecting a freshwater reservoir operating level ~1 m (several ft) below the normal high tide peak “renders a conventional fish passage facility totally incapable of passing adult fish during the time the tide level is above the level of the reservoir”. The engineering solution suggested for this problem would be a complex design for “unique fishery protective devices” including a mechanical pumping arrangement. Alternatively, the idea of installing telescopic weir gates at the fishway entrance to provide a constant attraction flow was under investigation. However, it was noted that any mechanical or underwater moving parts would potentially develop serious maintenance problems when exposed to silt-laden Bay of Fundy tides.

An important consideration at any tidal obstruction was the provision for adequate maintenance flows below the obstruction during a substantial portion of the ebb tide cycle. "This requirement is critical at locations in the Bay of Fundy estuaries because of the very shallow river gradient below the obstruction and the unusual tidal amplitude."

"The current practice of sizing water control gates at tidal installations to accommodate maximum flood conditions and at the same time maintain a fairly restrictive reservoir level is frequently incompatible with fisheries best interests. During the normal run-off periods which unusually coincide with the adult migration season, it is physically impossible to provide a significant sustained maintenance flow below the obstruction and retain desired reservoir levels."

Riley, D.C. 1976. Salmon escapement at Petitcodiac River causeway – a situation report. Memo to C.P. Ruggles. Fisheries and Marine Service, Department of the Environment. August 31 1976. 3p.

Fishway counts of ascending salmon were summarized for the years 1969-1972.

Time	1968	1969	1970	1971	1972
To Sept. 15		1	19	96	59
Sept. 16-30		14	57	71	40
Oct. 1-15		16	148	141	202
Oct. 16-31		21	84	448	125
Nov. 1-15		56	27	99	31
Nov. 16-30		22	10	36	N/A
Dec. 1-15		1	0	4	N/A
Total	101	131	345	895	457

It was estimated that in the decade previous to 1968 the annual salmon runs were 1,500-3,000 fish. "Reduced levels of spawning escapement can be expected since no fishway is 100% effective and those subject to large tidal oscillations appear to be even less effective than those that are not." In 1971, the number of drift net commercial licenses in the estuary (9) was reduced by 62.5%; it was expected that subsequent salmon spawning escapements to the river benefited from the reduced fishing pressure.

"In conclusion, there is no simple solution to the inefficiency of the causeway fish pass since it is created by the large tidal fluctuations prevalent at this site. It should not be construed however that the causeway is totally obstructing the ascent of salmon. Most recent salmon counts through the fishway indicate that present annual river escapements are between 15 and 60% of those estimated for precauseway construction years."

Ritter, J. A. 1991. Effects of Moncton-Riverview causeway on anadromous fish stocks of the Petitcodiac River. Fisheries and Oceans Canada, Halifax, NS. Brief to New Brunswick Department of Transportation. 11 p.

In compliance with the Federal Fisheries Act, a 19-pool vertical slot fishway was incorporated into the northern end of the spill-gate structure during causeway construction in 1967-68. The fishway was intended to provide upstream passage of Atlantic salmon, American shad, alewife (gaspereau), rainbow smelt, striped bass and sea-run brook trout. Downstream passage of juveniles and spent adults of the various species originally was limited to occurring through the fishway or by sounding under the gates when they are partially raised to spill river flow when the tide level is lower than the reservoir. In 1981-82, two surface ports (each spanning 3.7 m (12 ft) with maximum depth of 1.2-1.5 m (4-5 ft)) were installed in gate 5, which is closest to the fishway. These ports were intended to provide downstream passage when the tide was lower than the reservoir. Studies conducted in 1983 indicated that these ports were used by about 40% of the adult salmon that achieved upstream passage past the causeway.

Despite attempts to improve fish passage opportunities and extensive hatchery stocking, Atlantic salmon runs sharply declined. Annual runs of adult salmon ascending the Petitcodiac River before the causeway were estimated to be 2,000-3,000 fish (Dominy). Elson expected annual returns to range from about one-third of this estimate to double in very good years. Pettigrew estimated, based on a map survey of salmon habitat, that the river could support an annual run of 5,000 salmon. These estimates collectively indicate that the production potential of the Petitcodiac River is in the range of 2,000-5,000 salmon annually.

Recreational catches of bright and black salmon declined dramatically after 1968. Commercial salmon catches in Cumberland Basin were much lower in 1970 and 1971 than in years up to 1968. Highest commercial landings of salmon in the 1960s were recorded in 1967 and 1968, probably due to construction-related delays in the spawning run. Commercial catches remained low since 1971 except in 1983. High salmon returns in 1983 were attributed to 91,000 hatchery-reared fall parr released in 1980. Returns reached an all-time low in 1990.

Despite extensive stocking of all juvenile stages from 1980 to 1990, adult salmon returns have been insignificant, even taking into consideration the high marine mortality experienced in recent years by Bay of Fundy stocks. Juvenile surveys conducted by electrofishing have documented reasonable survival of released parr one year after stocking. The high return in 1983ºFrom the 1980 parr release coincides with the headpond being drawn down to the lowest level possible (for construction) from February to September 1982, the year in which the contributing smolts exited the system. Operation of the gates consisted of closing gates to the incoming tide and opening them at low tide to flush out any excess fresh water behind the gates.

No evidence of improved survival could be attributed to the spring opening of gates, initiated in 1988. Grilse returns in 1989 were <25% of expected returns. Following the 1989 opening of the gates, the grilse return in 1990 was the lowest on record.

Kelt survival was considerably poorer than expected. Both the remnant native stock and the main donor stock (Big Salmon River) were of the inner Bay of Fundy grouping of stocks with average between-spawning survivals of 50%. Kelts had evidently encountered the same obstacles to a successful return to the river as smolts.

According to P.F. Elson, shad spawned in the main Petitcodiac River and possibly in the lower few miles of its major tributaries. The spawning run into the river occurred in May and June, and juveniles probably exited the system in August through October. Data on shad movement through the fishway were limited to 1971-1973, the only years that the fishway trap was operated in May and June. Counts at the fishway for the three years were 1, 19 and 0 shad respectively. The vertical slot fishway had 30.5 cm (1 ft) drops between pools. The proven and recommended design for passing shad is a pool-and-weir structure with drops of 15-23 cm (6-9 in). Shad were reported by anglers to be more abundant upstream of the causeway following opening of the gates in 1988.

Commercial catches of gaspereau declined from 11-17 tonnes (in the 1960s) to 0-16 tonnes (1970s) to 0-4 tonnes (1980s). The first evidence of decline was in 1972 when the catch dropped to 6 tonnes. The 4 yr between construction of the causeway and reduced landings was consistent with the most common life cycle (egg to adult) for southern New Brunswick alewives. Alewives were also reported to be more abundant upstream of the causeway following the 1988 opening of the gates. Fishway design for alewife is similar to that recommended for shad.

The recreational dip net fishery for smelt in the Salisbury area ceased to exist after construction of the causeway, but a similar fishery subsequently developed below the causeway. At the time of writing, smelts were considerably less abundant than before the causeway was constructed.

It is unclear whether the Petitcodiac River had/has a spawning population of striped bass. Passage through the fishway of 5 fish in 1971 and 4 fish in 1972 were recorded in June and July.

Historical commercial catch records for the late 1800s and early 1900s indicated that large runs of sea-run brook trout entered the river. Fishway trap records in 1971, 1972 and 1983 did not confirm their presence, but all but very large trout would be able to pass through the fishway undetected. Silvery-coloured sea trout were more evident in angling catches in 1988.

In order to maximize anadromous fish production, it was recommended that free flow of the river be allowed from April 1 to December 15.

Ritter, J. A. 1995. Moncton-Riverview Causeway-Related fisheries concerns. Brief by Fisheries and Oceans Canada, Moncton, NB. May 23 1995. 4p.

The effects of the Moncton-Riverview causeway on the anadromous fish stocks of the Petitcodiac River were summarized. Concerns about changes in siltation patterns affecting the lobster and scallop resources in the upper Bay of Fundy from Alma fishermen were also addressed. The Department of Fisheries and Oceans supported the opening of at least one gate from April 1 to December 15 each year to allow free flow which would provide adequate fish passage.

Sawh, M.B. 1984. A computer model for the hydraulics of the control structure at the Petitcodiac River causeway, New Brunswick. M.Eng. Thesis, University of New Brunswick, Fredericton, NB. 230 p.

The computer model developed by ADI in 1979 to evaluate flow conditions at the control gates with all gates removed did not function correctly under all flow conditions and was not fully documented. This thesis presented a modified version of the ADI computer program and more complete documentation.

Schell, T.M. 1998. Compilation of suspended particulate matter (SPM) recorded in the Shepody Bay/Petitcodiac River system. Canadian Technical Report of Fisheries and Aquatic Sciences 2246: vii+29 p.
Also published as: **Schell, T.M. 1998. Compilation of suspended particulate matter (SPM) recorded in the Shepody Bay/Petitcodiac River system. Pages 124-154 97 *in* Environmental Monitoring Working Group. 1998. Environmental monitoring of the Petitcodiac River system, 1997: Trial opening of the Petitcodiac River causeway gates. December 1998. 280 p.**

Considerable work had been conducted on suspended particulate matter in Chignecto Bay, but only very limited data had been collected for Shepody Bay and the Petitcodiac River. Fluvial input of sediment in the bays was low (0.3 x 10^6 m^3/yr) relative to shoreline erosion (1.0 x 10^6 m^3/yr) and current scouring and erosion of the seabed (6 x 10^6 m^3/yr). Fluvial supply increased during spring runoff or freshets. Of the total 7.3 x10^6 m^3/yr of sediment mobilized each year, 99% was transported in suspension.

The seabed was primarily composed of silts and clays. Sand occurred subtidally at Bay margins, including near the mouth of the Petitcodiac River in Shepody Bay. Muds predominated on the littoral margins of Shepody Bay. Muddy sands, gravelly muds, and sandy muds were also present throughout.

Schweiger, P.G. 1986. Flow modelling for well-mixed estuaries in relation to estuarine sedimentation due to man-made changes. M.Eng. Thesis, University of New Brunswick, Fredericton, NB. 233 p.

The theory and methods for development of “a new type of cohesive sediment model which can simulate the interaction of tidal and fluvial flows in narrow well-mixed estuaries like that of the Petitcodiac River” are described. The modelling process for this river was described as “challenging”. Hydraulic parameters such as bed shear stress, shear force, and stream power were found to provide the basis for estimating the relative change in channel size that would take place in the estuary due to man made works. The final equilibrium morphology of the estuary was estimated. The model was not field-tested.

The Petitcodiac estuary was defined according to its morphology and hydrology as “well-mixed”: narrow and shallow estuary, high tidal amplitude, low freshwater contribution. The estuary was considered to extend downstream to Hopewell Cape.

River cross-sections were summarized from Canadian Hydrographic Service Chart 4130, representing the only complete survey of the estuary (in 1861), and from Department of Transportation surveys of the headpond in 1968 and 1973. Figure 4.5 shows a longitudinal bed profile from Salisbury to Hopewell Cape.

Several observations concerning the change in the hydraulic environment before and after the causeway were common to all modelling scenarios (i.e., independent of the parameters used). (1) Construction of the causeway significantly increased the high water stage along the estuary. The increase in water surface elevation was maximal just below the causeway and gradually decreased downstream to Hopewell Cape. (2) The lowest depth along the estuary decreased after the construction of the causeway. This was due to the elimination of the tidal prism above the causeway, thus decreasing the volume of water flowing out of the system on ebb tide. Prior to the causeway, the ebb water from above the causeway location prevented the flows from Moncton to Hopewell Cape from ever reaching a constant water surface profile. After the upstream ebb flows were eliminated, the flows in much of the channel below the causeway reached "normal depth for uniform flow" before the next flood tide occurred. (3) After the causeway was in place, the maximum water surface elevations increased from Hopewell Cape to the causeway much more than before the estuary was modified.

The largest change in the hydraulic environment occurred between the causeway and a point 15 km below the causeway. From this point to Hopewell Cape, the change was less significant.

"Prior to the construction of the causeway in 1968, the Petitcodiac estuary was in a state of quasi-equilibrium. This natural system was delicately adjusted to its physical, chemical, and biological environment. The construction of the causeway introduced a new boundary condition into the estuarine system and disturbed the equilibrium of the estuary. In response to the new boundary condition, the Petitcodiac estuary has been adjusting to a new state of equilibrium." According to one of the models, it was suggested that 25×10^6 m^3 of sediment would accumulate in the estuary in the process of reaching equilibrium. The cross section located 4.7 km downstream of the causeway had been reduced by 70% within 13 yr after completion of the causeway. Additional changes of at least 30% were expected. At the downstream end of the estuary, some erosion might occur despite the reduction in tidal prism upstream. This was because the duration of the flood had been reduced relatively more than the tidal prism. An additional model, adjusted for the modern cross-sectional areas and therefore with a smaller tidal prism, indicated that the estuary might fill with mud to the point that freshwater flows would eventually determine the minimum cross-sectional area. "A new transition region must develop from an estuarine-dominated regime to a river-dominated regime".

Deposition of sediments immediately below the causeway site before the causeway was built were expected to occur for only 10 min/tidal cycle. After the causeway was in place, the time during which deposition was expected to occur increased to 3.6 hr/tidal cycle.

Semple, J.R. 1975. River causeways and fisheries. Fisheries and Marine Service contribution to Subcommittee on Causeways for the Canada-Nova Scotia Advisory Committee on Stream Alterations. 33 p.

Freshwater portions of the Petitcodiac River system which were accessible to anadromous fish in 1975 included: <40 km (25 miles) of the main Petitcodiac above the causeway, 48 km (30 miles) of Coverdale (Little), 32 km (20 miles) of Pollett, 32 km (20 miles) of North, and 16 km (10 miles) of Anagance rivers. The upper 24 km (15 miles) of Pollett R. were blocked by a falls and Turtle Creek had a water supply dam which blocked fish passage near its mouth.

The river supported populations of Atlantic salmon, brook trout, striped bass, American shad, alewives, smelt, sturgeon and eels as well as cyprinids and "coarse fish". Annual sport fisheries of 82 to 670 Atlantic salmon and 2,000 to 4,000 brook trout were recorded. Shad were also caught in the sport fishery, but numbers were not recorded. Striped bass were once caught in the sport fishery, but none were recorded after 1954. Prior to completion of the causeway, the annual salmon run was estimated as 2,000-3,000 fish. The main run began in September, peaked in October, and continued into November. Fish passage investigations from mid-September to mid-December of 1969 to 1972 indicated 140, 345, 895 and 468 adult salmon entering the river yearly. The causeway was also considered to have virtually eliminated shad, sea-run brook trout and striped bass from the system. Historical shad runs into the Petitcodiac were estimated to have been in excess of 50,000 to 75,000 fish annually. A fishway count at the causeway in 1972 totalled only 19 shad. The demise of shad in the river was attributed to difficulty in finding the fishway, loss of spawning grounds and water quality changes.

Semple, J. R. 1979. Anadromous fish stocks in the Petitcodiac River system and the Moncton causeway: a status report. Draft of a Fisheries and Marine Service Manuscript Report. April, 1979. 29 p.

The effect of the Petitcodiac causeway on fisheries in the first 10 yr of its operation was evaluated. Reduced harvests of anadromous fishes, delays in or failures of anadromous fishes to use the causeway fishway, and stranding of fish on exposed tidal flats during ebb tides were reported. The causeway became operational in July 1968.

Siltation in the first 10 yr had an adverse effect on operation of the fishway. When the causeway was initially built, tide levels at the structure reached +8.23 m Mean Sea Level (MSL) during spring tides and a minimum level of +4.27 m MSL during neap tides. The bottom of the river at this time was -1.52 m MSL. Infilling with silt had reduced the tidal fluctuation by 1979 to ±1.83 m. Infilling of the reservoir had also resulted from the intrusion of silt-laden flood tides into the reservoir through defective gate seals. Backwatering (i.e., reverse flow) through the fishway occurred when tides were higher than reservoir levels and sometimes prevented the fishway from operating or reduced the amount of freshwater flow and subsequent effectiveness of the fishway in passing fish. The volume of water leaked through the gates was approximately 12 times that through the fishway.

Commercial landings of Atlantic salmon during 1960-1967 were slightly in excess of 2,000 kg/yr but declined by two-thirds to 668 kg/yr during 1968-1977. Angling harvest also declined, from 171 bright and 263 black salmon/yr in 1960-1967 to 25 bright and 66 black salmon/yr in 1968-1978, a reduction in 85% in bright and 75% in black salmon.

Counts of salmon passing through the fishway showed a steady increase from 101 fish in 1968 to 895 fish in 1971, but dropped by nearly 50% (relative to 1971) in 1972 to 457 fish. This drop in numbers occurred in the first year that progeny of the 1968 spawning escapement would have contributed to the fishery as grilse. Approximately 95% of the 1970 and 1971 spawning escapements consisted of 1-sea-winter grilse. A low grilse contribution of 18% in 1969 was an unusual situation, which occurred in both this river and other Bay of Fundy rivers nearby. The 33% grilse contribution seen in 1972 is likely attributable to the low proportion of grilse recruited into the fishery from the low spawning escapement of 1968.

Annual runs of salmon to the Petitcodiac River at the time the causeway was completed were estimated as 2,000-3,000 fish. These figures were thought to be “realistic estimates” but the range might have been from as low as 1/3 in poor years to double in very good years. Estimates of potential salmon production based on the proportion of salmon rearing area in nearby rivers and expected smolt-to-adult survival of 12% suggested that annual returns of 7,000-9,000 fish might be possible if the entire rearing area was made available. An estimate derived from a physical survey of the river, a smolt production of 1-6 smolts/83.6 m^2 and smolt-to-adult survival of 5% indicated an annual run of 5,000 fish was possible. With the removal of the Jordan Sanatorium Dam, a run of at least 4,000 fish/yr was considered realistic. With the exception of Gordon Falls, located 29 km above the mouth of the Pollett River, the only remaining obstruction to salmon passage in the Petitcodiac system was the dam located 6 km above the mouth of Turtle Creek.

Juvenile salmon densities determined by electrofishing supported the conclusion that adult salmon were having difficulty in passing upstream beyond the causeway. Few or no salmon fry and parr were recorded from spawning escapement of years after 1968. The density of age 1 salmon parr in the Coverdale River in 1969 (from the 1967 spawning escapement) was 28 parr/100 m^2, but was only 8 and 6 parr/100 m^2 in 1970 and 1971 respectively.

During the spring (1971 and 1972 only) and fall (1968 to 1972), fish passage evaluation studies were conducted at the causeway. The passage of salmon through the water-control gates and fishway was studied, by catching salmon in the tailrace (drift nets, 1970 only), in the fishway, and a picket trap (1971 only) located 6.25 km above the causeway. Some fish were tagged with ultrasonic transmitters or Carlin tags and their subsequent movements monitored.

In 1968, 13 salmon captured in the fishway were marked and released below the causeway. None were recovered in the fishway. Visual observations at the open water control gates revealed that ≥ 4 salmon used this route when head differences between the reservoir and tailrace were between 0.3-0.6 m.

Water management practices at the causeway gates in 1969 were found to discourage entry of salmon to the fishway. Water levels in the reservoir were allowed to build up, after which the gates were opened and a large volume of water was released in the shortest time possible. The 1969 data showed that most fish passed through the fishway trap on days when little or no water was released, but no fish entered the fishway while the gates were open. It was speculated that the water management practices were confusing salmon during their search for an upstream migration route, and that this resulted in lower fishway effectiveness when it should be greatest (i.e., low tide, when the freshwater signal should be strongest). Only 36% of salmon entered at low tide ± 3 hr. Eleven salmon captured in the fishway were tagged with ultrasonic transmitters and released below the fishway. None were recorded in the fishway or passing through the open control gates. Seven fish that had passed through the fishway were flushed back downstream through the gates and were subsequently recaptured in the fishway after median delays of 8 days (range 1-43 days).

During 1970 and 1971, an attempt was made to provide an alternate fish passage route for salmon, by way of the causeway gates. Gate openings were restricted to 0.5 m (1.5 ft) maximum at low tide, and at no time were the gates to be fully opened at low tide. When the opportunity arose, one of more gates closest to the fishway were fully opened when the rising tide was equal to or less than 0.6 m (2 ft) below the reservoir level. At these head differences, water velocity through the gates ≤ 7.62 m/sec would be passable to salmon. Sufficient gates were opened to provide a flow of 14-28 m^3/sec ("maintenance flow") which was considered adequate to induce salmon to move up the estuary to the causeway. The gates were opened 3-4 hr after high tide and left open for 7-8 hr, on an intermittent basis. For transmitter-tagged fish released in 1970, this measure did not appear to improve the use of the control gates as a fish-passage route, since only one of the 25 tagged fish was monitored passing through the causeway gates. Counts of salmon in the fishway in relation to river flows supported the recommended gate flow criteria. In 1970 (and again in 1971), the proportion of salmon using the fishway on high and low tides ±3 hr was nearly equal. In the years when fish passage flows were not provided, 64% of the salmon ascended the fishway at high tide ±3 hr.

In 1970, 75 salmon captured in the fishway were marked with Carlin tags and 25 salmon captured in the fishway were tagged with ultrasonic transmitters and released below the causeway. Of the 75 Carlin-tagged fish, 8 were recaptured in the fishway after absences ranging from 1 to 28 days. Of the 25 transmitter-tagged fish, only 2 were recaptured in the fishway and one was recorded passing through the open control gates. Seven additional salmon captured in drift nets below the causeway were marked and released, but none were observed passing through the fishway or control gates.

In the fall of 1971, 15 salmon were tagged in the fishway and released below the causeway. Eight of these were recaptured in the fishway, 7 after a mean absence of 24 hr and one after 12 days.

Captures of salmon at a picket trap located 6.25 km above the causeway were used to determine the effectiveness of the fishway in 1971. Of the fish that used the fishway, 47.8% were recaptured at the picket trap. Eight unmarked salmon captured at the picket trap had not used the fishway. It was estimated that 15-20 salmon of the total run of 910-915 (895 counted at the fishway plus 15-20 that entered via the gates) used the control gates when fish passage flows were provided. This was considered to be relatively high usage of the gates since fish passage opportunities were provided on only four occasions during the fall of 1971 due to extremely low river discharge.

Timing of salmon return to the Petitcodiac may have been delayed for individual fish, but the overall timing of the salmon run was similar before and after construction of the causeway. In 1971 and 1972, some salmon entered fresh water in August, but most entered in October and early November. Median delays for individual fish ranged from 1-8 days in different years with an overall range of 1-43 days.

An examination of fish passage success on normal and reversed fishway flows showed that only salmon had better fish passage under normal flows. Salmon, shad, alewives, smelt and striped bass all used the fishway when fishway flow was reversed. In 1972, alewives and smelt passed through the fishway in greatest numbers when fishway flow was reversed. This finding was not apparent from the 1971 data. Too few shad and striped bass were captured to say anything other than they also used the fishway on reverse flows. It was recommended that normal flows be maintained to improve salmon passage from September to late fall when >90% of salmon return to the river. There was no recommendation regarding passage of other species.

Before the causeway was built, there was increasing recreational interest in fishing shad between Salisbury and Moncton. Angling interest in this species weakened following construction of the causeway. Commercial catches of shad (statistical district 80B) were reduced by 37% from 13,091 kg/yr in 1960-1967 to 8,182 kg/yr in 1968-1977. Only 1 shad was recorded ascending the fishway from May 1-Sept. 15 in 1971 and 19 shad for the same time period in 1972.

Alewives were reported by Elson to spawn mainly in the still water reaches of the Anagance River but were also captured in the Pollett River. A small fishery in districts 79 and 80B showed a small increase in commercial landings from 14,000 kg in 1960-1967 to 16,000 kg in 1968-1977. Low numbers of alewives were counted through the fishway in 1971 (360 fish) and 1972 (3,354 fish) but alewives could potentially ascend through the open gates of the causeway during early spring flushing of flood waters.

Smelt could also potentially use the early spring opening of the gates for passage. In 1972, over 33,000 smelt were recorded at the fishway trap in May. There was no commercial fishery, but a dip net fishery was carried out in the Salisbury area of the main river for many years. This recreational fishery was severely depleted following construction of the causeway.

Only 4 striped bass were recorded at the fishway in 1972 and only 5 in 1971. Striped bass provided some angling during summer and fall but catches were low and the size of the run fluctuated widely from year to year. There was no commercial striped bass fishery in the Petitcodiac River.

Complete removal of the causeway gates was recommended as "the best means of assuring fish passage at the causeway". Alternatively, leaving all the spill gates fully open from April to mid-June and September through November would allow passage during the critical fish migration periods. "As a last resort and a less satisfactory solution to the fish passage problem at the causeway, it is recommended that changes be made in the fishway to improve attraction water flow at the fishway entrance over the full tide cycle and that automated or manually controlled discharges through the spill gates be provided to induce salmon to move up the estuary through the fishway or spill gates."

Semple, J. R. 1984. Stock abundance, composition and passage of Atlantic salmon at Moncton causeway, Petitcodiac River, New Brunswick, 1983. Unpublished report, Department of Fisheries and Oceans Canada, January 18 1984. 23 p.

Salmon stock abundance and composition was evaluated by means of a mark-recapture experiment, which also evaluated new fish passage provisions. The gate nearest the fishway entrance was modified in late autumn of 1983 to provide river maintenance flows of 14 to 28 m^3/s and an alternate means of passing salmon during certain stages of the tide. Leakage through the remaining four gates was sealed, the vertical slot baffle at the entrance to the fishway was extended to elevation 8.3 m geodetic and the interior and exterior walls of the fishway as well as the last six baffles of the fishway were extended to elevation 8.08 m.

A tagging trap was operated in the fishway from May 20 to November 16, on weekdays only. All salmon ascending the fishway were counted and either marked (fin punch) or tagged (Carlin or spaghetti tag) or both. A picket trap was operated in the Petitcodiac River at Boundary Creek for recovery of marked salmon, from June 13 to October 28 on weekdays only.

The first salmon was captured in the first week of July, and 20 salmon were captured on November 16, the last day of trapping. The run peaked during the last two weeks of October (489 fish, representing 40% of the total run, ascended during this period).

The total population estimate of Atlantic salmon ascending the Petitcodiac River from May 20 to October 28 was 1,203ºFish (95% confidence interval, 1,453-2,941 fish). It is further estimated that an additional 709 salmon entered the river from October 29 to November 16, for a total run of 1,912 fish, excluding 87 grilse removed for broodstock. Increased returns in comparison to previous years were attributed to the 1980 stocking of approximately 91,000 hatchery-reared fall fingerlings, since 94% of the aged salmon were 1-sea-winter salmon derived from the 1979 spawning year. Only 5.6% of the salmon run was represented by multi-sea-winter salmon. A total potential deposition of 3,140,000 salmon eggs was estimated for the Petitcodiac River system during 1983. This was ~46% less than the optimum egg deposition for the system.

Of the total salmon aged, 99.1% had spent two winters in freshwater before their descent to the sea as smolts. This was not considered to be typical of the Petitcodiac River nor of other Bay of Fundy rivers, where age 3 smolts are usually equally represented.

Overall, 39% of the total salmon ascending the river passed through the modified flow control gate of the causeway rather than through the fishway. The modified gate was judged to be an effective supplementary means of passing salmon upstream. Only 4% of the salmon tagged at the fishway subsequently descended downstream through the modified control gate and re-ascended through the fishway. The average time to recapture in the tagging trap was 5 days (median 2 days, range 0-42 days).

A total of 13 salmon that had been tagged at the fishway were later captured at the Boundary Creek trap, 17 km upstream. The average time to recapture was 15 days (median 8 days, range 1-32 days).

T. Pettigrew (N.B. Dept. of Natural Resources) conducted a visual survey of spawning salmon and salmon redds. He counted 84 salmon redds and 18 salmon along a 22.2 km stretch of the Pollett River below Gordon Falls. In Little River he counted 131 redds and 125 salmon in a 21.2 km stretch of river.

Sirois, G., H. Jansen and J. Ritter. 1996. Controversy over failed fish passage at the Moncton-Riverview causeway, Petitcodiac River, New Brunswick. Briefing package for N.A. Bellefontaine, Canada Department of Fisheries and Oceans. June 29 1996. 8 p.

The original construction of the causeway in 1967-1968 included a fishway to comply with the federal Fisheries Department's request to provide fish passage. At that time, downstream fish passage was viewed as possible through the fishway and by sounding beneath the gates when partially raised. Downstream passage should have been improved with the installation of two surface ports in one of the gates in 1981-82.

Upstream fish passage had been inadequate for all anadromous species. This situation seemed not to be rectifiable by piecemeal measures because of the large variation in the requirements of the different species, and more importantly, the peculiar situation in the tailrace of the causeway created by the rise and fall of the tide. Downstream fish passage was also inadequate, particularly for Atlantic salmon smolts and kelts. The mechanics of the downstream passage problems were not fully understood.

Atlantic salmon runs had declined dramatically in spite of the existing fishway, extensive hatchery stocking, and springtime manipulation of the gates (attempted for 3 years) to aid the passage of smolts and kelts to the sea. The only relatively high return was in 1983ºFrom a 1980 parr release. This exceptional return coincided with the headpond being drawn down to the lowest possible level from February to September in 1982, the year in which the contributing smolts exited the system.

It was stated that Department of Fisheries and Oceans "supports free flow through the Moncton-Riverview causeway annually from April 1 to December 15 as the preferred operational strategy for maximizing anadromous fish production. The opening of at least one of the gates, described as Approach B or C in the recently completed report would provide the desired fish passage. The scenarios with the highest water levels upstream of the gates and the largest gate opening are preferred because they would provide the longest time for fish passage on the flood tide without orifice flow."

St-Hilaire, T. Milligan and H. Dupuis. 1998. Monitoring of turbidity in the Petitcodiac River. Pages 156-171 97 *in* Environmental Monitoring Working Group. 1998. Environmental monitoring of the Petitcodiac River system, 1997: Trial opening of the Petitcodiac River causeway gates. December 1998. 280 p.

Near downtown Moncton, turbidity reached 4,764 NTU (13.1 g sediment/L) on October 10 1997. The maximum for each tidal cycle was usually 2,500-3,500 NTU (2.4-5.8 g/L). Higher values were associated with maximum ebb flow and with spring tides. Suspended sediment concentrations were low (generally <1 g/L) on high and low slack water. Results at a control site opposite Stoney Creek were apparently similar.

Turbidity values upstream of the causeway never exceeded 2,064 NTU (6.9 g/L) and did not fluctuate tidally.

Warren, L. 1946. The Petitcodiac drift-net fishery. Fisheries Research Board of Canada, Manuscript reports of the biological stations 392; Atlantic salmon and trout investigations, 1946: 36(16): 52 p.

The Petitcodiac fisheries were described as being in decline, relative to the beginning of the century. The fishing fleet had decreased from ~70 to ≤10 boats. Shad catches were on the decline from 1938 to 1945 while salmon catches were increasing over the same period. In 1946, 13,745 shad and 798 salmon were caught in the Petitcodiac estuary by 6 boats. An estimated total of 19,500 shad and 900 salmon were caught from Cumberland and Shepody Bay and the Petitcodiac River in 1946 using drift nets. The number of salmon had probably increased more in the previous 4-5 yr than the records of catches indicated, since "modern" nets were weaker than pre-war materials and "can hardly hold salmon". An observer counted 34 holes made by salmon along the top 1.8 m (6 ft) of one half of one net, which had been in operation for one month. The net had retained about 25 salmon.

The Petitcodiac drift-net fishery was primarily for shad. The fishing season opened June 15, after spawning was completed. This opening date was strictly enforced and ovigerous females were rarely captured. The fishing therefore was on shad returning to the sea after spawning. Fishing rarely extended beyond the middle of September. Fishing was restricted to five days/week.

Fishing took place below Stoney Creek in the last 24 km (15 miles) of the tidal Petitcodiac River and in Upper Shepody Bay as far south as Two Rivers Inlet. The main fishing areas were characterized by "the presence of a light brown sediment which makes observation over a foot down in the water almost impossible". The concentration of this mud was greater in the river than in the bay. Concentration in the bay was increased by the river water during ebb flow and especially with high tides. "One may safely say that the water is never clear in the river."

Fishing was conducted in the river only during high water because of the shallowness of the upper river and increasing numbers of both shad and salmon at high slack water. Fishing was restricted to the "streak-of-tide" [a front caused by the incoming tide] and to eddies within the fishing areas mentioned above. At flood and ebb tide when the flow was greatest almost the entire river was considered the "streak-of-tide". The distribution of the "streak", currents and eddies between Cape Enrage and Stoney Creek were discussed in some detail. Certain eddies were less suitable for fishing shad and salmon - for example, a large eddy south of Mary Point contained too many dogfish. On low tides, fishermen either moved down to the bay to fish or tied up their boats. At full ebb, the river as far south as Edgett's Cape was ≤1.5 m (5 ft) deep and ≤15.2 m (50 ft) across. "Thus the fresh water Petitcodiac River is almost insignificantly small. Its importance lies in the fact that it is filled by a rapid inrush of salt water from the sea and is swollen to a great size. It serves as a conduit to fresh water spawning grounds for salmon and shad." The bore started to form abreast of Pre d'en Haut. "As it rolls along it churns the mud bottom" and increased in height with the narrowing of the river. Most fishing in the river was conducted during daylight. Night fishing occurred only when salmon were abundant, since it usually resulted in lower catches of shad and higher catches of sharks. Salmon catch was equally good regardless of time of day.

Fishing in rainy and non-windy conditions at dawn seemed to yield the best shad catches. Rain was considered to bring shad closer to the surface. Water temperature was considered unimportant. Better catches were made in muddy water, probably because shad could not see the net. However, night fishing was not very successful. Fishermen believed that shad swam deeper at night and that this accounted for the difficulty of catching shad at night. In the morning, most were captured at depths of 2.4-2.7 m (8-9 ft) in the river, although the distribution was deeper in the bay (3-5.2 m, 10-17 ft). Larger shad were generally found caught in the deeper portions of the net.

Fishing gear was described in some detail. Dimensions and rigging of the 12.7 cm (5 in) mesh gill nets and various types of boats used for fishing were discussed. Fishing was always concentrated in areas with depth ≥5.5-6.1 m (18-20 ft) since nets were 5.2 m (17 ft or 50 meshes) deep. The duration of the net drifts (hauls) varied with each fishermen and weather conditions. In 1946, eleven fishing boats were licensed, of which six fished heavily.

Petitcodiac shad were considered superior to shad from other parts of the province because they were so fat. Fishermen claimed that this was because they fed on "shad worms" which lived exclusively in the mud bottom and flats of the Grande Anse. These "shad worms" were reputedly yellow, 7.6 cm (3 in) long and 1.3 cm (0.5 in) diameter. The writer was somewhat sceptical as to their reality. The fish caught weighed as much as 3.6 kg (8 lb) but were mainly in the 1-1.8 kg (2.5-4 lb) range. The majority of shad caught measured between 43.5 and 44.4 cm in length.

Shad were bought at the wharves by fish vendors, peddled from door to door by the fishermen, sold to Moncton fish markets or salted for winter use. There had been some discussion of establishing a co-operative cannery in the area. Petitcodiac shad had been canned commercially, on an experimental scale, under the brand name of “Under Two Flags”.

Salmon were the second most abundant fish caught from mid-July onwards. Special nets (only half as deep as the shad nets, 25 meshes of 12.7 cm (5 in) mesh, or 2.6 m (8.5 ft)) were sometimes fished for salmon, since they swam closer to the surface than shad. Alternatively, the same nets could be used for salmon or shad. Nets intended to hold salmon also had to be much stronger than those for shad, and fishermen often timed the purchase of new nets for the start of the salmon season. The female:male ratio of salmon caught was 3:1.

Other species caught as bycatch in the shad drift-nets were spiny dogfish (*Squalus acanthias*), possibly (2 specimens with unconfirmed identities) black dogfish (*Centroscyllium fabricii*), mackerel (*Scomber scombrus*), sturgeon (*Acipenser* sp.), grey shark [now known as Greenland shark] (*Somniosus microcephalus*), thresher shark (*Alopias vulpinus*), anglerfish (*Lophius americanus*) and sea bass [presumably, striped bass, *Morone saxatilis*]. Porpoises [presumably, harbour porpoises] were also caught. Tomcod (*Microgadus tomcod*), smelt (*Osmerus mordax*), cod (*Gadus morhua*), eels (*Anguilla rostrata*), squid and whales were observed but not netted.

Dogfish were especially abundant in May and June in the river, but were found at all times in the bay. They were particularly abundant near shore. Dogfish caused damage to the nets when caught, frightened shad away from the nets, and were considered a nuisance. Every dogfish caught was killed and discarded. As many as 400 were caught in a season. Experiments with shark repellent showed that neither shad, salmon or dogfish were affected by the repellent.

Eels were so plentiful around the wharves when fishermen were eviscerating shad in July and August that they were caught “in unusual quantities” by lowering a basket into the water.

Grey [Greenland] shark appeared mainly in August and September and caused much damage to nets in the bay.

Salinity, temperature, chlorine, specific gravity and silt concentration were measured on a transect between Gautreau Village and the shore opposite Dover Hill. Salinities were on the order of 29-30‰. Similar salinities were obtained at the Moncton Bridge [Gunningsville Bridge] and at Gautreau Village on August 4 1946. Maximum salinity at Moncton was almost as high as it was at Gautreau Wharf, indicating that the river consisted almost entirely of sea water at full flood and that freshwater influence was negligible. Surface and bottom salinities at Moncton hardly differed from one another, indicating considerable vertical mixing. At Salisbury railroad bridge, samples taken at high water during 7 and 7.3 m (23 and 24.1 ft) tides found very little salt in the water (approximately 0.25‰). The volume of water in the river at the time was estimated to be 20 times that of the fresh water stream. With higher tides (7.6 m, 24.9 ft) salinity increased to 11‰ at the railroad bridge.

Washburn and Gillis Associates Ltd. 1994. Suggested watershed management and freshwater and anadromous fisheries improvement opportunities – Moncton region. Washburn and Gillis Associates Ltd., Fredericton, NB. Report to Recreational Fisheries Division, Dept. of Fisheries and Oceans, Moncton, NB. February 10 1994. vii+105 p.

Moncton was described as having “the largest disparity between recreational fisheries opportunities and supply of any in the Province”. This report discusses current angling status of the Petitcodiac watershed and suggests some development opportunities.

Several small streams within the city limits probably supported remnant brook trout populations, but were under severe stress from habitat degradation. Several water supply reservoirs could provide angling opportunity, but it had been a policy to prohibit their use for recreational purposes including angling. The Irishtown Reservoir, which was abandoned and maintained only as a back-up supply, was one of the few lakes in the area which was thermally stratified. The majority of the 120 ha reservoir was very shallow and choked with weeds, but the arm adjacent to the outlet dam was at least 7.3 m (24 ft) in depth. The trout production capacity was limited by white suckers and by oxygen deficiency (0.4 ppm) in the thermocline and hypolimnion. It was suggested that this reservoir could be developed for angling by use of an onshore aeration chamber and by stocking with splake for a put-and-take fishery.

The West Branch Halls Creek was proposed as an area for fishery development because it discharged downstream of the causeway and might therefore provide some anadromous fish production. The location proposed for development extended from the confluence of Gorge Brook downstream to the confluence with North Branch Halls Creek, a stretch of ~5 km length and assumed mean width of 4 m. The major problem was habitat degradation. During a site visit in November 1993, storm sewers draining Mountain Road housing developments were discharging water with noticeably elevated levels of suspended solids into this stream. It was suggested that sources of sediment would have to be addressed, followed by habitat improvement with digger logs. An alternative site with less on-going damage during the site visit was Jonathan Creek.

The lower reaches of the Petitcodiac, Little, Pollett, North and Anagance Rivers were considered to be too warm for brook trout in the summer, and would normally hold adult salmon during their spawning run. Given "extreme fish passage problems at tidal gates", a large amount of habitat was vacant or underutilized. The presence of smallmouth bass and the occasional striped bass was noted.

The report suggests that "The only viable solution [to the limitations on the Atlantic salmon fishery locally] appears to allow re-established tidal flow, and to restore fish passage. ADI and Washburn & Gillis Associates Ltd. (1992) calculated that a salmon run of at least 5,000 fish could be restored through such action, generating angling activity of an equivalent number of angler-days per year." A suggested option "if the operation of the Petitcodiac gates are to remain as an impediment to fish passage for the foreseeable future is to stock the system with brown trout." The consequence for existing recreational fisheries would be competition between brook and brown trout which would restrict brook trout to the headwaters, where they were already restricted by water temperature. It was suggested that the brown trout would utilize the vacant salmon habitat.

The upper reaches of the Petitcodiac including Turtle Creek could provide brook trout habitat because of cool water conditions in summer. All of the drainage except the headwaters and the Pollett upstream of Gordon Falls also had potential as nursery area for salmon. The principal problem limiting the fisheries potential was habitat degradation due to past and current land use practices. This had resulted in diminished trout and salmon production.

Mechanic Lake, a headwater lake of the Pollett River watershed (elevation 302 m), had an area of 22 ha, a shoreline of 2,631 m, and a maximum depth of 3.1 m. An outlet structure controlled the water level. On July 18 1974, the New Brunswick Dept. of Natural Resources determined that pH was 7 and dissolved oxygen was 9 mg/L at both surface and bottom. Temperature was 21.7ºC and 16.7ºC at surface and bottom respectively, indicating slight stratification during the summer. The lake had resident populations of brook trout, American eel, blacknose dace, finescale dace, and recently introduced brown bullhead. The angling pressure for brook trout was "intense". Fish were reported to be abundant but small, with the best angling in spring and early summer. Prior to bullhead colonization, the limitation to a good trout fishery in this lake was determined to be the overabundance of stunted brook trout. Currently, the presence of competitive species, principally the brown bullheads which were probably inadvertently introduced by anglers using them as live bait, "seriously limits trout production". The suggested solution was to rotenone the lake and restock it with brook trout. The outlet structure would need to be modified to exclude bullheads that might attempt to recolonize from downstream.

Blackwood Lake, a headwater lake of the Little River watershed (elevation 372 m) was approximately 8.4 ha in area, had a shoreline of 1,257 m, and a maximum depth of 2 m. The catchment basin was approximately 1.2 km^2. In 1988, a dam was placed on the outlet, increasing the lake volume by 80%. Blackwood Lake was slightly acidic (pH 6.4-7), with low alkalinity (3 mg/L) and soft water (8-17.1 mg/L). The concentration of total phosphorus was 0.011 mg/L. The lake was isothermal in summer at 20ºC with dissolved oxygen at 8 mg/L to the bottom. These data indicated that the lake was probably not very productive. In 1978, brook trout were found to be the only fish species in the lake. It was suggested that productivity could be improved by liming, fertilization, and improvement in spawning habitat.

The conclusion of the report was "the Moncton watershed region presents a difficult challenge in providing angling opportunity for native species." It was acknowledged that the opportunities suggested, which involved non-native or non-sustainable species were not naturally sustainable. Long-term solutions were the operation of the causeway gates to allow tidal flow, or reducing angling mortality on trout by enforcing restricted creel limits.

Wells, P.G. 1999. Environmental impacts of barriers on rivers entering the Bay of Fundy: Report of an *ad hoc* Environment Canada working group. Canadian Wildlife Service Technical Report Series No. 334: 46 p.

Barriers exist on at least 25 of 44 major rivers around the Bay of Fundy. They have caused or are thought to have caused a wide range of ecological effects, including reduced lengths of tidal rivers, changed freshwater discharges, reduced movement of salt water upstream, changed hydrodynamics, sedimentation (often severe), reduced open salt marsh, reduced nutrient transfer to the Bay, and interference with the movement of fish and invertebrates. The full scope of environmental impacts was not well understood. Except for a few rivers, the data were largely anecdotal.

The Petitcodiac River situation was considered to be well documented. The following effects of the causeway were listed: obstruction to fish passage (e.g., salmon, sea trout, gaspereau, smelt, shad); reservoir was eutrophic and deoxygenated in summer; provided new recreation and waterfowl staging areas; extensive silting downstream restricted waterway; new mudflats/saltmarsh developed; possible effects on mudflat composition, fauna and shorebirds; concern over contaminants in sediments in river and Shepody Bay.

White, H.C. 1952. Eels and planted salmon fry. Pages 115-116 *in* Needler, A.W.H. Fisheries Research Board of Canada. Report of the Atlantic Biological Station for 1952. (Appendix No. 72).

About 500,000 salmon fry were distributed along 6 km (4 miles) of the Pollett River below the Forest Glen dam. The planting started earlier than in former years and the fry were much smaller than usual. In other years it was found that eels took a very high percentage of the larger fry during and shortly after planting. Observations of the fate of the fry were made starting on August 8 1952 while planting was in progress.

Immediately after planting on August 8, the fry were clustered along the edge mostly within 1 m (3ºFt) of the shore and crowded under “every loose stone”, i.e., the “very places one would expect to find eels”. Six eels were captured for stomach content analysis. The smallest (11.4 cm, 4.5 in) eel contained 1 fry but the others (30-41 cm, 11.75-16 in) were empty.

On August 9, the first night after planting was completed, small eels were captured using baited hooks. Additional sampling was carried out on the 5th and 6th nights after planting. By the 5th and 6th night, the fry had become very scarce. The only ones found were in very shallow water, some resting in water 0.6-1.3 cm (¼-½ in) deep. A few were resting on stones which came near the surface. Numerous small eels were observed in water so shallow that they splashed when a flashlight was turned on them. In other years it had been observed that larger eels were taking large numbers of the fry, but in 1952 it appeared that smaller eels were getting them more readily.

Time	Eels		Gut contents		
	No.	Length, cm (in)	Salmon fry	Other fish	Insect larva
Aug. 8, mid-day	1	11.4 (4.5)	1	0	0
	4	63.5-101.6 (25-40)	0	0	0
Aug. 9, 2200h-Aug. 10 0100h	2	33-34.3 (13, 13.5)	12	0	0
	4	43.2, 44.5, 56, 63.5 (17, 17.5, 22, 25)	0	0	0
Aug.13, 2200h-Aug.14, 0200h	1	32 (12.5)	0	0	Trichoptera
	1	35.6 (14)	0	1 minnow	0
	1	56 (22)	0	1 sucker	0
	3	41, 43.2, 51 (16, 17, 20)	0	0	0
Aug.14, 2200h-Aug.15, 0130h	2	29, 30.5 (11.5, 12)	0	0	Trichoptera
	2	37, 38 (14.5, 15)	2	0	0
	3	41, 51 (16,16,20)	0	0	0

White, H.C. 1953. Merganser life history and food on St. Mary River, N.S., Coverdale and Sevogle Rivers, N.B., and Port Daniel River, P.Q. Pages 119-122 *in* Needler, A.W.H. Fisheries Research Board of Canada report of the Atlantic Biological Station for 1953. (Appendix No. 63).

The Coverdale River, although smaller than the Pollett River, was equally rich in food for parr, and provided good trout and salmon fishing. On July 16 1953, the stream was low, and was easily waded at nearly all points. The water was clear and visibility was good. Local residents reported 25-40 mergansers in a single flock, which had been seen over a length of 32 km (20 miles) of stream. Others had seen a brood of 8 mergansers. Visual examination of the stream indicated a “severe depletion” of all fishes of the sizes taken by mergansers. The only fish remaining were fry (too small for mergansers to eat) and suckers (too large to swallow), but some of the latter “showed markings indicating that they had been mauled by mergansers”. The ducks had depleted Prosser Brook as far as the gorge where the highway borders the stream through the gorge. Above this area the brook contained a normal population of fishes of various species. The upper limit of the mergansers on the main river had been the two Parkindale bridges, which are close together on the main highway. The merganser ducklings had been limited to the part of the stream between the muddy waters of the Petitcodiac estuary and the traffic over the bridges at Parkindale.

Drives were made over about 16 km (10 miles) of stream, where 7 well-grown young and an adult female were the only ducks encountered. The 7 ducklings contained remains of 3ºFishes – 1 dace (60 mm), 1 sucker (75 mm), 1 eel (20 cm). The adult female contained remains of 4 suckers (13, 7, 7 and 7 cm). The young had also been eating aquatic insects and grass.

White, H.C. 1953. Homing of salmon to Petitcodiac River. Page 148 *in* Needler, A.W.H. Fisheries Research Board of Canada report of the Atlantic Biological Station for 1953. (Appendix No. 72).

Large numbers of smolt from non-indigenous fry plantings had been marked and released during their descent of the Pollett River, but only a few of the spawning run of mature salmon had been marked fish. In contrast, there had been good returns of marked salmon to Holmes Brook, where only indigenous smolts had been marked.

To determine whether indigenous hatchery-stocked salmon would return to the Pollett River, ~10,000 eggs were collected from native stock at the trap below the experimental area. The eggs were placed in a hatching box in a large spring at Portage Vale in the upper waters of the Kennebecasis River over winter. Hatching began in late February and yolk sac absorption was complete late in April. On May 2, most of the fry were taken to the Collingwood hatchery to be reared to fingerlings. On May 5, the remaining 2,500 fry were transferred to the Northwest Miramichi counting fence where they were retained in a floating trough. Many died due to disease and warm temperatures, but 515 survivors were transported to Petitcodiac. These were marked by removing the adipose fin and planted above the experimental area in the Pollett River on August 21. Of the 2,869 fingerlings brought from the Collingwood hatchery on October 2, about 2,000 "appeared to be from the Petitcodiac River stock". [There is no indication in the paper what the remainder were.] All were marked on October 5 and planted in the upper Pollett River.

White, H.C. 1954. Young salmon in merganser stomachs collected on 21 streams. Pages 138-139 *in* Hart, J.L. Fisheries Research Board of Canada. Report of the Atlantic Biological Station for 1954. (Appendix No. 67).

Stomach analysis of mergansers from the Pollett River was summarized:

- Number of stomachs = 120
- Total fish eaten = 880
- Total salmon eaten = 352
- % of salmon/total fish = 40.0%
- Average number of salmon/stomach = 2.9
- % occurrence (frequency of stomachs containing salmon) = 55.8%.

White, H. C. 1957. Food and natural history of mergansers on salmon waters in the maritime provinces of Canada. Bulletin of the Fisheries Research Board of Canada 116: 63 p.

Life history and food of American, red-breasted and hooded mergansers were discussed with reference to several New Brunswick, Nova Scotia and Prince Edward Island salmon streams.

Investigations along the Pollett River in 1952 revealed many merganser nests in abandoned trees and rock cavities. However, raccoons were occupying most of the likely nesting trees.

During 1949-1952, stomach contents of 120 American mergansers killed during the merganser control experiment in the Pollett River were analyzed. Of the thirteen fish species identified in merganser guts, juvenile Atlantic salmon, white suckers, lake chubs and blacknose dace were the most abundant. Young salmon appeared to be selected preferentially, perhaps because of their size.

In the Glades Pond, a small pond above a dam on the Pollett River, American mergansers had fed largely upon suckers (3.5-25 cm long) and eels (10-29 cm long) from the pond. Larval lampreys, a threespine stickleback, and dragonfly nymphs were also eaten.

Winter (March) food of American mergansers in the main Petitcodiac River was mainly suckers and eels. The eels taken were large.

In July 1953, the Coverdale River was characterized as a stream where mergansers had depleted the fish. The water was very low and ~16 km (10 miles) of stream were examined for fish and merganser. Visibility to the bottom, even in the large pools, was excellent, and many large suckers were seen. Some medium-size suckers showed "unmistakable marks of having been mauled by mergansers". These were fish which were a little too big to be swallowed by half-grown mergansers. "We could find no fish of the sizes ordinarily taken". The food consumed by young American mergansers included a 7.5 cm sucker, a 6 cm blacknose dace, and a 20 cm eel. Other food items included: dragonfly nymph, water strider, cranefly larva, mayfly nymph and grass-like leaves. The mother merganser had consumed 4 suckers ranging in length from 7 to 13 cm.

In contrast to the Coverdale River, the Pollett River with merganser control in effect had large populations of young salmon, minnows, suckers and eels. "During low water many fish are readily seen when walking beside or wading in the stream."

Red-breasted mergansers from the Petitcodiac system had eaten salmon smolts, suckers, minnows, golden shiners, fourspine sticklebacks, threespine sticklebacks and eels.

White, H.C. 1943. Fishes of the Petitcodiac river. Fisheries Research Board of Canada, Manuscript reports of the biological stations 336; Atlantic salmon and trout investigations, 1943; 29(11): 2 p.

Nineteen fish species were found in surveys of the freshwater Petitcodiac watershed with seines and traps. (Where scientific names have changed since 1943, the modern name is presented first.)

sea lamprey (*Petromyzon marinus*)
alewife (*Alosa pseudoharengus = Pomolobus pseudoharengus*)
American shad (*Alosa sapidissima*)
Atlantic salmon (*Salmo salar*)
brook trout (*Salvelinus fontinalis*)
white sucker (*Catostomus commersoni*)
creek chub (*Semotilus atromaculatus*)
lake chub (*Couesius plumbeus*)
blacknose dace (*Rhinichthys atratulus*)
northern redbelly dace (*Chrosomus eos*)
blacknose shiner (*Notropis heterolepis*)
golden shiner (*Notemigonus crysoleucas*)
American eel (*Anguilla rostrata = A. bostoniensis*)
banded killifish (*Fundulus diaphanus*)
striped bass (*Morone saxatilis = Roccus lineatus*)
slimy sculpin (*Cottus cognatus*)
threespine stickleback (*Gasterosteus aculeatus*)
ninespine stickleback (*Pungitius pungitius*)
fourspine stickleback (*Apeltes quadracus = A. quadraculus*).

Lake chub was one of the most abundant as well as being the most widespread species throughout the whole system, from cold highland brooks to lowland weedy backwaters. Blacknose dace was found on the rapids over most of the system and extended up most of the brooks even further than lake chub. Suckers were distributed throughout the system except in the colder brooks. Creek chub was "fairly abundant where found" and had a wide distribution. Northern redbelly dace was not plentiful, but widely distributed in the quieter waters. Golden shiner was found only at the Pollett River dam [presumably, the Sanatorium dam, although this could have been the dam at Forest Glen] and in the backwaters of the lower Petitcodiac River. Only one specimen of blacknose shiner was found. Slimy sculpin was found only in three of the colder spring-fed systems but probably occured near the source of many others.

Wilder, D. G. 1942. Operation of Petitcodiac and Pollett smolt traps in 1942. Fisheries Research Board of Canada, Manuscript reports of the biological stations 327; Atlantic salmon and trout investigations, 1942; 5(3): 9 p.

In the spring of 1942, counting fences were installed in the Petitcodiac and Pollett Rivers in order to intercept downward migrating smolts from the 1941 fry stocking experiments in the North River, and any naturally produced smolts in the Pollett River. Details on the construction of the two fences, their locations and the bottom substrate are provided and there are photographs of the fences and sites.

The Petitcodiac River counting fence, located 0.4 km (0.25 mile) above the junction of the Petitcodiac and Pollett Rivers, was operated from May 8 to June 17. It had to be modified to provide passage for "the large numbers of shad [which] migrate up the Petitcodiac River during May and June". The modifications were not immediately successful and "by May 11th large numbers of shad had collected below the barrier". Traps were fished several times a day and frequently throughout the night, primarily to remove shad which "died rather quickly in the trap". In total, 2,318 smolts were taken from May 10 to June 13. The major run occurred from May 17 to May 27, during which 63% of the smolts descended. Total lengths were recorded for 253 smolts, with a mean length of 16.1 cm. Scale samples were collected from 257 smolts. Scales had not been read at the time of publication, but "it appears that the majority of these smolts were two plus years of age".

The Pollett River trap was located 0.4 km (0.25 mile) above the mouth of the river and operated from May 13 to June 17. High water from log driving operations at Forest Glen caused some erosion problems with the fence. There was no comment as to the presence of a shad run, although the fact that no upstream fishway was provided suggests that shad did not ascend this river. Smolts were taken for the full duration of the fence operation, for a total of 559 smolts. Large numbers of parr started to descend from June 12. The 216 smolts that were measured had a mean total length of 17.6 cm. The 217 scale samples had not been read, but it appeared that there was a higher percentage of three plus fish than in the Petitcodiac River sample.

Downstream movements of all fish species were recorded as follows. Striped bass and white perch were present in the main Petitcodiac but not in the Pollett River.

Common name	Scientific name	Petitcodiac R.	Pollett R.
Atlantic salmon (smolts)	*Salmo salar*	2,318	559
Atlantic salmon (parr)	*Salmo salar*	82	933
Shad	*Alosa sapidissima*	1,103	4
Gaspereau	*Alosa* sp.	1,400	863
Eels	*Anguilla rostrata*	373	208
Trout	*Salvelinus fontinalis*	73	18
White suckers (large)	*Catostomus commersoni*	91	231
White suckers (small)	*Catostomus commersoni*	442	179
Lake chub	*Couesius plumbeus*	>639	~469
Golden shiner	*Notemigonus crysoleucas*	2	1
Creek chub	*Semotilus atromaculatus*	5	27
Finescale dace	*Chrosomus neogaeus (=Pfrille neogaea)*	1	4
Blacknose dace	*Rhinicthys atratulus*	13	34
Banded killifish	*Fundulus diaphanus*	6	1
Sea lamprey	*Petromyzon marinus*	18	119
Striped bass	*Morone saxatilis*	14	0
White perch	*Morone americana*	4	0
Threespine stickleback	*Gasterosteus aculeatus*	1	2

Wilder, D. G. 1942. Water temperatures and heights, Petitcodiac and Pollett rivers, 1942. Fisheries Research Board of Canada, Manuscript reports of the biological stations 327; Atlantic salmon and trout investigations, 1942: 25(4): 8 p.

Maximum and minimum daily temperatures at the Petitcodiac and Pollett River smolt counting fences are presented in graph form.

Daily maximum temperatures at the Petitcodiac River fence (May 8-June 17) ranged 9-31ºC (48.3-88.0ºF). At the Pollett River fence (May 13-June 17), the range was 11-31.4ºC (52.0-88.5ºF). In mid-May, the Pollett River was considerably cooler than the Petitcodiac River, but by June the two rivers had similar temperatures.

The maximum temperature was reached on June 13 and resulted in mortalities of many shad, as well as lesser numbers of smolts, gaspereau, trout, eels, lake chub (*Couesius plumbeus)*, creek chub (*Semotilus atromaculatus)* and suckers. On June 13, "many" dead shad were seen in the vicinity of the Petitcodiac River counting fence. On the morning of June 14, 673 dead shad were counted in the river from 3 km (2 miles) below Petitcodiac village to the junction of the Petitcodiac and Pollett Rivers. On June 17, the Department of Public Health buried 1,968 shad between Boundary Creek and 2 km (1.5 miles) above Salisbury. In all, 2,577 dead shad were recorded in the period May 8 to June 17. Of these, 2,517 died between June 12 and June 17, with the "great majority" of these dying on June 13.

Large numbers of parr began to descend to both fences on June 12. This movement was attributed to the warm temperatures. Probably many of these parr were not counted, since the fence was being left open at night to allow downstream passage for the shad. However, at both counting fences, many parr descended during the daytime. Comparison of the daytime parr numbers led to the conclusion that the

Pollett River had the larger parr run. There was also considerable mortality of parr during the warm temperatures. Large numbers were reported dead in the "swimming pool" at the base of Fawcett Hill and in the Coverdale River on June 14.

Water levels at the traps were recorded at least daily. The period of fence operations was unusual in the lack of heavy rains; the river dropped steadily at the Petitcodiac trap from 45.7 cm (18 in) on May 8 to 19 cm (7.5 in) on June 14. At the Pollett River trap, logging operations at Forest Glen produced artificial freshets, usually two per day, until May 15. After this period, the water level decreased more-or-less steadily from 56 cm (22 in) on May 16 to 30.5 cm (12 in) on June 16.

Wilder, D. G. 1942. Traps and shad migration, Petitcodiac River, 1942. Fisheries Research Board of Canada, Manuscript reports of the biological stations 327; Atlantic salmon and trout investigations, 1942; 25(5): 4 p.

Shad were first observed moving upstream in the Petitcodiac River just above the Pollett River at 2000h on May 5. The start of the run probably did not predate this by many days. By May 11, a large number of shad had collected below the counting fence, being reluctant to use the fish passage facilities provided. The opening in the barrier was enlarged from 0.9 to 4 m (3 to 13ºFt), and shad started to move through it, but in small numbers. The construction of a funnel fishway was also unsuccessful. Details of the construction of these fish passage structures are provided in Wilder (1942a).

Observations of behaviour of shad explained why fish passage was unsuccessful. Shad moved in schools below the barrier and at dusk would run up into the funnel, often four or five at a time. In most cases, the whole school then turned downstream without any shad moving through the opening. The shad that did move through the opening did so singly for the most part and at intervals of 5 to 10 minutes or longer. This appeared to break up the schools and the shad did not continue upstream but wandered randomly above the barrier then entered the downstream trap.

No shad were ever observed to use the funnel during the day. From the limited observations made, it was concluded that the most upstream movement through a funnel of this type occurs during an hour period just at dusk. Movement was observed from 2000h to 2200h.

The funnel was deemed unsatisfactory for upstream passage of shad. "It should have an opening at least a foot wide and be at the deepest part of the stream...It might be possible to provide the funnel with a ramp at the apex to lead the shad over."

Shad entered the downstream trap the first night it was in operation (May 8) and continued to do so every night until June 17, with the exception of May 20. Until May 27, the numbers entering were few and it was assumed that this represented the normal movements of the shad, or the effects of the funnel breaking up the schools during their upstream movement. On May 28, the run increased and continued to do so until June 1, after which it dropped off for four days and then increased abruptly on June 6. The fence operators removed a total of 1,103 shad from the trap, and additional shad were removed by poachers on the nights of May 30, June 3, and June 5.

Shad could not live overnight in the trap. In high water, shad could not withstand the current produced by the funnel and were repeatedly swept against the sides of the trap. In early May, with relatively high but cool water, some shad died in the trap in 8-10 hr. Later in the season, the water was considerably warmer and was too low in the trap for the shad to swim properly. During June 7-11, some shad died in 3-5 hr. On June 12-13, one shad died in the trap in 20 minutes but in general deaths occurred in 1-2 hr. During the period the trap was operated, 67 shad died in the trap and some of those liberated were very weak.

A large percentage of the shad dying in the downstream trap were ripe fish that had not spawned. Of 65 males examined, only 4 had spawned. Of 42 females, 20 had spawned.

Willis, D.H. 1999. Feasibility of modelling the Petitcodiac estuary. D.H. Willis and Associates Ltd., Ottawa, ON. Report No. NBE-1 for New Brunswick Dept. of the Environment, Fredericton, NB. March 31 1999. 65 p.

Hydronumerical modelling of the physical results of opening the causeway would be "at the 1999 leading edge of feasibility" but was determined to be feasible based on a questionnaire sent to numerical modellers. The model would be challenging because of:

- the necessity for fine grid spacing and large number of grid points, because of the length (55 km) and narrow width (50 m) of the present low water channel
- rapid sediment deposition rates, because of suspended sediment concentrations on the order of 10 g/L
- current velocities of 3-6 m/sec, because of the tidal bore
- erosion processes appear to be 'bank erosion' of the steep face of the low water channel banks.

The geographical extent of a model and questions to be answered by a model were described, and data requirements were listed. Field data needs were listed and prioritized.

Wilson, R.C.H. and I.C. Travers. 1976. Mercury in the Atlantic provinces. Environmental Services Branch, Environment Canada. Surveillance Report EPS-5-AR-77-10, ARB No. 1, Atlantic Region. Nov. 17, 1976.

Mercury was measured in water samples from the Petitcodiac River at Moncton and Salisbury on March 29 1974. The geometric mean of 2 samples taken at Moncton was 0.19 μg/L, and the maximum value was 0.74 μg/L. Geometric mean and maximum values at Salisbury (N=3) were 0.13 and 0.58 μg/L, respectively.

Appendix 1. Summary of recreational catch statistics for Atlantic salmon in the Petitcodiac River system for the years 1951-1989.

Data were summarized from the following sources. We assumed all salmon caught in April or May to be "black" even when the reports listed them as "bright".

O'Neil, S.F., M. Bernard, P. Gallop and R. Pickard. 1987. 1986 Atlantic salmon sport catch statistics, Maritime provinces. Canadian Data Report of Fisheries and Aquatic Sciences 663: 69 p.

O'Neil, S.F., M. Bernard and J. Singer. 1985. 1984 Atlantic salmon sport catch statistics, Maritime provinces. Canadian Data Report of Fisheries and Aquatic Sciences 530: 98 p.

O'Neil, S.F., M. Bernard and J. Singer. 1986. 1985 Atlantic salmon sport catch statistics, Maritime provinces. Canadian Data Report of Fisheries and Aquatic Sciences 600: 71 p.

O'Neil, S.F., K. Newbould, and R. Pickard. 1989. 1987 Atlantic salmon sport catch statistics, Maritime provinces. Canadian Data Report of Fisheries and Aquatic Sciences 770: 73 p.

O'Neil, S.F., D.A. Stewart, K.A. Newbould and R. Pickard. 1991. 1988 Atlantic salmon sport catch statistics, Maritime provinces. Canadian Data Report of Fisheries and Aquatic Sciences 852: 79 p.

O'Neil, S.F., D.A. Stewart, K. Rutherford and R. Pickard. 1996. 1989 Atlantic salmon sport catch statistics, Maritime provinces. Canadian Data Report of Fisheries and Aquatic Sciences 999: 81 p.

O'Neil, S.F. and D.A.B. Swetnam. 1991. Collation of Atlantic salmon sport catch statistics, Maritime provinces, 1951-1959. Canadian Data Report of Fisheries and Aquatic Sciences 860: 259 p.

Swetnam, D.A.B. and S.F. O'Neil. 1985. Collation of Atlantic salmon sport catch statistics, Maritime provinces, 1960-69. Canadian Data Report of Fisheries and Aquatic Sciences 533: 289 p.

Swetnam, D.A.B. and S.F. O'Neil. 1984. Collation of Atlantic salmon sport catch statistics, Maritime provinces, 1970-79. Canadian Data Report of Fisheries and Aquatic Sciences 481: 297 p.

Swetnam, D.A.B. and S.F. O'Neil. 1984. Collation of Atlantic salmon sport catch statistics, Maritime provinces, 1980-83. Canadian Data Report of Fisheries and Aquatic Sciences 450: 194 p.

The following reports also contain Petitcodiac River catch statistics. In some cases the data differ from those reported in the above reports. The newer series of reports is considered to be more accurate.

Dunfield, R.W. 1973. 1970 Atlantic salmon sport catch statistics, Maritimes Region. Fisheries Service, Department of the Environment, Halifax, NS. January 1973. 35 p.

Dunfield, R.W. 1973. 1971 Atlantic salmon sport catch statistics, Maritimes Region. Fisheries Service, Department of the Environment, Halifax, NS. January 1973. 35 p.

Dunfield, R.W. 1973. 1972 Atlantic salmon sport catch statistics, Maritimes Region. Fisheries Service, Department of the Environment, Halifax, NS. March 1973. 37 p.

Dunfield, R.W. 1974. 1973 Atlantic salmon sport catch statistics, Maritimes Region. Resource Development Branch, Fisheries and Marine Service, Department of the Environment, Halifax, NS. March 1974. 35 p.

Dunfield, R.W. 1975. 1974 Atlantic salmon sport catch statistics, Maritimes Region. Resource Development Branch, Fisheries and Marine Service, Department of the Environment, Halifax, NS. Data Report No. MAR/D-75-1. 37 p.

Dunfield, R.W. 1976. 1975 Atlantic salmon sport catch statistics, Maritimes Region. Resource Branch, Fisheries and Marine Service, Department of the Environment, Halifax, NS. Data Record Series No. MAR/D-76-2. 45 p.

Dunfield, R.W. 1977. 1976 Atlantic salmon sport catch statistics, Maritimes Region. Resource Branch, Fisheries and Marine Service, Department of the Environment, Halifax, NS. Data Record Series No. MAR/D-77-1. 41 p.

Mitham, S. and M. Bernard. [undated]. 1977 Atlantic salmon sport catch statistics, Maritimes Region. Resource Branch, Fisheries and Marine Service, Department of Fisheries and the Environment, Halifax, NS. 43 p.

Mitham, S. and M. Bernard. [undated].1978 Atlantic salmon sport catch statistics, Maritimes Region. Resource Branch, Fisheries and Marine Service, Fisheries and Oceans Canada, Halifax, NS. 45 p.

O'Neil, S. F. and M. Bernard. 1982. 1982 Atlantic salmon sport catch statistics, Maritimes Region. Fisheries Research Branch, Department of Fisheries and Oceans, Halifax, NS. 55 p.

O'Neil, S.F., M. Bernard, P. Gallop and R. Pickard. 1987. 1986 Atlantic salmon sport catch statistics, Maritime provinces. Canadian Data Report of Fisheries and Aquatic Sciences 663: 69 p.

O'Neil, S.F., M. Bernard and J. Singer. 1984. 1983 Atlantic salmon sport catch statistics, Maritimes Region. Fisheries Research Branch, Department of Fisheries and Oceans, Halifax, NS. 53 p.

Smith, S.J. 1981. Atlantic salmon sport catch and effort data, Maritimes region, 1951-79. Canadian Data Report of Fisheries and Aquatic Sciences 258: 267p.

Smith, S. and M. Bernard. [undated]. 1979 Atlantic salmon sport catch statistics, Maritimes Region. Resource Branch, Fisheries and Marine Service, Department of Fisheries and Oceans, Halifax, NS. 43 p.

Swetnam, D. and M. Bernard. [undated]. 1980 Atlantic salmon sport catch statistics, Maritimes Region. Resource Branch, Department of Fisheries and Oceans, Halifax, NS. 45 p.

Swetnam, D. and M. Bernard. 1981. 1981 Atlantic salmon sport catch statistics, Maritimes Region. Fisheries Research Branch, Department of Fisheries and Oceans, Halifax, NS. 55 p.

Table 1.1. Bright salmon angling catches, effort, and catch per unit effort (CPUE) in the Petitcodiac system (sum of Pollett, Coverdale and main Petitcodiac River catches).

Year	Month	Grilse		Salmon		Total		Effort rod-days	CPUE fish/rod-day
		No.	Wt.(kg)	No.	Wt. (kg)	No.	Wt. (kg)		
1951	Aug	0	0	0	0	0	0	16	0
1951	Sept	0	0	4	9	4	9	28	0.143
1951	Oct	0	0	3	5	3	5	8	0.375
1951	Total	0	0	7	14	7	14	57	0.123
1952	Aug	0	0	1	2	1	2	8	0.125
1952	Sept	7	14	0	0	7	14	30	0.233
1952	Oct	0	0	0	0	0	0	16	0
1952	Total	7	14	1	2	8	16	54	0.148
1953	Aug	0	0	0	0	0	0	10	0
1953	Sept	3	6	4	8	7	15	52	0.135
1953	Oct	0	0	50	113	50	113	126	0.397
1953	Total	3	6	54	121	57	128	188	0.303
1954	July	3	6	0	0	3	6	10	0.300
1954	Aug	23	49	0	0	23	49	83	0.277
1954	Sept	7	14	0	0	7	14	36	0.194
1954	Oct	5	9	0	0	5	9	38	0.132
1954	Total	38	78	0	0	38	78	167	0.228
1955	Sept	0	0	5	14	5	14	6	0.833
1955	Oct	6	14	0	0	6	14	6	1.000
1955	Total	6	14	5	14	11	28	12	0.916
1956	Aug	0	0	0	0	0	0	18	0
1956	Sept	1	2	0	0	1	2	42	0.024
1956	Oct	11	20	0	0	11	20	36	0.306
1956	Total	12	22	0	0	12	22	96	0.125
1957	July	3	6	0	0	3	6	36	0.083
1957	Aug	7	14	0	0	7	14	112	0.063
1957	Sept	38	65	0	0	38	65	219	0.174
1957	Oct	19	41	0	0	19	41	137	0.139
1957	Total	67	127	0	0	67	127	504	0.133
1958	July	1	2	0	0	1	2	9	0.111
1958	Aug	4	9	0	0	4	9	36	0.111
1958	Sept	8	18	0	0	8	18	110	0.073
1958	Oct	32	72	0	0	32	72	81	0.395
1958	Total	47	104	0	0	45	104	252	0.187

Year	Month	Grilse		Salmon		Total		Effort rod-days	CPUE fish/rod-day
		No.	Wt.(kg)	No.	Wt. (kg)	No.	Wt. (kg)		
1959	July	0	0	0	0	0	0	6	0
1959	Aug	0	0	1	4	1	4	56	0.018
1959	Sept	0	0	0	0	0	0	97	0
1959	Oc1	0	0	4	15	4	15	66	0.067
1959	Total	0	0	5	18	5	18	225	0.022
1960	July	0	0	0	0	0	0	26	0
1960	Aug	0	0	0	0	0	0	80	0
1960	Sept	8	15	0	0	8	15	90	0.089
1960	Oct	20	36	0	0	20	36	72	0.278
1960	Total	28	51	0	0	28	51	268	0.104
1961	July	0	0	0	0	0	0	12	0
1961	Aug	0	0	0	0	0	0	27	0
1961	Sept	1	2	0	0	1	2	36	0.028
1961	Oct	0	0	0	0	0	0	31	0
1961	Total	1	2	0	0	1	2	106	0.009
1962	July	0	0	15	38	15	38	21	0.714
1962	Aug	0	0	24	69	24	69	108	0.222
1962	Sept	0	0	33	82	33	82	250	0.132
1962	Oct	0	0	89	323	89	323	334	0.266
1962	Total	0	0	161	512	161	512	713	0.226
1963	July	5	10	0	0	5	10	20	0.250
1963	Aug	19	39	0	0	19	39	144	0.132
1963	Sept	89	182	0	0	89	182	189	0.471
1963	Oct	34	69	0	0	34	69	228	0.149
1963	Total	147	300	0	0	147	300	581	0.253
1964	July	0	0	0	0	0	0	42	0
1964	Aug	0	0	0	0	0	0	84	0
1964	Sept	0	0	11	22	11	22	132	0.089
1964	Oct	0	0	5	10	5	10	96	0.052
1964	Total	0	0	16	32	16	32	345	0.046
1965	July	0	0	0	0	0	0	2	0
1965	Aug	1	2	0	0	1	2	19	0.053
1965	Sept	8	15	0	0	8	15	113	0.071
1965	Oct	26	53	6	19	32	72	192	0.167
1965	Total	35	70	6	19	41	89	326	0.126

Year	Month	Grilse		Salmon		Total		Effort	CPUE
		No.	Wt.(kg)	No.	Wt. (kg)	No.	Wt. (kg)	rod-days	fish/rod-day
1966	July	0	0	0	0	0	0	14	0
1966	Aug	5	10	0	0	5	10	75	0.067
1966	Sept	50	90	3	11	53	101	290	0.183
1966	Oct	253	459	5	18	258	477	612	0.422
1966	Total	308	559	8	29	316	588	991	0.319
1967	July	0	0	0	0	0	0	12	0
1967	Aug	17	31	5	19	22	49	287	0.077
1967	Sept	90	163	16	58	106	221	524	0.202
1967	Oct	260	472	66	254	326	726	748	0.436
1967	Total	367	666	87	331	454	996	1571	0.289
1968	No data								
1969	Total	0	0	1	2	1	2	608	0.002
1970	Aug	0	0	0	0	0	0	9	0
1970	Sept	19	26	0	0	19	26	112	0.170
1970	Oct	30	41	0	0	30	41	154	0.195
1970	Total	49	67	0	0	49	67	275	0.178
1971	Aug	0	0	0	0	0	0	12	0
1971	Sept	16	22	0	0	16	22	132	0.121
1971	Oct	6	8	0	0	6	8	45	0.133
1971	Total	22	30	0	0	22	30	189	0.116
1972	Aug	0	0	0	0	0	0	33	0
1972	Sept	3	5	0	0	3	5	84	0.036
1972	Oct	4	17	0	0	4	17	56	0.071
1972	Total	7	22	0	0	7	22	173	0.040
1973	June	0	0	0	0	0	0	5	0
1973	July	0	0	0	0	0	0	45	0
1973	Aug	30	54	8	27	38	82	175	0.217
1973	Sept	1	2	0	0	1	2	118	0.008
1973	Oct	4	7	1	4	5	11	34	0.147
1973	Total	35	63	9	31	44	95	417	0.106

Year	Month	Grilse		Salmon		Total		Effort rod-days	CPUE fish/rod-day
		No.	Wt.(kg)	No.	Wt. (kg)	No.	Wt. (kg)		
1974	June	2	3	0	0	2	3	2	1.000
1974	July	5	9	0	0	5	9	100	0.050
1974	Aug	1	2	0	0	1	2	40	0.025
1974	Sept	6	11	0	0	6	11	63	0.095
1974	Oct	13	21	0	0	13	21	51	0.255
1974	Total	27	46	0	0	27	46	256	0.105
1975	Aug	0	0	0	0	0	0	25	0
1975	Sept	5	9	0	0	5	9	45	0.111
1975	Oct	10	18	2	6	12	24	40	0.300
1975	Total	15	27	2	6	17	33	133	0.128
1976	July	0	0	0	0	0	0	19	0
1976	Aug	7	13	0	0	7	13	31	0.226
1976	Sept	39	71	0	0	39	71	147	0.265
1976	Oct	17	31	0	0	17	31	90	0.189
1976	Total	63	115	0	0	63	115	287	0.220
1977	July	0	0	0	0	0	0	20	0
1977	Aug	8	15	0	0	8	15	25	0.320
1977	Sept	35	66	0	0	35	66	135	0.259
1977	Total	43	81	0	0	43	81	180	0.239
1978	July	0	0	0	0	0	0	20	0
1978	Aug	7	13	0	0	7	13	20	0.350
1978	Sept	0	0	0	0	0	0	10	0
1978	Total	7	13	0	0	7	13	50	0.140
1979	July	0	0	0	0	0	0	3	0
1979	Aug	0	0	0	0	0	0	15	0
1979	Sept	1	2	0	0	1	2	40	0.025
1979	Oct	0	0	0	0	0	0	10	0
1979	Total	1	2	0	0	1	2	73	0.014
1980-83	no data								
1984	July	1	2	0	0	1	2	10	0.100
1984	Aug	8	15	0	0	8	15	120	0.067
1984	Sept	7	12	0	0	7	12	133	0.053
1984	Total	16	29	0	0	16	29	263	0.061
1985	July	9	17	0	0	9	17	112	0.080
1985	Aug	16	31	0	0	16	31	156	0.103
1985	Sept	4	7	0	0	4	7	78	0.051
1985	Oct	0	0	0	0	0	0	10	0
1985	Total	29	55	0	0	29	55	356	0.081

Year	Month	Grilse		Salmon		Total		Effort rod-days	CPUE fish/rod-day
		No.	Wt.(kg)	No.	Wt. (kg)	No.	Wt. (kg)		
1986	no data								
1987	Sept	0	0	0	0	0	0	30	0
1987	Oct	0	0	0	0	0	0	30	0
1987	Total	0	0	0	0	0	0	60	0
1988-89	No data								

Table 1.2. Bright salmon angling catches, effort, and catch per unit effort (CPUE) in the Coverdale River.

Year	Month	Grilse		Salmon		Total		Effort	CPUE
		No.	Wt.(kg)	No.	Wt. (kg)	No.	Wt. (kg)	rod-days	fish/rod-day
1951-52	No data								
1953	Aug	0	0	0	0	0	0	10	0
1953	Sept	3	6	0	0	3	6	22	0.136
1953	Oct	0	0	50	113	50	113	116	0.431
1953	Total	3	6	50	113	53	120	148	0.358
1954	July	3	6	0	0	3	6	10	0.300
1954	Aug	15	31	0	0	15	31	80	0.188
1954	Sept	4	7	0	0	4	7	34	0.118
1954	Oct	5	9	0	0	5	9	38	0.132
1954	Total	27	54	0	0	27	54	162	0.167
1955-56	No data								
1957	Aug	0	0	0	0	0	0	18	0
1957	Sept	3	6	0	0	3	6	24	0.125
1957	Oct	2	3	0	0	2	3	12	0.167
1957	Total	5	9	0	0	5	9	54	0.093
1958	Sept	2	4	0	0	2	4	12	0.167
1958	Oct	2	4	0	0	2	4	5	0.400
1958	Total	4	8	0	0	4	8	17	0.235
1959-61	No data								
1962	July	0	0	0	0	0	0	3	0
1962	Aug	0	0	1	3	1	3	8	0.125
1962	Sept	0	0	2	5	2	5	30	0.067
1962	Oct	0	0	26	94	26	94	126	0.207
1962	Total	0	0	29	102	29	102	167	0.174
1963	July	0	0	0	0	0	0	6	0
1963	Aug	0	0	0	0	0	0	36	0
1963	Sept	3	6	0	0	3	6	24	0.125
1963	Oct	34	69	0	0	34	69	84	0.405
1963	Total	37	75	0	0	37	75	150	0.247
1964-65	No data								
1966	Aug	0	0	0	0	0	0	3	0
1966	Sept	6	10	0	0	6	10	50	0.120
1966	Oct	145	263	2	7	147	270	312	0.471
1966	Total	151	273	2	7	153	280	365	0.419

Year	Month	Grilse		Salmon		Total		Effort	CPUE
		No.	Wt.(kg)	No.	Wt. (kg)	No.	Wt. (kg)	rod-days	fish/rod-day
1967	Aug	2	4	1	4	3	7	14	0.214
1967	Sept	13	24	1	3	14	27	80	0.175
1967	Oct	109	198	24	93	133	290	285	0.467
1967	Total	124	226	26	100	150	324	379	0.396
1968-69	No data								
1970	Oct	2	3	0	0	2	3	16	0.125
1971-72	No data								
1973	June	0	0	0	0	0	0	5	0
1973	July	0	0	0	0	0	0	45	0
1973	Aug	30	54	8	27	38	82	125	0.304
1973	Sept	0	0	0	0	0	0	70	0
1973	Oct	0	0	0	0	0	0	6	0
1973	Total	30	54	8	27	38	82	251	0.151
1974	June	1	1	0	0	1	1	1	1.000
1974	July	2	3	0	0	2	3	40	0.050
1974	Aug	1	2	0	0	1	2	12	0.083
1974	Total	4	6	0	0	4	6	53	0.075
1975	No data								
1976	Aug	1	2	0	0	1	2	6	0.167
1977-78	No data								
1979	Aug	0	0	0	0	0	0	5	0
1980-83	No data								
1984	July	1	2	0	0	1	2	10	0.100
1984	Aug	2	4	0	0	2	4	35	0.057
1984	Sept	3	5	0	0	3	5	48	0.063
1984	Total	6	11	0	0	6	11	93	0.065
1985	July	2	4	0	0	2	4	27	0.074
1985	Aug	2	4	0	0	2	4	30	0.067
1985	Sept	2	4	0	0	2	4	48	0.042
1985	Total	6	12	0	0	6	12	105	0.057
1986-89	No data								

Table 1.3. Bright salmon angling catches, effort, and catch per unit effort (CPUE) in the Petitcodiac River (main stem).

Year	Month	Grilse		Salmon		Total		Effort	CPUE
		No.	Wt.(kg)	No.	Wt.	No.	Wt.	rod-days	fish/rod-day
1951	Sept	0	0	4	9	4	9	12	0.333
1951	Oct	0	0	3	5	3	5	8	0.375
1951	Total	0	0	7	14	7	14	20	0.350
1952	Aug	0	0	1	2	1	2	8	0.125
1952	Sept	7	14	0	0	7	14	12	0.583
1952	Oct	0	0	0	0	0	0	12	0
1952	Total	7	14	1	2	8	16	32	0.250
1953	Sept	0	0	4	8	4	8	30	0.133
1953	Oct	0	0	0	0	0	0	10	0
1953	Total	0	0	4	8	4	8	40	0.100
1954	Aug	8	18	0	0	8	18	3	2.667
1954	Sept	3	7	0	0	3	7	2	1.500
1954	Total	11	25	0	0	11	25	5	2.200
1955	Sept	0	0	5	14	5	14	6	0.833
1955	Oct	6	14	0	0	6	14	6	1.000
1955	Total	6	14	5	14	11	28	12	0.917
1956	Aug	0	0	0	0	0	0	18	0
1956	Sept	1	2	0	0	1	2	40	0.025
1956	Oct	11	20	0	0	11	20	36	0.306
1956	Total	12	22	0	0	12	22	94	0.128
1957	Aug	3	5	0	0	3	5	14	0.214
1957	Sept	28	44	0	0	28	44	105	0.267
1957	Oct	17	39	0	0	17	39	125	0.136
1957	Total	48	88	0	0	48	88	244	0.197
1958	July	1	2	0	0	1	2	9	0.111
1958	Aug	4	9	0	0	4	9	36	0.111
1958	Sept	6	14	0	0	6	14	90	0.067
1958	Oct	30	68	0	0	30	68	76	0.395
1958	Total	41	93	0	0	41	93	211	0.194
1959	July	0	0	0	0	0	0	6	0
1959	Aug	0	0	0	0	0	0	44	0
1959	Sept	0	0	0	0	0	0	85	0
1959	Oct	0	0	4	15	4	15	60	0.067
1959	Total	0	0	4	15	4	15	195	0.021
1960	July	0	0	0	0	0	0	12	0
1960	Aug	0	0	0	0	0	0	44	0
1960	Sept	8	15	0	0	8	15	90	0.089
1960	Oct	20	36	0	0	20	36	72	0.278
1960	Total	28	51	0	0	28	51	218	0.128

Year	Month	Grilse		Salmon		Total		Effort	CPUE
		No.	Wt.(kg)	No.	Wt.	No.	Wt.	rod-days	fish/rod-day
1961	July	0	0	0	0	0	0	12	0
1961	Aug	0	0	0	0	0	0	27	0
1961	Sept	1	2	0	0	1	2	36	0.028
1961	Oct	0	0	0	0	0	0	24	0
1961	Total	1	2	0	0	1	2	99	0.010
1962	July	0	0	15	38	15	38	18	0.833
1962	Aug	0	0	20	59	20	59	76	0.263
1962	Sept	0	0	29	73	29	73	180	0.161
1962	Oct	0	0	63	229	63	229	208	0.303
1962	Total	0	0	127	399	127	399	482	0.263
1963	July	5	10	0	0	5	10	14	0.357
1963	Aug	19	39	0	0	19	39	108	0.176
1963	Sept	86	176	0	0	86	176	165	0.521
1963	Oct	0	0	0	0	0	0	144	0
1963	Total	110	225	0	0	110	225	431	0.255
1964	July	0	0	0	0	0	0	21	0
1964	Aug	0	0	0	0	0	0	84	0
1964	Sept	0	0	11	22	11	22	120	0.092
1964	Oct	0	0	5	10	5	10	96	0.052
1964	Total	0	0	16	32	16	32	321	0.050
1965	July	0	0	0	0	0	0	2	0
1965	Aug	1	2	0	0	1	2	15	0.067
1965	Sept	8	15	0	0	8	15	105	0.076
1965	Oct	26	53	6	19	32	72	180	0.178
1965	Total	35	70	6	19	41	89	302	0.136
1966	July	0	0	0	0	0	0	14	0
1966	Aug	5	10	0	0	5	10	72	0.069
1966	Sept	41	74	3	11	44	85	225	0.196
1966	Oct	108	196	3	11	111	207	300	0.370
1966	Total	154	280	6	22	160	302	611	0.262
1967	July	0	0	0	0	0	0	12	0
1967	Aug	15	27	4	15	19	42	255	0.075
1967	Sept	77	140	15	54	92	194	378	0.243
1967	Oct	151	274	42	162	193	436	375	0.515
1967	Total	243	441	61	231	304	672	1020	0.298
1968-69	Total	0	0	0	0	0	0	0	0
1970	Aug	0	0	0	0	0	0	9	0
1970	Sept	15	20	0	0	15	20	72	0.208
1970	Oct	25	34	0	0	25	34	120	0.208
1970	Total	40	54	0	0	40	54	201	0.199

Year	Month	Grilse		Salmon		Total		Effort	CPUE
		No.	Wt.(kg)	No.	Wt.	No.	Wt.	rod-days	fish/rod-day
1971	Aug	0	0	0	0	0	0	12	0
1971	Sept	14	19	0	0	14	19	105	0.133
1971	Oct	6	8	0	0	6	8	45	0.133
1971	Total	20	27	0	0	20	27	162	0.123
1972	Aug	0	0	0	0	0	0	33	0
1972	Sept	0	0	0	0	0	0	60	0
1972	Oct	4	17	0	0	4	17	48	0.083
1972	Total	4	17	0	0	4	17	141	0.026
1973	Aug	0	0	0	0	0	0	50	0
1973	Sept	1	2	0	0	1	2	48	0.021
1973	Oct	4	7	1	4	5	11	28	0.179
1973	Total	5	9	1	4	6	13	126	0.046
1974	June	1	2	0	0	1	2	1	1.000
1974	July	2	4	0	0	2	4	50	0.040
1974	Aug	0	0	0	0	0	0	22	0
1974	Sept	6	11	0	0	6	11	63	0.095
1974	Oct	12	19	0	0	12	19	45	0.267
1974	Total	21	36	0	0	21	36	181	0.116
1975	Aug	0	0	0	0	0	0	25	0
1975	Sept	5	9	0	0	5	9	45	0.111
1975	Oct	10	18	2	6	12	24	40	0.300
1975	Total	15	27	2	6	17	33	110	0.155
1976	July	0	0	0	0	0	0	19	0
1976	Aug	6	11	0	0	6	11	25	0.240
1976	Sept	39	71	0	0	39	71	147	0.265
1976	Oct	17	31	0	0	17	31	90	0.189
1976	Total	62	113	0	0	62	113	281	0.221
1977	July	0	0	0	0	0	0	20	0
1977	Aug	8	15	0	0	8	15	25	0.320
1977	Sept	35	66	0	0	35	66	135	0.259
1977	Total	43	81	0	0	43	81	180	0.239
1978	July	0	0	0	0	0	0	20	0
1978	Aug	7	13	0	0	7	13	20	0.350
1978	Sept	0	0	0	0	0	0	10	0
1978	Total	7	13	0	0	7	13	50	0.140
1979	July	0	0	0	0	0	0	3	0
1979	Aug	0	0	0	0	0	0	15	0
1979	Sept	1	2	0	0	1	2	30	0.033
1979	Oct	0	0	0	0	0	0	10	0
1979	Total	1	2	0	0	1	2	63	0.016
1980-83	no data								

Year	Month	Grilse		Salmon		Total		Effort	CPUE
		No.	Wt.(kg)	No.	Wt.	No.	Wt.	rod-days	fish/rod-day
1984	Aug	5	9	0	0	5	9	60	0.083
1984	Sept	1	2	0	0	1	2	20	0.050
1984	Total	6	11	0	0	6	11	80	0.075
1985	Aug	9	16	0	0	9	16	96	0.094
1985	Sept	2	4	0	0	2	4	30	0.067
1985	Oct	0	0	0	0	0	0	10	0
1985	Total	11	20	0	0	11	20	136	0.081
1986	no data								
1987	Sept	0	0	0	0	0	0	30	0
1987	Oct	0	0	0	0	0	0	30	0
1987	Total	0	0	0	0	0	0	60	0
1988-89	no data								

Table 1.4. Bright salmon angling catches, effort, and catch per unit effort (CPUE) in the Pollett River.

Year	Month	Grilse		Salmon		Total		Effort	CPUE
		No.	Wt.(kg)	No.	Wt.	No.	Wt.	rod-days	fish/rod-day
1951-56	No data								
1957	July	3	6	0	0	3	6	36	0.083
1957	Aug	4	9	0	0	4	9	80	0.050
1957	Sept	7	15	0	0	7	15	90	0.078
1957	Total	14	30	0	0	14	30	206	0.068
1958	Sept	0	0	0	0	0	0	8	0
1959	Aug	0	0	1	4	1	4	12	0.083
1960	July	0	0	0	0	0	0	14	0
1960	Aug	0	0	0	0	0	0	36	0
1960	Total	0	0	0	0	0	0	50	0
1961	No data								
1962	Aug	0	0	3	8	3	8	24	0.125
1962	Sept	0	0	2	5	2	5	40	0.050
1962	Total	0	0	5	13	5	13	64	0.078
1963-65	No data								
1966	Sept	3	5	0	0	3	5	15	0.200
1967-68	No data								
1969	Sept	0	0	0	0	0	0	10	0
1969	Oct	0	0	0	0	0	0	12	0
1969	Total	0	0	0	0	0	0	64	0
1970	Sept	4	5	0	0	4	5	40	0.100
1970	Oct	3	4	0	0	3	4	18	0.167
1970	Total	7	10	0	0	7	9	58	0.121
1971	Sept	2	3	0	0	2	3	27	0.074
1972	Sept	3	5	0	0	3	5	24	0.125
1973	No data								
1974	July	1	2	0	0	1	2	10	0.100
1974	Aug	0	0	0	0	0	0	6	0
1974	Oct	1	2	0	0	1	2	6	0.167
1974	Total	2	4	0	0	2	4	22	0.091
1975-78	No data								

Year	Month	Grilse		Salmon		Total		Effort	CPUE
		No.	Wt.(kg)	No.	Wt.	No.	Wt.	rod-days	fish/rod-day
1979	Total	0	0	0	0	0	0	5	0
1980-83	no data								
1984	Aug	1	2	0	0	1	2	25	0.040
1984	Sept	3	5	0	0	3	5	65	0.046
1984	Total	4	7	0	0	4	7	90	0.044
1985	July	7	14	0	0	7	14	85	0.082
1985	Aug	5	11	0	0	5	11	30	0.167
1985	Total	12	25	0	0	12	25	115	0.104
1986-89	no data								

Table 1.5. Bright salmon angling catch, effort and catch per unit effort (CPUE) in Turtle Creek.

Year	Month	Grilse		Salmon		Total		Effort	CPUE
		No.	Wt.(kg)	No.	Wt.	No.	Wt.	rod-days	fish/rod-day
1951-68	No data								
1969	Oct	0	0	0	0	0	0	6	0
1970-89	No data								

Table 1.6. Black salmon angling catch, effort and catch per unit effort (CPUE) in the Petitcodiac system.

Year	Month	Grilse		Salmon		Total		Effort rod-days	CPUE fish/rod-day
		No.	Wt.(kg)	No.	Wt. (kg)	No.	Wt. (kg)		
1951	April	0	0	44	88	44	88	93	0.473
1951	May	0	0	0	0	0	0	5	0
1951	Total	0	0	44	88	44	88	98	0.449
1952	April	14	27	2	8	16	35	99	0.162
1952	May	1	2	0	0	1	1.6	8	0.125
1952	Total	15	29	2	8	17	37	107	0.159
1953	April	0	0	127	202	127	202	400	0.318
1953	May	5	8	0	0	5	8	24	0.208
1953	Total	5	8	127	202	132	210	424	0.311
1954	April	123	196	0	0	123	196	402	0.306
1954	May	7	13	0	0	7	13	24	0.292
1954	Total	130	209	0	0	130	209	426	0.305
1955	April	20	39	138	219	158	258	525	0.301
1955	May	0	0	6	10	6	10	22	0.273
1955	Total	20	39	144	229	164	268	547	0.300
1956	April	14	22	0	0	14	22	239	0.059
1956	May	14	22	0	0	14	22	56	0.250
1956	Total	28	44	0	0	28	44	295	0.095
1957	April	54	73	0	0	54	73	446	0.121
1957	May	12	16	0	0	12	16	41	0.293
1957	Total	66	89	0	0	66	89	487	0.136
1958	April	0	0	262	354	260	354	835	0.311
1958	May	2	3	24	33	26	36	112	0.232
1958	Total	2	3	286	387	284	***386***	947	0.300
1959	April	218	297	0	0	218	297	788	0.277
1959	May	6	8	18	24	24	33	102	0.235
1959	Total	224	305	18	24	242	329.4	890	0.272
1960	April	120	218	0	0	112	218	816	0.147
1960	May	16	29	0	0	9	29	76	0.211
1960	Total	136	247	0	0	121	247	892	0.136
1961	April	51	82	0	0	51	82	286	0.178
1961	May	30	50	0	0	30	49	214	0.140
1961	Total	81	132	0	0	81	131	500	0.162

Year	Month	Grilse		Salmon		Total		Effort rod-days	CPUE fish/rod-day
		No.	Wt.(kg)	No.	Wt. (kg)	No.	Wt. (kg)		
1962	April	128	203	0	0	128	203	279	0.416
1962	May	71	108	0	0	71	108	182	0.390
1962	Total	199	311	0	0	199	311	461	0.432
1963	April	152	242	0	0	152	242	406	0.374
1963	May	35	58	0	0	35	58	104	0.337
1963	Total	187	300	0	0	187	300	510	0.367
1964	April	15	22	174	257	189	279	555	0.341
1964	May	0	0	35	57	35	57	108	0.324
1964	Total	15	22	209	314	224	336	663	0.338
1965	April	199	271	30	87	229	358	645	0.355
1965	May	55	75	4	13	59	88	192	0.307
1965	Total	254	346	34	100	288	445	837	0.344
1966	April	213	338	0	0	213	338	705	0.302
1966	May	57	99	0	0	57	99	152	0.375
1966	Total	270	437	0	0	270	437	857	0.315
1967	Total	669	807	19	57	668	864	1247	0.552
1968	April	442	601	41	56	483	657	844	0.572
1968	May	137	186	9	12	146	199	301	0.485
1968	Total	579	787	50	68	629	856	1145	0.549
1969	April	0	0	51	70	51	70	489	0.104
1969	May	0	0	27	49	27	49	157	0.172
1969	Total	0	0	78	119	78	119	646	0.119
1970	April	4	7	4	12	8	19	220	0.036
1970	May	0	0	3	9	3	9	45	0.067
1970	Total	4	7	7	21	11	28	265	0.042
1971	April	12	16	1	3	13	20	216	0.060
1971	May	21	29	0	0	21	29	39	0.538
1971	Total	33	45	1	3	34	48	255	0.133
1972	April	3	4	0	0	3	4	57	0.053
1972	May	7	10	0	0	7	10	74	0.095
1972	Total	10	14	0	0	10	14	131	0.084

Year	Month	Grilse		Salmon		Total		Effort rod-days	CPUE fish/rod-day
		No.	Wt.(kg)	No.	Wt. (kg)	No.	Wt. (kg)		
1973	April	0	0	0	0	0	0	35	0
1973	May	0	0	0	0	0	0	5	0
1973	Total	0	0	0	0	0	0	40	0
1974	April	8	13	0	0	8	13	75	0.107
1974	May	5	7	0	0	5	7	38	0.132
1974	Total	13	20	0	0	13	20	113	0.115
1975	April	0	0	0	0	0	0	15	0
1975	May	0	0	0	0	0	0	8	0
1975	Total	0	0	0	0	0	0	23	0
1976	April	7	10	0	0	7	10	20	0.350
1976	May	2	3	0	0	2	3	13	0.154
1976	Total	9	13	0	0	9	13	33	0.273
1977	April	6	8	0	0	6	8	18	0.333
1977	May	3	4	0	0	3	4	32	0.094
1977	Total	9	12	0	0	9	12	50	0.180
1978	May	4	5	0	0	4	5	33	0.121
1979	May	0	0	0	0	0	0	5	0
1980-89	no data								

Table 1.7. Black salmon angling catch, effort and catch per unit effort (CPUE) in the Coverdale River.

Year	Month	Grilse		Salmon		Total		Effort	CPUE
		No.	Wt.(kg)	No.	Wt. (kg)	No.	Wt. (kg)	rod-days	fish/rod-day
1951	April	0		40	82	40	82	90	0.444
1951	May	0	0	0	0	0	0	5	0
1951	Total	0	0	40	82	40	82	95	0.421
1952	April	14	27	0	0	14	27	96	0.146
1952	May	1	1	0	0	1	1	8	0.125
1952	Total	15	28	0	0	15	28	104	0.144
1953	April	0	0	127	202	127	202	400	0.318
1953	May	5	8	0	0	5	8	24	0.208
1953	Total	5	8	127	202	132	210	424	0.311
1954	April	121	192	0	0	121	192	390	0.310
1954	May	7	13	0	0	7	13	24	0.292
1954	Total	128	205	0	0	128	205	414	0.309
1955	April	0	0	138	219	138	219	510	0.271
1955	May	0	0	6	10	6	10	22	0.273
1955	Total	0	0	144	229	144	229	532	0.271
1956	April	14	22	0	0	14	22	237	0.059
1956	May	14	22	0	0	14	22	56	0.250
1956	Total	28	44	0	0	28	44	293	0.096
1957	April	52	71	0	0	52	71	444	0.117
1957	May	10	14	0	0	10	14	40	0.250
1957	Total	62	84	0	0	62	84	484	0.128
1958	April	0	0	252	343	252	343	775	0.325
1958	May	0	0	24	33	24	33	96	0.250
1958	Total	0	0	276	376	276	376	871	0.317
1959	April	171	233	0	0	171	233	660	0.259
1959	May	6	7	0	0	6	7	48	0.125
1959	Total	177	240	0	0	177	240	708	0.250
1960	April	112	203	0	0	112	203	762	0.147
1960	May	9	16	0	0	9	16	52	0.173
1960	Total	121	219	0	0	121	219	814	0.149
1961	April	47	75	0	0	47	75	252	0.187
1961	May	22	35	0	0	22	35	160	0.138
1961	Total	69	110	0	0	69	110	412	0.167
1962	April	116	184	0	0	116	184	234	0.496
1962	May	14	22	0	0	14	22	42	0.333
1962	Total	130	206	0	0	130	206	276	0.471
1963	April	127	202	0	0	127	202	315	0.403

Year	Month	Grilse		Salmon		Total		Effort	CPUE
		No.	Wt.(kg)	No.	Wt. (kg)	No.	Wt. (kg)	rod-days	fish/rod-day
1964	April	0	0	158	233	158	233	435	0.363
1964	May	0	0	14	19	14	19	42	0.333
1964	Total	0	0	172	252	172	252	477	0.361
1965	April	140	191	12	44	152	234	420	0.362
1965	May	8	11	0	0	8	11	32	0.250
1965	Total	148	202	12	44	160	245	452	0.354
1966	April	111	176	0	0	111	176	390	0.285
1966	May	10	14	0	0	10	14	36	0.278
1966	Total	121	190	0	0	121	190	426	0.284
1967	April	289	320	10	29	299	349	495	0.604
1967	May	297	370	0	0	297	370	594	0.500
1967	Total	586	690	10	29	596	719	1089	0.547
1968	April	318	433	0	0	318	433	540	0.589
1968	May	46	63	0	0	46	63	126	0.365
1968	Total	364	496	0	0	364	496	666	0.547
1969	April	0	0	19	26	19	26	176	0.108
1969	May	0	0	16	29	16	29	84	0.190
1969	Total	0	0	35	55	35	55	260	0.135
1970	April	1	2	3	9	4	11	135	0.030
1970	May	0	0	2	5	2	5	25	0.080
1970	Total	1	2	5	14	6	16	160	0.038
1971	April	8	11	1	3	9	14	120	0.075
1971	May	12	16	0	0	12	16	19	0.632
1971	Total	20	27	1	3	21	30	139	0.151
1972	April	3	4	0	0	3	4	35	0.086
1972	May	7	10	0	0	7	10	60	0.117
1972	Total	10	14	0	0	10	14	95	0.105
1973	April	0	0	0	0	0	0	35	0
1974	April	5	8	0	0	5	8	45	0.111
1974	May	2	3	0	0	2	3	20	0.100
1974	Total	7	11	0	0	7	11	65	0.108
1975	April	0	0	0	0	0	0	8	0
1976	April	1	1	0	0	1	1	4	0.250
1976	May	0	0	0	0	0	0	5	0
1976	Total	1	1	0	0	1	1	9	0.111
1977	April	1	1	0	0	1	1	3	0.333
1977	May	0	0	0	0	0	0	5	0
1977	Total	1	1	0	0	1	1	8	0.125
1978	May	0	0	0	0	0	0	6	0

Year	Month	Grilse		Salmon		Total		Effort	CPUE
		No.	Wt.(kg)	No.	Wt. (kg)	No.	Wt. (kg)	rod-days	fish/rod-day
1979-89	no data								

Table 1.8. Black salmon angling catch, effort and catch per unit effort (CPUE) in the Petitcodiac River (main stem).

Year	Month	Grilse		Salmon		Total		Effort	CPUE
		No.	Wt.(kg)	No.	Wt.	No.	Wt.	rod-days	fish/rod-day
1951	April	0	0	4	7	4	7	3	1.333
1952	April	0	0	2	8	2	8	3	0.667
1953	No data								
1954	April	2	4	0	0	2	4	12	0.167
1955	April	20	39	0	0	20	39	15	1.333
1956	April	0	0	0	0	0	0	2	0.000
1957	April	2	2	0	0	2	2	2	1.000
1957	May	2	2	0	0	2	2	1	2.000
1957	Total	4	4	0	0	4	4	3	1.333
1958	April	0	0	8	11	8	11	60	0.133
1958	May	2	3	0	0	2	3	16	0.125
1958	Total	2	3	8	11	10	14	76	0.132
1959	April	47	64	0	0	47	64	128	0.367
1959	May	0	0	18	24	18	24	54	0.333
1959	Total	47	64	18	24	65	88	182	0.357
1960	April	8	15	0	0	8	15	54	0.148
1960	May	7	13	0	0	7	13	24	0.292
1960	Total	15	28	0	0	15	28	78	0.192
1961	April	4	7	0	0	4	7	34	0.118
1961	May	8	15	0	0	8	15	54	0.148
1961	Total	12	22	0	0	12	22	88	0.136
1962	April	12	19	0	0	12	19	45	0.267
1962	May	57	86	0	0	57	86	140	0.407
1962	Total	69	105	0	0	69	105	185	0.373
1963	April	25	40	0	0	25	40	91	0.275
1963	May	35	58	0	0	35	58	104	0.337
1963	Total	60	98	0	0	60	98	195	0.308
1964	April	0	0	16	24	16	24	60	0.267
1964	May	0	0	21	38	21	38	66	0.318
1964	Total	0	0	37	62	37	62	126	0.294
1965	April	59	80	6	22	65	102	180	0.360
1965	May	47	64	4	13	51	77	160	0.319
1965	Total	106	144	10	35	116	179	340	0.341

Year	Month	Grilse		Salmon		Total		Effort	CPUE
		No.	Wt.(kg)	No.	Wt.	No.	Wt.	rod-days	fish/rod-day
1966	April	102	162	0	0	102	162	315	0.324
1966	May	47	85	0	0	47	85	116	0.405
1966	Total	149	247	0	0	149	247	431	0.346
1967	April	3	4	0	0	3	4	30	0.100
1967	May	18	22	0	0	18	22	35	0.514
1967	Total	21	26	0	0	21	26	65	0.323
1968	April	70	95	0	0	70	95	130	0.538
1968	May	84	114	0	0	84	114	144	0.583
1968	Total	154	209	0	0	154	209	274	0.562
1969	April	0	0	9	12	9	12	108	0.083
1969	May	0	0	11	20	11	20	49	0.224
1969	Total	0	0	20	32	20	32	157	0.127
1970	April	3	5	1	3	4	8	85	0.047
1970	May	0	0	1	3	1	3	20	0.050
1970	Total	3	5	2	6	5	11	105	0.048
1971	April	2	3	0	0	2	3	60	0.033
1971	May	9	12	0	0	9	12	20	0.450
1971	Total	11	15	0	0	11	15	80	0.138
1972	Total	1	1	0	0	1	1	15	0.067
1973	May	0	0	0	0	0	0	5	0.000
1974	April	3	5	0	0	3	5	30	0.100
1974	May	3	4	0	0	3	4	18	0.167
1974	Total	6	9	0	0	6	9	48	0.125
1975	April	0	0	0	0	0	0	7	0.000
1975	May	0	0	0	0	0	0	8	0.000
1975	Total	0	0	0	0	0	0	0	0
1976	April	6	8	0	0	6	8	16	0.375
1976	May	2	3	0	0	2	3	8	0.250
1976	Total	8	11	0	0	8	11	24	0.333
1977	April	5	7	0	0	5	7	15	0.333
1977	May	3	4	0	0	3	4	27	0.111
1977	Total	8	11	0	0	8	11	42	0.190
1978	May	4	5	0	0	4	5	27	0.148
1979	May	0	0	0	0	0	0	5	0.000
1980-89	no data								

Table 1.9. Black salmon angling catch, effort and catch per unit effort (CPUE) in the Pollett River.

Year	Month	Grilse		Salmon		Total		Effort	CPUE
		No.	Wt.(kg)	No.	Wt.	No.	Wt.	rod-days	fish/rod-day
1951-66	No data								
1967	Total	59	87	9	27	68	114	78	0.872
1968	April	54	73	0	0	54	73	90	0.600
1968	May	7	10	0	0	7	10	15	0.467
1968	Total	61	83	0	0	61	83	105	0.581
1969	April	0	0	0	0	0	0	30	0
1969	May	0	0	0	0	0	0	12	0
1969	Total	0	0	0	0	0	0	42	0
1970	Total	0	0	0	0	0	0	0	0
1971	April	2	3	0	0	2	3	36	0.056
1972	April	0	0	0	0	0	0	12	0
1972	May	0	0	0	0	0	0	9	0
1972	Total	0	0	0	0	0	0	21	0
1973-89	no data								

Table 1.10. Black salmon angling catch, effort and catch per unit effort (CPUE) in Turtle Creek.

Year	Month	Grilse		Salmon		Total		Effort	CPUE
		No.	Wt.(kg)	No.	Wt.	No.	Wt.	rod-days	fish/rod-day
1951-63	No data								
1964	April	15	22	0	0	15	22	60	0.250
1965	April	0	0	12	22	12	22	45	0.267
1966	No data								
1967	April	3	4	0	0	3	4	15	0.200
1968	April	0	0	41	56	41	56	84	0.488
1968	May	0	0	9	12	9	12	16	0.563
1968	Total	0	0	50	68	50	68	100	0.500
1969	April	0	0	1	2	1	2	98	0.010
1969	May	0	0	0	0	0	0	12	0
1969	Total	0	0	1	2	1	2	110	0.009
1970-89	No data								

Appendix 2. Commercial catches of Atlantic salmon in statistical districts 24 (Cumberland Basin area), 79 (Shepody Bay area), and 81 (Petitcodiac River area).

Data were summarized from the following sources:

Dunfield, R.W. 1973. 1972 Atlantic salmon commercial catch statistics, Maritimes region. Resource Development Branch, Fisheries Service, Department of the Environment of Canada, Halifax, NS. 77 p.

Dunfield, R.W. 1974. 1973 Atlantic salmon commercial catch statistics, Maritimes region. Resource Development Branch, Fisheries and Marine Service, Department of the Environment of Canada, Halifax, NS. 77 p.

Dunfield, R.W. 1975. 1974 Atlantic salmon commercial catch statistics, Maritimes region. Resource Development Branch, Fisheries and Marine Service, Environment Canada, Halifax, NS. Data Record Series No. MAR/D-75-2. 77 p.

Dunfield, R.W. 1976. 1975 Atlantic salmon commercial catch statistics, Maritimes region. Resource Branch, Fisheries and Marine Service, Environment Canada, Halifax, NS. Data Record Series No. MAR/D-76-3. 72 p.

Dunfield, R.W. 1977. 1976 Atlantic salmon commercial catch statistics, Maritimes region. Resource Branch, Fisheries and Marine Service, Environment Canada, Halifax, NS. Data Record Series No. MAR/D-77-7. 76 p.

Mitham, S.J. and M. Bernard. [undated] 1977 Atlantic salmon commercial catch statistics, Maritimes region. Resource Branch, Fisheries and Marine Service, Environment Canada, Halifax, NS. 67 p.

Mitham, S.J. and M. Bernard. [undated] 1978 Atlantic salmon commercial catch statistics, Maritimes region. Resource Branch, Fisheries and Oceans Canada, Halifax, NS. 81 p.

O'Neil, S.F. and M. Bernard. 1983. 1982 Atlantic salmon commercial catch statistics, Maritimes provinces. Fisheries Research Branch, Fisheries and Oceans Canada, Halifax, NS. 71 p.

O'Neil, S.F., M. Bernard and P.A. Gallop. 1984. 1983 Atlantic salmon commercial catch statistics, Maritimes provinces. Fisheries Research Branch, Fisheries and Oceans Canada, Halifax, NS. 73 p.

O'Neil, S.F., M. Bernard and P.A. Gallop. 1985. 1984 Atlantic salmon commercial catch statistics, Maritimes provinces. Fisheries Research Branch, Fisheries and Oceans Canada, Halifax, NS. 57 p.

Smith, S.J. and M. Bernard. [undated] 1979 Atlantic salmon commercial catch statistics, Maritimes region. Resource Branch, Fisheries and Oceans Canada, Halifax, NS. 83 p.

Swetnam, D. and M. Bernard. 1981. 1980 Atlantic salmon commercial catch statistics, Maritimes region. Resource Branch, Fisheries and Oceans Canada, Halifax, NS. 83 p.

Swetnam, D. and M. Bernard. [undated] 1981 Atlantic salmon commercial catch statistics, Maritimes region. Fisheries Research Branch, Fisheries and Oceans Canada, Halifax, NS. 85 p.

Wykes, C.E. 1970. 1967 Atlantic salmon commercial catch statistics, Maritimes region. Resource Development Branch, Fisheries Service, Department of Fisheries and Forestry of Canada, Halifax, NS. 57 p.

Wykes, C.E. 1970. 1968 Atlantic salmon commercial catch statistics, Maritimes region. Resource Development Branch, Fisheries Service, Department of Fisheries and Forestry of Canada, Halifax, NS. 61 p.

Wykes, C.E. 1970. 1969 Atlantic salmon commercial catch statistics, Maritimes region. Resource Development Branch, Fisheries Service, Department of Fisheries and Forestry of Canada, Halifax, NS. 63 p.

Wykes, C.E. and R.W. Dunfield. 1971. 1970 Atlantic salmon commercial catch statistics, Maritimes region. Resource Development Branch, Fisheries Service, Department of the Environment of Canada, Halifax, NS. 101 p.

Wykes, C.E. and R.W. Dunfield. 1972. 1971 Atlantic salmon commercial catch statistics, Maritimes region. Resource Development Branch, Fisheries Service, Department of Fisheries and Forestry of Canada, Halifax, NS. 97 p.

Table 2.1. Commercial Atlantic salmon catch in statistical districts adjacent to the Petitcodiac system.

Year	Catch (kg) in statistical district (SD)				SD81 as % of Total
	SD 24	SD 79	SD 81	Total	
1967	75	639	2287	3001	76
1968	127	181	3949	4257	93
1969	182	61	943	1185	80
1970	0	12	137	150	92
1971	91	31	473	595	79
1972	197	16	134	347	39
1973	135	4	90	228	39
1974	282	13	199	494	40
1975	25	3	36	65	56
1976	53	10	141	204	69
1977	80	39	228	346	66
1978	120	23	142	284	50
1979	193	73	155	421	37
1980	204	0	18	222	8
1981	340	0	23	363	6