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Follow-up assessments of Atlantic salmon in the Saint John River drainage, N.B., 1998

by

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ABSTRACT

This document is a sequel to that of previously more detailed assessments (Marshall *et al.* MS 1997; MS 1998) and a companion document to Marshall et al. (MS 1999). New in this document are assessments of adult returns to the Hammond River and spring smolts from the Nashwaak River in 1998.

Estimated returns in 1998 to the Mactaquac Dam, Saint John River, numbered 4,982 1SW and 971 MSW fish; wild 1SW returns were the second lowest in 29 years and wild MSW returns were the lowest of record. Return rates for one-year (hatchery) smolts were 0.75 for 1SW salmon (up from that of 1997) and 0.08 for MSW salmon, the lowest of record. Spawners numbered 4,622 1SW and 627 MSW, 94 and 13%, respectively, of the fish requirement above Mactaquac. Egg deposition was only 18% of the egg requirement, down by approximately 60% from that in 1997. Eggs from hatchery-origin fish potentially contributed to 76% of the total deposition; the conservation requirement has not been met since 1985.

A mark-and-recapture experiment on the Hammond River in 1998 estimated total river returns to be 196 1SW and 164 MSW salmon, 20.6% and 17.5%, respectively, being of hatchery origin. Escapement was estimated to be 28% and 29%, respectively, of the interim fish conservation requirements and 33% of egg requirements. Redd counts suggested that conservation requirements were approached in a 11.75 km section of main river where they have been met in all but two of the 18 years of redd counts. Densities of juvenile salmon were the third highest of the 18-year data set but still below ‘normal’ parr abundance.

A mark-and-recapture experiment on the Nashwaak River suggested that the most probably number of spring smolt originating above the adult counting fence site in 1998 was 22,750 fish (17,900 – 32,850). There was no assessment of the numbers of pre-smolts that may have left the system the previous October and November.

Forecasts of returns to the Mactaquac Dam in 1999 suggest a <1% probability that 1SW and MSW returns will meet the conservation egg requirements. Forecasts of returns to the Hammond River were not possible but most indices of stock status suggest that returns in 1999 will be low with respect to conservation requirements.

RÉSUMÉ

Le présent document fait suite à des évaluations antérieures plus détaillées (Marshall et coll, ms. 1997; ms. 1998) et accompagne un document de Marshall et coll. (ms. 1999). On y trouve de nouvelles évaluations des remontées d’adultes dans Hammond River et des saumoneaux de printemps dans Nashwaak River en 1998.

Les remontées estimées au barrage de la Mactaquac, rivière Saint-Jean, en 1998 s’élèvent à 4 982 UBM et à 971 PBM; les remontées de UBM sauvages ont été les deuxièmes plus petites en 29 années et celles de PBM sauvages les plus faibles jamais notées. Les taux de retour des saumoneaux d’un an (pisciculture) ont été de 0,75 pour les UBM, (en hausse par rapport à 1997) et de 0,08 pour les PBM, les plus faibles jamais obtenus. Les nombres de géniteurs se sont élevés à 4 622 UBM et à 627 PBM, ce qui correspond à, respectivement, 94 % et 13 % des besoins en amont de Mactaquac. La ponte n’a atteint que 18 % des besoins et est à la baisse de 60 % environ par rapport à 1997. Les œufs d’origine piscicole ont pu représenter 76 % de la ponte totale et les besoins de conservation n’ont pas été atteints depuis 1985.

Une expérience par marquage-recapture menée dans Hammond River en 1998 a permis d’estimer à 196 UBM et à 164 PBM les remontées totales et, respectivement, 20,6 % et 17,5 % étaient d’origine piscicole. Les échappées ont été estimées à, respectivement, 28 % et 29 % des besoins de conservation provisoires et à 33 % des besoins de ponte. Le dénombrement des nids de fraie porte à croire que les besoins de conservation ont été presque atteints dans une section de 11,75 km du cours principal où, à l’exception de deux années, ils avaient été atteints au cours de 18 années de dénombrement. La densité des saumons juvéniles était la troisième plus élevée de la série de données de 18 ans, mais demeure en deçà de l’abondance « normale » des tacons.

Une expérience par marquage-recapture faite dans Nashwaak River indique que le nombre le plus probable de saumoneaux de printemps provenant de l’amont de la barrière de dénombrement des adultes en 1998 s’élevait à 22 750 poissons (17 900 – 32 850). Il n’y a pas eu d’évaluation du nombre de pré-saumoneaux pouvant avoir quitté le bassin en octobre et novembre précédents.

Des prévisions des remontées au barrage de la Mactaquac en 1999 indiquent une probabilité <1% que celles des UBM et des PBM donnent lieu à une ponte satisfaisant aux besoins de conservation. Il a été impossible d’effectuer une prévision des remontées de Hammond River, mais la plupart des indices de l’état du stock laissent croire que celles de 1999 seront faibles par rapport aux besoins de conservation.

INTRODUCTION

This document presents data background to earlier assessments, outlook and management considerations (Marshall et al. MS 1999 and Anon. 1999) for Atlantic salmon management of stocks originating at and above Mactaquac, Saint John River, NB in 1999. Data for these stocks continue the format of Marshall et al. (MS 1998), methodology and interpretations are largely contained in Marshall et al. (MS 1999). New in this document is an assessment of adult returns to the Hammond River in 1998 and an assessment of spring smolt migration from the Nashwaak River in 1998.

STOCKS ORIGINATING AT AND UPRIVER OF MACTAQUAC

An earlier assessment of the status of salmon stocks returning to Mactaquac Dam on the Saint John River (Marshall et al. MS 1999) was somewhat preliminary. Although the count at the sorting facility was complete, details of age analyses, adjustment of hatchery and wild composition, adjusted mean lengths for egg carrying capacity etc. were approximated. The material provided here-in is a sequel to that of previous more detailed assessments (e.g. Marshall et al. MS 1997; MS 1998) and is intended to be a companion document to Marshall et al. (MS 1999). These data are largely consistent with those used in Marshall et al. MS 1999 and do not affect conclusions and advice emanating from that document.

Preseason forecasts of 1SW fish returning to Mactaquac in 1998 had suggested that homeriver returns could number 7,800 to 9,400 fish, 160-190% of conservation requirements. MSW returns were forecasted to be 3,100 to 3,600 fish, 63-73% of requirements.

Description of fisheries

In 1998, the Saint John River (Fig. 1) was closed for the entire season to directed fisheries for Atlantic salmon. Aboriginal peoples had allocations of 3,700 1SW salmon (Marshall et al. MS 1998), “pending” a favorable in-season outlook on July 29 that egg deposition would exceed the 32% of conservation requirements attained in 1997. However, by July 29, it had become clear that egg depositions in 1998 would be significantly less than in 1997.

Returns destined for Mactaquac

Methods

Total returns of 1SW and MSW salmon of both wild and hatchery origin from above Mactaquac Dam are the sum of Mactaquac counts, estimates of removals in the main stem below Mactaquac Dam, and assumed by-catch in May and early-June in downriver shad, gaspereau and "other" species net fisheries.

Mactaquac counts consist of fish captured between May 28 and October 26 at the fish collection facilities at the Mactaquac Dam and at the smolt migration channel at the Mactaquac Fish Culture Station.

Identification at the Mactaquac sorting facility of 1SW and MSW returns from one-year smolts released at Mactaquac and juveniles (essentially fall parr) released above Mactaquac was principally dependent on erosion of the dorsal fin (a few returns were either tagged or adipose-clipped). Fish of sea-cage origin (four were recorded in 1998) were identified by erosion and partial regeneration of fin rays on the upper and/or lower lobes of the caudal fin. Returns from hatchery-origin unfed and feeding fry are more likely to have "clean" fins and be indistinguishable from wild-origin fish.

The distribution of increased numbers of juvenile salmon, particularly fry and summer parr (App. 1) has increased the difficulty of ensuring that "wild"-looking returns are the result of natural rather than artificial recruitment. Interpretation of ages from scale samples taken from approximately every second fish through July 29 and four samples of ten fish thereafter (exceptions included the complete sampling of all broodstock, adipose clipped, and serpentine fish) suggested that counts be "adjusted" to better reflect wild and hatchery contributions. All fish externally classified as being of hatchery origin remained so. Fish originally classified "wild" that were of freshwater age one were reassigned to "hatchery". The proportions of hatchery freshwater age one fish that were misclassified in the total sample of age 1.1 and age 1.2 fish were used to adjust counts of externally identified hatchery fish of freshwater age two and freshwater age three upwards and, conversely, to adjust counts of the "wild" counterparts downwards. The few fish in which sea-age changed were reassigned to 1SW or MSW categories. Scales of fish for which freshwater ages were unreadable (10-15% of hatchery-origin fish) were apportioned into the readable sample without weighting. These procedures, with sub-sampling from among groups (broodstock, earliest-run fish etc.) which were completely sampled, provided the basis for "adjusted" counts at Mactaquac, estimated returns and, return rates for hatchery fish released as age one smolts and some age 0^+ parr.

Removals in 1998 were theoretically zero. Losses were ascribed, however, to by-catch in the lower river and (assumed catch rates of 1% of the 1SW and 2.5% of the MSW river returns) and to poaching (and disease) upriver of Mactaquac.

Results

Unadjusted counts of fish at Mactaquac in 1998 totalled 4,889 1SW and 991 MSW salmon (Tables 1 and 2). These counts of wild 1SW fish were up from those of 1997, i.e., but were only 25% and 11% of the previous five- or ten-year means, respectively, (Table 2) and the second lowest of a 32-year record. Counts of wild MSW salmon were the lowest in 32 years and were only 19% and 14% of the respective five- and ten- year means (Table 2). River temperatures were similar to those of 1997, but warmer than those of 1996 (Fig. 2).

Interpretation of scales reduced the MSW component by 4% (1SW component increased by 1%) and shifted the hatchery component among 1SW fish from 90.3% to 93.1% and, among MSW fish from 62.8% to 66.9%. Proportionate age composition among adjusted hatchery and wild components was:

Origin	Age 1.1	Age 2.1	Age 3.1	Age 4/5.1	Tot	Age 1.2	Age 2.2	Age 3.2	Age 4.2	Tot	Incid. R.S
Hatch	0.46	0.21	0.32	0.01	1.0	0.43	0.22	0.33	0.02	1.0	0.15
Wild		0.43	0.55	0.12	1.0		0.31	0.69	0.05	1.0	0.32

The incidence of repeat spawners among wild salmon is perhaps the highest on record.

Estimated homewater returns in 1998 totalled **4,982 1SW** and **971 MSW** fish (Table 1); wild 1SW returns were the second lowest in 29 years, wild MSW returns were the lowest of record (Table 3). Counts comprised 99% of combined 1SW and MSW returns estimated to have been destined for Mactaquac. The return rate of one-year smolts as 1SW fish destined for Mactaquac was 0.00745, up from that of 1997 (Table 4a). The adjusted return rate of one-year smolts as 2SW salmon (Table 4b) was 0.00082, the lowest of record.

Removals of fish destined for Mactaquac

Methods

Removals include the estimate of salmon lost to by-catch in the estuary, fish passed or trucked above Tinker Dam on the Aroostook, held at Mactaquac as broodstock or estimated to have been lost to poaching/disease, scientific investigation or handling operations at Mactaquac.

Losses to poaching and disease were assumed to be 1% for 1SW and 2.5% for 2SW fish. Fish lost to poaching and disease are considered, by definition, as "spawners". Fish were apportioned to hatchery/wild components on the basis of known or estimated stock composition in the vicinity of the event. Losses to spawning also occurred as a result of late-season mishaps at the Beechwood and Tobique Narrows fishway.

Results

Removals below Mactaquac were confined to an assumed 49 1SW and 24 MSW salmon. (Table 5). Transport from Mactaquac to the Aroostook River above Tinker consisted of only 50 1SW, an additional 26 1SW and four MSW fish ascended the Tinker fishway (Tables 5 and 7) to the USA production area external of “above Mactaquac” conservation requirements. Losses to poaching and disease were estimated at 46 1SW and 16 MSW salmon. Additional losses of 212 1SW and 12 MSW fish occurred at the Tobique and Beechwood facilities.

Total river removals by all factions were estimated at **406 1SW** and **356 MSW** fish (Tables 5 and 6) of which 22 1SW and 299 MSW early/summer-run salmon were held at Mactaquac for broodstock. These broodstock yielded about 1.5 million eggs.

Conservation requirements

Conservation requirements are based on an accessible salmon-producing substrate above Mactaquac of 13,472,200 m^2 (>0.12% and <15.0% gradient; excludes headponds and 21 million m^2 of river with gradient <0.12%; Marshall et al. MS 1998), an assumed requirement of 2.4 eggs per m^2, a length-fecundity relationship (Log_e Eggs = 6.06423 + 0.03605 Fork Length; Marshall and Penney MS 1983), and biological characteristics of escaping hatchery and wild 1SW and MSW salmon, 1988-1995 (1SW fish: 15% female, 59.64 cm fork length and 63% of escapement; MSW fish: 94% female, 77.59 cm fork length and 37% of escapement; Marshall et al. MS 1997). On average, approximately **4,900 MSW** fish are needed to provide the 32.33 million eggs. An assumed 1:1 male:female requirement among spawners prescribes approximately **4,900 1SW** fish; females among those 1SW fish would, in an average year, contribute an additional 2.8 million eggs in excess of the requirement (Marshall et al. op.cit.).

Escapement

Collation of the total returns (Table 1) and total removals (Table 5) indicates that escapement was an estimated **4,622 ISW** and **627 MSW** salmon, 94 and 13%, respectively, of the requirement above Mactaquac (Table 8). Biological characteristics of spawners released above Mactaquac are:

Biological parameter	1SW wild	1SW hatch	MSW wild	MSW hatch
Proportion Female	0.135	0.113	0.929	0.881
Mean length, female (cm)	58.54	58.55	79.72	77.28

Differences from 1997 were increases in the proportion of females among wild (+0.074) and hatchery (+0.021) 1SW fish and a decrease in their mean lengths (-2.8 and -3.45 cm, respectively). The proportion of females among both wild and hatchery MSW fish decreased by 0.02 and 0.05, respectively. Mean lengths, the length-fecundity relationship, and estimated escapement indicate that total potential deposition (including estimated losses to poaching and disease) was 5.91 million eggs (0.439 eggs per m^2) or 18% of the requirement -- down by approximately 60% of that in 1997. Eggs from 1SW fish comprised 32% of the total deposition; eggs from hatchery-origin fish potentially contributed to 76% of the total deposition.

Juvenile Densities

Electrofishing was conducted at 40 sites upriver of Mactaquac in 1998 (Table 9). Summary of results (Fig. 3) for the Tobique, Shikatehawk, Becaguimec and Meduxnekeag indicate declines in age 0^+ densities, consistent with a low escapement in 1997. Age 1^+ and 2^+ parr densities increased from those of 1997, with the exception of the Shikatehawk, which averaged less than 10 fish per 100 m^2.

Forecasts

Numerous models have been explored to forecast separate returns of wild and hatchery (including smolts released below and juveniles released above Mactaquac) 1SW and MSW fish (Marshall et al. MS 1998). Summed-point estimates of the various population components derived from elaborate (and failing) forecast models were in 1997 replaced by summed components of forecasts based, for the most part, on mean and modal values of returns, proportions of hatchery fish-at-age, and return rates in recent years. The earlier assessment of stocks originating at and upriver of Mactaquac (Marshall et al. MS 1999) simplified the prognoses to Bayes derived probability of attaining the conservation requirement from the mean and standard deviation of 1SW and MSW returns and egg depositions in the previous five years.

Prognoses for returns in 1999 were 4,700 1SW and, optimistically, 2,200 MSW salmon (Marshall et al. MS 1999). Bayes derived probabilities of attaining conservation requirements of 4,900 of each of 1SW and MSW fish (ignores the requirement for 300 MSW broodstock) were 56% and <1%, respectively. Conversion of total returns to eggs (using eggs per fish for spawners in 1998) suggested a probability of <1% that 1SW and MSW returns in 1999 would meet conservation egg requirements.

At peer review it was suggested that a forecast of MSW salmon be derived as the product of 1SW returns in 1998 and the mean ratio of MSW:1SW for the last five smolt classes. Data, for the hatchery, wild, and combined 1969-1996 smolt classes are plotted in Table 10. Wild smolts have produced more MSW fish per 1SW fish than have hatchery smolts in 26 of the 28 years of record. Forecast of MSW returns in 1999 from 341 wild 1SW, 4,641 hatchery 1SW, or the 4,982 total hatchery and wild 1SW returns in 1998 are 283 wild, 1,517 hatchery and 2,409 total MSW salmon (Table 10). This value exceeds the earlier forecast of 2,200 MSW salmon, but 95% confidence limits of 1,566-3,252 indicate about the same probability (near 0%) of returns equaling the 4,900 fish requirement.

HAMMOND RIVER

With a drainage area of about 453 km^2, the mainstem Hammond River flows approximately 60 km in a southwestwardly direction from the Caledonia Highlands of Kings County to its confluence with the tidal reaches of Kennebecasis Bay in the lower Saint John River estuary at Nauwigewauk (Fig. 1 and 4). The drainage has an estimated 1.662 million m^2 of juvenile salmon producing habitat (Marshall et al. MS 1998) about 8% of the total habitat available below Mactaquac Dam. The Hammond River was, as were all rivers of Southwest New Brunswick in 1998, closed to directed salmon fisheries (including hook-and-release of 1SW fish).

Salmon assessment activities have, in the recent past, been limited to the estimation of juvenile densities and, in most years since 1976, counts of redds and salmon conducted by the New Brunswick Department of Natural Resources and Energy[1] (NBDNRE) (Marshall et al. MS 1998) on 11.75 km of the main stem. New in 1998 was a mark-and-recapture experiment conducted largely by the Hammond River Anglers Association[2] with significant funding from New Brunswick Wildlife Trust. The experiment permitted the estimation of total river returns of 1SW and MSW salmon. Biological sampling of salmon caught during “marking” operations also provided information with which to develop an interim estimate of the numbers of 1SW and MSW fish to meet conservation egg requirements.

Estimation of Returns

Mark-and-recapture experiments in 1998 provided data for estimation of in-river populations of salmon using Bayes estimation procedures of Gazey and Staley (1986) on September 9, October 20, 26 and November 9/10. Assumptions inherent to the experiments (Ricker 1975) are that (i) marked and unmarked fish have the same mortality, (ii) marked and unmarked fish are equally vulnerable to recapture, (iii) marked fish retain their mark, (iv) marked fish are randomly mixed among unmarked fish at the time of sampling, (v) all marks are recognized and reported, and (vi) recruitment is negligible during the recovery period.

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Marks

Serially-numbered small blue Carlin tags were affixed with monofilament ties to all salmon captured at the trapnet, with the exception of two late-entering grilse which were tagged with large orange Carlins. Tags were not applied to any salmon if water temperatures exceeded 22°C. Each fish was given an adipose punch to assist in later identification of tag loss or removal. All captured fish were measured (fork length), scale sampled, sexed on the basis of external characteristics, and classified as to wild or hatchery origin on the basis of fin erosion.

The trapnet was located about 0.4 km downstream from the Highway #1 bridge, about 5 km upstream of the confluence of the Hammond River and Kennebecasis Bay (Fig. 4). The water level at the trap was subject to tidal fluctuations of up to 0.5 m. There was no evidence of salt water intrusion. The trapnet was supported by a framework of steel re-bar "pickets" faced with 2-inch x 4-inch spruce studs and positioned in the deepest part of the river channel. Leads, supported by re-bar pickets, angled downstream and outwards from the trap. The lead on the west side was affixed to the shore, the lead to the eastern shore ended in the river channel so that, in total, about 60% of the river width could be said to be fished. Trap mesh-size was 1¼-inch knotless nylon, leaders were of four-inch mesh. The trap was fished once a day between eight-nine a.m. until late October when an additional late afternoon check was added.

Recaptures

Pools were seined for broodstock in early September and for recaptures in October, although broodstock were kept from both October outings. A swim-thru by paired divers was conducted during low and moderately clear water conditions in November. A regular broodstock seine of 2 ¼" knotless nylon, about 150 ft in length and 10 ft depth, and a "tangle net" seine, of 2 ¾" knotless nylon, about 130 ft and 10 ft deep, were used to seine the pools. The tangle net, designed for swifter water, was normally floated by divers, usually two or three, who recovered fish within seconds of their entanglement in the net. Before release, records were made of fish length and tags/marks and occasionally a sample of scales was taken.

Estimates of Returns

The trapnet was operated June 22 to October 30 with the exception of three days, October 12-14, when it was inoperable due to high water. The majority of the catch of 34 1SW and 40 MSW salmon was captured in the last week of September (Fig. 5). After scale analysis, the trapnet catch comprised 27 wild and seven hatchery 1SW salmon and 33 wild and seven hatchery MSW salmon. Fifty-seven percent of the wild 1SW fish originated from two-year-old smolts. Two-year smolts represented 91% of the wild 2SW salmon sampled. Scale analysis also revealed a high proportion (45.9) of the MSW salmon were previous spawners, and of the previous spawners, 82.3% originally spawned as maiden 2SW. The high percentage of previous spawners is consistent with increased proportions in the Nashwaak (36%) and the above Mactaquac (32%) stocks. Two-thirds of the hatchery returns originated from one-year-old smolts reared and released by the Saint John Fish Culture Station. Tags were applied to all but six fish captured in the trapnet. Five grilse seined on Sept 9 were also tagged.

Recapture operations yielded few fish and can be summarized as follows:

Date and Location	1SW No mark	1SW Mark	MSW No mark	MSW Mark	Total No mark	Total Mark
Sep 9, seine Palmer Bk.	9	2	5	1	14	3
Oct 20, seine Silver Hill/ Tabor Bridge/ Robichauds/ Kilpatricks/ Deep Hole	1	0	2	1	3	1
Oct 26, seine Silver Hill/ Smiths/ Cusacks Bridge swim-thru Robichauds/ Tabor Bridge	1	0	2	1	3	1
Nov 9/10, seine Silver Hill/ Robichauds/ Kilpatricks swim-thru Tabor Bridge/ Crowleys/Hillsdale Area (5 pools above Silver Hill)	2	1	1	0	3	1

Despite the low number of captures, each of the four outings essentially yielded three unmarked fish for each tagged fish. Chi-square analyses, although of low power of test, indicated a low probability that the four proportions of marked fish among captures were the result of chance alone.

Cumulative data for each of the recovery dates was submitted to Bayes estimation procedures and resulted in an estimate that converged on a modal value of **342 fish** (90% CLs 220-941) by Nov 9/10 (Fig. 6). The number of marks available for recapture did not always increase because of the removal of a few tagged fish for broodstock purposes on the previous date. A ratio of 0.55:0.45, 1SW:MSW from seining data yields an estimated escapement of **189 1SW** and **153 MSW** salmon. Seining ratio is preferred over trapnet (0.46:0.54) because of the possibility of grilse escaping the trapnet through muskrat holes. A count at three major holding pools (Cusack Bridge, Tabor Bridge, and Silver Hill) on Oct 7 by NBDNRE staff, of 32 grilse and eight salmon, suggests an even greater 1SW salmon proportion. Escapement plus broodstock of six 1SW and 11 MSW fish and one 1SW trapnet mortality estimates returns of **196 1SW** and **164 MSW** salmon. Fish of hatchery origin comprised 20.6% of 1SW and 17.5% of MSW returns.

Removals

In the absence of fisheries, known removals were limited to one 1SW salmon mortality in the trapnet and the above-mentioned six 1SW and 11 MSW broodstock, which were taken to Mactaquac Fish Culture Station, spawned and returned to the Hammond River.

Conservation requirements

Salmon production area for the Hammond River was estimated from air photos and orthophotographic maps (Amiro 1993) to be 1,662,000 m^2 of habitat $\geq$ 0.12% gradient (Marshall et al. MS 1997: excludes 978,000 m^2 area <0.12% grade). The product of production area and 2.4 eggs per m^2 yields a conservation requirement of four million eggs. Biological characteristics of the 60 wild salmon (excluding hatchery-origin fish) captured in the trapnet in 1998 (Table 11) and the length-fecundity relationship of Log_e Eggs=6.06423+ 0.03605(fork length) for salmon at Mactaquac (Marshall and Penney MS 1983) indicates that **530 MSW** salmon would be required to provide four million eggs. An additional **680 1SW** fish (1SW:MSW ratio in 1998 indicates that about 650 1SW fish would have accompanied 530 MSW fish) are required to provide an assumed requirement of one male for each female spawner. These requirements will be reviewed as additional biological characteristics and estimates of production area become available.

Escapement

Spawners were estimated to be **189 1SW** and **153 MSW** salmon. Sea-age, origins, female composition and mean lengths for the trapnet sample can be summarized as follows:

	1SW salmon		MSW salmon	
Biological parameter	Wild	Hatchery	Wild	Hatchery
Sample size	27	7	33	7
Proportion female	0.318	0.333	0.935	0.833
Mean length female (cm)	57.7	49.0	81.4	79.8

Numbers of both 1SW and MSW spawners were 28 and 29%, respectively, of the interim fish conservation requirements and 33% of egg requirements (Table 11). There is only a 2% probability that the November population estimate equalled a conservation requirement of 1,210 salmon. One-sea-winter females contributed to 15% of the total estimated egg deposition.

Redd Counts

As in previous years, an assessment of returns with respect to conservation requirements for the 11.75 km section of the mainstem Hammond River was based on redd counts and an average number of redds required to meet conservation. The 11.75 km section is bounded by the Tabor and Hillsdale bridges and is 25.7% of the mainstem length, averages 0.25% grade and contains an estimated 160,610 m^2 of stream habitat (Marshall et al. MS 1998). The method assumes that 1.86 redds result from each MSW spawner (including males) (Marshall et al. MS 1997). The number of redds per female MSW fish is calculated as the product of redds per MSW and the reciprocal of the proportion of females among the MSW population. Past analyses assumed that the MSW stock was 75% female and thus every 2.48 redds equated to one female salmon.

Counts of redds, 1976-1998, exclusive of 1984 and 1988-1991, appear in Table 12. Counts of large redds (small redds could be false or those of 1SW fish) ranged from 78 to 305, a count of 92 in 1998 (possibly reduced somewhat by visibility) was 59% of the value for 1997 and 52% of the 15-year mean for large redds (Table 12).

Conservation requirements for the redd survey area have previously been described as the product of the 160,610 m^2 substrate in the study area and an assumed requirement of 2.4 eggs per m^2, i.e., 0.385 million eggs. Required eggs were previously assumed to be met by 53 MSW females ([385,464/7,306]*2.48) or 132 “total” redds under the assumption that MSW salmon were 75% female and that each female carried 7,306 eggs (Marshall et al. MS 1997). Values of 8,093 eggs per MSW female and 94% females among wild MSW salmon captured in the trapnet in 1998 (Table 11) indicates the possibility that required eggs could be provided by **48 MSW** females in 119 redds. A count of 111 total redds and current biological data indicate that conservation requirements were approached on the 11.75 km in 1998 and were met in all but two (1976,1995) of the 18 years of "total redd" record (Table 12). There are no redd counts permitting the extension of this type of assessment to the total drainage.

Juvenile Densities

Densities of juvenile salmon (age 1^+ and 2^+ parr) at four sites on the Hammond River, 1981-1998 (Fig. 7) averaged 17.4 parr per 100 m^2, the third highest of the 18-year data set. (Densities may have been influenced by the release in July 1997 of 28,000 0^+ parr in the vicinity of two index sites, Table 13). Age 0^+ parr averaged 8.35 fish per 100 m^2, the lowest of the 18-year data set. Densities of age 0^+ and age 1^+ and older parr were 29% and 46%, respectively, of normal parr abundance (Elson 1967; 29 age 0^+ and 38 age 1^+ and older parr). Two additional tributary sites (Salt Springs Brook and Hanford Brook), were surveyed by the NBDNRE and association staff and similar densities were observed. Average age 0^+ and age 1^+ and older parr densities were 3.7 and 24.5 fish per 100m^2, respectively, and consistent with the average densities from the four index sites (Table 9).

Forecasts

There are few data and no demonstrated stock-and-recruit relationships with which to forecast numbers of salmon returning to the Hammond River or Hammond River redd survey area (Marshall et al. MS 1997). Consistently moderate juvenile densities (Fig. 7), low with respect to normal abundance, are not, however, suggestive of potential for increased returns. Returns to and upriver of Mactaquac and to the Nashwaak River in 1998 were 16% and 31% of respective requirements and forecast of returns in 1999 suggested near zero probabilities of attaining conservation requirements (Marshall et al. MS 1999). Indices of stock status on the Hammond River, i.e. unchanging juvenile densities, the nearly lowest redd count of record, and an estimated return in 1998 of perhaps 30% of conservation requirement support the contention that the Hammond, like other assessed stocks in the Saint John River drainage, is at a low level and that returns in 1999 will be low with respect to conservation requirements.

NASHWAAK RIVER

With a drainage area of about 1,700 km^2, the Nashwaak River flows approximately 110 km in an easterly and southerly direction from Nashwaak Lake on the York/Carleton county line to its confluence with the Saint John River in Fredericton North (Figs. 1 and 8). The river is the largest single salmon-producing tributary of the Saint John below Mactaquac - its production area having recently been estimated from orthophoto measurements as 7.7 million m^2 or 28.5% of the total below Mactaquac Dam (Marshall et al. MS 1998; Table 8). A salmon counting fence at kilometre 23 (Fig. 8) from the confluence with the Saint John River was operated by the Department of Fisheries and Oceans (DFO) in 1972, 1973 and 1975 (Francis and Gallop MS 1979), and by First Peoples from 1993-1998. Juvenile surveys in the Nashwaak have been conducted annually since 1981 with a continuous data set for eight index sites (seven above the counting fence). The preliminary adult estimates and electrofishing densities were reported in a pre-stock assessment document (Marshall et al.

MS 1999). In 1998, a co-operative project was initiated between DFO, Nashwaak Watershed Association, Atlantic Salmon Federation and the New Brunswick Wildlife Trust Fund, and the results are the focus of this section.

Wild Smolt Estimate

Methods

Total wild smolt production for the Nashwaak River above Durham Bridge was estimated using mark-and-recapture techniques.

Smolts were marked at a portable counting fence installed in the Tay River, 4.2 km above the confluence of the Tay River with the mainstem Nashwaak River (Fig. 8). The juvenile salmon production area of the entire Tay River represents approximately 8% of the total Nashwaak River parr habitat above Durham Bridge. The Tay is also the largest tributary and offered the best single opportunity to capture and mark smolts. All healthy smolts were adipose clipped and 20% were also tagged with numerical streamer tags. The tags were applied to determine the run timing of the Tay River fish into the main Nashwaak. A few suspected aquaculture escapee smolts from a private hatchery at Tay Falls were lethally sampled at the Tay River fence, others were used in the mark-recapture experiment.

A rotary screw trap (smolt wheel) stationed in the main stem of the Nashwaak River just below Durham Bridge and near the adult fence site (Fig 8) provided the sampling platform for marked and unmarked smolts. Twenty percent of all smolts captured were measured and scale sampled. This information provided biological data for the total smolt run above Durham Bridge.

Results

Tay River Smolt Counting Fence

The portable smolt fence was installed on April 30th and fished approximately 80% of the river width. On May 3-4, every second conduit was removed, on May 5th additional fence material was added which provided complete river coverage and passage for upstream migrants (there was no upstream enumeration) and from May 10-12, the fence was inoperable because of modification to the trap. Fence operation ceased on June 5th with very few smolts being captured during the last two weeks of operation (Fig. 9).

A total of 532 wild smolts were counted during the fence operation. On May 13, it was noted that a certain number of large smolt with at least 20% dorsal erosion were being identified at the fence. These fish were suspected to be from a private hatchery on the system since stocking from Mactaquac FCS ceased in 1996 with the release of 9,000 one-year-old smolts (Marshall et al. MS 1997). Scale analysis revealed those sampled to be one-year-old smolts with growth patterns similar to those of hatchery-reared fish. A total of 552 smolts (23% possible aquaculture escapees) were given an adipose fin clip for later identification at the recapture site, 20% were also given a numeric streamer tag. The downstream counts of all species can be summarized as follows:

Common Name	Count
Wild salmon smolt	532
Aquaculture smolt	134
Wild salmon parr (age 1)	113
Brook trout	17
Sea lamprey	173
American eel	51
Gaspereau	66
White sucker	429

The wild smolt run on the Tay River peaked on May 7-8 when estimated daily water temperatures averaged 11°C (Fig. 9). Tay River daily average water temperatures were estimated by using the following formula {[TR temp @ time(x) divided by NR temp @ time(x)]*NR daily average}. The aquaculture smolts appeared to peak after the wild run, with the largest counts on May 21-22 (Fig. 9). Water levels on the Tay generally dropped throughout May, but slight increases were observed to "flush out" any late migrants (Fig. 9). Smolts migrating from the Tay were generally recaptured at Durham Bridge, one day after release from the fence. Four of the 109 smolts tagged with streamer tags were recaptured one day following release while one other smolt took two days.

Smolt Wheel

A rotary screw trap developed by E.G. Solutions Inc. of Corvallis, Oregon was installed at the head of Church Pool, just below Durham Bridge, on the main Nashwaak River. The wheel had a trap diameter of five feet (sampling area of 8.6 ft^2) and was operated from April 28 until June 5. It captured 30 marked and 1,206 unmarked smolt (Fig. 10). Only two aquaculture escapees were identified at the smolt wheel and both had been marked at the Tay fence. In an attempt to increase the wheel capture efficiency, an 8' x 4' small mesh leader (wing) was added on May 4. The wheel stopped turning during the evening of May 4 and therefore no smolt were captured on May 5th. Only one smolt mortality occurred at the wheel. Eighty-five emerging salmon fry were also captured May 27-June 5. The catch of all species can be summarized as follows:

Common Name	Count
Wild salmon smolt	1,234
Aquaculture smolt	2
Wild salmon parr (age 1)	81
Emerging salmon fry	85
Smallmouth bass	5
Sea lamprey	101
American eel	378
White sucker	43
Rainbow smelt	1

The smolt migration started before daily water temperatures reached 10°C but certainly peaked once temperatures averaged 11°C (Fig. 10). Discharge data for the Nashwaak River was unavailable because of ice damage to the gauging station but water levels generally dropped throughout the smolt run with small increases on May 23 and June 4, both of which can be identified by morning water levels at the Tay River fence (Fig. 10). Scale samples from 20% of the wheel catch revealed the following:

Smolt age	Number	Percentage	Mean length (cm)	Standard Deviation (cm)
2 year old	162	79.4%	14.5	0.93
3 year old	42	20.6%	15.7	1.22
Total	204	100.0%	14.8	1.12

Estimate

Mark-recapture data were submitted to a Bayesian estimation procedure (Gazey and Staley 1986) to describe the most probable estimate (mode) among a binomial distribution of less probable solutions. Data submitted to mark-recaptured analysis were: M=552; C=1,226 and R=30 (wheel efficiency 5.4%) and is similar to the streamer tag data of M=109 and R=5 (wheel efficiency 4.6%). Adipose clip data suggests the most probable number of spring smolt originating above Durham Bridge was 22,750 (Fig. 11; 90% CL 17,900-32,850). This estimate assumes that the 125 suspected aquaculture escapee smolt captured, marked and released at least migrated below the smolt wheel (two were recaptured) and that very few spring smolts migrated before April 27. The extent of the out migration of fall pre-smolts is unknown, but potentially of significance given the evidence that 150 pre-smolts (and 48 parr) were captured at the adult fence (not designed to capture downstream migrating smolts), Oct 22-Nov 2, 1973.

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Table 1. Estimated total arrivals of wild and hatchery 1SW and MSW fish destined for Mactaquac Dam on the Saint John River, N.B., 1998.

Sea-age	Components	Wild	Hatchery	Aqua-culture	Total
1SW					
	Mactaquac counts[a]	476	4,413	0	4,889
	Mactaquac counts adjusted[b]	338	4,595	0	4,933
	Angled main stem below Mactaquac	0	0	0	0
	First Peoples' Food Fishery	0	0	0	0
	By-catch[c]	3	46	0	49
	Totals	341	4,641	0	4,982
MSW					
	Mactaquac counts[a]	367	620	4	991
	Mactaquac counts adjusted[b]	312	631	4	947
	First Peoples' Food Fishery	0	0	0	0
	By-catch[c]	8	16	0	24
	Totals	320	647	4	971

[a] Hatchery/wild origins per external characteristics in previous assessments; fishway closed Oct 26.

[b] Adjusted by analyses of scales from sampled fish. (See text for explanation.)

[c] Estimated to be 1% of total 1SW returns and 2.5% total MSW returns, considered to include losses to poaching.

Table 2. *Counts of wild, hatchery and sea-cage-origin Atlantic salmon (as identified by fishway operators) trapped at fishways/fences of four rivers in southwest and central New Brunswick, 1967-1998.*

Year	Saint John				Nashwaak					Magaguadavic				St. Croix [e]					
	Wild		Hatchery		Wild		Hatchery		Dates of Operation	Wild		Aquaculture		Wild		Hatchery		Aquaculture	
	1SW	MSW	1SW	MSW	1SW	MSW	1SW	MSW		1SW	MSW	1SW	MSW	1SW	MSW	1SW	MSW	1SW	MSW
1967	1,181	1,271	-	-															
1968	1,203	770	-	-															
1969	2,572	1,749	-	-															
1970	2,874	2,449	94	-															
1971	1,592	2,235	336	37															
1972	784	4,831	246	583	259	859	-	-	8/18-10/29										
1973	1,854	2,367	1,760	475	596	1,956	-	-	6/10-11/05										
1974	3,389	4,775	3,700	1,907															
1975	5,725	6,200	5,335	1,858	1,223	1,036	-	-	6/28-10/29										
1976	6,797	5,511	7,694	1,623															
1977	3,504	7,257	6,201	2,075															
1978	1,584	3,034	2,556	1,951															
1979	6,234	1,993	3,521	892															
1980	7,555	8,157	9,759	2,294															
1981	4,571	2,441	3,782	1,089															
1982	3,931	2,254	2,292	728										10	51	-	-		
1983	3,613	1,711	1,230	299						282	607	21	30 b	22	78	-	-		
1984	7,353	7,011	1,304	806						255	512			166	64	6	8		
1985	5,331	6,390	1,746	571						169	466			41	264	8	31		
1986	6,347	3,655	699	487										38	204	25	53		
1987	5,106	3,091	2,894	344										128	135	67	42		
1988	8,062	1,930	1,129	670						291	398			93	190	9	102		
1989	8,417	3,854	1,170	437										79	94	37	21		
1990	6,486	3,163	1,421	756 a										10	52	2	46		
1991	5,415	3,639	2,160	587 a										16	75	37	79		
1992	5,729	3,522	1,935	681 a						155	139	83	62 cf						
1993	2,873	2,601	1,034	379 a	72	113	11	42	8/19-10/12 fg	112	125	96	52 cf	3	30	5	66		f
1994	2,133	1,713	1,180	493 a	376	251	27	23	7/15-10/25 fg	69	61	1,059	81 cf	24	19	23	18	97	- f
1995	2,429	1,681	2,541	598 a	544	294	25	14	7/12-10/18 fg	49	30	491	168 cf	7	14	7	19	7	6 f
1996	1,552	2,413	4,603	726 a	854	391	86	38	6/13-10/18 fg	48	21	174	20 cf	10	32	13	77	15	5 f
1997	380	1,147	2,689	629	332	339	38	27	6/18-11/02 f	35	24	59	23 cf	7	8	26	2	11	16
1998	476	367	4,413	624 a	464	142	1	9	6/08-10/27 fg	28	3	211	8 cf	11	6	21	3	18	6
Means:																			
1993-97	1,873	1,911	2,409	565	436	278	37	29		63	52	376	69	10	21	15	36	33	9
1988-97	4,348	2,566	1,986	596	-	-	-	-		108	114	-	-	28	57	18	48	-	-
1998 as % of:																			
1993-97	25%	19%	183%	110%	107%	51%	3%	31%		45%	6%	56%	12%	108%	29%	142%	8%	55%	67%
1988-97	11%	14%	222%	105%	-	-	-	-		26%	3%	-	-	40%	11%	119%	6%	-	-

[a]- Small numbers of aquaculture fish, see Tables 3, 4a&b. [b]- No record of stocking in years previous. [c]- Aquaculture.
[e]- Hatchery designation to be reviewed; sea-cage fish could be among hatchery fish prior to 1994. [f]- Corrected by scale analysis. [g]- Partial count.

Table 3. Estimated river returns of wild, hatchery and aquaculture 1SW and MSW salmon destined for Mactaquac Dam, Saint John River, 1970-1998.

	Wild		Hatchery		Total (W+H)		Aquaculture [a]	
Year	1SW	MSW	1SW	MSW	1SW	MSW	1SW	MSW
1970	3,057	5,712	100	0	3,157	5,712		
1971	1,709	4,715	365	77	2,074	4,792		
1972	908	4,899	285	592	1,193	5,491		
1973	2,070	2,518	1,965	505	4,035	3,023		
1974	3,656	5,811	3,991	2,325	7,647	8,136		
1975	6,858	7,441	6,374	2,210	13,232	9,651		
1976	8,147	8,177	9,074	2,302	17,221	10,479		
1977	3,977	9,712	6,992	2,725	10,969	12,437		
1978	1,902	4,021	3,044	2,534	4,946	6,555		
1979	6,828	2,754	3,827	1,188	10,655	3,942		
1980	8,482	10,924	10,793	2,992	19,275	13,916		
1981	6,614	5,766	5,627	2,728	12,241	8,494		
1982	5,174	5,528	3,038	1,769	8,212	7,297		
1983	4,555	5,783	1,564	1,104	6,119	6,887		
1984	8,311	9,779	1,451	1,115	9,762	10,894		
1985	6,526	10,436	2,018	875	8,544	11,311		
1986	7,904	6,128	862	797	8,766	6,925		
1987	5,909	4,352	3,328	480	9,237	4,832		
1988	8,930	2,625	1,250	912	10,180	3,537		
1989	9,522	4,072	1,339	469	10,861	4,541		
1990	7,263	3,329	1,533	575	8,796	3,904	8	221
1991	6,256	4,491	2,439	700	8,695	5,191	56	24
1992	6,683	4,104	2,223	778	8,906	4,882	34	16
1993	3,213	2,958	1,156	425	4,369	3,383	0	6
1994	2,276	1,844	1,258	503	3,534	2,347	0	28
1995	2,168	1,654	2,907	599	5,075	2,253	4	102
1996	1,326	2,309	5,394	1,002	6,720	3,311	3	10
1997	343	1,128	2,912	843	3,255	1,971	0	0
1998	341	320	4,641	647	4,982	967	0	4

[a] 1990-94, 1SW and MSW classification based on lengths and count data; 1995-97, count raised by estimated removals below Mactaquac and adjusted according to ages from scale samples.

Table 4a. Estimated total number of 1SW returns to the Saint John River, 1975-1998, from hatchery-reared smolts released at Mactaquac, 1974-1997.

Releases			Returns									
		Prop	Mactaquac			Native	Angled	By-	Com-		% return	
Year	Smolts	1-yr	Year	Mig ch (combined)	Dam	fishery	main SJ	catch	mercial	Total[a]	Unadj	Adj[b]
1974	337,281	0.00	1975	1,771	3,564	28	977	34		6,374	1.890	
1975	324,186	0.06	1976	2,863	4,831	219	1,129	32		9,074	2.799	
1976	297,350	0.14	1977	1,645	4,533	36	708	70		6,992	2.351	
1977	293,132	0.26	1978	777	1,779	49	369	70		3,044	1.038	
1978	196,196	0.16	1979	799	2,722	100	186	20		3,827	1.951	
1979	244,012	0.09	1980	3,072	6,687	335	640	59		10,793	4.423	
1980	232,258	0.12	1981	921	2,861	139	350		1,356	5,627	2.423	
1981	189,090	0.08	1982	828	1,464	64	267		415	3,038	1.607	
1982	172,231	0.06	1983	374	857	39	69		225	1,564	0.908	
1983	144,549	0.22	1984	476	828	36	63	48		1,451	1.004	0.976
1984	206,462	0.28	1985	454	1,288	82	128	66		2,018	0.977	0.920
1985	89,051	1.00	1986	64	635	53	93	17		862	0.968	0.868
1986	191,495	1.00	1987	152	2,063	74	222	52		2,563	1.338	1.170
1987	113,439	1.00	1988	(717)		15	46	16		794	0.700	0.672
1988	142,195	1.00	1989	(1,018)		0	107	23		1,148	0.807	0.763
1989	238,204	0.98	1990	(903)		0	57	20		980	0.411	0.401
1990	241,078	0.98	1991	(1,490)		88	108	35		1,721	0.714	0.649
1991	178,127	0.97	1992	(1,123)		26	135	26		1,310	0.735	0.688
1992	204,836	1.00	1993	(743)		11	60	17		831	0.406	0.406
1993	221,403	1.00	1994	(828)		37	0	18		883	0.399	0.393
1994	225,037	1.00	1995	(1,514)		15		15		1,544	0.686	0.661
1995	251,759	1.00	1996	(2,649)		215	0	29		2,893	1.149	1.140
1996	286,400	1.00	1997	(1,542)		58	0	16		1,616	0.564	0.558
1997	286,485	1.00	1998[c]	(2,114)		0	0	21		2,135	0.745	0.745
1998	300,000	1.00										

[a]Includes some returns from smolts stocked downriver of Mactaquac or escaped from sea-cages (Table 3: as determined from erosion of margins of upper and lower caudal fins).

[b]Adjusted return rates exclude smolts stocked downriver from Mactaquac (Marshall 1989) and fish of probable sea-cage origin. (Marginal numbers of returns from approx. 5,000 age 2.1 smolts, 1989-1991 are not included; no returns from tagged smolts released to the Nashwaak River, 1992 or 1997; 1997 count yielded 2 tagged 1SW fish from among 2,000 tagged smolts released to the Nashwaak in 1996 (9,017 smolts total).

[c]Hatchery origin 1SW fish at Mactaquac in 1998 were assigned an origin on the basis of freshwater age (scale reading) and fin condition, i.e., age 1.1 @ 0.460,age 2.1 @ 0.211, age 3.1 @ 0.318 and age 4.1 @ 0.012.

Table 4b. Estimated total number of MSW returns to the Saint John River, 1976-1998, from hatchery-reared smolts released at Mactaquac, 1974-1996.

Releases			Returns									
			Mactaquac								% return	
Year	Smolts	Prop 1-yr	Year	Mig ch (combined)	Dam	Native fishery	Angled main SJ	By-catch	Commercial	Total[a]	Unadj	Adj[b]
1974	337,281	0.00	1976	310	1,313	392	267	20		2,302	0.683	
1975	324,186	0.06	1977	341	1,727	206	417	34		2,725	0.841	
1976	297,350	0.14	1978	223	1,728	368	165	50		2,534	0.852	
1977	293,132	0.26	1979	145	747	210	65	21		1,188	0.405	
1978	196,196	0.16	1980	302	1,992	506	146	46		2,992	1.525	
1979	244,012	0.09	1981	126	963	252	125		1,262	2,728	1.118	
1980	232,258	0.12	1982	88	640	462	181		398	1,769	0.762	
1981	189,090	0.08	1983	44	255	76	17		712	1,104	0.584	
1982	172,231	0.06	1984	84	722	201	5	103		1,115	0.647	0.560
1983	144,549	0.22	1985	73	492	189	5	116		875	0.605	0.553
1984	206,462	0.28	1986	16	471	266	4	40		797	0.386	0.346
1985	89,051	1.00	1987	4	338	110	4	24		480	0.539	0.453
1986	191,495	1.00	1988	(511)		150	0	35		696	0.363	0.354
1987	113,439	1.00	1989	(379)		0	0	20		399	0.352	0.330
1988	142,195	1.00	1990	(480)		0	0	25		505	0.355	0.170
1989	238,204	0.98	1991	(359)		62	0	46		467	0.196	0.173
1990	241,078	0.98	1992	(546)		58	0	32		636	0.264	0.256
1991	178,127	0.97	1993	(196)		16	0	11		223	0.125	0.121
1992	204,836	1.00	1994	(435)		10		23		468	0.228	0.214
1993	221,403	1.00	1995	(440)		5	0	11		456	0.206	0.205
1994	225,037	1.00	1996	(567)		18	0	15		600	0.267	0.267
1995	251,759	1.00	1997	(428)		45	0	12		485	0.193	0.186
1996	286,400	1.00	1998[c]	(220)		0	0	6		235	0.082	0.082
1997	286,485	1.00										
1998	300,000											

[a]Includes some returns from smolts stocked downriver of Mactaquac or escaped from sea-cages (Table 3: erosion of margins of upper and lower caudal fins).

[b]Adjusted return rates exclude smolts stocked downriver from Mactaquac (Marshall 1989) and fish of probable sea-cage origin. (Marginal numbers of returns from approx. 5,000 age 2.1 smolts, 1989-1991 are not included; no returns from tagged smolts released to the Nashwaak River, 1992; possibly 3 returns from 12,516 smolts >12cm to Nashwaak in 1993; no returns from 15,059 stocked in the Nashwaak in 1994 and 2 returns from 3,989 tagged [13,283 total] in 1995.

[c]Hatchery origin MSW fish at Mactaquac in 1997 were assigned an origin on the basis of freshwater age (scale reading) and fin condition, i.e., age 1.2 @ 0.424, age 2.2 @ 0.223, age 3.2 @ 0.329 and age 4.2 @ 0.023. Repeat spawners constitute 0.146 of the MSW returns.

Table 5. Estimated homewater removals[a] of 1SW and MSW salmon destined for Mactaquac Dam on the Saint John River. N.B.. 1998.

	1SW			MSW		
Components	*Wild*	*Hatch*	*Total*	*Wild*	*Hatch*	*Total*
Native Food Fishery						
Below Mact.	0	0	0	0	0	0
Above Mact.	0	0	0	0	0	0
Recreational fishery						
Tobique River	-	-	-	-	-	-
Mainstem abv Mact.	-	-	-	-	-	-
Mainstem blw Mact.	-	-	-	-	-	-
Hook-release mort.	0	0	0	0	0	0
Passed abv Tinker	11	65	76	1	3	4
Mortality @ Beechwood	-	4	4	1	2	3
Trapped in Tobique Fishway	15	193	208	3	6	9
Hatchery broodfish	1	21	22	119	180	299
mortalities, etc.[b]	0	1	1	0	1	1
Poaching/disease[c]	3	43	46	5	11	16
By-catch	3	46	49	8	16	24
Totals	33	373	406	137	219	356

[a] Wild:hatchery composition per adjusted counts and assumed availability.

[b] Four cage fish "removals" included in MSW hatchery.

[c] Assumed to be 1% and 2.5% of all unaccounted for 1SW and MSW fish respectively, above Mactaquac.

Table 6. Estimated landings (numbers of fish) of Native, sport, commercial and by-catch 1SW and MSW salmon originating at or above Mactaquac on the Saint John River, 1970-1998.

	Native[a]		Recreational[b]		Commercial		By-catch[c]		Total	
Year	1SW	MSW	1SW	MSW	1SW	MSW	1SW	MSW	1SW	MSW
1970			392	333	105	3,204			497	3,537
1971			319	357	57	2,391			376	2,748
1972			311	770			41	6	352	776
1973			704	420			37	60	741	480
1974	27	569	2,034	2,080			26	8	2,087	2,657
1975	73	739	3,490	1,474			70	56	3,633	2,269
1976	526	2,038	3,580	2,134			61	90	4,167	4,262
1977	64	1,070	2,540	3,125			109	156	2,713	4,351
1978	92	1,013	1,151	899			114	129	1,357	2,041
1979	328	771	2,456	589			55	69	2,839	1,429
1980	713	2,575	3,260	2,409			105	211	4,078	5,195
1981	361	891	2,454	1,085	2,749	3,666			5,564	5,642
1982	235	2,088	1,880	921	1,020	1,446			3,135	4,455
1983	203	588	1,453	637	786	4,173			2,442	5,398
1984	353	2,135	1,824				338	896	2,515	3,031
1985	471	2,526	3,060				412	1,771	3,943	4,297
1986	600	2,400	1,692				175	346	2,467	2,746
1987	280	1,120	1,650				185	242	2,115	1,362
1988	300	1,200	1,755				204	177	2,259	1,377
1989	560	240	2,304				217	27	3,081	267
1990	273	247	2,110				176	206	2,559	453
1991	657	957	1,690				175	261	2,522	1,218
1992	560	748	2,104				179	245	2,843	993
1993	241	462	852				87	169	1,180	631
1994	250	90	0				71	119	321	209
1995	50	25					51	59	101	84
1996	675	285	0				67	83	742	368
1997	361	265	0				32	49	393	314
1998							49	24	49	24

[a] Kingsclear, 1974-88; Tobique 1988-90; Kingsclear, St. Mary's, Oromocto and Tobique in 1991-94; Aboriginal Peoples Council, 1994; St. Mary's, 1995; all FNs/aboriginals 1996; St. Mary's, Kingsclear & Tobique, 1997.

[b] NBDNRE and DFO sources.

[c] Guesstimates from various sources or assumed prop. (Table 1) of the run; incl. in commercial, 1981-83.

Table 7. Numbers of adult salmon (inc. females) released above Tinker Dam on the Aroostook River and above Grand Falls on the mainstem Saint John, 1983-1998.

	Tinker								Grand Falls			
	Trucked				Fishway[a]		Total		Trucked			
Year	1SW	(F)	MSW	(F)	1SW	MSW	1SW	MSW	1SW	(F)	MSW	(F)
1983	34		0				34	0				
1984	58		29				58	29				
1985	65		24				65	24			12	(10)
1986	50		0				50	0				
1987	77		9				77	9				
1988	70		30		17?	39?	70	30				
1989	88	(6)	35	(30)	81	22	169	57				
1990	0		0		45	18	45	18				
1991	50	(3)	50	(47)	39	0	89	50	90	(5)	50	(47)
1992	225	(24)	90	(84)	117	6	342	96	230	(16)	110	(106)
1993	85	(17)	71	(63)	50	13	135	84	109	(12)	64	(53)
1994	105	(6)	16	(12)	14	5	119	21	62	(8)	17	(14)
1995	100	(11)	40	(36)	20	2	120	42	0		0	
1996	140	(8)	40	(40)	53	12	193	52	0		0	
1997	50	(5)	20	(19)	6	6	56	26	0		0	
1998	50	(6)	0	0	26	4	76	4	0		0	

[a] sea-age based on fork length measurements & differs from that ascribed by Tinker Fishway operator.

Table 8. Estimated homewater returns, removals and spawning escapement of 1SW and MSW salmon destined for/above Mactaquac Dam, Saint John River, 1998.

Sea-age	*Components*	*Wild*	*Hatch*	*Total*
1SW				
	Homewater returns	341	4,641	4,982
	Homewater removals[a]	33	373	406
	Spawners[b]	311	4,311	4,622
	Conservation requirement			4,900
	% of requirement			94
MSW				
	Homewater returns	320	647	967
	Homewater removals[a]	137	219	356
	Spawners[b]	188	439	627
	Conservation requirement			4,900
	% of requirement			13

[a] Includes Mactaquac broodfish and losses to poaching and disease (Table 5).

[b] [Returns minus removals] + poaching/diseases.

Table 9. Densities of wild juvenile salmon from electrofishing surveys in the Saint John watershed, 1998.

River	Site Name	Site No.	Marking Month	Marking Day	Recap Time (days)	Area (m²)	Marking Run Fry Count	Marking Run Parr Marked	Marking Run Mort	Recapture Run Fry Count	Recapture Run Parr Unmark	Recapture Run Parr Marked	Mark Run Efficiency	Density / 100 m² 0+	Density / 100 m² 1+	Density / 100 m² 2+
	Tributaries below Mactaquac Dam															
Canaan River																
new 98	Nevers Brook	1	9	1	2	1485	0	5	0	0	1	1	0.63	0.0	0.5	0.0
new 98	Thorne's Brook	- 2	9	1	2	1179	12	50	1	16	75	14	0.17	6.1	24.1	1.9
Hammond River																
DNR Site	Salt Springs [2]	1	9	1	1	936	24	40	0	22	26	12	0.33	7.8	12.0	1.0
DNR Site	Hanford [2]	1.1	9	1	1	1346	1	87	1	0	99	21	0.18	0.4	32.4	3.5
	Smithtown	2	9	8	1	1563	45	30	0	42	9	18	0.67	4.4	2.8	0.1
	Hanford Brook	3	9	3	1	2793	14	230	0	19	135	137	0.50	1.0	15.5	0.8
	Burke's Farm	4	9	10	1	1316	55	184	0	47	40	80	0.67	6.2	19.9	1.0
	Hillsdale	5	9	8	1	1576	163	218	2	146	108	95	0.47	21.8	27.9	1.5
													0.54	**9.5**	**18.4**	**1.0**
Kennebecasis River																
	Mt. Pisgah, Smiths Creek	1	8	11	1	1734	17	17	0	35	19	4	0.20	4.9	4.5	0.4
	Penobsquis	3	8	12	1	1912	172	18	0	97	21	5	0.21	42.5	4.2	0.2
	South Branch	4	8	11	1	1084	0	0	0	0	1	0	0.19 [1]	0.0	0.0	0.1
	Goshen	5	8	11	2	1963	3	19	0	1	18	4	0.21	0.7	3.9	0.7
	Millstream	6	8	10	3	1469	3	88	0	24	93	15	0.15	1.4	40.1	1.1
													0.19	**9.9**	**10.6**	**0.5**
Nashwaak River																
	Penniac Stream	1	7	22	2	1229	39	73	0	19	26	27	0.51	6.2	8.9	2.7
	Above Durham Bridge	2	7	7	2	917	9	0	0	10	0	0	0.39 [1]	2.5	0.0	0.0
	Tay River	3	7	14	1	1153	4	10	0	17	17	18	0.50	0.7	1.7	0.0
new 98	Tay River (North) [2]	3.1	8	24	1	598	12	83	0	10	54	44	0.45	4.5	24.3	6.5
new 98	Tay River (South) [2]	3.2	8	24	1	1035	22	86	0	38	68	37	0.36	6.0	18.7	4.7
	MacKenzie Brook	4	7	8	1	860	1	10	0	1	10	6	0.38	0.3	1.3	1.7
	Above Nashwaak Bridge	5	7	8	1	1258	0	1	0	0	1	0	0.39 [1]	0.0	0.2	0.0
	Cross Creek [2]	6	8	25	1	1056	43	37	0	124	36	19	0.35	11.6	6.7	3.2
new 98	Cross Creek (Hwy 625) [2]	6.1	8	31	1	1029	26-	50	0	22	52	22	0.30	8.4	13.2	2.8
	Below Stanley [2]	7	8	4	1	1141	4	2	0	2	1	1	0.50	0.7	0.4	0.0
	Above Stanley	8	7	14	1	1031	21	6	0	13	1	1	0.60	3.4	1.0	0.0
	Cedar Bridge	9	7	20	1	1132	8	16	0	8	24	1	0.07	9.7	17.5	1.9
	Doughboy Brook	10	7	20	1	1080	3	3	0	3	4	1	0.27	1.0	0.8	0.3
													0.39	**3.0**	**3.9**	**0.8**
Keswick River																
	Jones Forks	1	7	27	2	964	63	119	0	36	98	21	0.18	35.9	62.4	5.4
	Stoneridge	3	7	27	2	986	60	21	0	122	40	11	0.22	27.3	9.5	0.0
	Hayne	4	8	4	1	1078	7	55	0	10	48	17	0.27	2.4	17.8	1.1
	Barton	5	7	28	1	857	14	18	0	12	32	0	0.22 [1]	7.5	8.6	1.0
													0.22	**18.3**	**24.6**	**1.9**
Nerepis River																
new 98	River George	5	9	1	1	1465	0	26	0	0	23	18	0.44	0.0	3.8	0.2
	Tributaries upriver of Mactaquac Dam															
Meduxnekeag River																
	Marven Brook	1	7	23	2	377	6	7	0	13	8	3	0.30	5.3	4.1	2.0
	Belleville [2]	2	8	4	0	2315	2	0	0	0	0	0	0.27 [1]	0.3	0.0	0.0
	North Br. @ Jackson Falls	3	7	21	2	446	20	17	0	9	15	6	0.30	14.8	12.6	0.0
	Hagerman Brook @ Oakville	4	7	20	2	750	9	1	0	6	4	1	0.20	6.0	0.5	0.2
	North Br. @ Carter Brook	5	7	20	2	1318	1	10	0	2	18	0	0.27 [1]	0.3	2.6	0.2
													0.27	**6.6**	**4.9**	**0.6**
Becaguimec River																
	Coldstream (Bannon)	1	7	27	3	1223	23	35	0	20	16	13	0.46	4.1	5.7	0.5
	East Coldstream	2	7	27	3	1092	5	9	3	6	5	1	0.35	1.3	2.6	0.5
	South Branch (County Line)	3	8	4	2	589	0	18	0	0	5	10	0.67	0.0	4.3	0.3
	North Branch (Cloverdale)	4	7	29	2	1527	18	23	5	13	9	9	0.62	1.9	2.8	0.1
	North Branch (Carlisle)	5	7	29	2	1290	10	67	0	5	36	23	0.40	1.9	11.6	1.5
													0.50	**1.8**	**5.4**	**0.6**
Shikatehawk River																
	Lockharts Mill	1	8	17	2	1170	10	240	4	9	129	140	0.53	1.6	34.9	4.4
	Gordonsville	2	29	7	1	1065	147	278	3	142	82	81	0.50	27.3	50.4	1.9
	West Glassville	3	8	17	2	1309	372	454	9	378	269	191	0.42	67.0	79.5	3.8
	Centre Glassville	4	7	30	1	1736	64	11	0	76	9	5	0.38	9.7	1.4	0.3
	Kenneth	5	7	30	1	968	0	15	0	0	7	6	0.48	0.0	1.5	1.7
													0.46	**21.1**	**33.5**	**2.4**

Table 9. Densities of wild juvenile salmon from electrofishing surveys in the Saint John watershed, 1998.

River	Site Name	Site No.	Marking Month	Marking Day	Recap Time (days)	Area (m²)	Marking Run Fry Count	Marking Run Parr Marked	Marking Run Mort	Recapture Run Fry Count	Recapture Run Parr Unmark	Recapture Run Parr Marked	Mark Run Efficiency	Density / 100 m² 0+	Density / 100 m² 1+	Density / 100 m² 2+
	Tributaries upriver of Beechwood Dam															
Salmon River																
	Sutherland Brook	1	8	10	3	715	32	12	0	29	6	4	0.43	10.5	3.0	0.9
	Sutherland Brook	1.2	8	10	3	661	32	28	5	30	16	9	0.45	10.9	10.0	1.2
	Sutherland Brook	1.3	8	10	3	206	6	11	0	2	0	7	1.00	2.9	5.3	0.0
	Above Simpson Brook	2	8	10	3	567	8	1	1	7	1	0	0.63 [1]	2.3	0.3	0.2
	Above Poitras Brook	3	8	10	3	944	1	1	0	0	0	0	0.63 [1]	0.2	0.2	0.0
													0.63	**8.1**	**6.1**	**0.7**
	Tributaries upriver of Beechwood and Tobique Narrows dams															
Tobique River																
	Fyke Net	1	7	20	2	1427	35	11	0	48	9	3	0.29	8.5	2.6	0.1
	Ben's Pole Road	2	7	20	2	2407	114	56	2	122	36	11	0.26	18.5	8.1	1.3
	Saddler Brook Road	3	7	15	1	1197	0	13	2	0	11	7	0.47	0.0	2.3	0.4
	Trouser's Lake Road	4	7	15	1	1390	0	41	1	0	25	11	0.33	0.0	8.6	0.7
	Burma Road	5	7	6	2	1222	0	27	4	0	18	12	0.47	0.0	4.2	1.2
	Campbell Landing	7	8	5	2	1362	254	45	1	227	32	13	0.31	60.8	9.9	1.1
	Shingle Gulch	8	7	21	2	505	25	35	0	39	28	16	0.37	13.3	18.4	0.2
	Hazelton Landing	9	8	5	2	1503	72	71	0	112	63	19	0.24	20.1	16.6	3.2
	Anvil Brook	10	8	4	2	1000	8	45	2	7	36	11	0.26	3.1	16.4	1.9
	South Branch	13	7	6	2	1174	0	36	8	0	27	12	0.39	0.0	8.9	0.7
	Pat's Crossing	14	8	4	2	885	13	2	0	16	1	0	0.37 [1]	4.0	0.6	0.0
	Above Lawson Brook	15	8	4	2	587	5	4	1	7	5	1	0.29	2.9	2.4	0.5
new 98	Three Brooks [2]	16	7	21	2	952	58	36	4	69	26	12	0.36	16.8	11.0	0.6
	Nation House	17	6	29	7	805	0	20	5	1	10	6	0.50	0.0	6.2	0.0
	Bob Barr	18	7	9	1	1804	0	24	4	0	9	10	0.64	0.0	2.3	0.1
	Rattray's Home	19	6	30	7	1433	0	41	12	0	37	14	0.37	0.0	10.0	0.1
	Pearl Road	20	6	30	7	817	0	35	5	0	32	10	0.29	0.0	14.8	2.3
													0.37	**8.2**	**8.3**	**0.9**

Note:

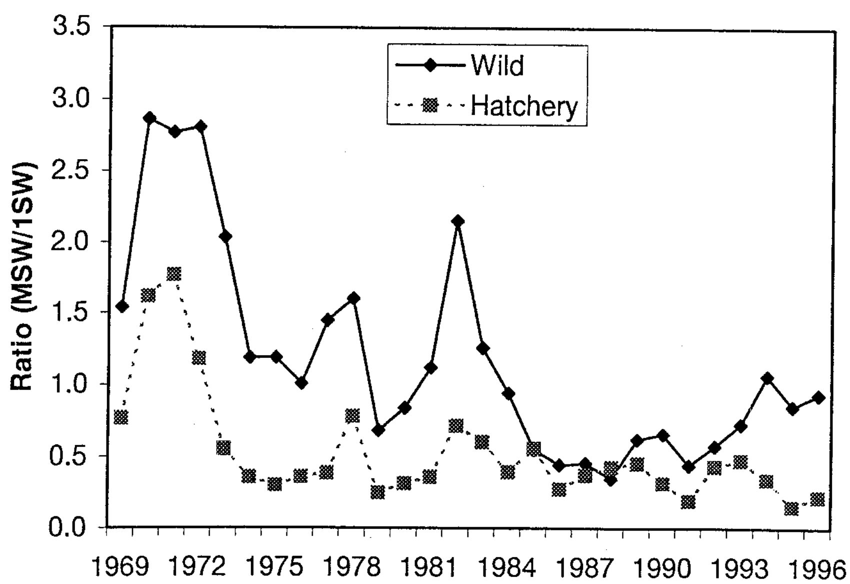
[1] average marking run efficiency used to calculate fry and parr estimates (same crew and river).

[2] site not used in the calculations of Fig. 3.

all age 1+ and 2+ densities were calculated based on mark recapture calculations, and age 0+ were estimated based a capture efficiency from parr.

Table 10. Forecasts of MSW returns in 1999 from 1SW returns in 1998 and average MSW/1SW ratios, for the 1992-1996 smolt years.

Smolt yr	Wild	Hatchery	Wild + Hatchery
1969	1.54	0.77	1.52
1970	2.87	1.62	2.65
1971	2.77	1.77	2.53
1972	2.81	1.18	2.02
1973	2.04	0.55	1.26
1974	1.19	0.36	0.79
1975	1.19	0.30	0.72
1976	1.01	0.36	0.60
1977	1.45	0.39	0.80
1978	1.60	0.78	1.31
1979	0.68	0.25	0.44
1980	0.84	0.31	0.60
1981	1.12	0.36	0.84
1982	2.15	0.71	1.78
1983	1.26	0.60	1.16
1984	0.94	0.39	0.81
1985	0.55	0.56	0.55
1986	0.44	0.27	0.38
1987	0.46	0.38	0.45
1988	0.35	0.43	0.36
1989	0.62	0.46	0.59
1990	0.66	0.32	0.56
1991	0.44	0.19	0.38
1992	0.57	0.44	0.54
1993	0.73	0.48	0.64
1994	1.06	0.34	0.65
1995	0.85	0.16	0.29
1996	0.93	0.22	0.30



	WS	HS	W+HS
Forecast	283	1,517	2,409
95% CLs	222-344	914-2,121	1,566-3,252

Table 11. Estimation of spawning requirements for the Hammond River.

Ortho-photo Estimate of Habitat Area		2,640,000	(Amiro 1993)
Area with stream gradient < 0.12%		978,000	
Area with stream gradient >= 0.12%		1,662,000	

Ortho-photo Estimate of Juvenile Production Area (stream gradient >= 0.12%)
Hammond River including tributaries. **1,662,000**

Conservation Requirements:

Rearing Units	=	16,620	(100 m²)	
Optimal Egg Deposition	=	240	per unit	(Elson 1975)
Total Egg Requirements	=	**4,000,000**		

Biological Characteristics (Trapnet Data 1998 - Wild Fish Only):
Length-Fecundity Relationship
= (LogeEggs=6.06423+0.03605(fork length)) (Marshall and Penny 1983)

1SW	% Female	=	32%
	Mean Length (cm)	=	57.7
	Fecundity	=	3444
MSW	% Female	=	94%
	Mean Length (cm)	=	81.4
	Fecundity	=	8093

Eggs per spawner	1SW	=	fecundity* %female
		=	3,444* 32%
		=	1,096
	MSW	=	fecundity* %female
		=	8,093* 94%
		=	7,571
Required number of MSW salmon		=	egg requirements / eggs per MSW salmon
		=	4,000,000 / 7,571
		=	528
	Females	=	494
	Males	=	34
Deficit Males (1SW)		=	460
Required number of 1SW salmon		=	deficit males / %male
		=	460 / 68%
		=	675
Minimum Requirements:	**MSW**	=	***530***
	1SW	=	***530*** **

** Reduced 1SW requirement to equal MSW requirement.

Estimated Egg Deposition, 1998:

	Female Mean Lgth	Fecundity	Prop Female	Counts Escape	Prop of # Req	Total Eggs	Prop Total	Prop of Egg
1SW								
Wild	57.7	3444	0.318	150		164,279	0.124	
Hatchery	49.0	2517	0.333	39		32,689	0.025	
				189	**0.36**		0.149	
MSW								
Wild	81.4	8093	0.935	126		953,437	0.721	
Hatchery	79.8	7639	0.833	27		171,809	0.130	
				153	**0.29**		0.851	
						1,322,214	1.000	**0.33**

Table 12. Atlantic salmon redd counts on an 11.75 km (25.7% of the mainstem) section of the Hammond River. The section is equivalent to 160,610 m² of stream habitat.*

Year	Date	No. of redds observed Large	Small	Total	No. fish observed	% Salmon	Comments
1976	Nov. 8	-	-	88	30	-	- moderate water levels, good visibility.
1977	Nov. 7-8	-	-	256	160	68.8	- moderate water levels, good visibility.
1978	Nov. 8	264	75	339	176	96.6	- low water, excellent visibility.
1979	Nov. 9	117	16	133	101	92.1	- moderate water levels, good visibility.
1980	Nov. 6	160	31	191	170	94.7	- moderate water conditions, spawning incomplete.
1981	Nov. 9	137	28	165	133	71.4	- water moderately high, poor visibility in some pools.
1982	Nov. 8	149	33	182	107	86.0	- water moderately high, poor visibility in pools.
1983	Nov. 8	162	41	203	104	76.0	- moderate water levels, good visibility except for 3 largest pools.
1984		Survey not done - water too low for canoeing.					
1985	Nov. 8	155	62	217	71	83.1	- water moderately high, good visibility on bars, poor in pools.
1986	Nov. 11	217	75	292	104	50.0	- low water, excellent visibility.
1987	Nov. 10	305	97	402	99	74.7	- water moderately high, good visibility on bars, poor in pools.
1988		Survey not done.					
1989		Survey not done.					
1990		Survey not done.					
1991		Survey not done.					
1992	Nov. 10	262	82	344	46	76.1	- water moderately low, good visibility.
1993	Nov. 10	97	25	122	28	85.7	- water high, visibility fair to good except in deeper runs & pools.
1994	Nov. 9	158	102	260	34	52.9	- water low to moderate, good visibility.
1995	Nov. 6	78	35	113	8	87.5	- water high, visibility fair to good except in deeper runs & pools.
1996	Nov. 7	256	77	333	6	66.6	- water moderate, visibility good to excellent on bars & flats, good in the runs & fair to poor in pools (larger deeper pools - poor to nil visibility).
1997	Nov. 7	157	58	215	18	66.6	- low water, excellent visibility.
1998	Nov. 8	92	19	111	4	50.0	-water high(slightly above previous high water count levels), visibility good on the bars.

Note:

* Main stem considered as being from the confluence of the North Hammond downstream to the bar above Steele's Pool (1st spawning site above normal head-of-tide). In 1976 and 1977, redds were not deferentiated between small and large.

In 1980 about 15-20% of fish still on or in the vicinity of redds.

In 1993, seven female salmon were removed from this stretch on Oct. 28th for broodstock, i.e., theoretically reduction of 14-17 large redds.

Table 13. Historical hatchery distributions to the Hammond River, 1976-1998.

Year	Stock	Age 0^+ fry		Age 0^+ parr		Age 1^+ parr			1-yr smolt			2-yr smolt		
		No mark	Ad clip	No mark	Ad clip	No mark	Ad clip	Tagged	No mark	Ad clip	Tagged	No Mark	Ad Clip	Tagged
1976	Mactaquac	33,018	.	49,076	.	.	29,984	.	.	.	.	.	.	.
1977	Mactaquac	36,936	.	.	.	.	.	.	.	.	.	.	.	.
1978	Mactaquac	.	.	19,995	.	.	.	.	.	.	.	.	.	.
1979	Mactaquac	.	.	19,952	.	.	.	.	.	.	.	.	.	.
1980		.	.	.	.	.	.	.	69	.	.	278	.	.
	Mactaquac	.	.	14,268	.	.	.	.	.	.	.	.	11,011	.
1982	Mactaquac	.	.	.	.	.	.	.	1,496	.	.	498	10,716	.
1983	Mactaquac	.	.	.	.	.	.	.	.	.	.	.	9,979	.
1984	Mactaquac	.	.	9,996	.	.	.	.	4,856	.	.	7,281	525	6,000
1985	Mactaquac	.	.	.	.	.	.	.	60,209	.	.	1,190	.	.
	Hammond	.	.	12,131	.	.	.	.	.	.	.	.	.	.
1986	Mactaquac	6,975	.	.	.	14,969	.	.	.	.	.	4,091	.	.
	Hammond	.	.	9,500	.	.	.	.	7,041	.	4,948	.	.	.
1987	Mactaquac	.	.	.	.	.	.	.	.	.	.	6,222	.	.
	Hammond	.	.	24,751	.	.	.	.	9,627	.	4,196	.	.	.
1988	Mactaquac	15,000	.	4,001	.	.	.	.	.	.	.	.	.	.
	Hammond	11,890	.	8,361	.	.	.	.	8,939	.	3,998	.	.	.
1989	Mactaquac	.	.	.	.	.	.	.	5,858	.	.	.	.	.
	Hammond	.	.	15,558	.	.	.	.	6,519	.	.	.	.	.
1990	Hammond	.	.	10,270	.	.	.	.	17,172	.	3,998	.	.	.
1991	Hammond	15,344	.	16,463	.	.	.	.	7,512	.	3,000	.	.	.
1992	Hammond	.	.	11,455	.	.	.	.	.	8,126	5,461	.	.	.
1993	Hammond	.	.	.	.	.	.	.	19,212	.	.	.	.	.
1994	Hammond	9,712	.	23,569	.	.	.	.	2,499	.	.	.	.	.
1995	Hammond	.	.	15,580	.	.	.	.	18,911	.	.	.	.	.
1996	Hammond	.	.	.	.	.	.	.	17,957	.	.	.	.	.
1997	Hammond	42,300	.	.	.	.	.	.	8,037	.	.	.	.	.
1998	Hammond	.	.	.	2,202	.	.	.	1,000	.	.	.	.	.
Total		**171,175**	**-**	**264,926**	**2,202**	**14,969**	**29,984**	**-**	**196,914**	**8,126**	**25,601**	**19,560**	**32,231**	**6,000**

0^+ fry: 0 to 14 weeks old.
0^+ parr:14 weeks but less than 1 year old.
1^+ parr: 1 year but less than 2 years old.

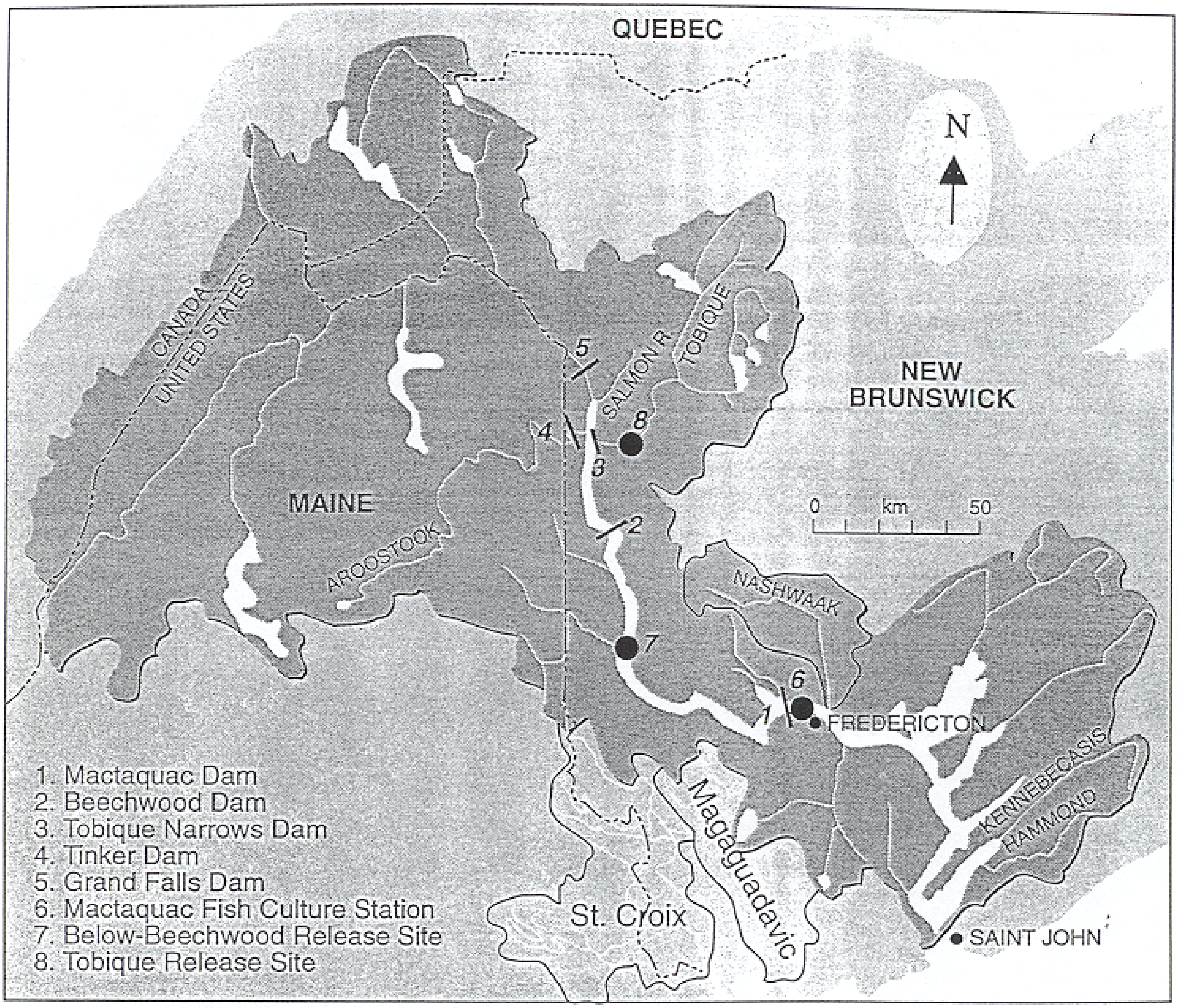


Fig. 1. Magaguadavic, St. Croix and Saint John River drainages including Nashwaak, Kennebecasis and Hammond rivers and major tributaries, dams and principal release sites for Atlantic salmon above Mactaquac. Fish trapping locations on the Hammond and Nashwaak drainages are shown on Figs. 4 and 8.

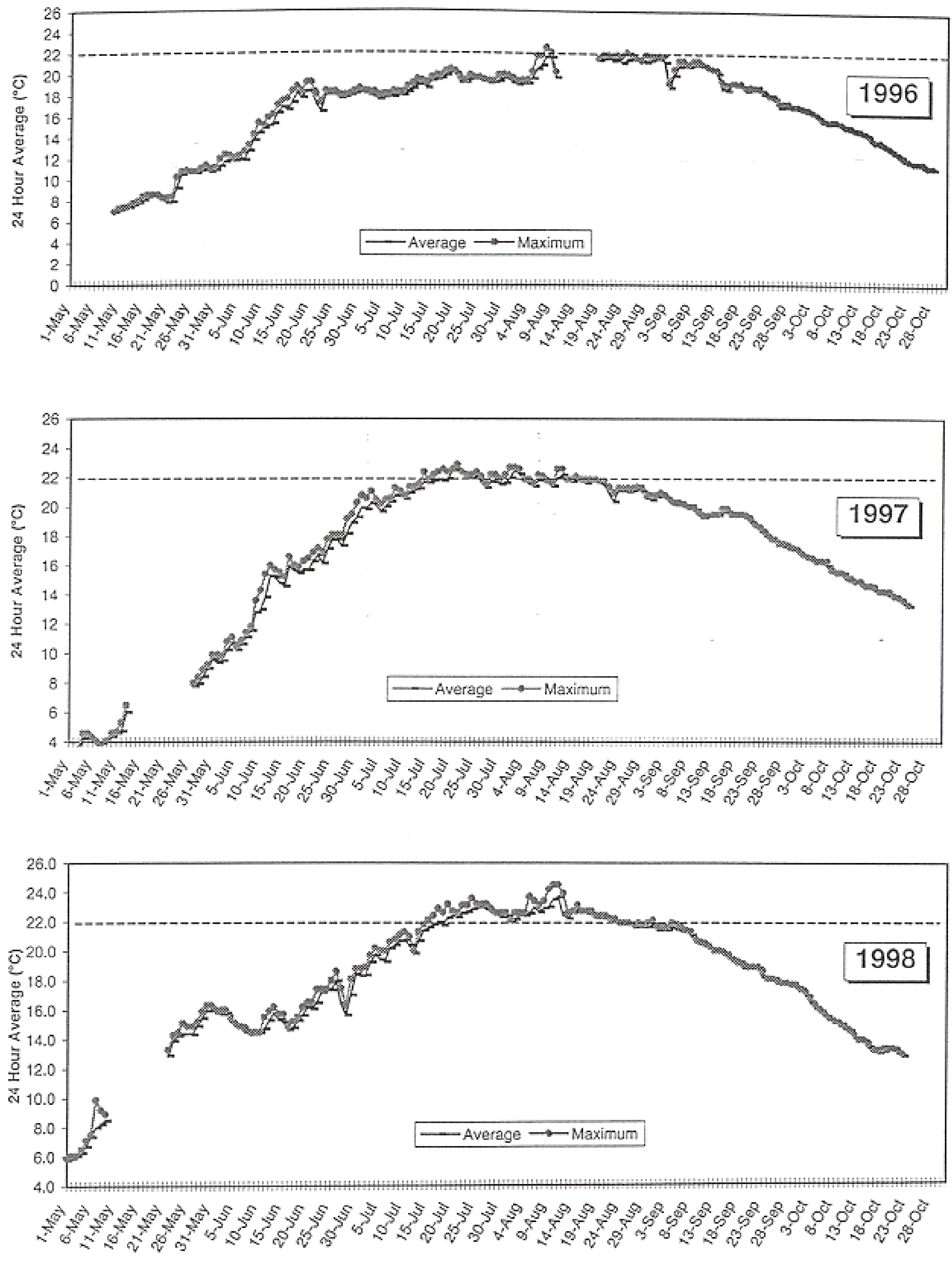


Fig. 2. Daily mean and daily maximum water temperatures in tailrace, Mactaquac Dam, 1996-1998.

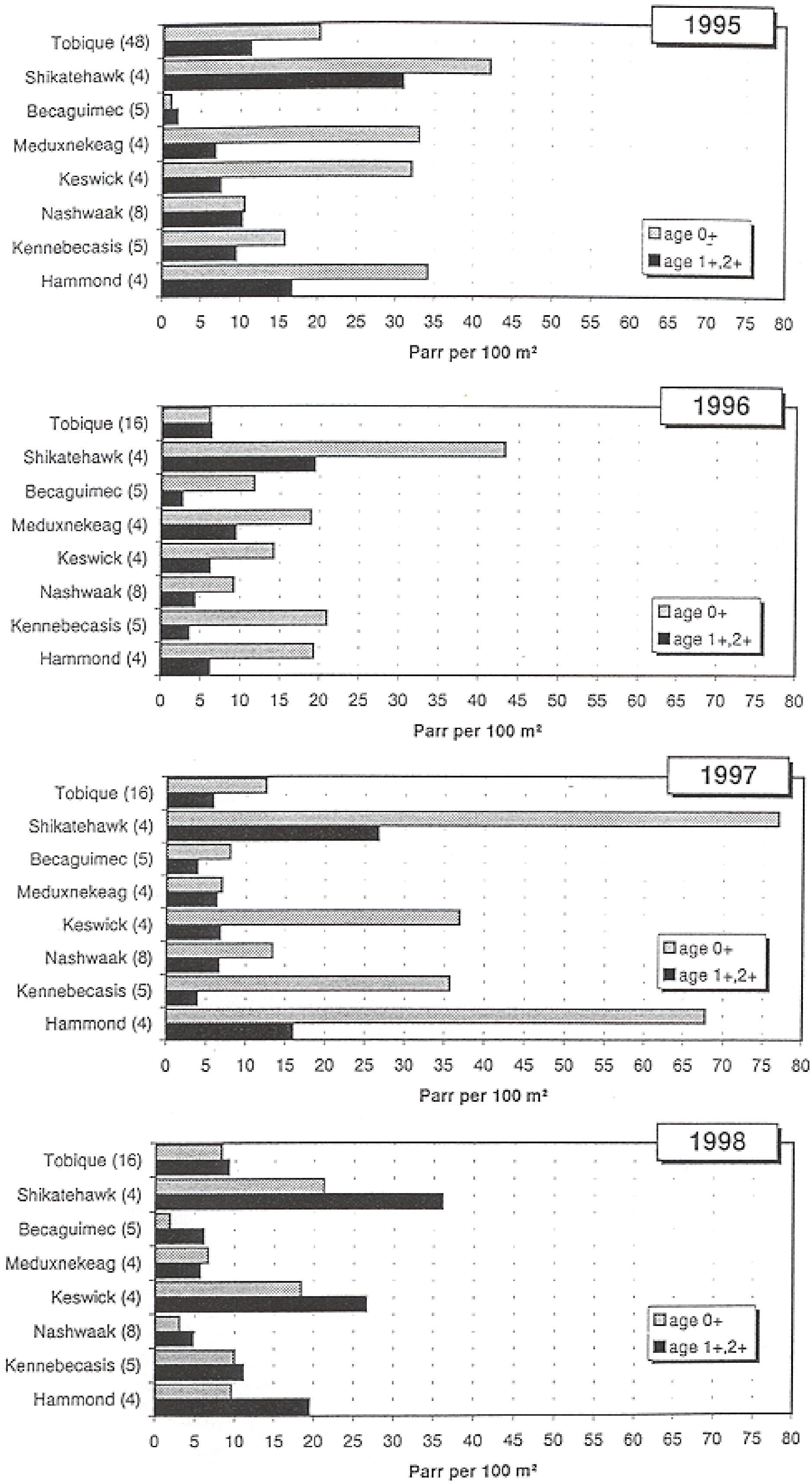


Fig. 3. Average parr densities for tributaries (no. of sites) of the Saint John River, 1995-98. Tobique 1995 - was not possible to use index sites only.

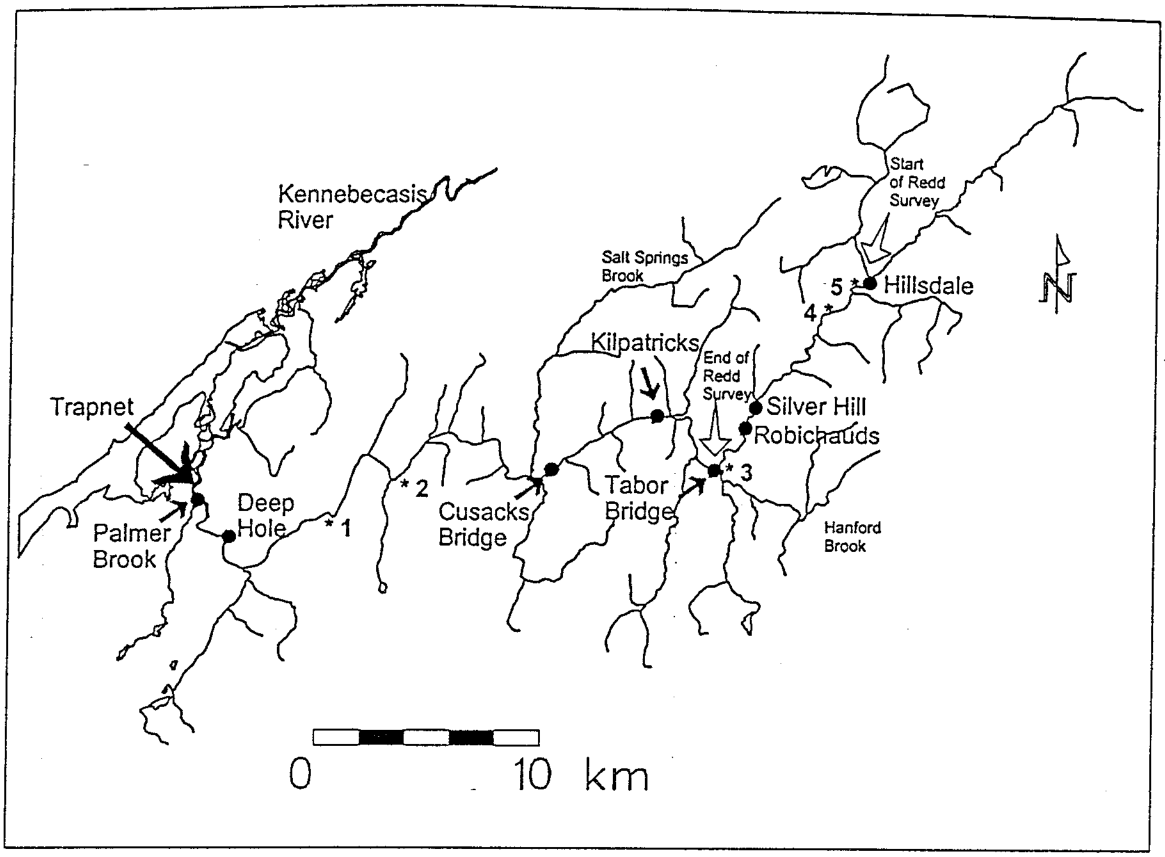


Fig. 4. Hammond River, site of trapnet, seined pools (●), electroseining sites (*) and location of redd survey.

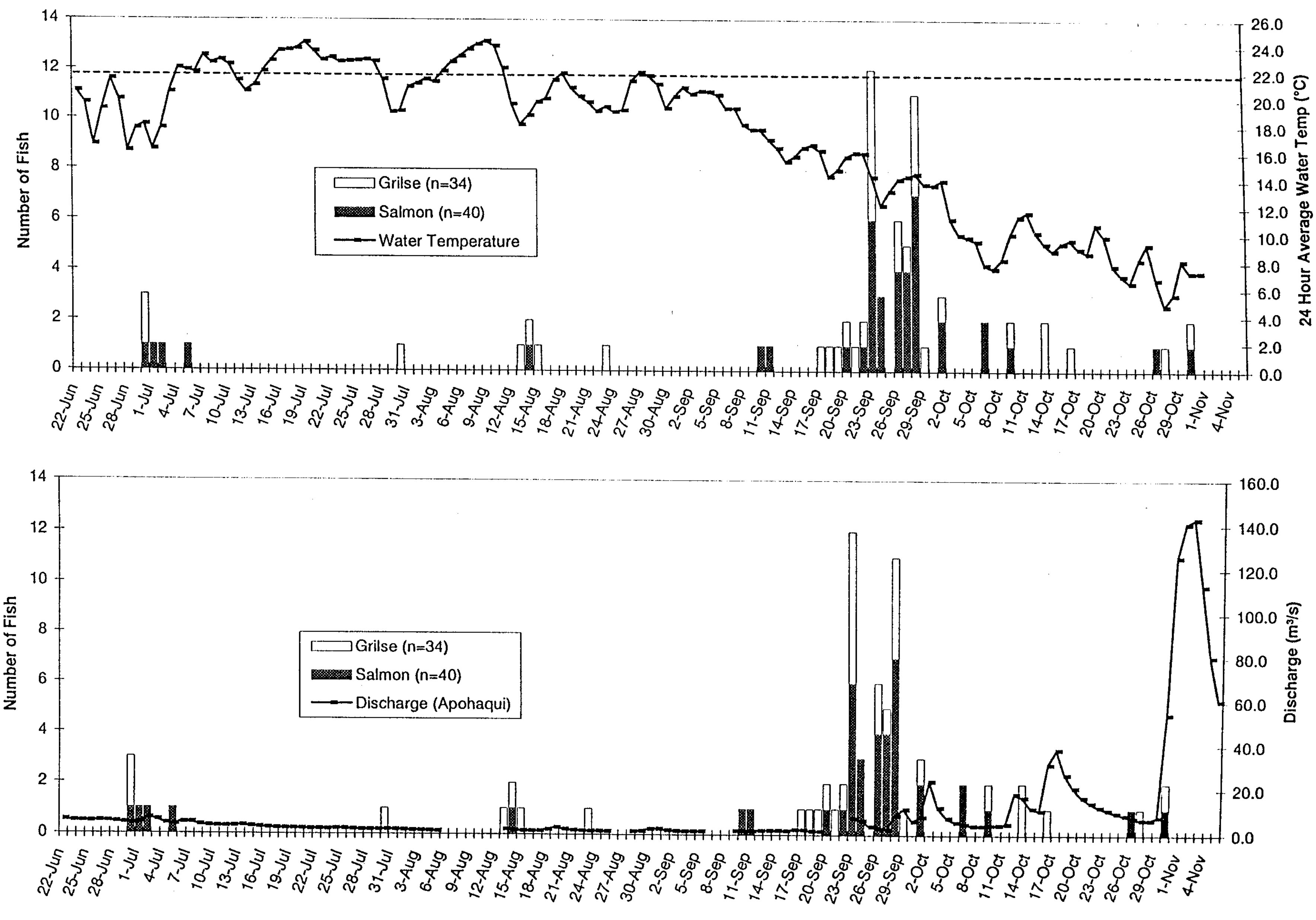


Fig. 5. Average daily water temperature (top) and discharge from lower Kennebecasis (bottom) and daily trapnet counts of 1SW and MSW salmon, Hammond River, 1998. Washout Oct. 12-14.

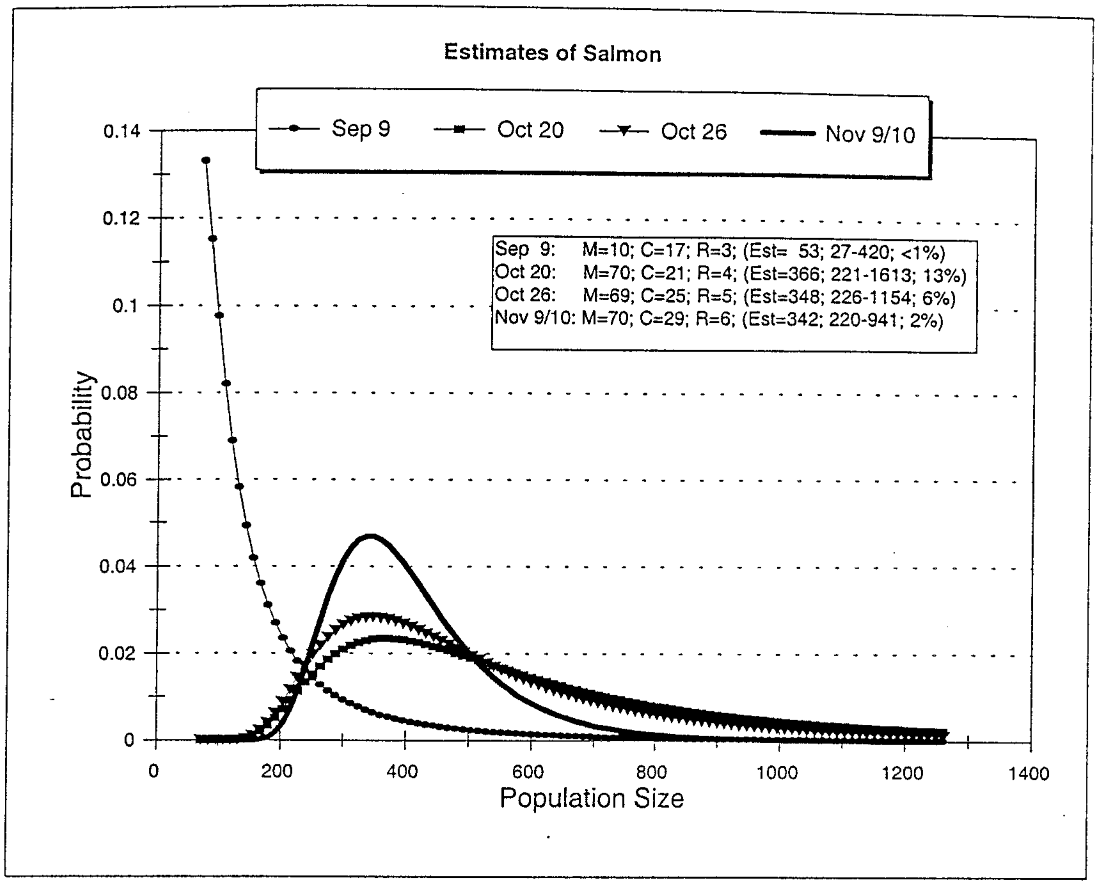


Fig 6. Estimates of total salmon returns to the Hammond River, 1998.

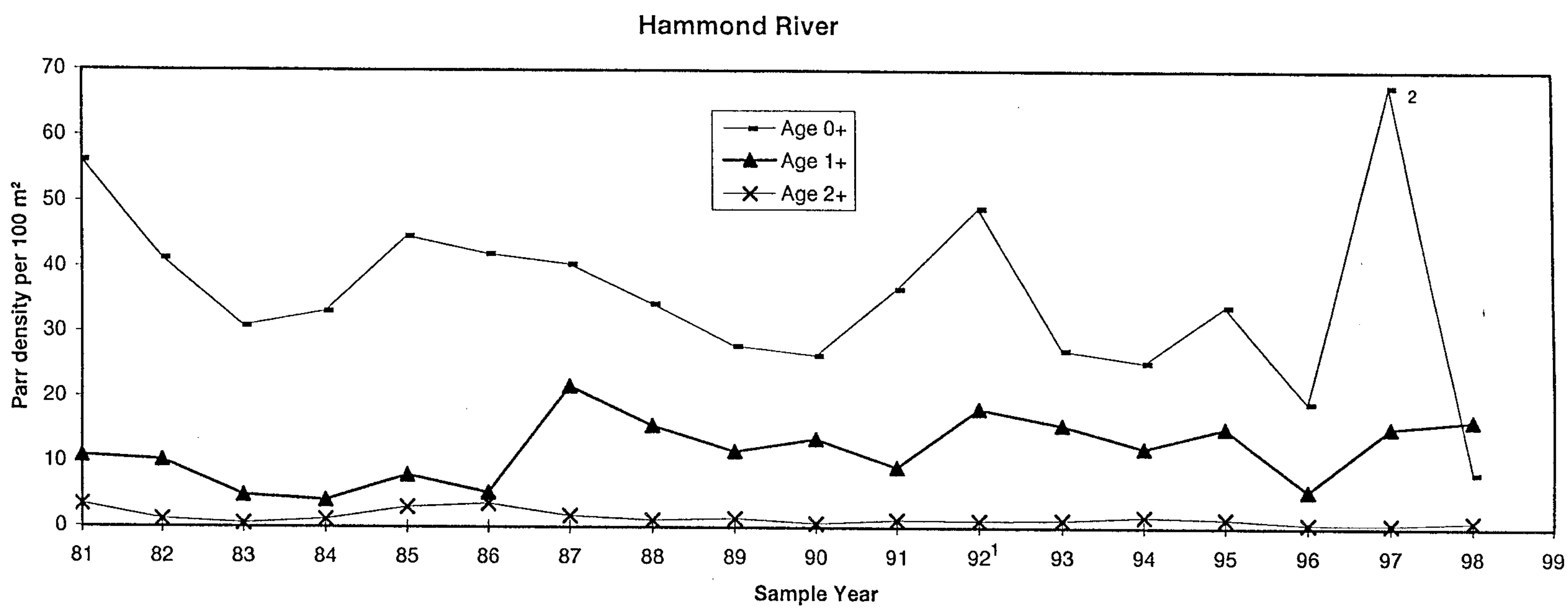


Fig. 7. Juvenile Atlantic salmon densities on Hammond River by sample year (n=4, excludes the French Village site).

[1]only two (Hanford Brook and Hillsdale) of the four index sites were electrofished in 1992.
[2]The 1997 0+ parr estimate may have been influenced by the release of 28,000 hatchery parr in July.

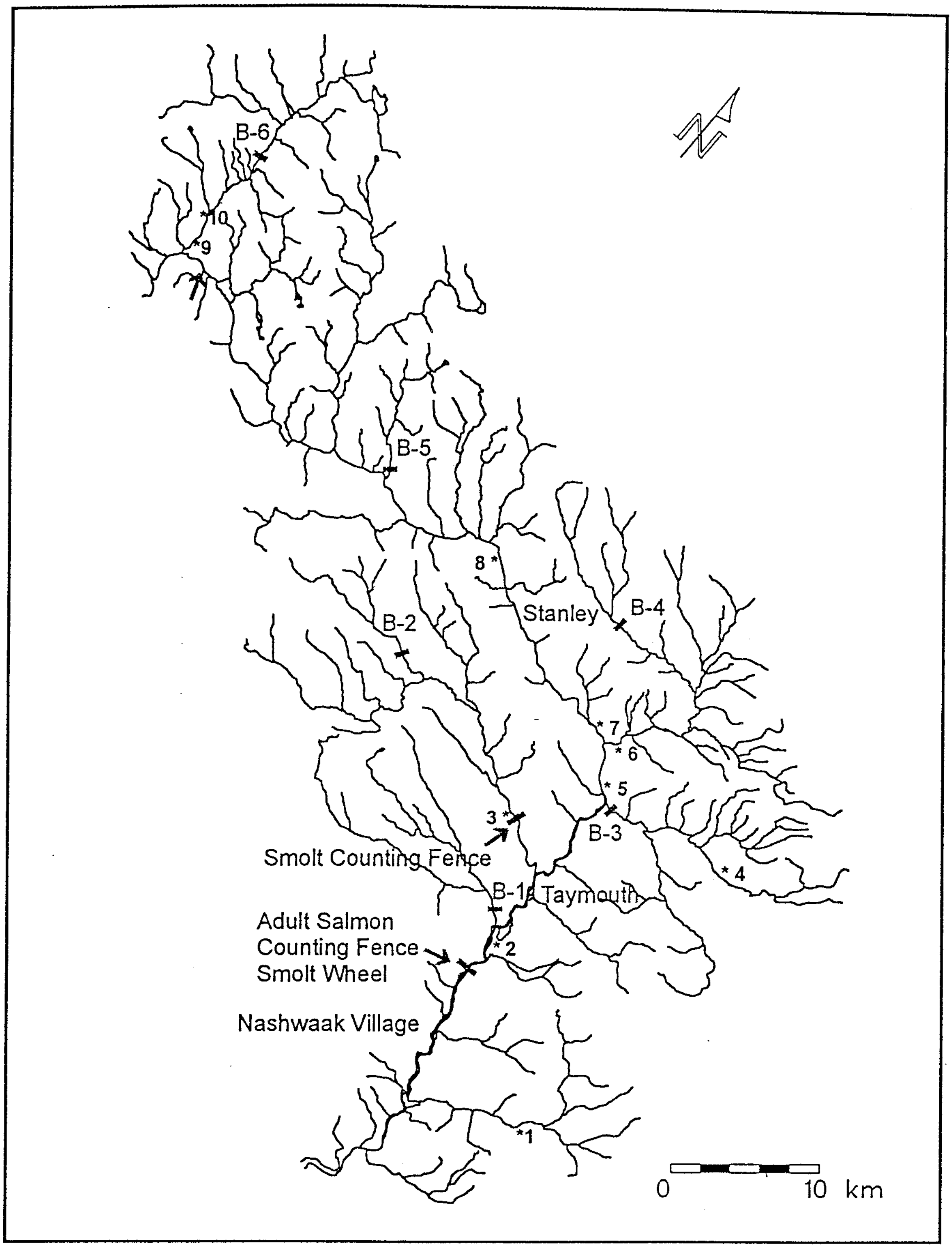
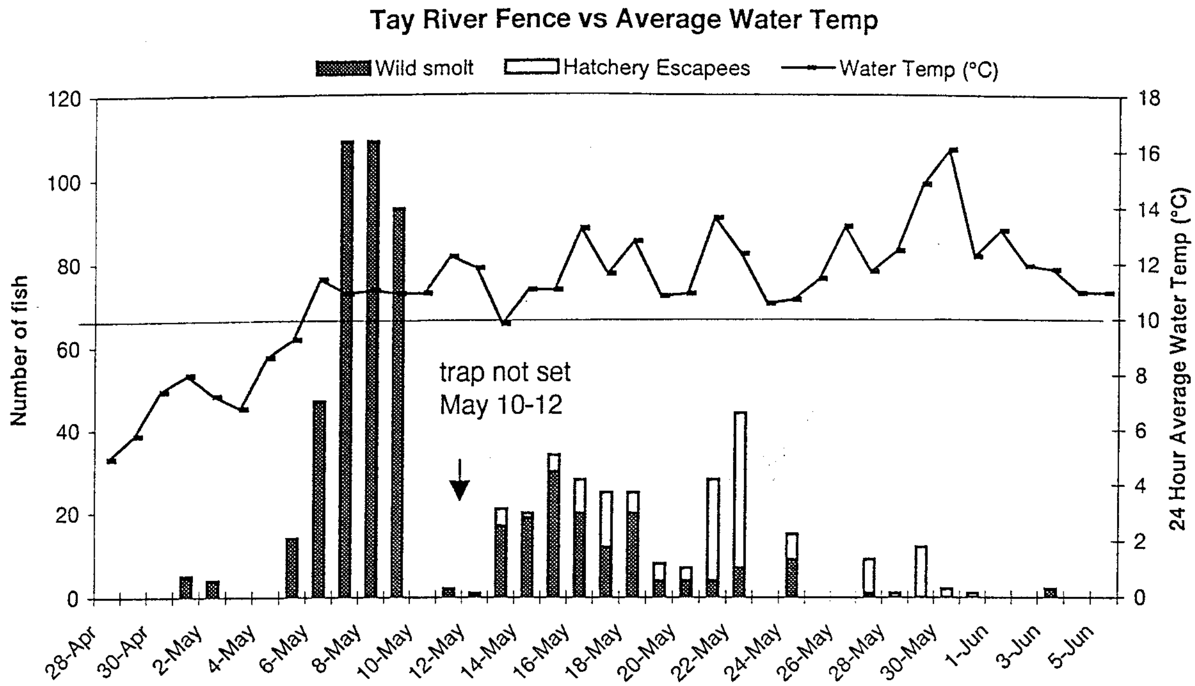


Fig. 8. Nashwaak River, site of adult counting fence, smolt wheel, smolt counting fence, electrofishing sites (*) and barriers [B-] to migration of salmon.



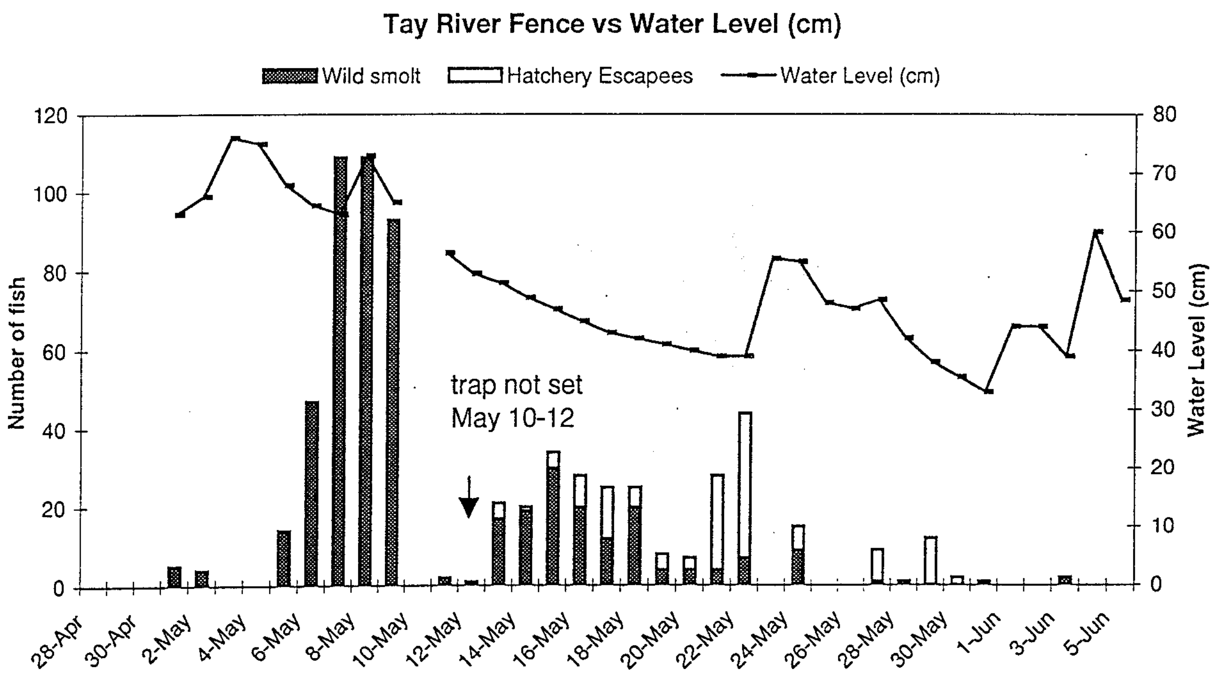
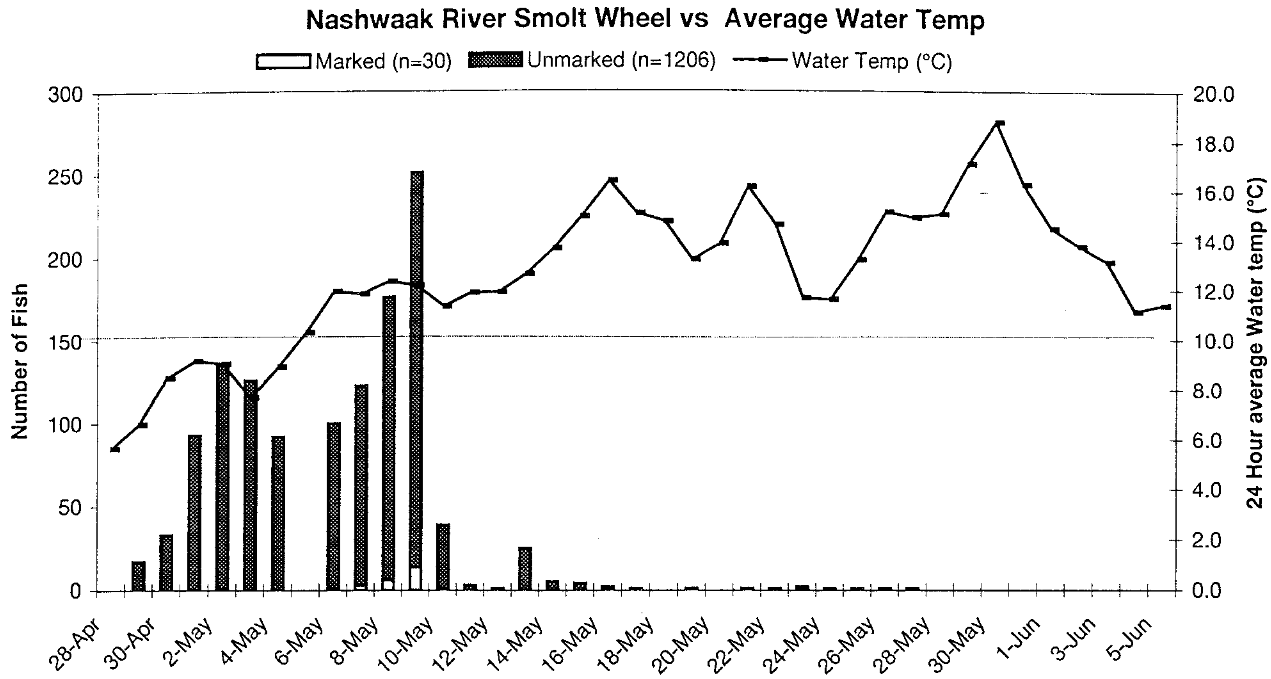


Fig 9. Average daily water temperature (top) and water level (bottom) as well as counts of Atlantic salmon smolts, Tay River, a tributary of the Nashwaak River, 1998.



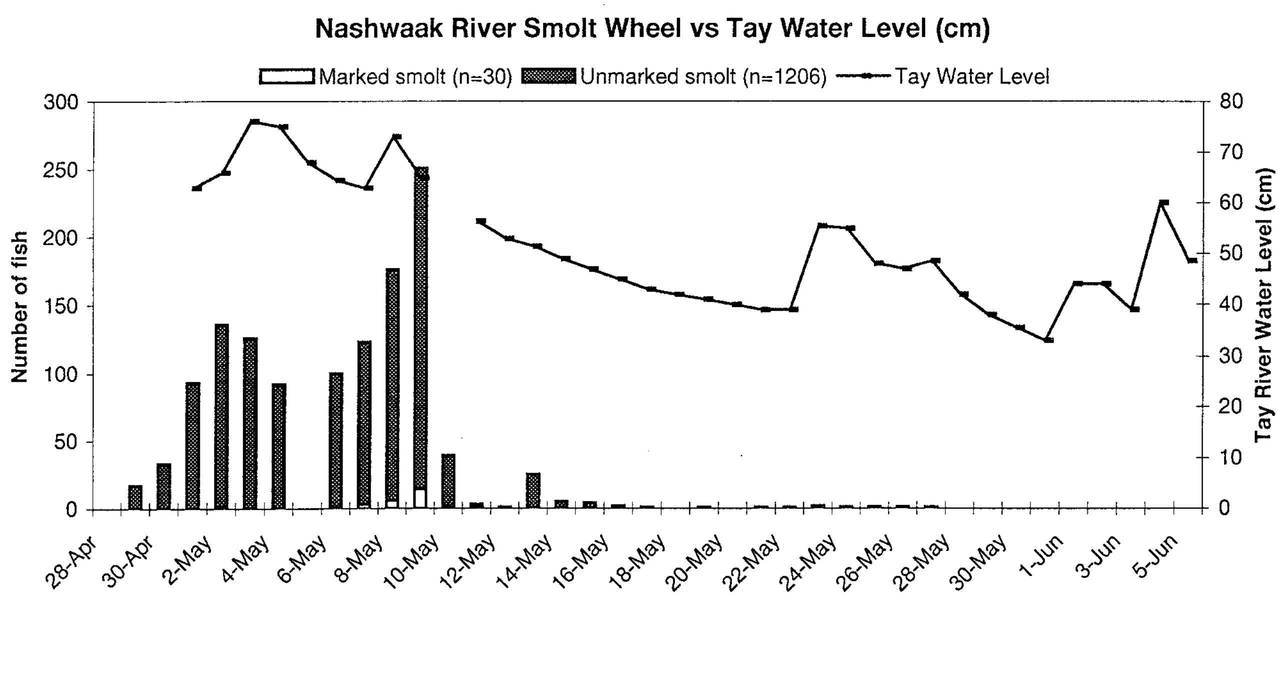


Fig 10. Average daily water temperature (top) and Tay River water level (bottom) as well as counts of Atlantic salmon smolts, Nashwaak River, 1998. Wheel was not fishing on May 5th.

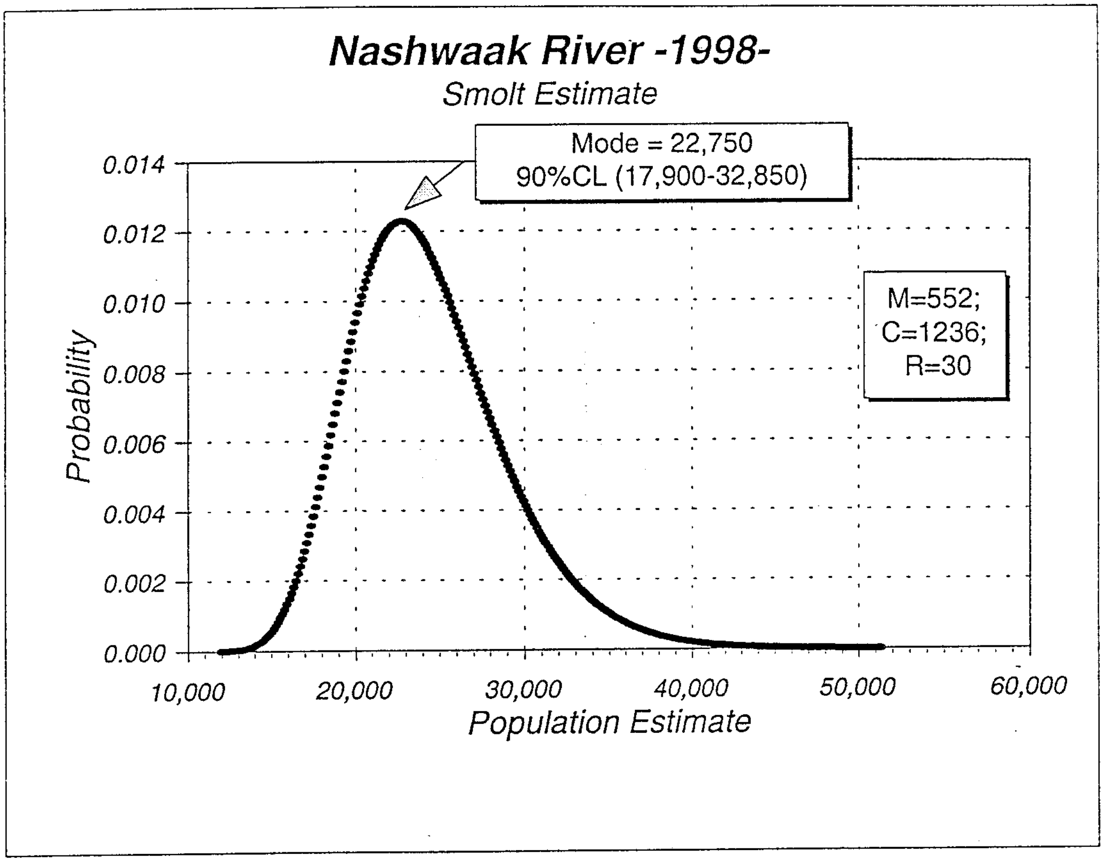


Fig 11. Estimated smolt run on the Nashwaak River above Durham Bridge based on mark and recapture techniques, 1998.

App. 1. Historical hatchery distributions above Mactaquac Dam, Saint John River, 1976-98.

	0+ fry		0+ parr		1+ parr			1 yr smolt			2 yr smolt		
Year	No mark	Ad clip	No mark	Ad clip	No mark	Ad clip	Tagged	No mark	Ad clip	Tagged	No mark	Ad clip	Tagged
1976						52,662	5,000						
1977			6,042	44,021									
1978			9,163										
1979													
1980													5,995
1981													5,998
1982			75,210										
1983													
1984			123,757	8,517									
1985			164,947	110,569	24,544								
1986	17,300		126,692	91,808									
1987	266,257		101,052	50,283									
1988	79,948		107,478	60,472									
1989	150,384		151,562	0				4,680	30,011		20,000		
1990	164,005		232,291	0				2,877	24,026			17,140	
1991	227,535		499,130	0					30,181			19,646	
1992	600,408		514,662	0									
1993	672,797		272,824	99,939				819					
1994	983,549	30,000	285,988	253,730									
1995	642,830		193,208	226,391									
1996	940,962		511,771	0									
1997	504,488		391,860	20,991									
1998	213,973			282,491 *									
Total	**5,464,436**	**30,000**	**3,767,637**	**1,249,212**	**24,544**	**52,662**	**5,000**	**8,376**	**84,218**		**20,000**	**36,786**	**11,993**

* includes 4,500 from satellite sites.