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Status of Atlantic salmon stocks of southwest New Brunswick, 1997

by

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ABSTRACT

Total one-sea-winter (1SW) returns (3,255) and multi-sea-winter (MSW) returns (1,971) destined for above Mactaquac in 1997 were the lowest in 28 years of record. Hatchery-origin fish comprised 89% of 1SW and 43% of MSW fish, the highest percentages of record. Return rates for hatchery-released smolts were 0.56 (1SW) and 0.19 (MSW), i.e., less than those of 1996 but similar to other low rates in the 1990s. Spawners numbered 2,742 1SW fish and only 1,340 MSW salmon, 56% and 27% of the respective requirements. Egg deposition (53% from wild fish) was 30% of requirement; the requirement has not been met since 1985.

Below Mactaquac, counts at the Nashwaak River fence contributed to an estimated return of 370 1SW and 366 MSW salmon. Nearly all fish escaped to spawn thereby contributing to 18% of respective 1SW and MSW conservation requirements. An egg deposition of 23% of requirement was the lowest since operation of the fence recommenced in 1993. Counts at a fence in the headwaters of the Kennebecasis River suggested an escapement above that point of 76 1SW and 45 MSW salmon and a resultant egg deposition of about 35% of conservation requirement. Redd counts on an 11.75 km stretch of the upper mainstem Hammond River were about "average" for the 15 year dataset. Egg deposition within those redds was estimated to be 163% of the requirement for the stretch.

Of 178 salmon captured in the Magaguadavic River trap, 119 (inc. some post smolts) were deemed of aquaculture origins and denied access to the river. Wild and hatchery (escaped from private hatcheries on the river) fish numbered 35 1SW and 24 MSW salmon. After accidental mortalities, escapement resulted in an egg deposition of about 12% of requirement, the lowest of a 10-year record. Salmon ascending the St. Croix River at Milltown numbered 70 fish of which 27 were of aquaculture origins. Egg deposition was about 2% of requirement and divided between the river and Mactaquac hatchery.

1SW returns destined for Mactaquac in 1998 chould number 5,800 (2,400-9,700) fish and thereby exceed the 4,900 1SW conservation requirement. The majority of the returns will be of hatchery origin - either smolts released directly from Mactaquac or age-0^+ fish released upriver of Mactaquac in 1994 and 1995. MSW returns destined for Mactaquac in 1998 could number 1,500 fish (700-2,100), or 14%-43% of the 4,900 MSW conservation requirement above Mactaquac. In total, it is highly unlikely that returns will provide one-half of conservation egg requirements.

Below Mactaquac, forecasted returns to the Nashwaak River fence may be as few as 320 (110-1,200) 1SW and 100 (50-130) MSW fish, i.e., equivalent to less than 10% of egg conservation requirements. Returns to other assessed Saint John River tributaries below Mactaquac and rivers flowing into Passamaquoddy Bay in 1998 are not expected to exceed either the numbers or proportionate achievement of conservation requirements experienced in 1997.

Résumé

Les remontées totales d'unibermarins (UBM), de 3 255 poissons, et de pluribermarins (PBM), de 1 971 poissons, vers l'amont de Mactaquac en 1997 ont été les plus faibles notées au cours de la période de 28 ans pour lesquelles des registres sont tenus. Les poissons de pisciculture représentaient 89 % des UBM et 43 % des PBM, les pourcentages les plus élevés jamais notés. Les taux de retour des saumoneaux de pisciculture ont été de 0,56 (UBM) et de 0,19 (PBM), valeurs inférieures à celles de 1996 mais semblables aux autres faibles taux notés au cours des années 1990. Le nombre de géniteurs UBM s'élevait à 2 742 saumons et celui des PBM à 1 340, ce qui correspond à, respectivement, 56 % et 27 % des besoins. La ponte (53 % de poissons sauvages) représentait 30 % des besoins, qui n'ont pas été atteints depuis 1985.

En aval de Mactaquac, les dénombrements effectués à la barrière de la rivière Nashwaak ont indiqué une remontée estimée de 370 saumons UBM et de 366 saumons PBM. Presque tous les poissons l'ont traversée pour frayer et ainsi contribué à 18 % des besoins de conservation en UBM et PBM. La ponte, de 23 % des besoins, a été la plus faible depuis la remise en exploitation de la barrière en 1993. Les dénombrements effectués à une barrière située dans les eaux d'amont de la rivière Kennebecasis portent à croire à une échappée en amont de ce point de 76 UBM et de 45 PBM, et à une ponte correspondant à 35 % environ des besoins de conservation. Le dénombrement des nids dans un tronçon de 11,75 km du cours supérieur principal de la rivière Hammond a été « moyen » par rapport à l'ensemble des données portant sur une période de 15 ans. La ponte effectuée dans ces nids a été estimée à 163 % des besoins de ce tronçon.

Des 178 saumons capturés dans le piège de la rivière Magaguadavic, 119 (y compris quelques post saumoneaux) ont été jugés être des poissons d'origine piscicole et ont été bloqués. On a décompté 35 UBM et 24 PBM d'origine sauvage ou d'élevage (échappés de piscicultures privées situées sur la rivière). Après décompte de la mortalité accidentelle, l'échappée a donné lieu à une ponte correspondant à 12 % environ des besoins, soit la valeur la plus faible des dix dernières années. Il a été dénombré 70 saumons remontant la rivière St. Croix, à Miltown, dont 27 étaient d'origine piscicole. La ponte correspondait à 2 % des besoins et a été répartie entre la rivière et la pisciculture de Mactaquac.

Les remontées de saumons UBM vers Mactaquac en 1998 ont pu atteindre 5 800 (2 400-9 700) poissons et donc être supérieures aux 4 900 UBM correspondant aux besoins de conservation. La plus grande partie des remontées devrait être constituée de poissons d'élevage, soit des saumoneaux libérés directement à partir de Mactaquac ou des poissons d'âge 0^+ libérés en amont de Mactaquac en 1994 ou 1995. Les remontées de PBM se dirigeant vers Mactaquac en 1998 pourraient s'élever à 1 500 poissons (700-2 100), soit de 14 à 43 % des besoins de conservation de 4 900 PBM en amont de Mactaquac. Au total, il est très peu probable que les remontées permettent d'obtenir la moitié de la ponte correspondant aux besoins de conservation.

En aval de Mactaquac, les remontées prévues à la barrière de la rivière Nashwaak ne pourraient s'élever qu'à 320 (110-1 200) UBM et 100 (50-130) PBM, soit l'équivalent de moins de 10 % de la ponte nécessaire aux besoins de conservation. Les remontées vers d'autres tributaires évalués de la Saint John, en aval de Mactaquac, et les rivières de la baie Passamaquoddy en 1998 ne devraient pas être supérieures, en nombres ou en proportions, aux besoins de conservation atteints en 1997.

SUMMARY SHEET

Stock: Saint John River, N.B. (*above Mactaquac*) SFA 23

Conservation requirement: 32.3 million eggs (4,900 MSW and 4,900 1SW fish)

Year	1992	1993	1994	1995	1996	1997	MIN[1]	MAX[1]	Mean[1]
Harvest:									
First Peoples									
Small	560	241	250	50	675	361	50	675	355
Large	748	462	90	25	285	265	25	748	322
Recreational[2]									
Small	2104	852	0	-	0	0	852	2104	1478
Counts (adjusted):									
1SW	7664	3907	3313	4978	6156	3106	3313	7664	5203
MSW	4203	2908	2206	2271	3138	1739	2206	4203	2945
Returns:									
1SW	8940	4369	3534	5079	6723	3255	3534	8940	5729
MSW	4849	3389	2375	2355	3231	1971	2355	4849	3240
Spawners:									
1SW	5128	2819	2901	4839	5476	2742	2819	5476	4233
MSW	3269	2149	1647	1887	2518	1340	1647	3269	2294
% of Target met:									
1SW	105	58	59	99	112	56	58	112	87
MSW	67	44	34	39	51	27	34	67	47
Eggs	74	46	35	41	57	30	35	74	51

[1] For the period 1992-1996

[2] Total closure in 1995; various seasons for hook-and-release only, 1994,1996 and 1997; summary stats, 1992-1993 only.

Harvests: SFA 23 was closed to recreational retention and commercial salmon fisheries in 1997. Allocations to First Nations totalled 3,700 1SW fish; estimates of harvest totalled 361 1SW and 265 MSW salmon.

Data and methodology: Counts of fish are obtained from the collection facility at Mactaquac Dam; returns destined for the Dam are the counts plus estimates of downriver removals. Spawners equal the releases above Mactaquac minus estimates of upriver removals, not including poaching and disease. Wild 1SW returns are forecast as the median returns, 1993-1997; forecasts of wild MSW returns are the product of 1SW returns in 1997 and modal ratio MSW:1SW returns, 1976-1997. 1SW and MSW fish of hatchery origin were forecasted separately for each of smolt and age-0^+ releases.

State of the stock: Wild 1SW and MSW returns were the fewest in 28 years of record. Hatchery origin 1SW returns (89% of the total) were the third highest since 1981; hatchery MSW returns (43% of the total) were the seventh highest since 1981. Egg deposition (47% from hatchery-origin fish) was 30% of requirement; the requirement has not been met since 1985. The 1SW return rate for hatchery smolts (0.56%) was half of that in 1996 but similar to values derived, 1988-1995; the MSW return rate (0.19%) also decreased from the 0.27% value of 1996 but was not dissimilar to other values since 1990.

Forecasts: Total 1SW returns destined for Mactaquac in 1998 are forecast to be 5,800 (2,400-9,700) fish or 49-198% of the 4,900 1SW conservation requirement. Wild 1SW returns are forecast to be 2,200 (300-3,200); hatchery releases could contribute to 3,600 (2,100-6,500) 1SW returns. Total MSW returns destined for Mactaquac in 1998 are forecast to be 1,500 (700-2,100) fish or 14-43% of the 4,900 fish requirement. Wild MSW returns destined for Mactaquac are forecast to be 400 (100-700) fish; hatchery-origin fish are forecast to be 1,100 (600-1,300) fish.

Management Considerations: Even in the absence of fishing mortality, returns in 1998 are highly unlikely to provide one-half of egg conservation requirements. Fishing mortality on 1SW "surpluses" (make only a minor contribution to conservation requirements) should be minimized prior to in-season assessments in mid-, late-July.

SUMMARY SHEET

Stock: Nashwaak River, N.B. (*above counting fence*) SFA 23
Conservation requirement: 12.8 million eggs (2,040 MSW and 2,040 1SW fish)

Year	1992	1993	1994	1995	1996	1997	MIN[1]	MAX[1]	Mean[1]
Harvest:									
First Peoples									
Small	-	2	40	-	-	-	2[2]	40[2]	21[2]
Large	-	5	30	-	-	-	5[2]	30[2]	18[2]
Recreational									
Small[3]	426	137	30[4]	-[6]	-[4]	-[4]	137[5]	426[5]	282[5]
Partial Counts:									
1SW	-	83	403	569	940	370	83	940	499
MSW	-	155	274	308	429	366	155	429	292
Returns:									
1SW	-	954	661	940	1829	370	661	1829	1096
MSW	-	555	388	436	657	366	388	657	509
Spawners:									
1SW	-	866	610	940	1804	363	610	1804	1055
MSW	-	555	349	436	641	362	349	641	495
% of Target met:									
1SW	-	42	30	46	88	18	30	88	52
MSW	-	27	17	21	31	18	17	31	24
Eggs	-	31	26	33	48	23	26	48	35

[1]For the period 1993-1996.
[2]For the period 1993-1994.
[3]Catch corresponds to above and below fence.
[4]Mandatory release.
[5]For the period 1992-1993; 1994 and 1996 were mandatory release over seasons of varying length.
[6]Closed to angling.

__Harvests__: No harvests were reported or allocated. The recreational fishery was restricted to hook-and-release fishing only, July 15-August 12. Removal of Nashwaak-origin fish, as by-catch and Food fish in the lower Saint John, would have been minimal.

__Data and methodology__: Partial counts are obtained from a counting fence located 23 km from the confluence with the Saint John River. Since 1993, total returns have been estimated using either mark-and-recapture technique or proportional method. The latter used the run timing of previous years when entire runs were estimated or monitored (1972, 1973, 1975). Forecasts of 1SW returns in 1998 were based on age-1^+ and -2^+ parr-to-1SW survival values in recent years; MSW forecasts are the product of 1SW returns in 1997 and the mean ratio 2SW:1SW returns, 1992-1995.

__State of the stock__: Counts at the fence and a mark-recapture estimate indicate a return of 370 1SW and 366 MSW in 1997 (only marked fish were recovered in late-season seining). Escapement of 363 1SW and 362 MSW fish represented 18% of respective conservation requirements. Egg deposition was 2.89 million eggs or 23% of the requirement; 18% of the total came from 1SW fish. The river has not attained more than one-half of requirements in the past five years. Hatchery-origin fish comprised 9% of returns. Densities of 13 age 0^+ and 7 age-$^{1+}$ and -2^+ parr $100m^{-2}$ at eight electrofishing sites are consistent with recent low escapements.

__Forecasts__: Returns of 1SW fish to the Nashwaak River fence in 1998 may be 320 (110-1,200) fish or 5-60% of the conservation requirement of 2,040 1SW fish. The contribution by hatchery-origin fish will be minor. 2SW returns may be as few as 100 (50-130) fish, i.e., less than 10% of requirements.

__Management Considerations__: Even in the absence of fishing mortality, returns are highly unlikely to provide one-quarter of egg conservation requirements in 1998. Fishing mortality on 1SW fish, which on the Nashwaak make a significant contribution to conservation egg requirements, should be avoided.

INTRODUCTION

This document assesses the status of Atlantic salmon stocks in 1997 for the **Saint John River above Mactaquac**, the **Nashwaak**, **Kennebecasis** and **Hammond** rivers (tributaries to the Saint John below Mactaquac), and the **Magaguadavic** and the **St. Croix** rivers of southwest New Brunswick. Prognoses of returns in 1998 are provided in various levels of detail. All are "outer-Fundy" rivers of Salmon Fishing Area 23 (SFA 23), New Brunswick, because their salmon stocks have a significant two-sea-winter (2SW) component which frequents waters off Newfoundland and Greenland. The status of stocks of "inner-Fundy" rivers of SFA 23 (east of the Saint John River) which do not have a significant maiden 2SW component and do not migrate to distant North Atlantic waters are assessed with those of SFA 22 in a separate document.

As in recent years, data and analyses of Saint John River stocks pertain largely to stocks originating above Mactaquac. Data and analyses of the status of salmon in the Nashwaak River, below Mactaquac, were again possible because of co-operative agreements with the Kingsclear and Oromocto First Nations. Data for the evaluation of the status of stocks in the Kennebecasis was provided by the NB Cooperative Fish and Wildlife Research Unit; data for the Hammond River was provided by NB Dept Natural Resources; data for the Magaguadavic River were provided by the Atlantic Salmon Federation and data for the St. Croix River were provided by the St. Croix Recreational Fisheries Development Program. Counts at Mactaquac were again adjusted on the basis of age determination of fish to account for hatchery returns undetected by external characteristics.

Numbers of MSW salmon in SFA 23 were expected to improve in 1997, but to remain less than conservation requirements and protected from any retention fisheries. 1SW returns in 1997 were forecasted to exceed conservation requirements and were slated to open to Aboriginal peoples, June 14-July 15 for harvest by angling (only). On July 15, fisheries were to open to holders of a NB Salmon Fishing Licence (hook-and-release only) and to Aboriginal peoples prosecuting food fisheries for 1SW salmon under the full terms of various "Agreements". Recreational and Aboriginal food fisheries opened as planned but were closed on August 12 after in-season assessments at Mactaquac at the end of July indicated that both 1SW and MSW returns would be significantly less than preseason forecasts and conservation requirements.

SAINT JOHN RIVER ABOVE MACTAQUAC

Physical attributes of the Saint John River drainage (Fig. 1), salmon production area barriers to migration, fish collection and distribution systems, the role of fish culture operations and biology of the stocks have been previously described (Marshall and Penney MS 1983). The state of the salmon stocks since 1970 were estimated beginning in 1983 (Penney and Marshall MS 1984) and continued through 1997 (Marshall et al. MS 1997). Preseason forecasts of 1SW fish for 1997 had suggested that home river returns destined for Mactaquac 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. Conservation requirements were not expected to be met or approached on any of the other systems assessed in SFA 23. The approach in this assessment of stocks in southwest New Brunswick is similar to that of 1996 (Marshall et al. MS 1997).

Description of fisheries

The entire Saint John River has been closed to commercial fishing for Atlantic salmon since 1984; the recreational fishery for spring (black salmon) was, as in 1996, again closed. Aboriginal Food fisheries for 1SW salmon using angling gear only were prosecuted June 17-July 15. On July 15 methods of capture for Aboriginal peoples were extended to trap nets. On August 12 the entire fishery was closed. Numbers of 1SW fish allocated for a June 17 opening were as follows:

	June 17	August 1[b]	Total
Tobique FN	610	410	1,020
Woodstock FN[a]	340	230	570
Kingsclear FN	350	235	585
St Mary's FN	565	375	940
Oromocto FN	215	140	355
NB Aboriginal Peoples' Council	140	90	230
Total	2,220	1,480	3,700

[a] Woodstock FN opted to surrender rights to 2 fish for each fish provided from Mactaquac.
[b] August 1 allocation pending in-season assessment.

The recreational fishery was opened to hook-and-release fishing (only) on July 15 and was closed on August 12.

The Maritime Province's commercial fishery for salmon has been closed since 1984 and, after several buy-backs of licences, has only four eligible licences remaining in the Saint John River area. The moratoria on commercial salmon fisheries in insular Newfoundland (1992) continued; Greenland, fished for a period of 5 weeks from August 18 and took their allocation of 57 t (including 2 tagged fish of Mactaquac origins). The Greenland fishery had been closed in 1993-1994, harvested 70 t of a 77 t quota in 1995 and 85t of a self-imposed 174 t quota in 1996. In northern Labrador in 1997, licensed salmon fishermen harvested 46.4 t of a 50 t quota (southern Labrador, SFA 14B, was closed). In 1995, they took 55 t of a 77.5 t quota; in 1996 they harvested 47.7 t of a 55 t quota.

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 at the fish collection facilities at the Mactaquac Dam and at the smolt migration channel at the Mactaquac Fish Culture Station. The fish collection facilities at the Dam and the migration channel at the Station were fished May 28-October 24.

Identification at the Mactaquac sorting facility of 1SW and MSW returns from 1-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 [none were recorded in 1997] are 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, 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 fifth hatchery fish and every tenth wild fish (exceptions included the complete sampling of all broodstock, earliest-run fish, and 40 1SW fish sacrificed for internal sexing [biased towards males] and otoliths) suggested that counts be "adjusted" to better reflect wild and hatchery contributions. All fish externally classified as being of hatchery origin remained so. Fish classified "wild" that were of freshwater age-1 were reassigned to "hatchery". The proportions of hatchery freshwater age-1 fish that were misclassified in the total sample of age-1.1 and age-1.2 fish were also used to adjust externally identified hatchery fish of freshwater age 2 and freshwater age 3 upwards and, conversely, 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-1 smolts and some age 0^+ parr.

Removals of 1SW fish by Aboriginal peoples angling or fishing trap nets below Mactaquac and in the Tobique were largely reported to DFO. Catches of 1SW and MSW fish in gear or by methods not sanctioned under "agreements" were estimated on the basis of catches observed by or known to Fishery Officers and technical staff. By-catch in the lower river and Harbour was monitored by Fishery Officers and Native Guardians. As in 1996, assumed catch rates were 1% of the 1SW and 2.5% of the MSW river returns. Catches of above-Mactaquac origin fish below Mactaquac were assumed to consist of fish of hatchery and wild origins in the same proportions as the adjusted counts at Mactaquac.

Results

Counts of fish at Mactaquac in 1997 totalled 3,069 1SW and 1,776 MSW salmon (Tables 1 and 2). Unadjusted counts of wild 1SW fish were down from those of 1996, i.e., only 13% and 8% of the previous 5- or 10- year means, respectively, (Table 2) and the lowest of a 31-year record. Counts of wild MSW salmon were the lowest in 29 years and were 48% and 42% of the respective 5- and 10-year means (Table 2).

Thirty-seven (0.7%) of the 4,845 salmon counted at Mactaquac were reassigned to 1SW and MSW categories on the basis of scale interpretation (Table 1). Interpretation of scales shifted the hatchery component among 1SW fish from 87.6% (Fig. 2) to 89.4% and, among MSW fish from 35.4% to 42.8%. 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	0.55	0.19	0.23	0.03	1.0	0.57	0.20	0.22	0.01	1.0	0.03
Wild		0.46	0.44	0.10	1.0		0.46	0.51	0.03	1.0	0.07

Three hundred salmon (including 27 1SW fish reported caught by Kingsclear anglers) were estimated to have been removed by Aboriginal peoples fishing below Mactaquac Dam (Table 1). Another 81 fish were ascribed to by-catch in the shad and gaspereau nets in the lower river and Saint John Harbour area.

Estimated homewater returns in 1997 totalled 3,255 1SW (Table 1) and 1,971 MSW fish; 1SW returns were the lowest estimated since 1972; MSW returns were the lowest of a 28-year record (Table 3). Counts comprised 94 and 90% of respective 1SW and MSW returns estimated to have been destined for Mactaquac. The adjusted return rate of 1-year smolts as 1SW fish destined for Mactaquac, (corrected by excluding the few returns to Mactaquac from smolts released to the Nashwaak River and from age-0^+ fall fingerlings released above Mactaquac) was 0.00558 - about one-half that of the newly adjusted 1996 value (footnote d; Table 4a) and the fourth lowest of a 23-year record. The adjusted return rate of 1-year smolts as 2SW salmon (Table 4b) was 0.00186 - 70% of the rate in 1996 and also the fourth lowest of record.

Removals of fish destined for Mactaquac

Methods

Removals include the estimate of salmon retained by Aboriginal peoples on the main stem below Mactaquac (described above) and a by-catch in the estuary. Additional removals from the potential spawning escapement in the traditional production areas above Mactaquac include 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, exclusive of those estimated to have been taken in the net fishery at Tobique, the sport fishery or passed into the Aroostook, were 1% for 1SW and 2.5% for 2SW fish. Fish lost to poaching and disease are considered, by definition, as "spawners". Losses were apportioned to hatchery/wild components on the basis of known or estimated stock composition in the vicinity of the event, e.g., adult distribution records of hatchery and wild, male and female, 1SW and MSW salmon to Arthurette and Woodstock.

Results

Removals below Mactaquac by Aboriginal peoples were approximated at 300 fish total; 117 1SW and 183 MSW salmon (Table 5). An estimated 326 fish were harvested by Tobique First Nation (126 being reported). Eighteen 1SW fish were provided to Woodstock First Nation in August after biological sampling at Mactaquac (inc. in "mortalities" footnote c, Table 5; another 22 1SW fish "sampled" in October were made available to Aboriginal people but not collected). Transport from Mactaquac to the Aroostook River above Tinker consisted of 50 1SW and 20 MSW salmon. An additional 6 1SW and 6 MSW fish ascended the Tinker fishway (Tables 5 and 7) to USA production area external of "above Mactaquac" conservation requirements. Losses to poaching and disease were estimated at 27 1SW and 34 MSW salmon.

Total river removals by all factions were estimated at 540 1SW and 665 MSW fish (Tables 5 and 6) of which no 1SW and 235 MSW salmon were held at Mactaquac for broodstock. These broodstock yielded about 1.5 million eggs (all early-run components); no eggs were layed down from Serpentine stock reared in sea-cages because of concern over the prevalence of ISA (Infectious Salmon Anaemia virus), the causative agent of HKS (Haemorrhagic Kidney Syndrome) in nearby sites.

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% grade; Table 8), an assumed requirement of 2.4 eggs/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 1,340 MSW salmon, 27% of the requirement above Mactaquac (Table 9). 1SW spawners numbered an estimated 2,742 fish or 56% of the requirement. Biological characteristics of spawners released above Mactaquac are:

Biological parameter	1SW wild	1SW hatch	MSW wild	MSW hatch
Prop. female	0.061	0.092	0.949	0.931
Mean length, female(cm)	61.34	62.00	76.96	77.78

Differences from 1996 were a reduction in proportion of females among wild (-0.071) and hatchery

(-0.026) 1SW fish and an increase in their mean lengths (+2.51 and +3.91 cm respectively). The proportion of females among MSW fish increased from 0.861 in 1996 to 0.949 in 1997. Mean lengths, the length-fecundity relationship and estimated escapement indicate that total potential deposition (including estimated losses to poaching and disease) was 9.78 million eggs (0.726 eggs per m^2) or 30% of the requirement - down by approximately 50% of that in 1996. Eggs from 1SW fish comprised 10% of the total deposition; eggs from hatchery-origin fish potentially contributed to 47% of the total deposition.

Forecasts

1SW wild (Methods)

The potential for returns of wild 1SW salmon originating above Mactaquac was examined through a regression of total wild 1SW fish returning to the Saint John River which were produced above Mactaquac, 1973-1995, on adjusted egg depositions in the Tobique River, 1968-1969 to 1990-1991 [method in Penney and Marshall (MS 1984), with updates on freshwater age composition from wild 1SW fish, App. 1, 2 and 3 this paper]. The 1993 and 1994 egg depositions, principal contributors to 1SW returns in 1998, were derived using angular-transformed mean proportions for age-2.1 fish in the previous 10-year period.

Stepwise regression analyses with F to enter and remove =0.15 was used to identify variables that might account for more of the variance in the existing model. Variables included: May discharge at Mactaquac (smolt year); Sea Surface Temperature, Atlantic Scotia area, June and July (post smolt year; Reddin[1] pers. comm.); thermal habitat values, January, February, March (1SW year; Reddin[1] pers. comm.); and estimates of harp seal populations (Amiro MS 1998) over the appropriate years.

As an alternative to statistically significant models that have demonstrated poor forecasting capabilities, the median value of recent returns was also examined as a "forecast".

1SW wild (Forecasts)

Potential returns to Mactaquac in 1998 were examined through the regression of 1SW returns to home waters which originated above Mactaquac on estimated Tobique River egg depositions adjusted for smolt age (i.e., column 4 on column 2, Table 10). The regression required differencing i.e., $Y_i' = y_i - y_{i-1}$ and $X_i' = x_i - x_{i-1}$ to remove autocorrelation in the residuals. The model (Table 11; eq'n 1; Fig. 4) yielded an estimate for 1SW returns in 1998, of 4,193 fish (90% CL 1,118 - 7,268) from a contributing egg deposition that was 68% of the value used in 1997. For 1997, the method forecast 5,183 1SW fish; only 343 (7%) were estimated to have returned. Only 23%, 34% and 35% of the forecasts from this model were estimated to have returned in 1996, 1995 and 1994, respectively. Variations between forecast and actual values since 1994 have contributed to proportionate reductions in stated expectations of returns.

A second model including SSTs in June of the smolt year (negative coefficient) was less complex but suggested that returns from the lowest number of contributing eggs in nearly 10 years would be as high as those of 1992 (5,938 returns; Table 11; eq'n 2). May discharge, in the smolt year, SST in July of the postsmolt year and thermal habitat values January, February, March of the 1SW year were excluded by step-wise procedures set with F to enter and remove =0.15.

Because neither of the regression models appear to be particularly responsive to the downward trend in wild 1SW returns over the last 8 years, the median value of the last 5 years (CL's of min and max values) i.e., **2,168** (343- 3,213) is provided as a more reasonable alternative (Table 11; eq'n 3).

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MSW wild (Methods)

Forecasts of MSW returns in 1998 were again developed from multiple regression. The log of MSW returns in year i+1 was estimated from the numbers and fork length of 1SW returns in year i. To account for heteroscedasticity the natural logarithms of the observed Y values were utilized in the analyses. The geometric mean (GM) Y resultant of the logarithmic relationship was converted to an arithmetic mean (AM) by the formula Log_{10} (AM/GM) = 0.2172 s^2 (N-1)/N, where s is the standard deviation from the regression line of the normally-distributed natural logarithms of the variate (Ricker 1975, p. 274).

Stepwise regression analyses with F to enter and remove =0.15 was used to investigate variables that might account for more of the variance in the previously used MSW forecast models. Variables included May discharge at Mactaquac (smolt year); Sea Surface Temperature, Atlantic Scotia area, June and July (post-smolt year; Reddin[1] pers. comm.); thermal habitat values, January, February, March (1SW and MSW year; Reddin[1] pers. comm.); Year effect and the estimates of harp seal populations (Amiro MS 1998) over the appropriate years.

Saint John River MSW salmon are known to frequent distant waters and mostly contribute to distant water fisheries as non-maturing 1SW fish. The moratoria on the commercial fisheries of insular Newfoundland, since 1992, and in Greenland in 1993 and 1994, could therefore result in returns in 1997 that are not reflected in the homewater MSW return data used in the above forecast model. Hence, tag return data from Insular Newfoundland and Greenland, varying rates for tag reporting, non-catch survival, tag retention rate and survival to home waters, were used to estimate potential gains in 2SW salmon returns to the Saint John River as a result of the moratoria (Table 5; Marshall and Cameron MS 1994). Estimates of the potential gains in 26 of the 27 years used above were added to the MSW returns and examined in the above MSW forecast models.

Selected periods were again tested (co-variate "period") within the 27 years of data by ANCOVA procedures to determine if abbreviated or modified models would be more responsive in predicting MSW returns from the 1SW fork length and low (outside the bounds of any model) 1SW returns of 1997.

Finally, modal values for recent ratios of 1SW:MSW returns were considered for the derivation of a forecast given that the 1997 1SW value used to forecast MSW returns in 1998 would be an outlier to the database of any regression model.

MSW wild (Forecasts)

A potential return of 1,950 (90% CL 1,207 - 3,151) wild MSW fish destined for Mactaquac in 1998 was derived from the regression of Log_e MSW on 1SW returns and their mean fork length in 1997 (Table 11; eq'n 4; column 7 on columns 4 and 5, Table 10: Fig. 4). For 1997 the method forecast a return of 2,051 MSW salmon- 1,128 (55%) were estimated to have returned. Returns in 1996, 1995, and 1994 were 81%, 80% and 103% of the respective preseason forecasts. The inclusion of the co-variate "period" in the model for MSW years 1971-1975; 1976-1984 and 1985-1997 and, as well, 1971-1975; 1976-1986 and 1987-1997 when ratios of MSW:1SW and lengths (Table 10) appeared to be different, indicated that period 1 was significantly different from either of the period 3's (p=0.064 and p=0.047, respectively). The above model exclusive of period 1 (1971-1975) provided a forecast of 1,720 MSW returns in 1998 (Table 11; eq'n 5).

Use of the estimated numbers of returning salmon in the absence of commercial fisheries in Newfoundland and Greenland, 1972-1997, (Table 10, one less year than in the above data set) indicates a forecast of 2,603 (1,333 - 5,083) wild MSW fish destined for Mactaquac in 1998 (Table 11; eq'n 7). In 1997 returns were 40% of the forecast from this model; in 1996, 1995 and 1994, returns were 56%, 75% and 50% of the forecast.

Period hypotheses were also tested for the model with the added effects of the moratoria and found to be significant when the latest period for MSW years was either 1985-1997 (p=0.002) or 1987-

1997 (p=0.003), i.e., period 1 was significantly different from period 2 or period 3. The subset model for the MSW period 1976-1997 reduced the full model forecast to 1,935 fish (25% reduction; Table 11; eq'n 8); returns in 1997 were but 50% of the forecast by this model. The subset model for the period 1985-1997 provided a forecast of 1,606 fish, (Table 11; eq'n 9). Estimated recruits in 1997 and 1996 were 55% and 83% of the values forecast by this model.

Stepwise techniques suggested an MSW-to-homewater model including, in addition to the Fork Length and 1SW variables, thermal habitat for Jan (Fig. 5) in the MSW year and seals. The additional variables (negative coefficients) accounted for another 7% of the variation in equation 4 (Table 11) and reduced the forecast to just over 1,000 fish. In the total recruit models (to home and distant fisheries), Year (effect; 1SW fish) and January thermal habitat in the MSW year, in addition to the Fork Length and 1SW variables provided the largest r^2 value and yielded a forecast for 1998 of 1,086 fish (Table 11; eq'n 10) several hundred of which are, on the basis of 2 tag returns from the 1997 Greenland fishery, already accounted for.

A wild MSW return of 1,128 fish in 1997 was only 55% of the most pessimistic pre-season forecast (2,051 fish; Marshall et al. MS 1997). Forecasts for 1998, based on only 343 wild 1SW fish in 1997, i.e., 25% of the number used in forecasting 1997 returns are, by the traditional 3-variable models, at worst only 20% less than for 1997. The most apparent difficulty with 1998 MSW forecasts is that the 1997 1SW value lies outside values contained in the forecast models. Hence, the most simplistic and most cautious forecast is that derived from the modal value of MSW/1SW ratios (Table 10; last column) for the MSW periods 2 and 3, 1976-1997; confidence limits expressed as $ratio_{min}$ to $ratio_{max}$. The forecast by this method is **408** (120-737) MSW returns (Table 11 eq'n 6).

1SW hatchery (Methods)

Since the shift to age-1 smolt production from Mactaquac in 1985, forecasts of returns from hatchery-reared smolts have generally been the product of the mean return rate of recent years and the number of smolts (i.e., fish>12 cm) expected to contribute to 1SW returns. A previously noted significant relationship between rates of return of hatchery 1SW fish and the March index of thermal habitat for salmon in the North Atlantic (R^2=0.604; p<0.001; n=21) suggested a forecast model of return rates from thermal habitat (January being available at the time of the assessment). The failure of the 1997 return rate to respond to increasing values of thermal habitat suggested that it might be prudent to consider return rates of recent years; the method of choice being the median return rate, 1993-1997, with confidence limits expressed as $rate_{min}$ to $rate_{max}$. Return rates for all age-1.1 returns to Mactaquac have been used and therefore account for the few fish that may result from large grade fall fingerlings released above Mactaquac.

Additional 1SW returns of age-2.1 and age-3.1 fish are expected at Mactaquac in 1998 from fry, summer and fall releases (age 0^+) taken from Saint John Hatchery or graded from the age-1 smolt program at Mactaquac and released into tributaries above Mactaquac in 1994 and 1995. Attempts to forecast 1997 returns using variously derived and selected return rates for each of the many age and size categories proved unproductive and prone to many individual errors which previously cancelled each other out. Particularly troubling in 1996, and again in 1997, was the low return rates (relative to forecasts; Marshall et al. MS 1997) among Ad-clipped fall fingerlings (Table 12).

A more simplistic approach to the forecasting of the remaining components of hatchery stocking is based on the evidence that the numbers of various-size juveniles recently placed above Mactaquac and their proportion of the total identified hatchery returns has been relatively consistent. Thus freshwater age-2 and -3 returns of hatchery origin in 1998 were forecast as the product of the median proportion age-2 and -3 fish among total hatchery returns, 1995-1997, and the forecast of age-1.1 returns for 1998.

1SW hatchery (Forecasts)

Regression of age 1.1 return rates on thermal habitat in January (a value of 2,018 in January 1998 is the highest in 25 years) yielded a forecast return rate of .02236. Such a return rate would be the highest since 1980 and yield a return of 6,406 fish (Table 11; eq'n 11). A more prudent forecast, given the unexplained low return rate relative to expectations for 1997, is the median value, 1993-1997, of 0.00686 (25% less than forecasting rate for 1997 and slightly higher than the measured return rate in 1997), i.e., which suggests a return from 286,485 smolts of **1,965** age 1.1 1SW fish (Table 11; eq'n 12 and Table 13). Returns of freshwater age-2 and -3 1SW fish are forecasted at **1,701** fish (from the age-1.1 median return rate model), considerably fewer than the nearly 4,000 forecast for 1997 and 40% more than those estimated to have returned in 1998 (Table 11, eq'n 13).

MSW hatchery (Methods)

Returns as MSW fish from age-1 smolts released at Mactaquac have been variously forecast from the product of mean return rates of recent years and the number of smolts released. Formerly the return rate was derived from a relationship between survival to home waters of $1SW_{yr\ i}$ and $2SW_{yr\ i+1}$ salmon originating from smolt releases, 1974-1993. Predictive models were this time sought from 1SW and 2SW fish released at Mactaquac, 1974-1995, or in the case of a few age 1.1 returns, released above Mactaquac as large age 0^+ parr, i.e., numbers contributing to unadjusted return rates in Tables 4a and 4b. Previously mentioned variables were also examined stepwise to account for additional variance. With the uncertainty of recent marine survival events and in the same manner as for the hatchery age-1.1 1SW forecast, a forecast was developed from the median return rate for the years 1993-1997 and numbers of smolts released in 1996.

Additional 2SW returns (and a few repeat spawners) of age-2.2 and age-3.2 fish are expected at Mactaquac in 1998 from fry, summer and fall releases (age-0^+) taken from Saint John Hatchery or graded from the age-1 smolt program at Mactaquac and released into tributaries above Mactaquac principally in 1993 and 1994. Attempts to forecast 1997 returns using variously derived and selected return rates for each of the many age and size categories proved unproductive and prone to many individual errors which previously cancelled each other out. Ad-clipped fish failed to materialize as MSW fish (Table 12) and the overall returns of age-2.2 and age-3.2 hatchery fish were but 320 of a forecast 483 fish (66%).

As with 1SW forecasts a more simplistic approach to the forecasting of the remaining components of hatchery stocking is based on the evidence that the numbers of various-size juveniles recently placed above Mactaquac and their proportion of the total identified hatchery returns has been relatively consistent. Thus freshwater age-2 and -3 returns of hatchery origin in 1998 were forecast as the product of the mean proportion age-2 and -3 among total hatchery returns, 1996-1997, and the forecast of age-1.2 returns for 1998.

MSW hatchery (Forecasts)

Regression of hatchery-smolt origin 2SW returns on hatchery-smolt origin 1SW returns over the 22-years of record (Tables 4a and 4b) yielded an estimated return in 1998 of 737 (0 - 1,538) fish (Table 11; eq'n 14; Fig. 5). Inclusion of the variable year (negative coefficient) reduced the estimate to 198 fish (Table 11; eq'n 15). The product of the median return rate of the last 5 years (0.00228) and the 286,400 smolts from Mactaquac yields a forecast of **653** age-1.2 returns (Table 11; eq'n 16). Estimated returns in 1997 were 485 fish.

Returns of age-2.2 and age-3.2 salmon in 1998 were projected from the age-1.2 median return rate model. The value is **459** fish (Table 11; eq'n 17), a 30% increase over those returning in 1997.

Ecological considerations

In-river

Discharges at Mactaquac in June and early July fluctuated about the mean value, 1972-1996 (Fig. 6). Weekly plots of salmon counts at the Dam, 1993-1997, (Fig. 2) do not indicate anything unusual regarding the arrival time of fish at the Dam. From mid-July through August, discharges tapered to the low values of 1995. September and October discharges remained low; water temperatures (Fig. 7) exceeded 20C by the end of the first week in July and remained at 22-23C until about the end of the first week in September. The majority of returns entered the fishway during warm water conditions (but good discharge) in July. Attraction water (and temperatures during fall) are not thought to have been detrimental to the entry of the last of the upriver migrants (Fig. 2) to the tailrace prior to the Oct 24 closure of the fishway. Juvenile densities in tributaries above Mactaquac (Fig. 8) increased significantly over those of 1996. Densities in 1996 were particularly disappointing in the major Tobique production area given that egg deposition in 1995 (1996 age 0^+) was estimated to have improved slightly over that of 1994.

The weekly cumulative proportions of 1SW and MSW salmon captured in the fishway at Mactaquac Dam in each of 23 seasons is the basis of a model used to predict end-of-season counts (Harvie and Marshall MS In prep). For 1SW models, mean daily river discharge July 2-14, July 2-21 and July 2-29 for respective forecast dates of July 15, 22, and 29, and for MSW models, mean daily discharge June 18-July 7, June 18-July 14, June 18-July 21 and June 18-July 27 for respective forecast dates of July 8, 15, 22, and 29, explains a significant amount of the annual variation in cumulative counts to date ($p<0.05$). End-of-season counts of 3,069 wild and hatchery 1SW and 1,776 wild and hatchery MSW salmon were forecast as:

Sea-age	July 15	July 22	July 29	August 5
1SW		6,233	5,460	4,638
MSW	2,122	1,933	1,876	1,833

1SW forecasts are not promoted as managerial tools until the end of July; MSW forecasts have usually been near end-of-season values beginning in mid July. Caveats regarding the uncertainty of July in-season estimates (1SW fish in particular) were afforded by separate forecasts of hatchery and wild components. Hatchery returns have been selected for early run-timing and, now being the major portion of the 1SW-run, were forecast separately. Despite indicating that the 4,900 1SW fish conservation requirement would not be met on Aug 5, the 1SW forecasts did not provide insight (until much later) into the excessive shortfall of returns for the fall period.

Stepwise regression used in the exploration of forecast models failed to reveal that discharge at Mactaquac in May of the smolt year was a significant or more significant factor than factors already in use, particularly Fork Length. Previous comments under this heading (Marshall et al. MS 1997) identified that the proportion of 1SW fish from a smolt class increases with decreasing discharges at Mactaquac ($p<0.001$) and high proportions of 1SW fish from a smolt class are correlated with longer average lengths of 1SW fish. The hypothesis that increased fork length and "grilsification" is a consequence of delays in downstream migration of smolts remains to be fully investigated. The failure of the variable "Year" to enter the 1SW-on-egg model is not consistent with the hypothesis that maturing Headponds and their increasing (?) populations of smallmouth bass *Micropterus dolomieui* muskellunge *Esox masquinongy* and pickerel *Esox niger* are affecting smolt output.

Marine

An upward trending thermal habitat index, 1994-1996 (Fig. 5) and improved return rates for hatchery origin fish supported a hypothesis that preseason forecasts of MSW returns in 1997 may have been minimal. The rationale was used to support the contention that 1SW returns should also have improved in 1997. However, returns to many of Atlantic Canada's rivers were down from those returns of 1996, many, including the Saint John had returns that were outside the confidence intervals of the forecasts (Amiro et al. MS 1998; Anon MS 1998). Factors examined for the possible decline in survival focused on marine events and included temperature profiles and thermal habitat indices, removals in legal and illegal fisheries, predation by cod, seals, seabirds, diseases or parasites, changes in biological characteristics of salmon and changes in marine fish species communities (Anon MS 1998). No global factor was identified as causative agent for the wide geographic declines in survival even though, as in the case of the Saint John stocks, the event should seemingly have occurred when both maturing 1SW fish (1996 smolt class) and maturing 2SW fish (1995 smolt class) were in proximity to each other (maturing 1SW fish from the 1995 smolt class had returned at an encouragingly increased rate in 1996).

An increase in thermal habitat, which on the basis of performance in ICES prefishery abundance forecast models, supported the argument for increased returns. Stepwise regression in the exploration of Saint John forecast models indicated that the most prevalent variables (negative coefficients) were Fork Length 1SW fish, Year, Harp seal populations and January thermal habitat (the latter either positive or negative). The Year effect can be interpreted as a proxy for any deleterious effect which is progressively increasing, e.g., increases in seal abundance over the last 10-15 years.

Relationships previously reported (Marshall et al. MS 1997), i.e., i) the March index of habitat and return rates for 1SW salmon from hatchery smolts, ii) return rates of hatchery 2SW salmon originating from hatchery smolts and the index of habitat for the first and second year at sea, iii) the fork length of wild 1SW returns and April index of habitat (negative slope) and iv) the fork length and proportion of 1SW salmon from a smolt class, have not been further explored. The linkage between proportion 1SW (and, by corollary, 2SW fish) and Fork Length has been previously interpreted by Ritter et al. (MS 1990) as an expression of environmentally induced "cross-over" of potential non-maturing 1SW fish to maturing 1SW fish, i.e., above average growth of fish at some time and place during the first year at sea results in an increase in the proportion of 1SW returns (and decrease in 2SW returns) from a smolt class.

Forecast summary

Uncertainty in on-going environmental events and forecast modelling suggest a cautious approach in the selection of forecast returns for 1998. Based on the January, 1998, index of thermal habitat (Fig. 5) the February and March indices should also improve from that of 1996 and 1997 and from the ICES prefishery abundance model (Anon MS 1997) generally expect an associated increase in survival at sea and to home waters. However, an improvement was expected in 1997 but was not seen. Other factors such as predation by fish, birds and mammals and a changing ecosystem may now be cancelling the benefits associated with an increasing thermal habitat signal.

Regression models for forecasting of wild 1SW and MSW salmon have seriously overestimated returns over the previous 3 and 4 years. Additionally, the models contain few if any values at the low end of the scale from which 1SW and MSW fish are being forecast for 1998. Forecasts of hatchery returns have been based on means of recent years and also exceeded observed returns but, where well founded, to a lesser extent than existing regression models. Thus, in view of the many uncertainties, the forecasts of choice are based on means and modes or ratios derived from more recent events.

Preferred forecasts of **1SW returns** in 1998 **total 5,834** (2,402-9,655) fish comprised of **2,168 (343-3,213) wild 1SW** and **3,666 (2,059-6,442) hatchery 1SW fish** (Table 11). Forecasts of **MSW returns** total 1,520 (718-2,067) comprised of **408 (120-737) wild MSW** and **1,112 (598-1,330) hatchery-origin MSW fish**. A return of 5,834 1SW returns would be 1.8 times the return in 1997 and 119% of conservation requirements. A return of 1,520 MSW salmon (90% CLs suggesting zero probability of attaining conservation requirement) would be 77% of the estimated return in 1997 and 31% of requirement (without broodstock for Mactaquac) and the new lowest value since 1970. In view of the uncertainty of preseason forecasts, inseason forecasts, July 15 -July 29, should be viewed prior to the finalization of plans, particularly those that involve the harvest of any surplus 1SW fish.

The long-term prognoses for MSW salmon is less favourable than for 1SW fish. Hatchery and wild MSW recruits are few relative to their 1SW counterparts. MSW salmon have not yet exhibited a significant increase in marine survival rates and therefore, in total, should not be expected to exceed returns estimated during the last decade, i.e., less than 1 chance in 10 that conservation requirements of 4,900 fish will be met.

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 9). 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 5.69 million m^2 (gradient > 0.12%) or 28.5% of the total below Mactaquac Dam (Marshall et al. MS 1997; Table 8). A salmon counting fence at kilometre 23 (Fig. 9) from the confluence with the Saint John was operated by DFO in 1972, 1973 and 1975 (Francis and Gallop MS 1979), and by Aboriginal peoples from 1993-1997. In 1997, the fence was jointly operated by Kingsclear and Oromocto First Nations.

Returns

Methods

All fish captured at the fence were recorded, measured for fork length, classified as hatchery or wild on the basis of fin deformities, scale sampled and marked with a caudal punch. As in previous years, pools were seined in early fall above the fence so that mark and recapture procedures (Gazey and Staley 1996) could be used to estimate the number of fish that may have by-passed the fence either previous to installation or during operation. However, in 1997, all fish recaptured above the fence had been caudal punched.

Results

Unadjusted counts at the Nashwaak fence during the June 18 - November 2 operating dates numbered 353 small and 383 large salmon. The start and finish dates were the second earliest and latest finish since operation resumed in 1993. The 1997 counts terminated with a washout on the evening of November 2. After scale analysis, small and large salmon components were revised to 370 1SW and 366 MSW salmon (Table 2). Hatchery returns were 38 1SW and 27 MSW salmon and represented about 10% and 7% of the total counts, respectively. Similar to 1996, 72% of the 1SW salmon passed through the fence prior to October 1 (Fig. 10). Unlike the 1SW salmon, the MSW salmon entry was delayed and may have been affected by the low discharge in the month of October (Fig. 10). The MSW salmon run peaked the last 3 days of October; 52% were counted after October 1 (Fig. 10). Scale samples revealed that sea-ages of the wild fish were 50% 1SW fish, 42% 2SW fish and 8% previous spawners. Low returns of 1SW salmon in 1997 resulted in the lowest proportion of grilse since the collection of biological characteristic data resumed in 1993. With the exception of 1995, previous spawners constitute 16-22% of the MSW component. Sea ages from 1993-1997 are as follows:

Year	n	Prop 1SW	Prop 2SW	Prop 3SW	Prop previous spawners(PS)	PS as p of MSW
1993	92	0.63	0.29	0.01	0.07	0.18
1994	204	0.63	0.29	0.01	0.07	0.19
1995	159	0.69	0.29	0.00	0.02	0.06
1996	153	0.74	0.20	0.00	0.06	0.22
1997	157	0.50	0.42	0.00	0.08	0.16

Seining of seven upriver pools (Colter's, Cross Creek, Nashwaak Bridge, Little Basin, Williamson's Camp, Burnt Camp, Sister's) on September 30 and October 2 resulted in the capture of 3 1SW and 8 MSW salmon, all marked previously at the counting fence. Thus the count at the fence of

736 fish with small and large components adjusted to **370** 1SW and **366** MSW salmon is regarded as the entire run. No account has been made of by-catch in the Harbour or of removals by Aboriginal peoples (fishing in the main Saint John below the confluence of the Nashwaak River) which may have been destined for the Nashwaak River.

Removals

The Nashwaak was open to hook-and-release angling July 15 to August 12 but no catch statistics were available with which to estimate hook-and-release mortality. Seven 1SW and 4 MSW mortalities were recovered on the upstream side of the fence, all mortalities were found between July 2 and August 12. There were no estimates of illegal removals. No Nashwaak fish have been collected for broodstock since 1994.

Conservation requirements

Salmon production area above the fence is estimated to be 5.35 million m^2 ; the conservation requirement is 12.8 million eggs (Marshall et al. MS 1997). Biological characteristics of fish at the fence, 1993-1996, indicate that 2,040 MSW salmon and an equal number of 1SW salmon would be necessary to meet requirements (Marshall et al. op cit). Egg deposition and spawners in 1997 were estimated on the basis of lengths, external sexing and interpretation of age from scales collected from fish passing through the fence.

Escapement

Spawners above the fence were estimated to be **363** 1SW and **362** MSW salmon. Sea-age, origins, female composition and mean lengths for spawners above the fence can be summarized as follows:

	1SW salmon		MSW salmon	
Biological parameter	Wild	Hatchery	Wild	Hatchery
Number	326	37	335	27
Proportion female	0.440	0.368	0.861	0.731
Mean length female (cm)	57.0	56.8	79.8	80.8

Numbers of both 1SW and MSW spawners were 18% of the conservation requirements. The 1SW and MSW spawners decreased by 80% and 44%, respectively from 1996. Egg deposition was estimated at 2.89 million (0.55 eggs m^{-2} or 23% of the egg requirement); lowest since fence operation resumed in 1993. One-sea-winter females contributed to 18% of the total estimated egg deposition, compared to an average of 35% from 1994-1996.

Egg deposition may in fact be overestimated. Disease analysis performed on 8 of the 11 mortalities which washed downriver onto the counting fence indicated that *Aeromonas salmonicida*, the causative agent of furunculosis, was isolated from half of the samples. All samples were collected during the warm water months of July and August.

Densities of juvenile salmon in 1997 (Fig. 8; Table 14) are consistent with low levels of egg deposition in recent years. A slight increase in the age-0^+ parr density corresponds with the higher egg deposition in 1996. The average age-1^+ and age-2^+ parr densities for the 8 index sites was 6.5 parr 100 m^{-2} which is well below Elson's (1967) "normal index" of 38 small and large parr 100 m^{-2}. Only the 1987 and 1990 year classes generated age-1^+ parr densities slightly above 10 parr 100 m^{-2} (Fig. 11).

Forecasts

Methods

Five years of adult data are too few to develop meaningful stock and recruit models. A 5-year mean of 1SW returns, 1993-1997 does offer some scope of the possible magnitude of returns in 1998. Forecasts of MSW returns in 1998 were approximated as the product of the mean (CL's min-max) ratio MSW/1SW returns for the 1992-1995 smolt classes and numbers of 1SW fish returning in 1997.

Forecasts of 1SW returns were also developed from a juvenile-to-1SW survival model utilizing electrofishing data (Table 14; Fig. 11) and estimates of 1SW returns to the fence. By this method, parr to 1SW survival rates were developed from parr densities at 7 index sites above the fence, by raising site densities to those of the total estimated production area and, on the basis of freshwater age among returning 1SW fish, apportioning the parr populations to 1SW returns to which they would have contributed. The forecast for 1998 is the product of parr densities with potential to contribute to 1998 1SW returns and the median survival rates for age-1^+ and -2^+ parr for the past five years (CL's min - max).

Results

The 5-year mean number of 1SW returns to the fence is 870 1SW fish. A return of this many 1SW fish in 1998 could be overly optimistic given the low densities of age-1^+ (1.64 100 m^{-2}) and age-2^+ (0.51 100 m^{-2}) parr in 1996. Median survival values of 0.12% (age 1^+) and 0.80% (age 2^+) and parr densities destined to contribute to 1SW returns in 1998 suggest a return of **320 (110 -1,220) wild 1SW** salmon. Hatchery 1SW returns will be fewer than in 1997 because of the discontinuation of smolt releases in 1997. Age-0^+ parr released in 1995 will contribute to a few returns. Neither estimate of wild 1SW returns suggests that more than about 40% of the conservation requirement for 1SW salmon could be met.

The product of the mean ratio 2SW/1SW returns for the smolt years, 1992-1995, i.e., 0.29 (0.15 - 0.39) and 1SW returns in 1997 suggests that returns in 1998 could be as few as **100 (50- 130) wild 2SW** fish. Even allowing for a modest return of repeat spawning salmon it is unlikely that MSW salmon will exceed 10% (200) of conservation requirement. In total, it is highly improbable that returns and egg depositions in 1998 will exceed those of 1997.

KENNEBECASIS RIVER

With a drainage area of about 1,422 km^2, the mainstem Kennebecasis River flows approximately 90 km in a northerly then southwesterly direction from the Caledonia Highlands of Kings and Albert counties to the tidal reaches of Kennebecasis Bay in the lower Saint John River estuary at Bloomfield (Figs. 1 and 12). The drainage is estimated by orthophotographic survey techniques (Table 8) to have the third highest quantity of salmon producing substrate below Mactaquac Dam. In 1997, as in 1996, a counting fence and upstream and downstream traps were installed at McCully Station (Fig. 12), 40 km from tidal waters, by the NB Cooperative Fish and Wildlife Unit. The installation was designed to study movements of brook trout, *Salvelinus fontinalis* and monitor returns of Atlantic salmon. NBDNRE estimates of salmon producing area for the Kennebecasis River is 2.908 million m^2; the area above the fence constitutes 405,800 m^2 or 15.5% of the total within the drainage.

Returns

Methods

All fish captured at the fence were recorded, classified as hatchery or wild on the basis of fin deformities, and marked with a caudal tail clip and the majority were measured for fork length and scale sampled. The count of 1SW and MSW fish past the fence may have excluded some fish that could have passed during high flow event in July but all salmon observed in the downstream trap in late fall were marked and therefore previously recorded.

Results

Adjusted by scale analysis, counts of 1SW and MSW fish at the McCully fence during the May 29-November 16 operating dates numbered 74 1SW and 44 MSW salmon. As in 1996, 77% of all fish ascended after September 15. The run peaked after October 29 despite seasonally low water levels (Fig. 13). Scale analysis revealed that 15 (20%) of the 1SW salmon were of hatchery origin, the result of stocking 16,000 Kennebecasis-origin smolts above (6,400) and below (remainder) the fence site. As in 1996, all MSW salmon were of wild origin. Scale samples revealed that sea-ages of the wild fish were 57% 1SW; 28% 2SW and 15% previous spawners. Sea ages from 1996-1997 are as follows:

Year	n	Prop 1SW	Prop 2SW	Prop 3SW	Prop previous spawners(PS)	PS as p of MSW
1996	83	0.62	0.29	0.00	0.09	0.24
1997	74	0.57	0.28	0.00	0.15	0.35

Removals

As in the rest of SFA 23, recreational fisheries were open and restricted to "hook-and-release", from July 15 until August 12 when all rivers in the SFA were closed. The commercial fisheries have been closed since 1983 and no allocations from the Kennebecasis were made to Aboriginal food fisheries. Although poaching of salmon has been known to occur above the fence site, all fish estimated to have ascended past the fence site were assumed to have spawned.

Conservation requirements

An accessible salmon-producing substrate (NBDNRE) of 450,800 m^2, an assumed requirement of 2.4 eggs m^{-2} (1.1 million total), the length-fecundity relationship for Mactaquac-origin 1SW and MSW fish (Marshall and Penney MS 1983) and 1SW:MSW ratios and sex composition in the 1996 fence count suggest that, **160 1SW** and **160 MSW** fish are required above the fence site (Marshall et al. MS 1997). Egg deposition was estimated on the basis of lengths, external sexing and counts from fish trapped at the fence.

Escapement

Seventy-four 1SW and 44 MSW salmon were known to have passed above the fence and were presumed to have spawned. Sea-age, origins, female composition and mean lengths for wild spawners above the fence can be summarized as follows:

	1SW salmon		MSW salmon	
Biological parameter	Wild	Hatchery	Wild	Hatchery
Number	59	15	44	0
Proportion female	0.300	0.000	0.927	
Mean length female (cm)	59.9	-	80.1	

Counted 1SW and MSW salmon were only 46% and 28% of the respective requirements. Deposition was estimated at 381,000 eggs (0.84 eggs m^{-2}) or **35% of requirement**. 1SW females contributed 16% of the total estimated egg deposition.

Forecasts

There are no adult data or indexes from which to forecast wild 1SW salmon returns to the fence in 1998. Age- 1^+ and -2^+ parr densities in 1996 (Figs. 8 and 11) which will contribute to 1SW returns in 1998, are 37% lower than the densities which contributed the 1SW returns in 1997. The 3.5 parr 100 m^{-2} average for 5 sites in 1996 would suggest a decrease in wild 1SW returns if no improvement in sea survival occurs. The hatchery-origin 1SW salmon should not vary from those counted at the fence in 1997 as a result of releasing 5,250 smolts (Kennebecasis origin) above the fence site in 1997 (no other smolts were released to the River). The product of 2SW/1SW ratio from the 1995 smolt class (0.27) and 1SW returns in 1997 provides a forecast that is similar to the returns in 1997. In total, there is little optimism that returns to and egg deposition above the fence site in 1998 will be appreciably different from those of 1997.

HAMMOND RIVER

With a drainage area of about 453 km^2, the mainstem Hammond River flows approximately 60 km in a southwestward 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 (Figs. 1 and 14). The drainage has an estimated 1.662 million m^2 of salmon producing habitat (Table 8; inc. Palmer Br.), about 8% of the total below Mactaquac Dam. Counts of redds and salmon have been counted in most years since 1976 and were reported by Marshall et al. (MS 1997). The surveyed area is 11.75 km in length (25.7% of the mainstem length) averages 0.25% grade and contains a revised estimate of 160,610 m^2 (T. Pettigrew[2] pers. comm.) of stream habitat (127,869 m^2 of salmon rearing habitat). The lower and upper limits are bounded by the Tabor and Hillsdale bridges, respectively.

Returns

Methods

Salmon returns to the surveyed section were not directly assessed, thus the assessment of returns with respect to conservation requirements is based on redd counts and an average number of redds required to meet conservation. The method requires an estimate of the number of redds that represent a female salmon of specified egg carrying capacity. Data background to the selection of a value of 1.86 redds MSW^{-1} male and female is summarized in 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 females among the MSW population. Preliminary analysis assumed that the MSW stock was 75% female and thus every 2.48 redds equate to one female salmon.

Results

Counts of redds, 1976-1996, exclusive of 1984 and 1988-1991 appear in Table 15. Counts of large redds (small redds could be false or those of 1SW fish) ranged from 78 to 305, a count of 157 in 1997 was 61% of the value for 1996 and 87% of the 14-year mean (Fig. 15).

Removals

As in the rest of SFA 23, recreational fisheries were restricted to "hook-and-release" fishing, July 15-August 12. Commercial fisheries have been closed since 1983 and no allocations from the Hammond River have been made to Aboriginal food fisheries. Assessments based on redds are, in any event, an assessment of escapement.

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[2] NB Dept. Natural Resources and Energy, PO Box 150, Hampton, NB, E0G 1Z0

Conservation requirements

The product of the 160,610 m^2 of substrate in the study area and an assumed requirement of 2.4 eggs m^{-2} suggests a conservation requirement of 0.385 million eggs. Required eggs would be met by 53 MSW females ([385,464/7,306]*2.48) or 132 "total" redds under the assumption that MSW salmon are 75% female and that each female carries 7,306 eggs (Marshall and Penney MS 1983).

Escapement

Large and total redds counted over the period of record suggest that escapement has varied and, in 1997, was next to the median value of the 15-year data set. Egg depositions, with respect to a 2.4 eggs m^{-2} requirement for the study area, were virtually exceeded in all years; those of 1997 are 163% of requirement. In only three years, 1976, 1985 and 1995 were there redd counts less than "requirement".

In 1997, redds in excess of "requirement" were counted on the North Hammond (22,294 m^2), mainstem from confluence of North Hammond to the Hillsdale Bridge (5,752 m^2) and the mainstem above the confluence of the North Hammond (30,584 m^2) and suggest that headwaters of the system received more than adequate egg depositions. Surveys of the lower stretches of the system remain to be assessed but are unlikely to harbour a count in the vicinity of the 195 required redds (T. Pettigrew[2] pers. comm.). However, a redd count for the total drainage will be instructive in the assessment of attaining requirements in the headwaters.

Densities of juvenile salmon (age-1^+ and -2^+ parr) at five sites on the Hammond River in 1981-1997 (Figs. 8 and 11) exceed those of the Kennebecasis Rivers in most years. The highest density of age 0^+ fish in 15 years may be related to the high redd counts in 1996 or the release in July of 28,000 0^+ parr in the vicinity of the two index sites. Their survivors in 1998 may reveal something of the parr carrying capacity, present significance of an Elson (1967) "normal abundance" index and potential smolt production.

A 35% decrease in redds (and presumably returns and escapement) in 1997 over that of 1996 is, however, consistent with decreases noted elsewhere within the greater Saint John drainage basin. Thus, the simplest interpretation and, requirement of the fewest assumptions, is that redd data over large areas is likely an index of abundance. However initial regression analyses in 1997 (Marshall et al. MS 1997) of i) age 0^+ and age-1^+ parr at three electrofishing stations on and within the bounds of the redd survey area on estimated egg depositions in $year_{i-1}$ and $year_{i-2}$, and ii) estimates of wild salmon returns at Mactaquac on total redd counts in the study area were not significant ($n=11$ and 10; $p> 0.05$ and $n=16$, $p >0.05$, respectively).

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 study area. Total redd counts in the study area, 1998, might reasonably be expected to be between the 113 and 344 values observed between 1992 and 1997, i.e., representative of an excess to conservation requirement to the study area. Juvenile data (age 1^+ 100 m^{-2}, Fig. 11) suggests that wild 1SW and 2SW returns recruiting to the Hammond from the 1993-1994 egg depositions could be low and of the same magnitude as returns to the Kennebecasis River. As well, 1SW recruits can be expected from 8,000 smolts distributed within the drainage in 1997.

MAGAGUADAVIC RIVER

With origins in Magaguadavic Lake, the Magaguadavic River flows southeasterly for 97 km to the Passamaquoddy Bay, Bay of Fundy at St. George, N.B. (Fig. 16; Martin MS 1984). A 13.4 m-high dam and 3.7 megawatt hydroelectric station is located at the head-of-tide. Upstream passage is afforded by a fishway; assessment of the anadromous resource is afforded by a trap in the third pool from the top of the fishway. In 1997, as 1996, the trap was monitored July through October and summary data and analyses were provided by J. Carr[3], Atlantic Salmon Federation. In 1997 (unlike 1996) no fish of aquaculture origins captured at the trap were released to the river. Rather they were released to various points in the Bay (as part of a homing experiment) or sacrificed for sampling of pathogens.

Preseason prognoses of wild returning salmon in 1997 suggested that returns were unlikely to improve beyond the 48 MSW and 21 1SW fish counted in 1996. Counts of aquaculture fish would be a function of escape events in the Fundy Isle area which in 1996 produced approximately 16,000t of Atlantic salmon. There were no "notable" escapes from cages in 1997. The industry, however, suffered significant financial losses as a result of the requirement to eradicate 1997 year class salmon in farms where ISA (Infectious Salmon Anaemia virus), the causative agent of HKS (Haemorrhagic Kidney Syndrome) was detected. Tests for ISA among a total of 56 wild Atlantic salmon from the Magaguadavic, St. Croix and Saint John rivers were negative.

Returns

Counts of salmon in the trap numbered 59 wild, and 119 aquaculture escapees of which 37 were post smolts (J. Carr[3] pers. comm.). "Wild" salmon could also be the result of juveniles escapees from any of 3 private hatcheries in the drainage. Counts made since 1992 when aquaculture escapees have been identified and those made by DFO in 1983-1985 and 1988, when escapees were largely unnoticed, are summarized in Table 2. Total wild counts are the lowest of the record. Aquaculture escapees are the lowest of recent record.

Removals

All aquaculture fish were denied access to the river. In addition, 10 wild fish were lost to spawning as a result of death in the trap (4) or in a broodstock holding facility (6). There has been no commercial fishery since 1983, no aboriginal food fishery and, in 1997, the recreational fishery was restricted to hook-and-release fishing for the period July 15-August 12.

Conservation requirements

An interim required deposition of 1.35 million eggs is based on an estimated 563,000 m^2 of juvenile rearing substrate and a deposition of 2.4 eggs 100 m^{-2} (Anon MS 1978). Spawners necessary to obtain those eggs are estimated at 230 MSW and 140 1SW salmon. Measurements from orthophotographic maps and air photos (Amiro 1993) indicate significantly more area (>0.125 but < 15% gradient) but their use has been delayed until new ground survey information is integrated into the data base.

Escapement

Thirty-two 1SW and 17 MSW fish were released above the fishway; 6 fish retained for broodstock died when equipment at the holding facility failed (J. Carr[3] pers. comm.). Biological characteristics of fish released to the river were as follows:

[3] Atlantic Salmon Federation, PO Box 429, St. Andrews, NB, E0G 2X0

Biological characteristic	1SW wild	MSW wild
Number	32	17
Prop. female	0.41	1.00
Mean length female (cm)	56.1	76.4

Mean lengths, the mean length fecundity relationship for Saint John River salmon of $Y=430.19e^{0.03605X}$ (Marshall and Penney MS 1983) and estimated number of females suggest a potential egg deposition of 156,946 eggs or 12% of requirement. Estimates of escapement and attainment of conservation requirements, 1994-1996, are as follows:

	Escapement		% Req'mt		
Year	1SW	MSW	1SW	MSW	Eggs
1994	639	143	456	62	56
1995	182	105	130	46	22
1996	222	34	159	15	18
1997	32	17	23	7	12

Forecasts

Since recruitment to the Magaguadavic appears to be based on escapement of wild fish which have been diminishing since records began, prospects for returns in 1998 are poor. Wild 1SW fish have diminished annually and the relationship MSW = 2.09 1SW - 121.19 ($n=6$; $R^2_{adj}= 0.83$; $p=0.019$) from count data, suggests that wild MSW returns will not exceed current levels. 1SW recruitment has been weak and potential escapement in 1993-1994 (Table 2) supports the contention that recruitment in 1998 will probably be fewer than the 35 fish recorded in 1997. Aquaculture fish at the fishway in 1998 will be a function of cage losses in the same year.

ST. CROIX RIVER

The St. Croix River, a USA/Canada international river bordering the State of Maine and Province of New Brunswick, drains southeasterly into Passamaquoddy Bay of the Bay of Fundy. Approximately 1,619 km^2 of the drainage basin is in New Brunswick and 2,616 km^2 is in Maine (Fig. 16). Once a significant producer of Atlantic salmon, the river and stocks succumbed to industrial development - initially cotton mills, then pulp mills, and now dams and headponds at 3 hydroelectric facilities. The main stem and East Branch (84 km), the Chiputneticook lakes (66 km) and Monument Brook (19 km) determine 169 km of the international boundary (Anon MS 1988), the fluvial portions of which comprise the bulk of the potential rearing area for Atlantic salmon.

In 1997, the river was open to hook-and-release fishing July 15-Aug 12. The river is essentially a development project and, based on stocking schedules, current escapements and on-going returns of fish cannot, at least without a dramatic shift in sea survival, be expected to yield any significant number of naturalized salmon in the near future. Recent stocking can be summarized as follows:

Year	Fry[a]	0^+ parr	1^+ parr	Smolts
1995	no record	20,962	0	17,537
1996	1,889	52,120	0	15,583
1997	2,261	100,400	24,000	0

[a] Fry of Penobscot and St. Croix origins via school programs.

Returns

Salmon were counted at the Milltown fishway, just above head-of-tide, between May 1 and October 31, 1997. Summer river discharges were generally low; water temperatures were generally high. As in recent years, counts, scale samples and external characteristics were provided by L. Sochasky[4] (pers. comm.). Interpretation of scales indicated a total return of 44 1SW and 26 MSW salmon (Table 2). Wild returns numbered only seven 1SW and 8 MSW salmon; the MSW component now numbers <3% of their numbers in the mid-1980s. Twenty-six hatchery-origin 1SW were progeny of St. Croix returns reared at Saint John Fish Culture Station and released in 1996 as Adipose-clipped age 1^+ smolts, i.e., return rate of 0.00167 or 30% that of fish released at Mactaquac. Two hatchery-origin MSW fish (Ad-clipped) resulted from the smolts stocked in 1995. Eleven 1SW and 16 MSW salmon were identified as fish of aquaculture origin.

Removals

Removals were restricted to 13 broodstock delivered to Mactaquac Fish Culture Station. Broodstock were mostly August- and October-run fish of both wild (naturalized stock) and hatchery origins.

Conservation requirements

Spawning requirements are based on an area of 3.079 million m^2 of juvenile production habitat and an average requirement of 2.4 eggs 100 m^{-2} (Anon MS 1988). Requirements total 7.389 million eggs. Adult requirements have been calculated on the basis of MSW salmon of male:female ratio 1:1 and females producing an average of 7,200 eggs. Adult requirements total 2,052 salmon. A recent re-evaluation of adult requirements in 1993 acknowledges the potential contribution to egg deposition by 1SW females and allowed that 1,710 MSW and 680 1SW fish might produce the egg requirement.

Escapement

Effective river escapement in 1997 fell to 10 MSW and 33 1SW salmon, lowest of recent years. Salmon of sea-cage origins were assumed to be non-contributors. Eggs were estimated from the length-fecundity relationship ($Y=430.19e^{0.03605X}$) for salmon of the Saint John River. Sea-age, origin, female composition and mean lengths for fish released above the Milltown Dam can be summarized as follows:

Biological characteristics	1SW wild	1SW hatch	1SW aqua	MSW wild	MSW hatch	MSW aqua
Number	7	26	11	8	47	16
Prop. female	0.33	0.20	1.00	0.60	0.64	0.66
Mean length female (cm)	57.0	60.0	57.7	88.0	74.0	70.3

The resultant egg deposition totalled about 84,800 eggs or 1% of requirements. Thirteen broodfish yielded 51,300 eggs that were laid down at Mactaquac Fish Culture Station.

Forecasts

The St. Croix is a restoration project. Mean numbers of wild and hatchery 1SW and MSW returns, 1993-1997 have been 32 and 51 fish, respectively, 70% of hatchery origin (smolts in

[4] St. Croix International Waterway Commission, St Stephen, NB, E3L 2Y7

particular). Neither recent levels of stocking nor natural spawning provide evidence that returns of each of 1SW and MSW fish in 1998 or for that matter 1999, will number more than a few dozen fish.

MANAGEMENT CONSIDERATIONS (SFA 23)

Forecast models and forecasts for 1SW returns destined for Mactaquac Dam in 1998 are more uncertain than those of 1997. This is because factors leading to poor 1SW and MSW returns in 1997 may still be in effect. Increasing winter thermal habitat values in the North Atlantic, 1995-97, did not result in expected increases in returns in 1997; continued increases in the thermal habitat in the winter of 1998 are now regarded with uncertainty rather than optimism. There is now also evidence of substantial ecological changes since the late 1980's in the north Atlantic. Changes include the southward extension of cold water species such as Arctic cod and Greenland halibut, decreases in species diversity in the over wintering area of salmon, increases in sea bird populations, changes in the diets of gannets, (more post smolts in stomach contents), escalating numbers of harp and hooded seals in areas which at time overlap with the expected occurrence of salmon and increasing temperatures and species diversity in the area encompassing Georges Bank and Scotian Shelf (Anon MS 1998). Some of these variables have been found to yield significant negative coefficients in some forecast models, i.e., offer partial explanation to the emerging declining trend in survival and returns over the last decade.

Low returns of 1SW fish in 1997 are interpreted as a low level of stock (1996 smolt class) remaining at sea to return to homewaters as 2SW fish. However, existing models have no comparable values describing the relationship between stock and recruits in proximity to the intercept (models generally intercept y-axis at values greater than zero, i.e., forecast values as reflected by their confidence limits, may be skewed in a positive manner). 1SW forecast models, for both wild and freshwater age-2 and -3 hatchery-origin fish were also noted to have been ineffective over the last few years. Thus, preseason prognoses for 1998 have been based on the assumption that events governing returns in recent years will continue and that expectations for 1998 are best described in terms of the mean/median/modal values of recent years.

Building on the results and experience from 1997, management options should be deferred until meaningful in-season assessments can be conducted. In-season assessments of end-of-season counts at Mactaquac should be maintained to allow adjustments to pre-season allocations of 1SW fish and track escapement of MSW salmon and the attainment of conservation requirements.

The significant shortfalls in egg deposition in 1994-1997 above Mactaquac and in the Nashwaak River have been purported to reflect escapement levels in unmonitored tributaries of the Saint John River (Marshall and Cameron MS 1995). Adult counts on the Kennebecasis River in 1997 and juvenile salmon densities in tributaries below Mactaquac, 1995-1997, are consistent with estimated low escapements above Mactaquac and in the Nashwaak; the interpretation of high redd counts on a prime section of the Hammond River requires further investigation. Egg deposition requirements above Mactaquac, on the Nashwaak, and Kennebecasis are highly unlikely to be met in 1998. 1SW requirements may be met above Mactaquac but not on the Nashwaak River. Returns to McCully fence on the Kennebecasis River, and redd counts on the Hammond River require further interpretation with respect to attainment of conservation requirements for each subdrainage.

Prospects for wild MSW salmon to the Magaguadavic River in 1998 do not exceed a few dozen fish. Similarly on the St. Croix River (a development project) counts of wild 2SW fish are now 3% of those of a decade ago and offer little support for a quick building of the stock. In summary, it is unreasonable to expect that any outer-Fundy salmon rivers of SFA 23 will achieve MSW fish and egg requirements for conservation.

Escapement of aquaculture-origin fish to rivers flowing into Passamaquoddy Bay, Magaguadavic River in particular, continues to be significant even in a season in which no major loses were acknowledged by the industry. Few externally recognizable aquaculture fish were reported at monitoring sites on the Saint John River. Recent proposals and actions have suggested a commitment by government and client groups to the removal of these fish from spawning escapements in monitored rivers.

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PEER REVIEW/OUTSIDE CONSULTATIONS

Vetting of the contents of this document took place during the week of March 9-12, 1998, in Moncton, N.B. Reviewers included regional staff of the Science Branch, DFO, biologists from the provinces of Quebec and New Brunswick, Atlantic Salmon Federation, and DFO Headquarters (Ottawa) Region, staff from the Biology Department, UNB and representatives of the NB Aboriginal Peoples Council. Science Branch publishes a précis of the assessment (DFO Science Stock Status Report D3-13 (1998) and a "Proceedings of peer review and client consultations for diadromous fish stocks (salmon) in the Maritime provinces in 1997" (DFO Can. Stock Assess. Sec. Proceed. Ser. 98/17).

Formal consultations re: status of stocks in 1996 and pre-season forecasts for 1997 were presented to the Zone 23 Salmon Management Advisory Committee (ZMAC) on January 9, and April 28, 1997 and to the Oromocto, Kingsclear and Woodstock First Nations, March 11-12, 1997 and St. Mary's First Nation, July 15, 1997. An in-season assessment of season-end returns to Mactaquac in 1997 was presented to ZMAC 23 on July 31, 1997 and at the same time, discussions were begun on a new and revised strategy involving greater participation by stakeholders through a Management Board/Board of Directors, to input to the management of salmon in the entire Saint John River watershed (previous plan [1992] dealt principally with area above Mactaquac). Clients at ZMAC 23 represented both Canadian and US (Aroostook River and upper Saint John River) interests. Minutes of all ZMAC 23 meetings are available from the Secretary, Conservation and Protection Branch, DFO, P.O. Box 277, Fredericton, N.B. E3B 4Y9.

"Consultations" on available data and possible interpretations, as prescribed within the Science Branch mandate, were conducted at ZMAC 23 on December 4, 1997 and again on January 31, 1998, in Fredericton.

Table 1. Estimated total arrivals of wild and hatchery 1SW and MSW fish destined for Mactaquac Dam on the Saint John River, N.B., 1997.

Sea-age	Components	Wild	Hatch.	Aqua.	Total
1SW					
	Mactaquac counts[a]	380	2,689	0	3,069
	Mactaquac counts adjusted[b]	328	2,778	0	3,106
	Angled MS below Mactaquac	0	0	0	0
	Native Food Fishery	12	105	0	117
	By-catch[c]	3	29	0	32
	Totals	343	2,912	0	3,255
MSW					
	Mactaquac counts[a]	1,147	629	0	1,776
	Mactaquac counts adjusted[b]	995	744	0	1,739
	Native Food Fishery	105	78	0	183
	By-catch[c]	28	21	0	49
	Totals	1,128	843	0	1,971

[a]Hatchery/wild origins per external characteristics in previous assessments; fishway closed Oct 24.

[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 and hook-and-release mortality.

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.

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 cfg	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
Means:																				
1992-96	2,943	2,386	2,259	575	462	262	37	29			87	75	381	77	11	24	12	45	40	6
1987-96	4,820	2,761	2,007	567	-	-	-	-			121	129	-	-	41	71	22	52	-	-
1997 as % of:																				
1992-96	13%	48%	119%	109%	72%	129%	102%	92%			40%	32%	16%	30%	64%	34%	217%	4%	28%	291%
1987-96	8%	42%	134%	111%	-	-	-	-			29%	19%	-	-	17%	11%	117%	4%	-	-

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, 1970-1997.

Year	Wild 1SW	Wild MSW	Hatchery 1SW	Hatchery MSW	Total (W+H) 1SW	Total (W+H) MSW	Aqua[a] 1SW	Aqua[a] 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

[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, 1975-1997, from hatchery-reared smolts released at Mactaquac, 1974-1996.

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[ba]
1974	337,281	0.00	1975	1,771	3,564	28	977	34		6,374	1.890	
75	324,186	0.06	76	2,863	4,831	219	1,129	32		9,074	2.799	
76	297,350	0.14	77	1,645	4,533	36	708	70		6,992	2.351	
77	293,132	0.26	78	777	1,779	49	369	70		3,044	1.038	
78	196,196	0.16	79	799	2,722	100	186	20		3,827	1.951	
79	244,012	0.09	80	3,072	6,687	335	640	59		10,793	4.423	
80	232,258	0.12	81	921	2,861	139	350		1,356	5,627	2.423	
81	189,090	0.08	82	828	1,464	64	267		415	3,038	1.607	
82	172,231	0.06	83	374	857	39	69		225	1,564	0.908	
83	144,549	0.22	84	476	828	36	63	48		1,451	1.004	0.976
84	206,462	0.28	85	454	1,288	82	128	66		2,018	0.977	0.920
85	89,051	1.00	86	64	635	53	93	17		862	0.968	0.868
86	191,495	1.00	87	152	2,063	74	222	52		2,563	1.338	1.170
87	113,439	1.00	88	(717)		15	46	16		794	0.700	0.672
88	142,195	1.00	89	(1.018)		0	107	23		1,148	0.807	0.763
89	238,204	0.98	90	(903)		0	57	20		980	0.411	0.401
90	241,078	0.98	91	(1.490)		88	108	35		1,721	0.714	0.649
91	178,127	0.97	92	(1.123)		26	135	26		1,310	0.735	0.688
92	204,836	1.00	93	(743)		11	60	17		831	0.406	0.406
93	221,403	1.00	94	(828)		37	0	18		883	0.399	0.393
94	225,037	1.00	95	(1.514)		15		15		1,544	0.686	0.661
95[e]	251,759	1.00	96	(2,649)		215	0	29		2,893	1.149	1.140
96	286,400	1.00	97[c]	(1,542)		58	0	16		1,616	0.564	0.558
97	286,485	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 1997 were assigned an origin on the basis of freshwater age (scale reading) and fin condition, i.e., age 1.1 @ 0.555,age 2.1 @ 0.187, age 3.1 @ 0.226 and age 4/5.1 @ 0.032.

[d] 1997 adjustment to return years 1995-97, based on Ad-clipped age1.1 returns from age-0^+ fall fingerlings stocked above Mactaquac, 1993-95. Total estimated returns number 22, 22 and 10 in 1995, 1996 and 1997, respectively (see Table 12).

[e] Revised "smolts released" includes 11,177 age-1 smolts released to the migration channel from Saint John Hatchery.

Table 4b. Estimated total number of MSW returns to the Saint John River, 1976-1997, from hatchery-reared smolts released at Mactaquac, 1974-1995.

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,d]
1974	337,281	0.00	1976	310	1,313	392	267	20		2,302	0.683	
75	324,186	0.06	77	341	1,727	206	417	34		2,725	0.841	
76	297,350	0.14	78	223	1,728	368	165	50		2,534	0.852	
77	293,132	0.26	79	145	747	210	65	21		1,188	0.405	
78	196,196	0.16	80	302	1,992	506	146	46		2,992	1.525	
79	244,012	0.09	81	126	963	252	125		1,262	2,728	1.118	
80	232,258	0.12	82	88	640	462	181		398	1,769	0.762	
81	189,090	0.08	83	44	255	76	17		712	1,104	0.584	
82	172,231	0.06	84	84	722	201	5	103		1,115	0.647	0.560
83	144,549	0.22	85	73	492	189	5	116		875	0.605	0.553
84	206,462	0.28	86	16	471	266	4	40		797	0.386	0.346
85	89,051	1.00	87	4	338	110	4	24		480	0.539	0.453
86	191,495	1.00	88	(511)		150	0	35		696	0.363	0.354
87	113,439	1.00	89	(379)		0	0	20		399	0.352	0.330
88	142,195	1.00	90	(480)		0	0	25		505	0.355	0.170
89	238,204	0.98	91	(359)		62	0	46		467	0.196	0.173
90	241,078	0.98	92	(546)		58	0	32		636	0.264	0.256
91	178,127	0.97	93	(196)		16	0	11		223	0.125	0.121
92	204,836	1.00	94	(435)		10		23		468	0.228	0.214
93	221,403	1.00	95	(440)		5	0	11		456	0.206	0.205
94	225,037	1.00	96	(567)		18	0	15		600	0.267	0.267
95[e]	251,759	1.00	97[c]	(428)		45	0	12		485	0.193	0.186
96	286,400	1.00										
97	286,485											

[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 @ 0.575, age 2.2 @ 0.199, age 3.2 @ 0.221 and repeat spawners @ 0.005.

[d]1997 adjustment to return year 1997 based on Ad-clipped age 1.2 returns from age-0+ fall fingerlings stocked above Mactaquac in 1994. Total estimated returns numbered 9 fish in 1997 (see Table 12).

[e] Revised "smolts released" includes 11,177 age-1 smolts released to the migration channel from Saint John Hatchery.

Table 5. Estimated homewater removals[a] of 1SW and MSW salmon destined for Mactaquac Dam on the Saint John River, N.B., 1997.

	1SW			MSW		
Components	**Wild**	**Hatch**	**Total**	**Wild**	**Hatch**	**Total**
Native Food Fishery						
Below Mact.	12	105	117	105	78	183
Above Mact.	4	240	244	23	59	82
Recreational fishery						
Tobique River	-	-	-	-	-	-
Mainstem abv Mact.	-	-	-	-	-	-
Mainstem blw Mact.	-	-	-	-	-	-
Hook-release mort.[b]	2	12	14	4	3	7
Passed abv Tinker	1	55	56	3	23	26
Passed abv Grand F.	-	-	-	-	-	-
Passed blw Mact.	-	-	-	-	-	-
Hatchery broodfish	0	0	0	153	82	235
mortalities, etc.[c]	8	42	50	26	23	49
Poaching/disease[d]	3	24	27	20	14	34
By-catch	3	29	32	28	21	49
Totals	33	507	540	362	303	665

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

[b] Assumed to be 0.5% of all remaining 1SW and MSW fish respectively, above Mactaquac.

[c] Includes 40 1SW fish for internal sexing and collection of otoliths.

[d] Assumed to be 1% and 2.5% of all remaining 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, 1970-97.

Year	Native[a]		Recreational[b]		Commercial		By-catch[c]		Total	
	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

[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, 1983-1997.

	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	

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

Table 8. Estimates of accessible juvenile salmon production area in the Saint John River, N.B. (Based on measures from air photos and orthophotographic maps; areas with gradient <0.12% are considered non-productive; Amiro 1993.)

Location	*Area (100m^2) units*			*Percentage*		
Tributary	*Total*	*<0.12%*	*Productive*	*Above*	*Below*	*Total*
Above Mactaquac						
Salmon R.	13,500	746	12,754	9.47		3.81
Tobique R.	145,730	67,168	78,562	58.31		23.49
Shikatehawk R.	4,540	-	4,540	3.37		1.36
Becaguimec R.	14,110	3,410	10,700	7.94		3.20
	-	-				
Nackawic R.(acces)@0.6	7,656	-	7,656	5.68		2.29
Mainstem Hrt-B'wood	87,640	87,640	-	0.00		0.00
Mainstem Aroos-GF	50,900	45,500	5,400	4.01		1.61
Little R., Tilley	-	-				
Muniac Str.	-	-				
Mactaquac R.	-	-				
Presquile R.	7,050	240	6,810	5.05		2.04
Meduxnekeag R.	13,960	5,660	8,300	6.16		2.48
Eel R.	-	-				
Shogomoc R.	-	-				
Pokiok R.	-	-				
	-	-				
Monquart R.(inacc)	5,110	-	5,110			
Nackawic R.(inacc)@0.4	5,104	-	5,104			
Total Above (accessible)	345,086	210,364	134,722	100.00		40.28
	-	-				
Below Mactaquac	-	-				
Keswick R.	14,200	4,100	10,100		5.06	3.02
Nashwaak R.	77,110	20,190	56,920		28.50	17.02
Little R. Gr Lk	13,500	3,340	10,160		5.09	3.04
Gaspereau R. Gr. Lk	18,890	650	18,240		9.13	5.45
Salmon R. Gr. Lk	35,970	19,690	16,280		8.15	4.87
Canaan R.	46,600	22,730	23,870		11.95	7.14
Kennebecasis R.	37,290	16,600	20,690		10.36	6.19
Hammond R.	26,400	9,780	16,620		8.32	4.97
Nerepis R.	12,410	5,650	6,760		3.38	2.02
	-	-				
Nashwaaksis R.	3,990	1,420	2,570		1.29	0.77
Portabello Cr. Gr. Lk	1,960	610	1,350		0.68	0.40
Noonan Br., Gr. Lk	-	-				
Burpe Mill Str., Gr. Lk.	2,190	-	2,190		1.10	0.65
Newcastle Cr., Gr. Lk	5,220	-	5,220		2.61	1.56
Coal Cr., Gr. Lk.	5,450	1,730	3,720		1.86	1.11
Cumberland Bay Gr. Lk	1,150	-	1,150		0.58	0.34
Youngs Cove Gr. Lk.	-	-				
Bellisle Cr.	4,360	460	3,900		1.95	1.17
Total Below	306,690	106,950	199,740		100.00	59.72
Total Saint John	651,776	317,314	334,462			100.00

Table 9. Estimated homewater returns, removals and spawning escapement of 1SW and MSW salmon destined for/ above Mactaquac Dam, Saint John River, 1997.

Sea-age	Components	Wild	Hatch	Total
1SW				
	Homewater returns	343	2,912	3,255
	Homewater removals[a]	33	507	540
	Spawners[b]	313	2,429	2,742
	Conservation req'm			4,900
	% of requirement			56
MSW				
	Homewater returns	1,128	843	1,971
	Homewater removals[a]	362	303	665
	Spawners[b]	786	554	1,340
	Conservation req'm			4,900
	% of requirement			27

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

Table 10. Tobique River egg deposition per100 m^2 weighted by smolt age of recruiting 1SW fish to Mactaquac in a single year (derivation in Apps. 1-3), fork length of recruiting 1SW fish (col 5) and estimated numbers of MSW fish (principally 2SW fish) of the same smolt class as 1SW recruits (col 4) that recruit to home (col 7) plus distant fisheries (cols 8 & 9).

Eggs per100 m^2		1SW recruits (wild)			MSW recruits (wild)				Ratio
			Number	Length		Number	Col 7	Col 8	MSW
Years	No.	Year	returns	(cm)	Year	returns	+ Nfld	+Grnld	/1SW
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(7/4)
1965-66		70	3,057	54.7	71	4,715			1.54
1966-67		71	1,709	55.8	72	4,899	5,724	10,599	2.87
1967-68		72	908	57.0	73	2,518	2,595	3,074	2.77
1968-69	42.70	73	2,070	54.6	74	5,811	6,411	10,011	2.81
1969-70	32.06	74	3,656	56.1	75	7,441	9,138	14,437	2.04
1970-71	66.26	75	6,858	55.5	76	8,177	11,913	15,181	1.19
1971-72	122.05	76	8,147	55.5	77	9,712	11,068	15,236	1.19
1972-73	82.47	77	3,977	56.1	78	4,021	5,637	5,975	1.01
1973-74	80.22	78	1,902	56.4	79	2,754	3,303	4,132	1.45
1974-75	391.21	79	6,828	56.4	80	10,924	11,684	16,197	1.60
1975-76	348.93	80	8,482	58.1	81	5,766	7,062	8,051	0.68
1976-77	267.20	81	6,614	56.3	82	5,528	5,934	7,773	0.84
1977-78	287.02	82	5,174	55.4	83	5,783	6,537	8,375	1.12
1978-79	173.40	83	4,555	55.4	84	9,779	11,484	11,694	2.15
1979-80	248.15	84	8,311	55.6	85	10,436	12,335	13,270	1.26
1980-81	229.42	85	6,526	55.8	86	6,128	7,803	9,269	0.94
1981-82	181.65	86	7,904	57.6	87	4,352	4,636	5,942	0.55
1982-83	99.63	87	5,909	58.1	88	2,625	4,132	5,615	0.44
1983-84	248.32	88	8,930	58.6	89	4,072	4,072	6,828	0.46
1984-85	362.09	89	9,522	59.1	90	3,329	4,333	5,075	0.35
1985-86	274.19	90	7,263	58.6	91	4,491	4,491	6,881	0.62
1986-87	208.86	91	6,256	57.8	92	4,104	4,104	5,505	0.66
1987-88	205.60	92	6,683	58.5	93	2,958	2,958	3,450	0.44
1988-89	154.50	93	3,213	58.3	94	1,844	1,844	1,844	0.57
1989-90	148.42	94	2,276	58.9	95	1,654	1,654	2,145	0.73
1990-91	199.53	95	2,168	57.1	96	2,309	2,309	2,309	1.06
1991-92		96	1,326	57.7	97	1,128	1,128	1,128	0.85
1992-93		97	343	57.1	98	____			
1993-94	102.36	98	____						

Table 11. Forecast models and estimates of wild and hatchery 1SW and MSW salmon destined for Mactaquac, Saint John River, 1998.

Sea-age/ origin	Eq'n no.	Model	n; R2adj; p	Forec 98	(90% CL's)	Forecast '97 (90% CL's)
1SW Wild						
	1.	$1SW = 2398.797 + 17.524\ Eggs_{diff}$	22; 0.49; 0.02E-2	4,193	(1,118 - 7,268)	5,183 (2,089 - 8,277)
	2.	$1SW = 22{,}946 + 14.910\ Eggs - 1{,}294.807\ SST_{Jun\ smolt\ yr}$	23; 0.44; 0.001	5,938	(2,545 - 9,331)	
	3.	$1SW = Median\ returns_{1993\text{-}1997}$	5;	$\boxed{2,168}$	(343 - 3,213)	
MSW Wild (Homewaters)						
	4.	$Log_e MSW = 26.761 + 0.152E\text{-}3\ 1SW - 0.337\ Length$	27; 0.81; 0.0E-6	1,950	(1,207 - 3,151)	2,051 (1,310 - 3,210)
	5.	$Log_e MSW = 26.498 + 0.169E\text{-}3\ 1SW - 0.335\ Length$	22; 0.86; 0.0E-6	1,720	(1,081 - 2,737)	
	6.	$MSW = 1SW * Ratio\ MSW/1SW_{mode\ 1978\text{-}97}$ where modal ratio = 1.19 (0.35 - 2.15)	22;	$\boxed{408}$	(120 - 737)	
MSW Wild (Homewaters + Distant)						
	7.	$Log_e MSW = 30.825 + 0.170E\text{-}3\ 1SW - 0.404\ Length$	26; 0.75; 0.0E-6	2,603	(1,333 - 5,083)	2,841 (1,547 - 5,216)
	8.	$Log_e MSW = 27.752 + 0.208E\text{-}3\ 1SW - 0.355\ Length$	22; 0.85; 0.0E-6	1,935	(1,116 - 3,355)	2,255 (1,370 -3,710)
	9.	$Log_e MSW = 22.063 + 0.216E\text{-}3\ 1SW - 0.259\ Length$	13; 0.85; 0.03E-3	1,606	(883 - 2,919)	2,052 (1,208 - 3,487)
	10.	$Log_e MSW = 25.966 + 0.150E\text{-}3\ 1SW - 0.212\ Length - 0.056\ Year_{1SW} - 0.753E\text{-}3\ HI\ Jan_{MSW\ yr}$	26; 0.86; 0.0E-6	1,086	(620 - 1,903)	
1SW Hatch (1-yr smolt)						
	11.	$Rtn\ rate\ 1SW_{arcsine} = -5.041 + 0.0068\ HI_{Jan}$	23 ;0.26; 0.007	0.02236	(0.00765-0.04452)	
		and $Smolts_{97} *$ Rtn rate =		6,406	(2,192 - 12,754)	
	12.	$Rtn\ rate\ 1SW = Rtn\ rate_{median\ 1993\text{-}1997}$	5;	0.00686	(0.00399-0.01149)	
		and $Smolts_{97} *$ Rtn rate =		$\boxed{1,965}$	(1,143 - 3,292)	
1SW Hatch (2-&3-yr smolt)						
	13.	$Prop\ hatch\ rtns_{fw\ age\ 2\&3} = Rtns_{fw\ age\ 2\&3} / Rtns_{fw\ age\ 1\text{-}3\ 1995\text{-}97}$	3;	0.464	(0.445 - 0.489)	
		$1SW\ Rtns_{fw\ age 2\&3}$ =(Rtns age1.1 /prop 1yr) - Rtns age 1.1, where prop. 1yr = (1 - prop hatch $rtns_{fw\ ages\ 2\&3}$)		$\boxed{1,701}$	(916 -3,150)	
MSW Hatch (1-yr smolt)						
	14.	$MSW = 289.710 + 0.2765\ 1SW$	22; 0.75; 0.0E-6	737	(0 - 1,538)	
	15.	$MSW = 5{,}677.3 + 0.1818\ 1SW - 59.521\ Yr_{1SW}$	22; 0.84; 0.0E-6	198	(0 - 892)	
	16.	$Rtn\ rate\ MSW = Rtn\ rate_{median\ 1993\text{-}1997}$	5;	0.00228	(0.00125-0.00267)	
		and $Smolts_{96} *$ Rtn rate =		$\boxed{653}$	(358 - 765)	
MSW Hatch (2- & 3-yr smolt)						
	17.	$Prop\ hatch\ rtns_{fw\ age\ 2\&3} = Rtns_{fw\ age\ 2\&3} / Rtns_{fw\ age\ 1\text{-}3\ 1996\text{-}97}$		0.413	(0.401 - 0.425)	
		$MSW\ Rtns_{fw\ age 2\&3}$ =(Rtns age1.1 /prop 1yr) - Rtns 1-yr		$\boxed{459}$	(240 - 565)	
Total cautious estimates:		1SW wild + hatch (2,168 + 3,666) =		**5,834**	**(2,402 - 9,655)**	
		MSW wild + hatch (408 + 1,112) =		**1,520**	**(718 - 2,067)**	

Table 12. Hatchery releases contributing to adult returns to Mactaquac in 1997, and estimates (based on external characteristics and age interpretation from scales) of 1SW and MSW returns and their return rates. Numbers do not include releases of unfed fry hatched from a total of 50,000 eggs provided to stakeholders for stream-side incubation in each of 1991, 1992 and 1993.

Release					*Returns in 1997*			
Year	*Loc*	*Stage*	*Number*		*Age*	*1SW*	*MSW*	*Rate*
1996	At	1-yr smolt	286,400		1.1	1,597		0.00558
1996	Bl	1-yr smolt (Nashw)	9,017		1.1	9		0.00100
1995	Abv	Fall fing [9.5-10.5cm]	87,340		1.1	3		0.00003
1995	Abv	Fall fing-*Ad clip ["]*	226,391		1.1	7		0.00003
1994	Abv	Feeding fry	417,840	c	2.1			
1994	Abv	Feeding fry-*Ad clip*	30,000		2.1			
1994	Abv	Fall fing [10.5-14cm]	126,684		2.1	2		0.00002
1994	Abv	Fall fing-*Ad clip ["]*	253,730		2.1	4		0.00002
1994	Abv GF	Fall fing [7.5cm]	159,311		2.1	539		
1994	Abv GF	Feeding fry	565,717	c	2.1			
1993	Aroos	Adults(eggs'94)	137,000	c	2.1			
1993	Abv GF	Adults(eggs'94)	123,630	c	2.1			
1993	Abv	Feeding fry/sum fing	306,558	c	3.1			
1993	Abv	Fall fing [10.5-13cm]	170,065		3.1	5		0.00003
1993	Abv	Fall fing-*Ad clip ["]*	99,939		3.1	3		0.00003
1993	Abv GF	Fall fing [10-11cm]	173,033		3.1	650		
1993	Abv GF	Summer fing [5cm]	290,484	c	3.1			
1992	Aroos	Adults(eggs'93)	779,000	c	3.1			
1992	Abv GF	Adults(eggs'93)	809,000	c	3.1			
	Total juveniles (n/c smolts)		2,907,092					
1995	At	1-yr smolt	251,759		1.2		469	0.00186
1995	Bl	1-yr smolt(Nashw)	13,283		1.2		7	0.00053
1994	Abv	Fall fing [10.5-14cm]	126,684		1.2		3	0.00002
1994	Abv	Fall fing-*Ad clip ["]*	253,730		1.2		6	0.00002
1993	Abv	Feeding fry	306,558	c	2.2			
1993	Abv	Fall fing [10.5-13cm]	170,065		2.2		4	0.00002
1993	Abv	Fall fing-*Ad clip ["]*	99,939		2.2		2	0.00002
1993	Abv GF	Fall fing [10-11cm]	173,033		2.2		152	
1993	Abv GF	Summer fing [5cm]	290,484	c	2.2			
1992	Aroos	Adults(eggs'93)	779,000	c	2.2			
1992	Abv GF	Adults(eggs'93)	809,000	c	2.2			
1992	Abv	Fall fing [10-13cm]	508,445	a	3.2			
1992	Abv	Unfed/frysum+fall fing	600,441	a	3.2		168	
1991	Aroos	Adults(eggs'92)	370,000	c	3.2			
1991	Abv GF	Adults(eggs'92)	370,000	c	3.2			
		Repeat spawners			-.-.-		28	
	Total juveniles (n/c smolts)		2,529,379					
Totals						2,819 b	839 b	

[a] Includes 135,309 fall fingerlings and 411,678 fry (5.8-6.4cm) to above Grand Falls.

[b] Excludes 93 fish of age 4.1 & 5.1 and 4 fish of age 4.2+ or 5.2+.

[c] Not expected to have been distinguishable from wild fish upon return.

Table 13. Numbers of hatchery fish released at (At), above (Abv) or below (Bl) Mactaquac that have potential to return to Mactaquac, possible return rates and, potential numbers of 1SW and MSW fish returning to the Saint John River and destined for Mactaquac in 1998. (Numbers do not include releases of unfed fry hatched from a total of 50,000 eggs provided to stakeholders for stream-side incubation in each of 1992 and 1993, and 150,000 in 1994 and 8,000 to Aroostook in 1995.)

Release				*Potential returns in 1998*			
Year	*Loc*	*Stage*	*Number*	*Age*	*Rate[e]*	*1SW*	*MSW*
1997	At	1-yr smolt	286,485	1.1	0.00686	1,965	
1995	Abv	Feeding fry	494,781 c	2.1	median value, 1993-97; see Table 11, eq'n 12.		
1995	Abv	Summer fing [6.5cm]	105,878	2.1			
1995	Abv	Fall fing [9.5-10.5cm]	87,340	2.1			
1995	Abv	Fall fing-*Ad clip ["]*	226,391	2.1			
1994	Aroos	Adults(eggs'95)	133,200 c	2.1			
1994	Abv GF	Adults(eggs'95)	93,600 c	2.1			
1994	Abv	Feeding fry	417,840 c	3.1			
1994	Abv	Feeding fry-*Ad clip*	30,000	3.1		1,701	
1994	Abv	Fall fing [10.5-14cm]	126,684	3.1	based on ratio of fw age 2&3 returns to fw age 1- 3 returns, 1995-97, see Table 11, eq'n 13.		
1994	Abv	Fall fing-*Ad clip ["]*	253,730	3.1			
1994	Abv GF	Fall fing [7.5cm]	159,311	3.1			
1994	Abv GF	Feeding fry	565,717 c	3.1			
1993	Aroos	Adults(eggs'94)	137,000 c	3.1			
1993	Abv GF	Adults(eggs'94)	123,630 c	3.1			
	Total juveniles (n/c smolts)		2,467,672				
1996	At	1-yr smolt	286,400	1.2	0.00228		653
1996	Bl	1-yr smolt(Nashw)	9,017	1.2	mean value, 1993-97; see table 11, eq'n 16		
1994	Abv	Feeding fry	417,840 c	2.2			
1994	Abv	Feeding fry-*Ad clip*	30,000	2.2			
1994	Abv	Fall fing [10.5-14cm]	126,684	2.2			
1994	Abv	Fall fing-*Ad clip ["]*	253,730	2.2			
1994	Abv GF	Fall fing [7.5cm]	159,311	2.2			
1994	Abv GF	Feeding fry	565,717 c	2.2			
1993	Aroos	Adults(eggs'94)	137,000 c	2.2			459
1993	Abv GF	Adults(eggs'94)	123,630 c	2.2	based on ratio fw age 2 & 3 returns to total returns 1996-97; see Table 11;eq'n 17.		
1993	Abv	Feeding fry/sum fing	306,558 c	3.2			
1993	Abv	Fall fing [10.5-13cm]	170,065	3.2			
1993	Abv	Fall fing-*Ad clip ["]*	99,939	3.2			
1993	Abv GF	Fall fing [10-11cm]	173,033	3.2			
1993	Abv GF	Summer fing [5cm]	290,484 c	3.2			
1992	Aroos	Adults(eggs'93)	779,000 c	3.2			
1992	Abv GF	Adults(eggs'93)	809,000 c	3.2			
		Repeat spawners		-.-.-			
	Total juveniles (n/c smolts)		2,593,361				
Totals						3,666	1,112

[c] Not expected to be distinguishable from wild fish upon return.

Table 14. Results of the electrofishing surveys in the Saint John watershed, 1997.

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																
Hammond River																
	Smithtown	2	9	3	1	1375	58	7	0	65	10	1	0.15	28.3	3.4	0.0
	Hanford Brook	3	9	4	1	2298	392	101	0	152	51	29	0.37	46.3	11.2	0.7
	Burke's Farm	4	9	3	2	1362	432	91	0	450	78	49	0.39	81.9	17.1	0.2
	Hillsdale	5	8	27	1	1632	719	194	0	893	103	64	0.39	114.2	29.9	0.9
Kennebecasis River																
	Mt. Pisgah, Smiths Creek [2]	1	8	11	2	1960	92	22	4	119	29	9	0.29	16.1	4.4	0.1
	Penobsquis	3	8	12	2	1287	427	13	2	380	10	5	0.42	79.6	2.8	0.0
	South Branch	4	8	12	2	987	0	0	0	0	0	0	-	0.0	0.0	0.0
	Goshen	5	8	11	2	1560	242	53	5	215	34	27	0.49	31.9	7.4	0.2
	Millstream	6	8	11	2	1469	344	24	2	322	14	10	0.46	50.4	3.3	0.5
Nashwaak River																
	Penniac Stream	1	8	12	1	750	34	41	0	24	27	10	0.28	15.9	15.0	4.2
	Above Durham Bridge	2	7	15	2	1000	147	3	0	142	0	1	1.00	14.7	0.3	0.0
	Tay River	3	7	17	1	1283	87	55	0	57	20	14	0.42	16.1	9.8	0.3
	MacKenzie Brook	4	7	28	2	1180	0	30	0	0	15	6	0.31	0.0	6.2	1.9
	Above Nashwaak Bridge	5	7	28	2	1970	58	9	0	63	11	1	0.14	20.9	3.2	0.0
	Below Stanley [2,3]	7	7	29	2	1381	22	9	0	34	19	3	0.16	10.1	4.1	0.0
	Above Stanley	8	7	29	2	1331	78	6	0	94	6	1	0.22	26.4	2.0	0.0
	Cedar Bridge	9	7	30	1	1241	17	17	0	20	11	5	0.34	4.0	3.0	1.0
	Doughboy Brook	10	7	30	1	1723	30	17	0	22	25	6	0.21	8.3	4.4	0.3
Keswick River																
	Jones Forks	1	8	12	1	817	160	28	0	174	31	10	0.25	77.0	9.6	3.9
	Stoneridge	3	9	22	2	1075	154	8	0	158	6	3	0.36	39.4	2.0	0.0
	Hayne	4	9	23	1	1117	63	28	0	58	10	8	0.47	12.1	4.9	0.5
	Barton	5	9	22	1	980	69	22	0	83	19	11	0.38	18.6	4.8	1.1
Tributaries Above Mactaquac Dam																
Meduxnekeag River																
	Marven Brook	1	7	28	2	363	7	16	0	16	10	10	0.52	3.9	6.6	1.9
	Belleville [3]	2	7	28	2	2348	0	2	1	2	1	0	0.45 [1]	0.0	0.3	0.0
	North Br. @ Jackson Falls	3	7	29	1	362	36	14	0	14	5	5	0.52	19.1	6.9	0.6
	Hagerman Brook @ Oakville	4	7	29	1	424	0	9	0	0	8	3	0.31	0.0	6.8	0.0
	North Br. @ Carter Brook	5	7	29	1	1349	27	12	0	10	3	0	0.45 [1]	4.4	1.9	0.1
Becaguimec River																
	Coldstream (Bannon)	1	8	5	2	1210	52	21	0	37	8	10	0.57	7.6	3.1	0.0
	East Coldstream	2	8	5	2	1063	1	9	0	0	3	5	0.64	0.2	1.3	0.0
	South Branch (County Line)	3	8	6	2	558	8	16	0	17	9	5	0.38	3.8	7.5	0.0
	North Branch (Cloverdale)	4	8	5	2	1396	79	9	0	74	10	2	0.21	26.4	3.0	0.0
	North Branch (Carlisle)	5	8	6	2	1395	14	39	0	23	10	18	0.65	1.6	4.2	0.1
Shikatehawk River																
	Lockharts Mill	1	8	5	2	1283	186	191	1	205	136	80	0.37	38.7	28.7	11.3
	Gordonsville	2	8	5	2	936	393	69	6	367	64	23	0.29	143.3	23.2	4.2
	West Glassville	3	8	6	2	1491	709	203	3	630	121	79	0.40	118.2	30.5	3.8
	Centre Glassville	4	8	6	2	1048	16	9	1	12	12	2	0.20	7.4	2.2	2.5
	Kenneth [3]	5	8	6	2	843	0	33	6	0	24	16	0.48	0.0	4.3	5.3
Salmon River																
	Sutherland Brook	1	8	18	2	605	103	22	3	148	9	11	0.64	26.6	6.4	0.0
	Sutherland Brook	1.2	8	18	2	417	72	25	0	67	22	8	0.28	61.4	19.0	2.3
	Sutherland Brook	1.3	8	18	2	280	17	7	0	12	2	5	0.70	8.6	3.6	0.0
	Above Simpson Brook	2	8	19	2	618	0	0	0	0	0	0	-	0.0	0.0	0.0
	Above Poitras Brook	3	8	19	2	875	0	0	0	0	0	0	-	0.0	0.0	0.0
Tributaries Above Beechwood and Tobique Narrows Dams																
Tobique River																
	Fyke Net	1	7	14	3	1060	17	22	4	21	14	9	0.48	3.3	5.1	0.0
	Ben's Pole Road	2	7	21	1	1425	48	18	1	48	20	3	0.17	20.0	7.7	0.2
	Saddler Brook Road	3	7	14	3	990	0	6	0	2	4	0	0.33 [1]	0.0	0.9	0.9
	Trouser's Lake Road	4	7	21	2	912	58	20	3	46	13	4	0.31	20.7	6.6	1.6
	Burma Road	5	7	29	2	1298	41	21	4	79	9	4	0.41	7.7	4.3	0.4
	Campbell Landing	7	7	22	2	1353	78	28	2	68	9	5	0.42	13.8	3.5	1.8
	Shingle Gulch	8	7	22	2	1050	81	14	0	76	14	2	0.17	46.3	3.7	4.3
	Hazelton Landing	9	7	30	2	1383	28	29	0	43	26	8	0.25	8.1	6.8	1.6
	Anvil Brook	10	7	30	2	928	22	12	0	22	18	2	0.13	17.8	6.7	3.0
	South Branch	13	7	30	2	1044	0	30	2	0	23	11	0.36	0.0	5.9	2.6
	Pat's Crossing	14	7	29	2	1128	39	8	0	31	1	1	0.62	5.6	1.2	0.0
	Above Lawson Brook	15	7	29	2	666	7	10	2	7	4	2	0.48	2.3	3.6	0.2
	Nation House	17	6	30	2	810	31	1	0	19	6	0	0.33 [1]	11.2	0.3	0.1
	Bob Barr	18	6	30	2	1549	31	32	11	11	20	4	0.26	7.6	10.3	0.3
	Rattray's Home	19	7	3	1	1555	177	12	0	189	17	0	0.33 [1]	33.5	2.1	0.2
	Pearl Road	20	7	3	1	1120	0	13	6	0	16	5	0.38	0.0	3.3	1.2

[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.11.
[3] - site not used in the calculations of Fig. 8.
- all age 1+ and 2+ densities were calculated based on mark-recapture calculations, and age 0+ were estimated based on a capture efficiency from parr.

Table 15. Atlantic salmon redd counts on an 11.75 km (25.7% of the main stem) section of the Hammond River. The section is equivalent to 160,610 m^2 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.

Note:

* Main stem considered as being from the confluence of the North Hammond downstream to the bar above Steele's Pool (1st spawing 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.

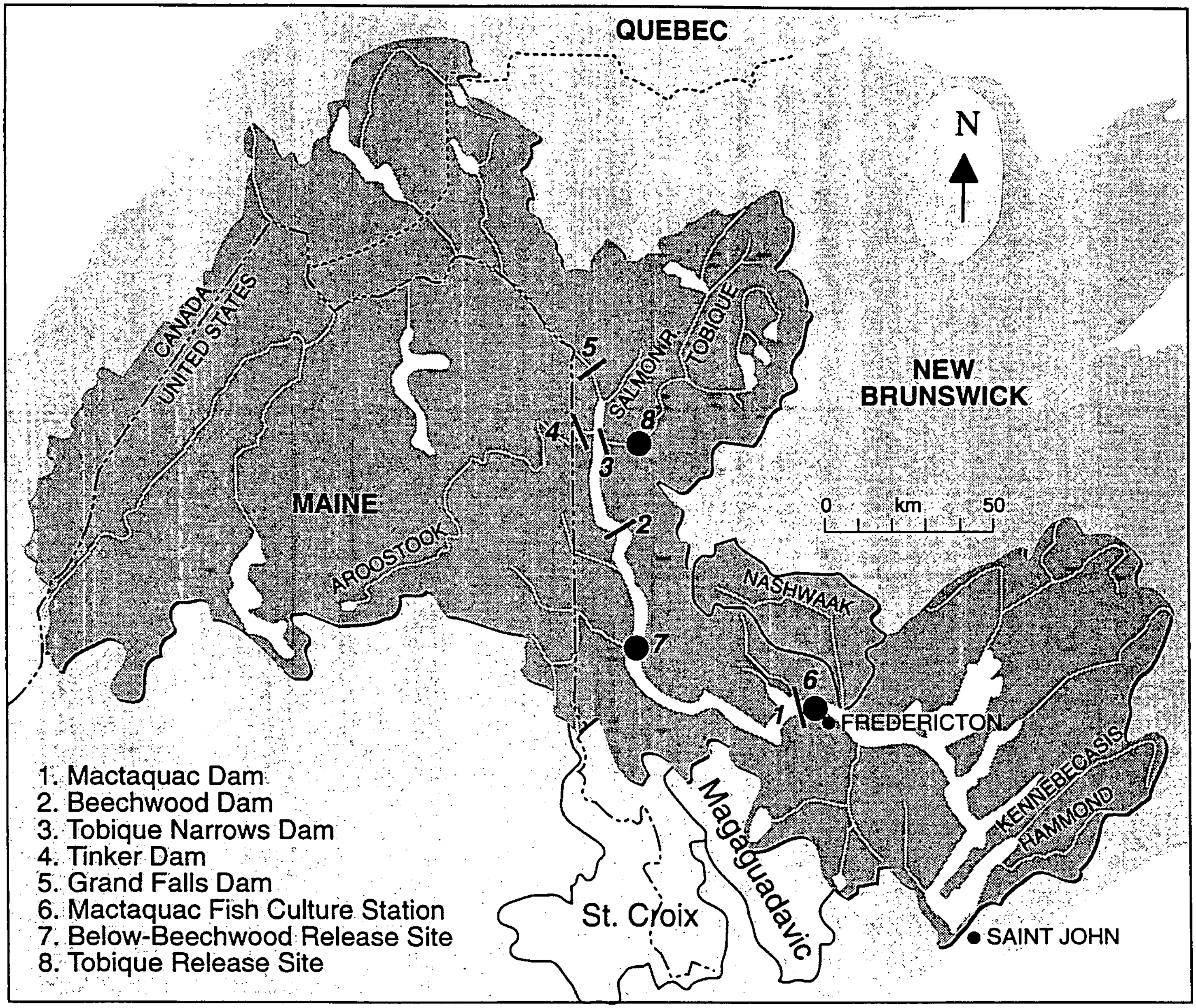


Fig. 1. Magaguadavic, St. Croix and Saint John river drainages including Nashwaak, Kennebecasis and Hammond rivers and major tributaries, dams and principal release sites for Atlantic salmon above Mactaquac. Fish trapping locations on Nashwaak, Kennebecasis, Magaguadavic and St. Croix drainages shown on Figs. 9, 12, 14 and 16.

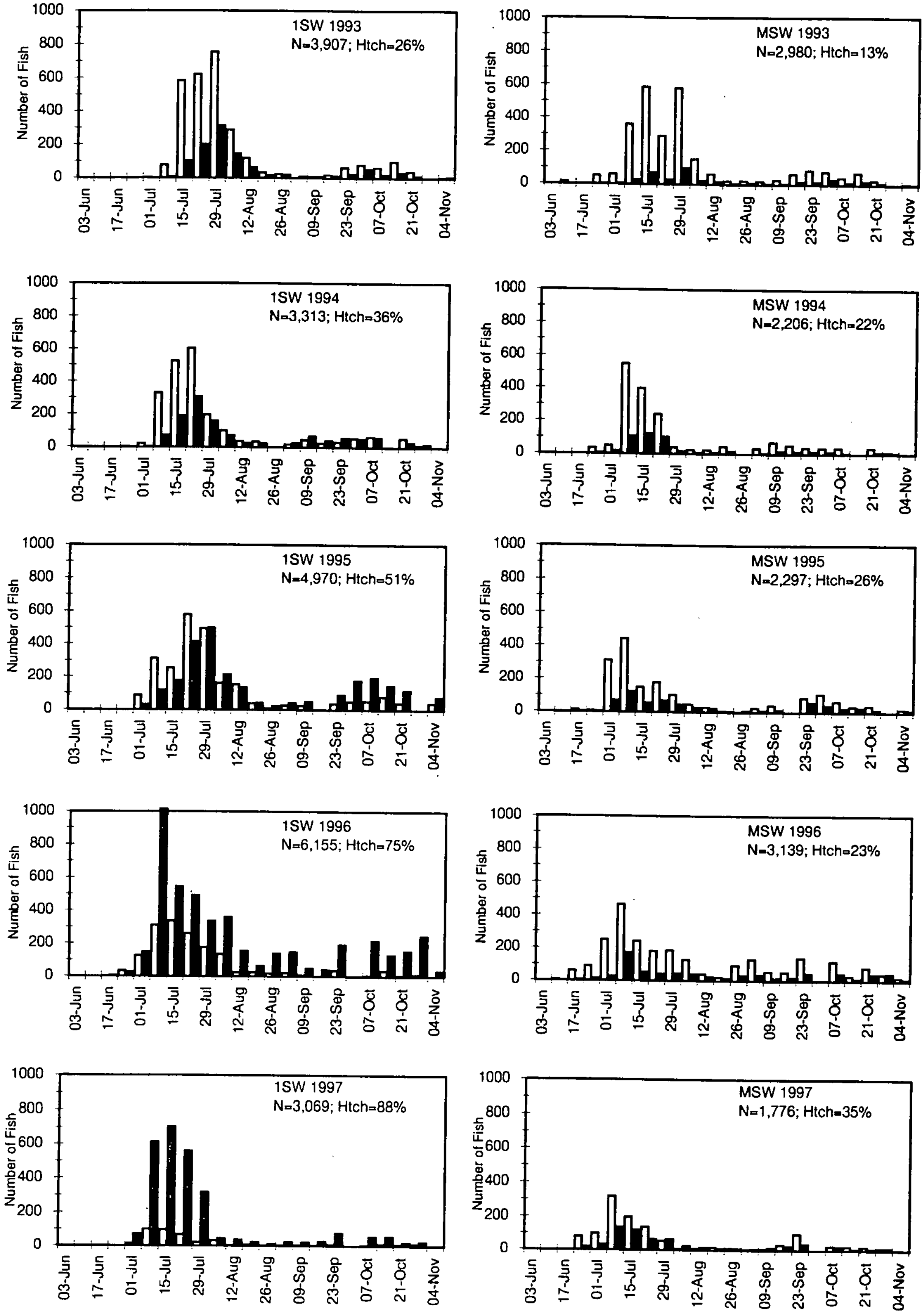


Fig. 2. Weekly unadjusted counts of wild (open) and hatchery (solid) 1SW and MSW salmon at the Mactaquac sorting facilities, 1993-1997.

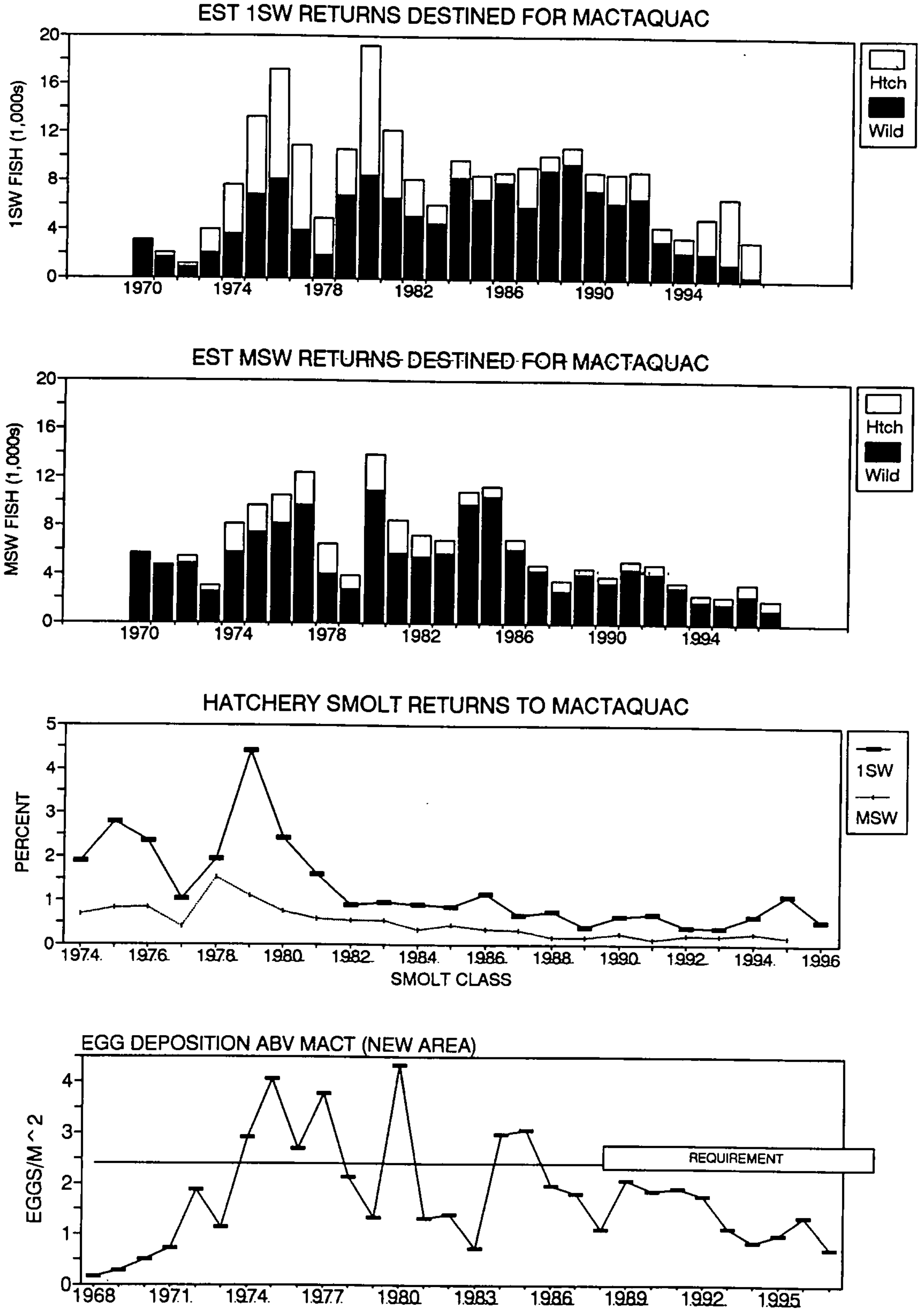
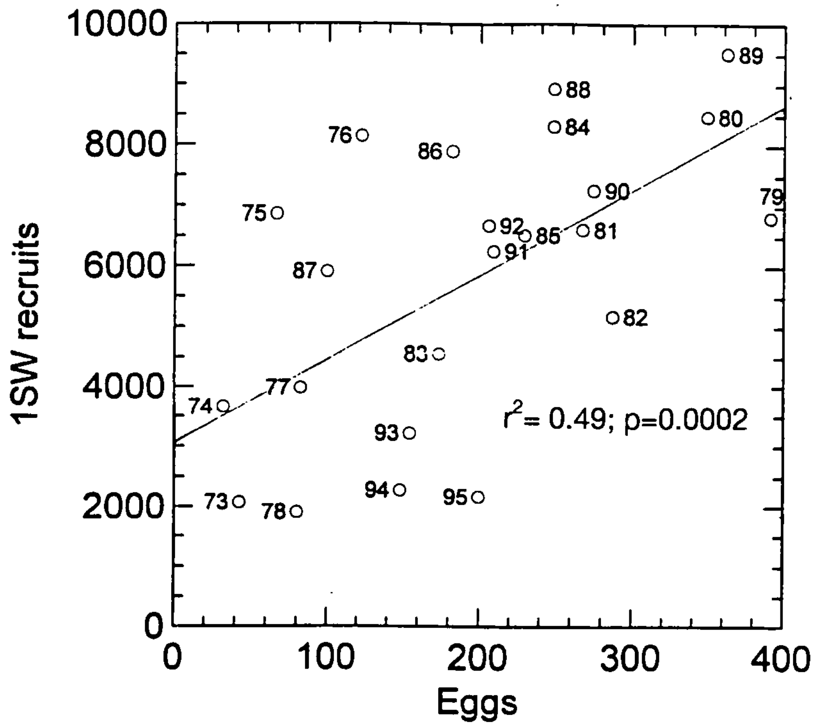


Fig. 3. Stock status of Atlantic salmon, Saint John River above Mactaquac, various years to 1997.



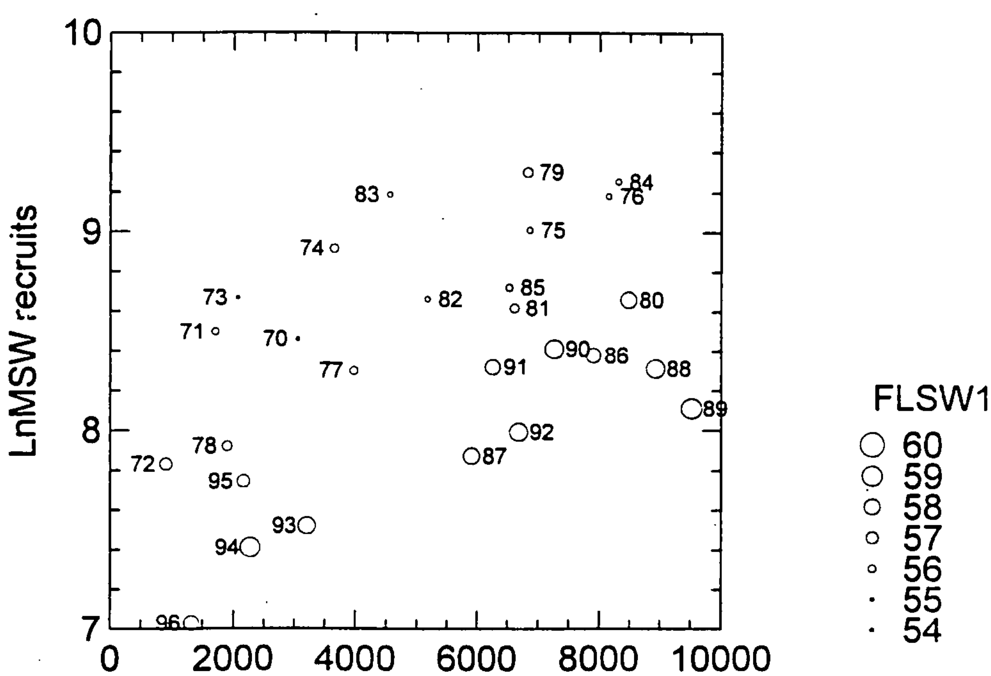
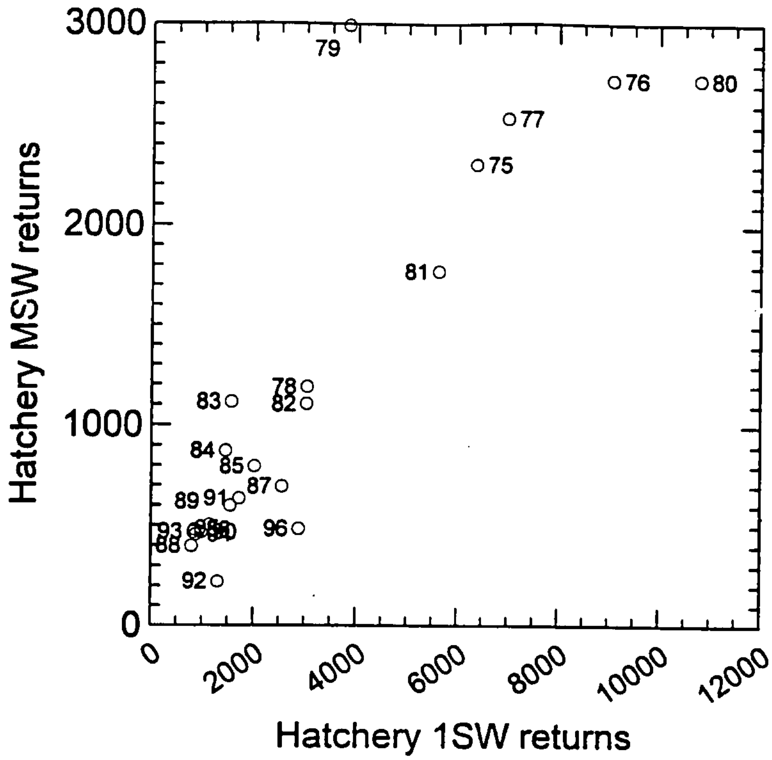


Fig. 4. Plots of 1SW recruits on eggs (above) and MSW recruits on 1SW recruits with symbols sized by the influence of 1SW Fork Length (below).



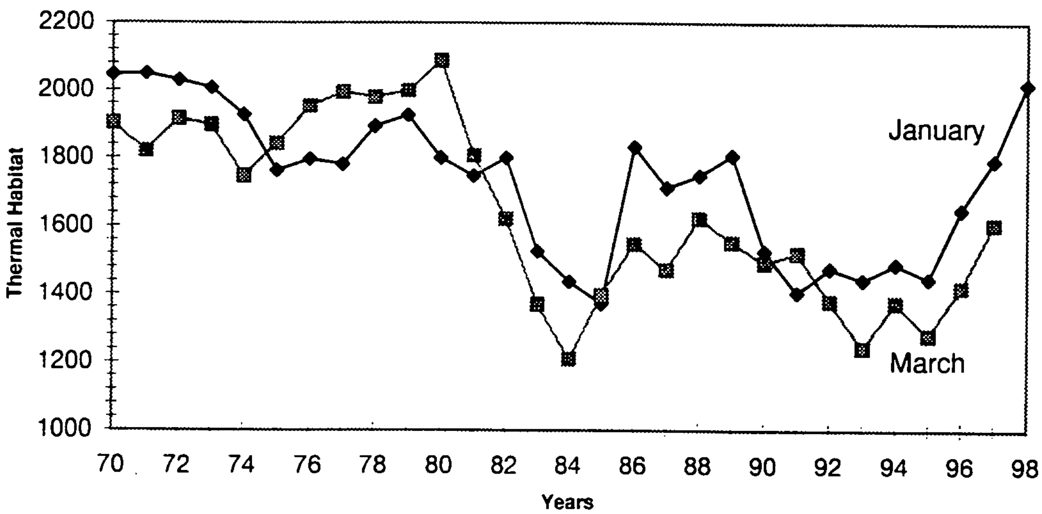


Fig. 5. Plots of hatchery-smolt-origin MSW returns on hatchery-smolt-origin 1SW returns (above) and January and March index of thermal habitat in the N.W. Atlantic,1970- 1998 (below).

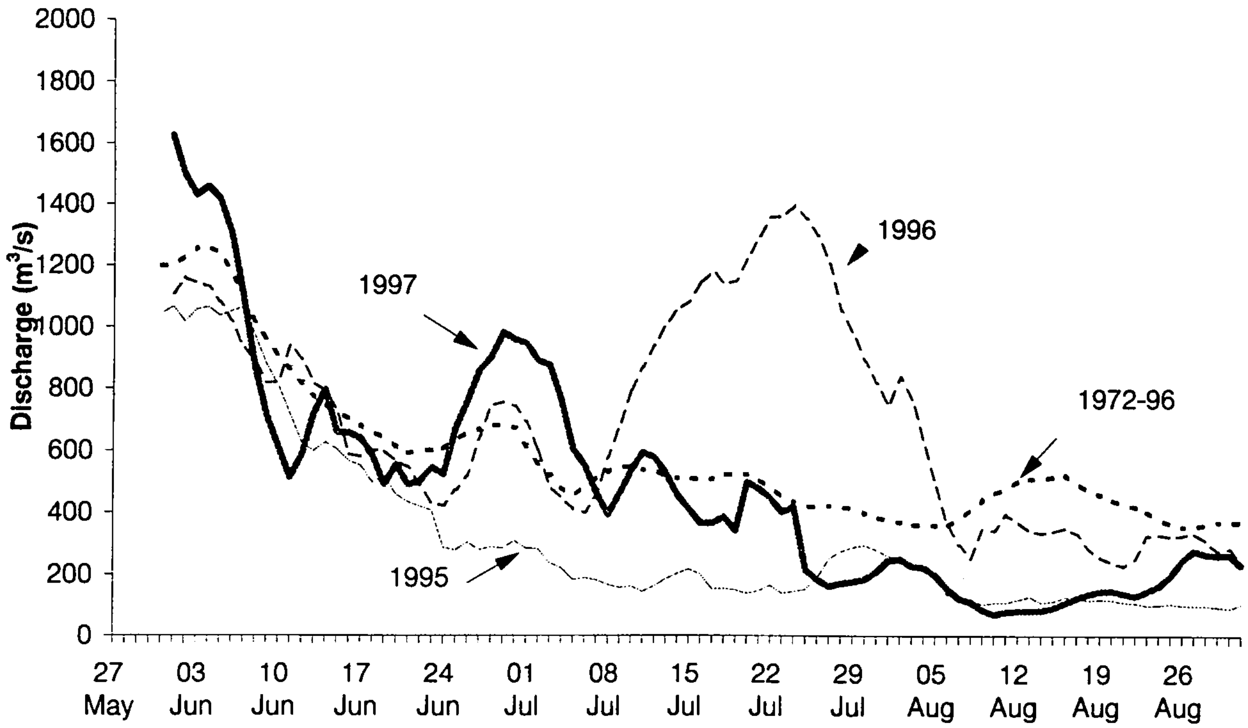
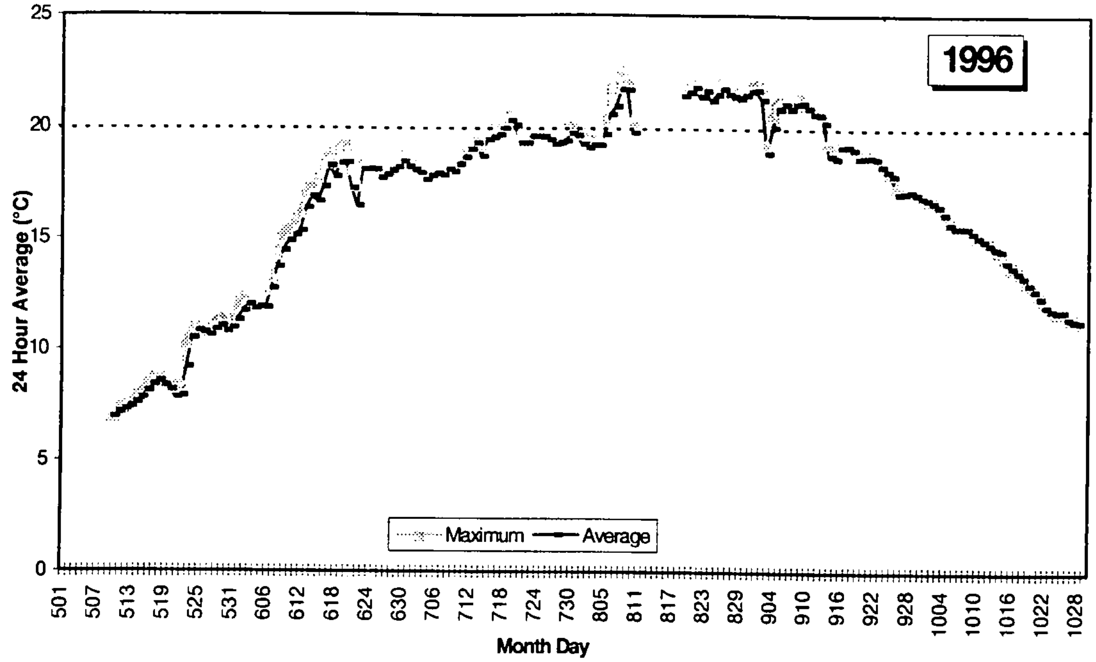


Fig. 6. Five-day moving averages of mean daily river discharge at Mactaquac, June through August, various years inc. 1997.



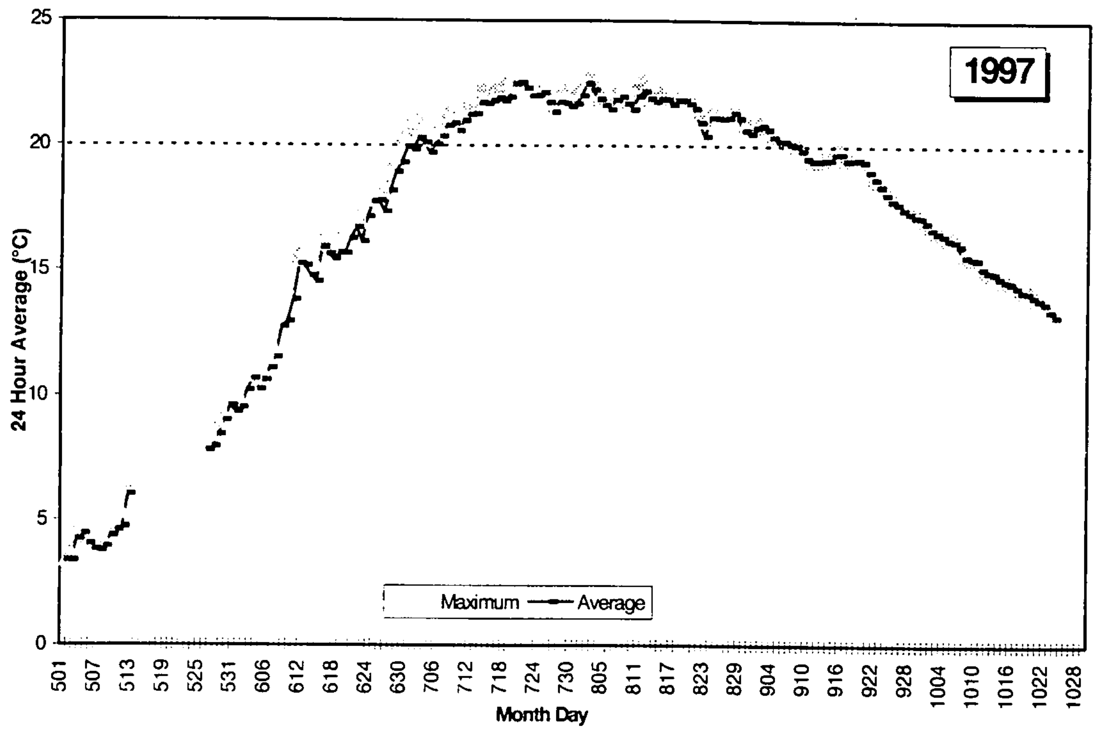


Fig. 7. Daily mean and maximum water temperatures in tailrace, Mactaquac Dam, 1996 and 1997.

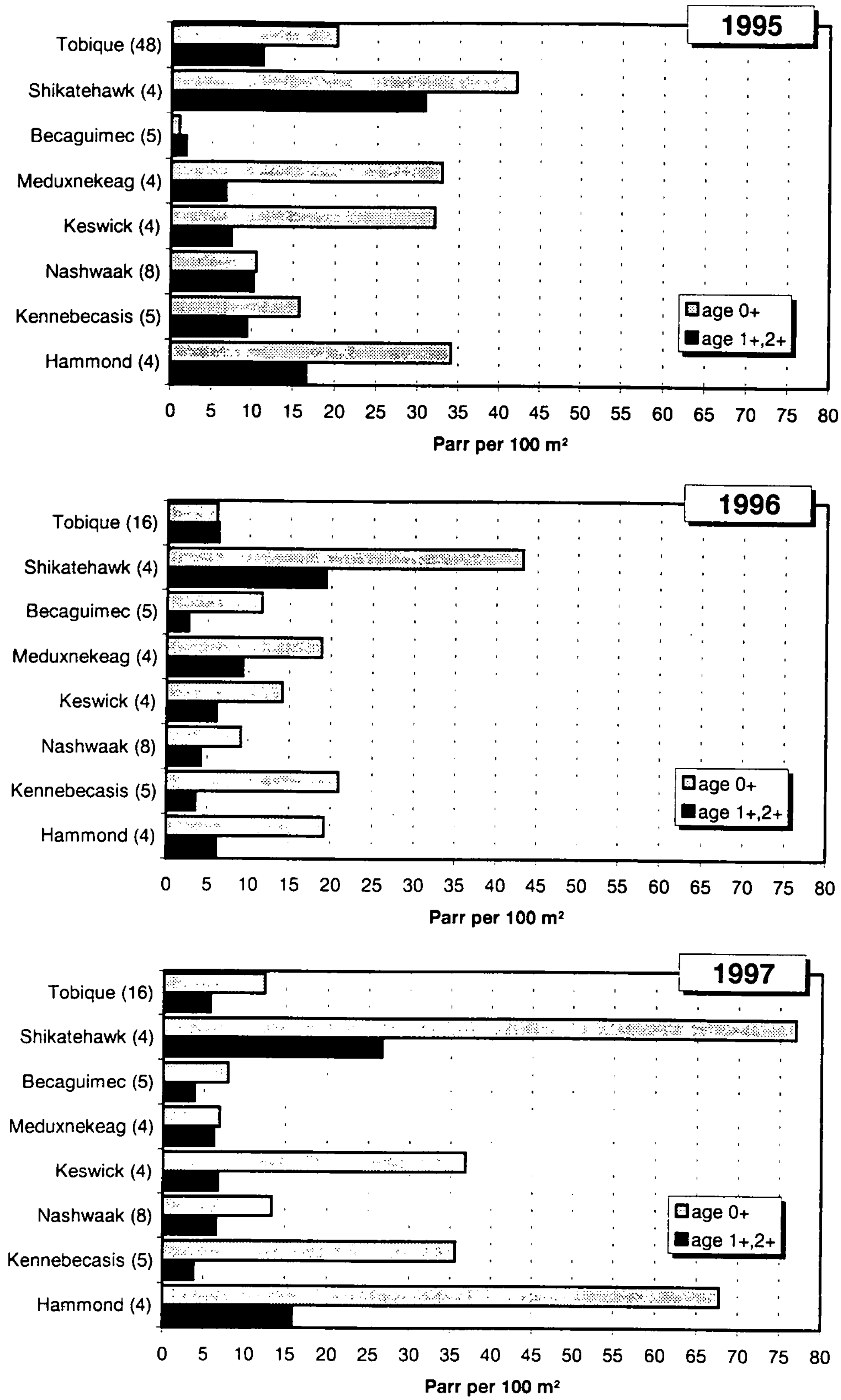


Fig. 8. Average parr densities for tributaries (no. of sites) of the Saint John River, 1995-97. Tobique 1995 - includes sites done by Tobique Rec Fish Group.

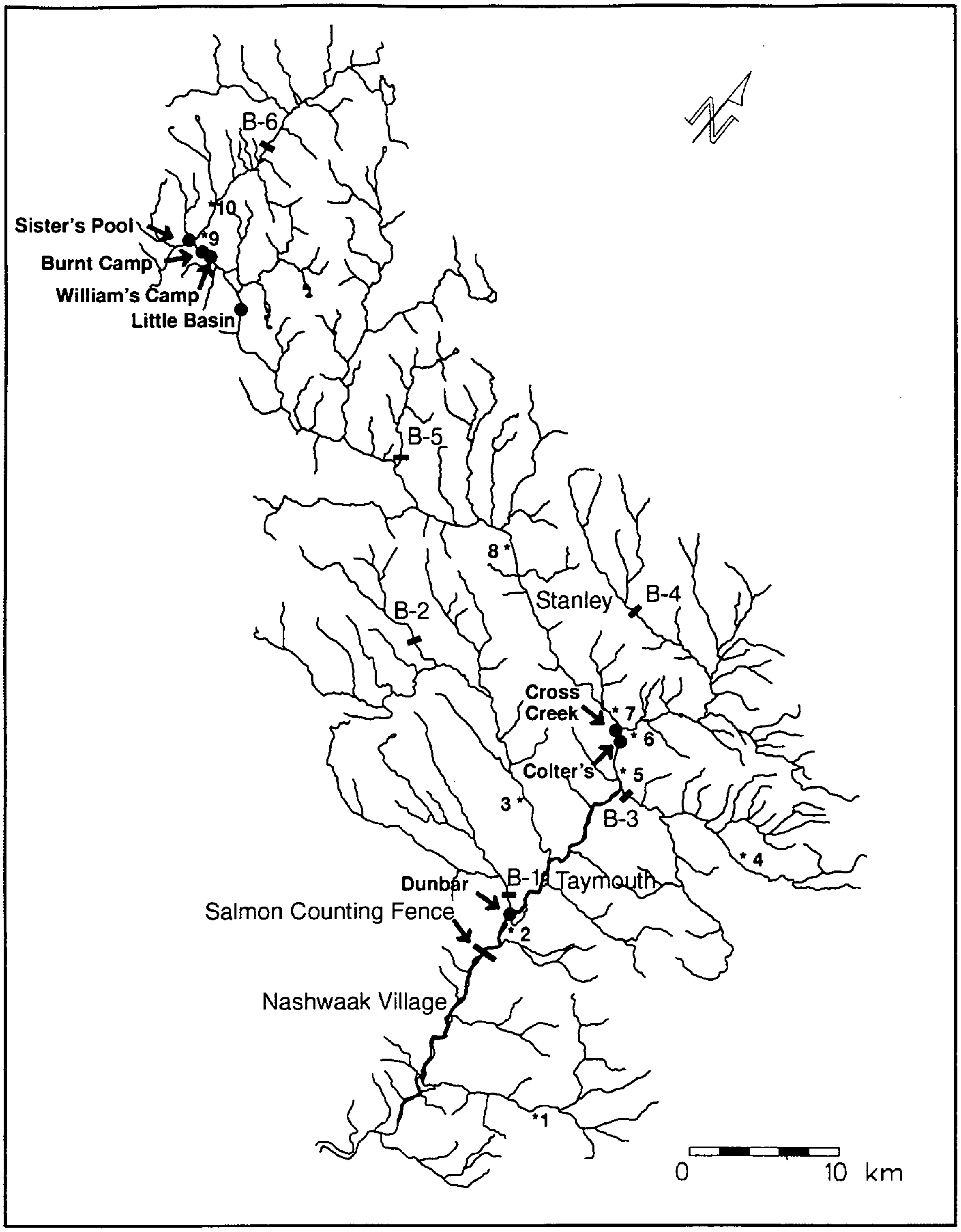


Fig 9. Nashwaak River, site of counting fence, seined pools (●), electrofishing sites (*) and barriers [B-] to migration of salmon.

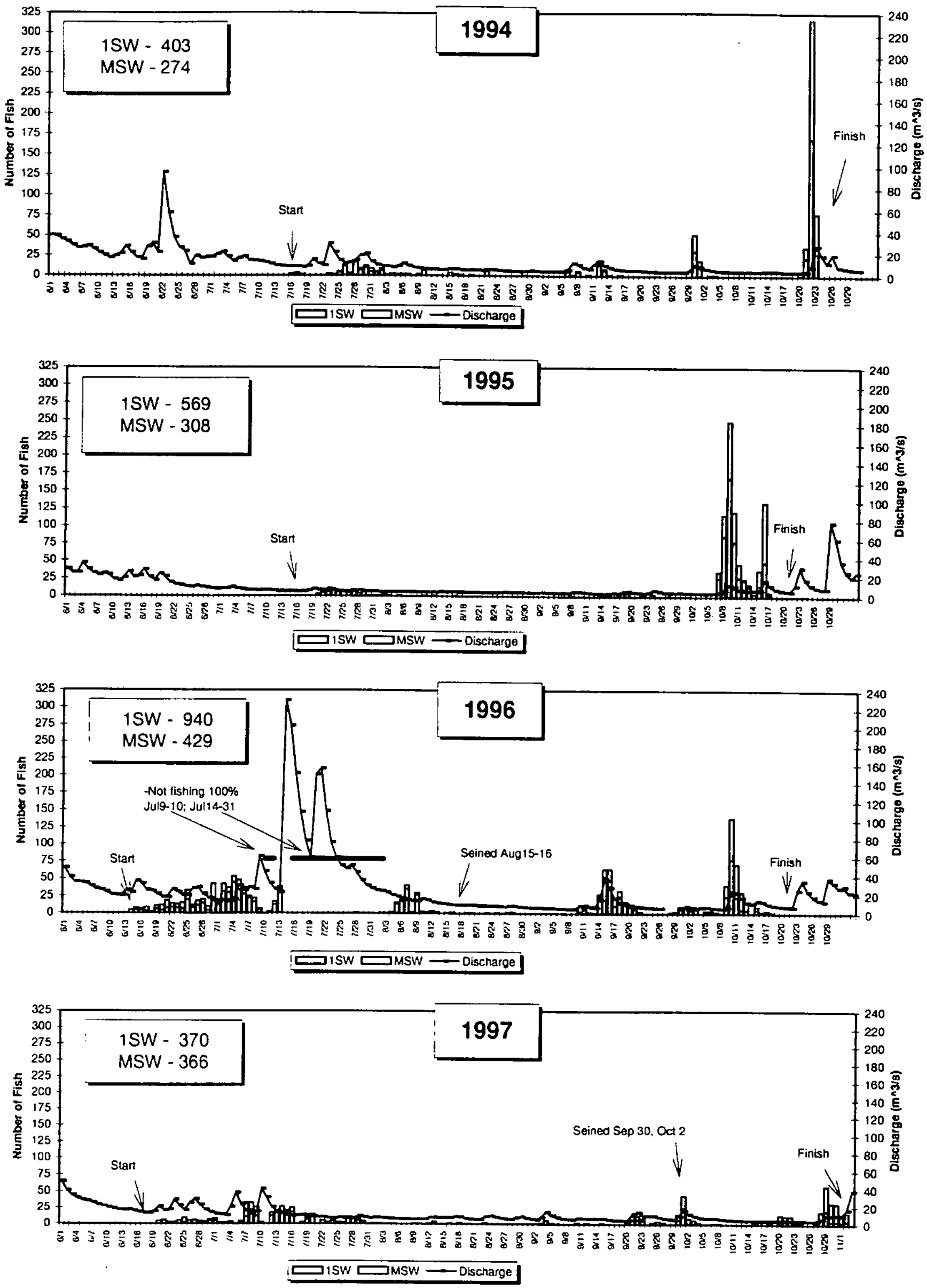
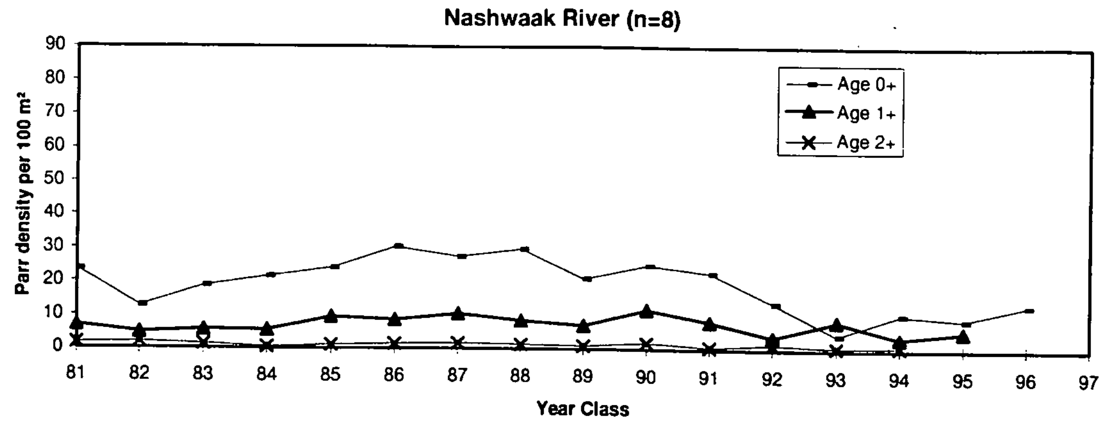
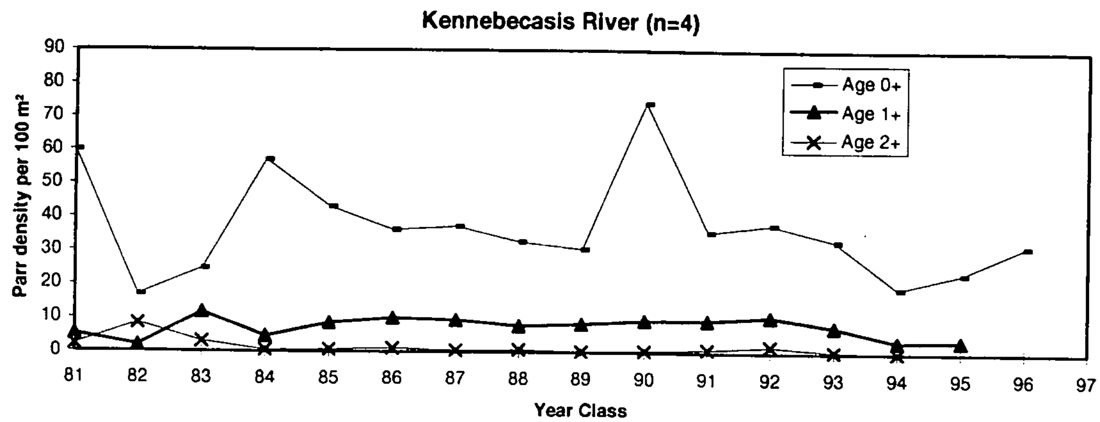


Fig. 10. Average daily discharge (m^3 s^{-1}) at Durham Bridge and adjusted fence counts of 1SW and MSW salmon, Nashwaak River, 1994, 1995, 1996 and 1997.





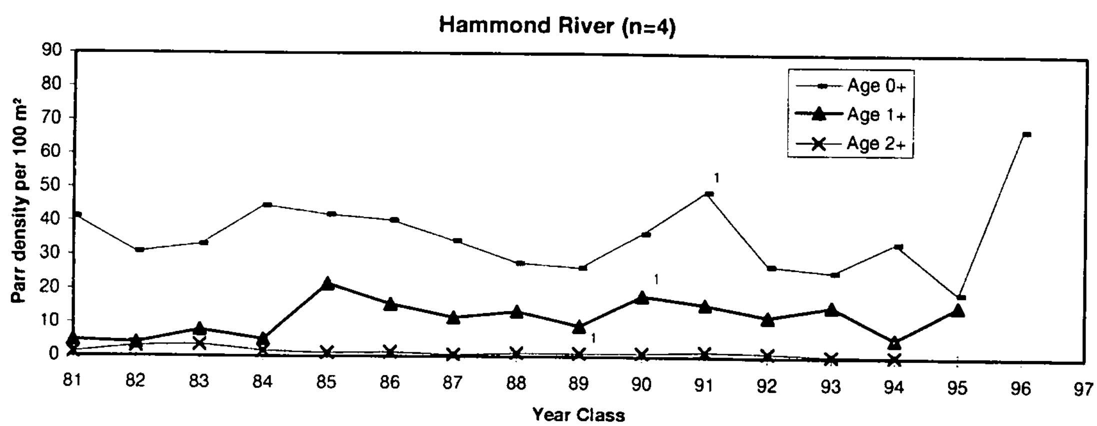


Fig. 11. Juvenile Atlantic salmon densities on Nashwaak, Kennebecasis and Hammond Rivers by year class.
[1] - only two of the four index sites on the Hammond River were electrofished in 1992.

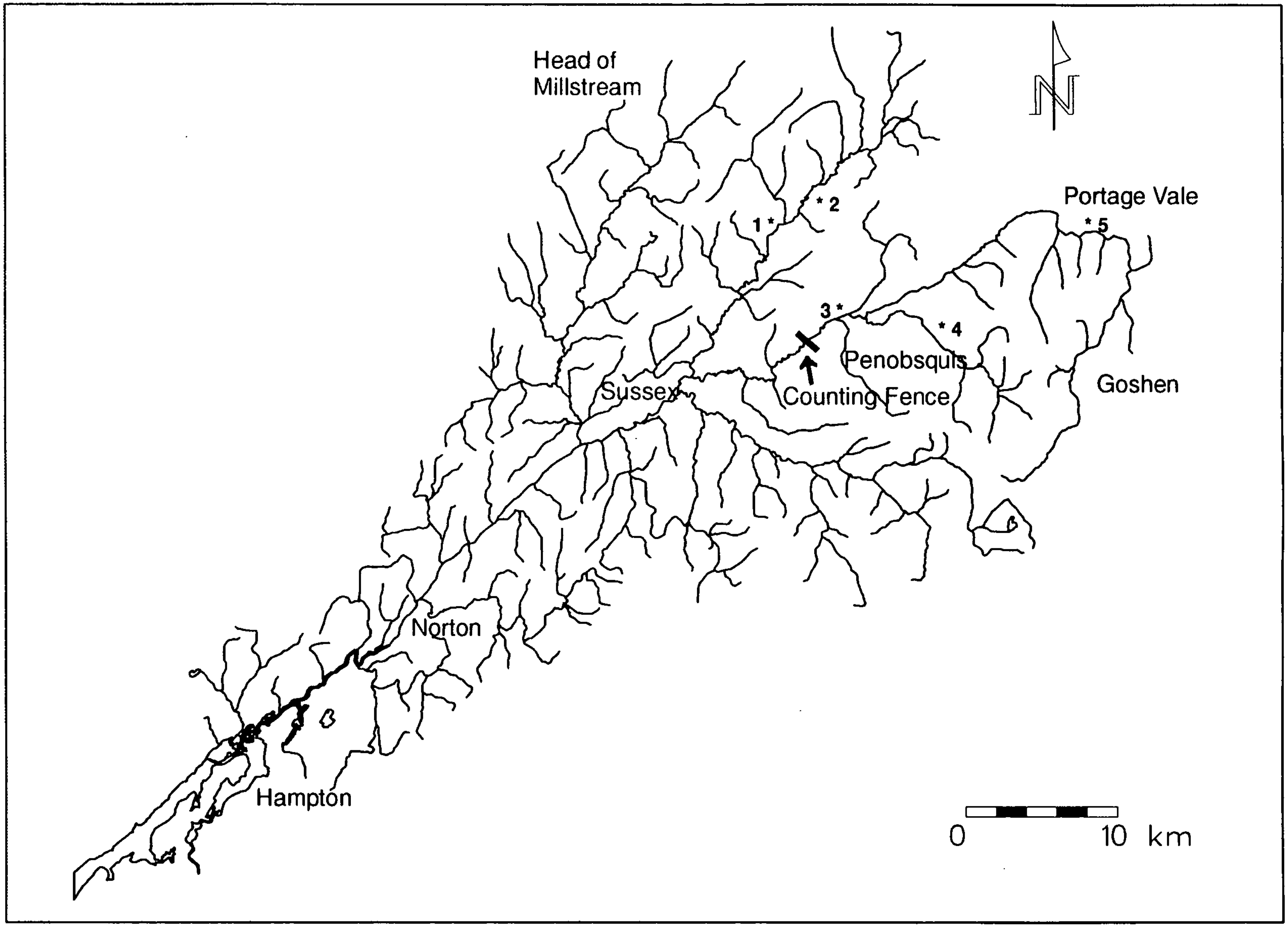


Fig.12. Kennebecasis River showing location of counting fence and electrofishing sites (*).

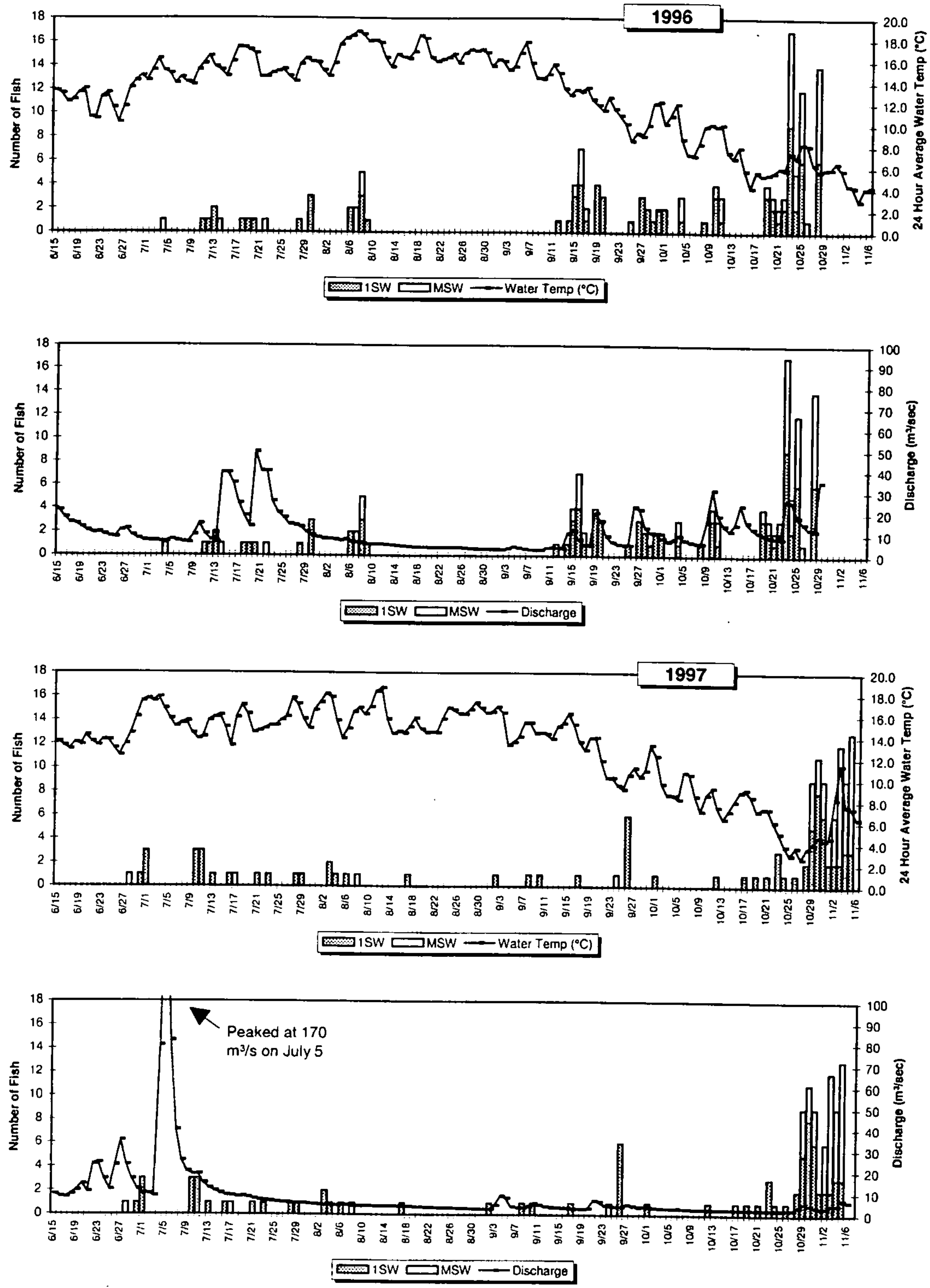


Fig. 13. Average daily water temperature (top) and discharge (below) as well as fence counts of 1SW and MSW salmon at McCully Station, South Branch, Kennebecasis River, 1996 and 1997.

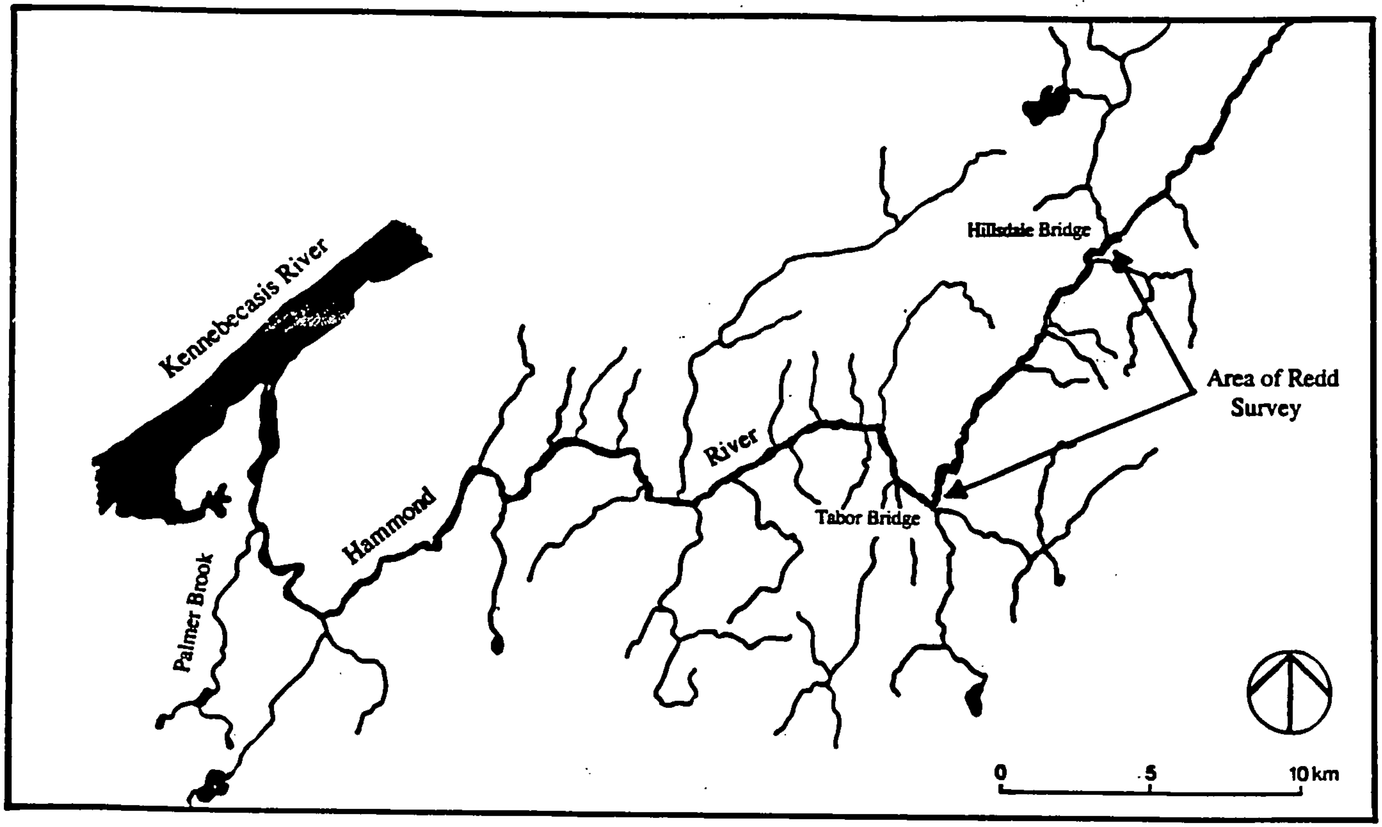


Fig. 14. Hammond River and location of redd survey area.

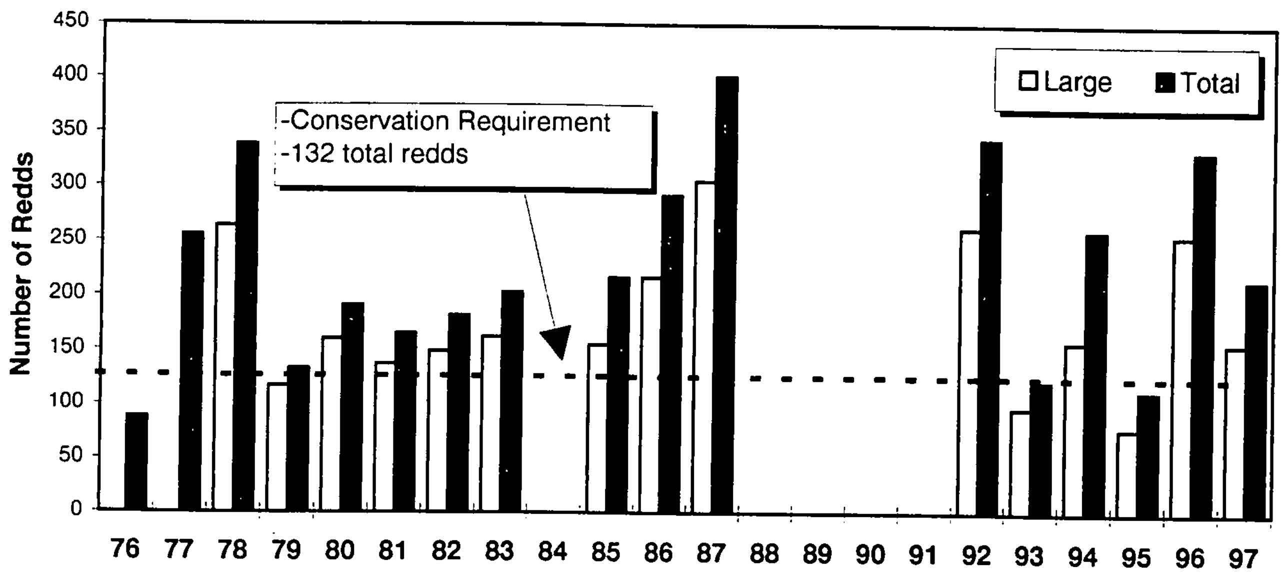


Fig. 15. Atlantic salmon redd counts on the Hammond River, 1976-97.
Requirement based on 2.5 redds per female MSW and 7,306 eggs/female.

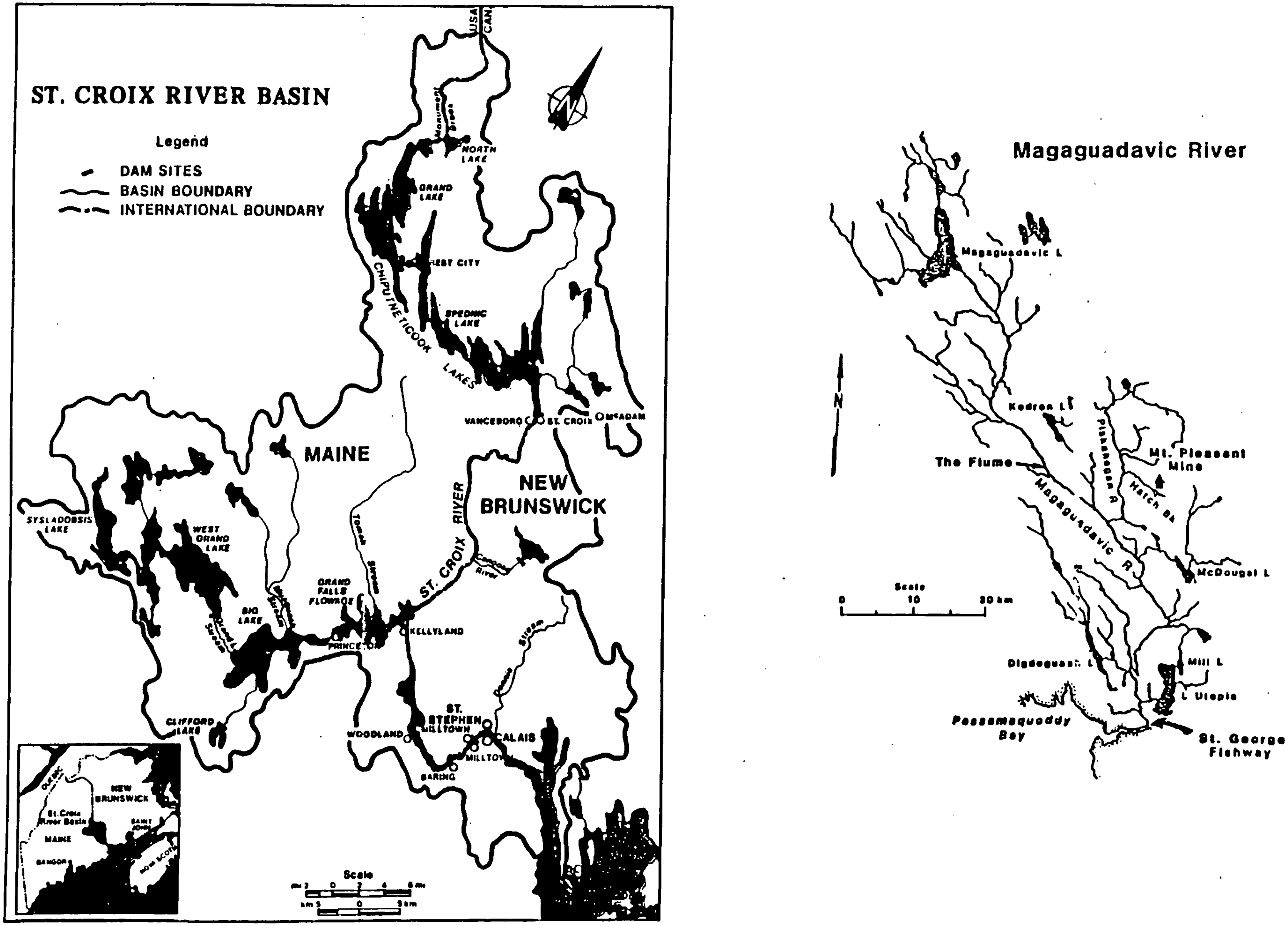


Fig. 16. St.Croix and Magaguadavic river systems of soutwest N.B.

App. 1. Number of eggs/100^2 deposited in the Tobique River, 1968-1993, and derivation of weighted number of eggs contributing to annual returns of wild 1SW fish at Mactaquac1973-95 and 1998 (explanation in Penney and Marshall 1984).

Egg depostion		Proportion age at smoltification[a]		Eggs/100m^2 contributing to 1SW fish		Total wt'd egg contrib/ 100 m^2 to 1SW fish
Year	Number	Age 2	Age 3	Yr i	Yr i+1	@ Mact (year)
1968	34.6	0.207				
			0.793		27.44	
1969	34.3	0.445		15.26		42.70 (1973)
			0.555		19.04	
1970	48.4	0.269		13.02		32.06 (1974)
			0.731		35.38	
1971	73.7	0.419		30.88		66.26 (1975)
			0.581		42.82	
1972	128.0	0.619		79.23		122.05 (1976)
			0.381		48.77	
1973	82.0	0.411		33.70		82.47 (1977)
			0.589		48.30	
1974	280.0	0.114		31.92		80.22 (1978)
			0.886		248.08	
1975	399.8	0.358		143.13		391.21 (1979)
			0.642		256.67	
1976	257.7	0.358		92.26		348.93 (1980)
			0.642		165.44	
1977	313.1	0.325		101.76		267.20 (1981)
			0.675		211.34	
1978	197.6	0.383		75.68		287.02 (1982)
			0.617		121.92	
1979	116.2	0.443		51.48		173.40 (1983)
			0.557		64.72	
1980	378.2	0.485		183.43		248.15 (1984)
			0.515		194.77	
1981	124.2	0.279		34.65		229.42 (1985)
			0.721		89.55	
1982	156.9	0.587		92.10		181.65 (1986)
			0.413		64.80	
1983	77.4	0.450		34.83		99.63 (1987)
			0.550		42.57	
1984	391.9	0.525		205.75		248.32 (1988)
			0.475		186.15	
1985	340.3	0.517		175.94		362.09 (1989)
			0.483		164.36	
1986	224.6	0.489		109.83		274.19 (1990)
			0.511		114.77	
1987	195.2	0.482		94.09		208.86 (1991)
			0.518		101.11	
1988	137.3	0.761		104.49		205.60 (1992)
			0.239		32.81	
1989	185.5	0.656		121.69		154.50 (1993)
			0.344		63.81	
1990	174.1	0.486		84.61		148.42 (1994)
			0.514		89.49	
1991	·186.2	0.591		110.04		199.53 (1995)
			0.409		76.16	
1992	191.9					
1993	111.7					
			0.444		49.60	
1994	94.9	0.556		52.76		102.36 (1998)

[a] Derived from App.2 and 3; underscored values are means of last 10 years (angular transformation).

App. 2. Number of wild 1SW salmon and proportion of age 2:1's of the total potential returns from the 1969-1992 year classes in the Saint John River destined for Mactaquac. Data from App. 3.

Year-class (i)	Number at age of 1SW returns to Mactaquac 2:1 (i+3)	3:1 (i+4)	4:1 (i+5)	Total	Prop. 2:1's of total
1968		690	41		
1969	127	451	37	615	0.207
1970	1,578	1,901	68	3,547	0.445
1971	1,718	4,465	212	6,395	0.269
1972	2,325	3,186	44	5,555	0.419
1973	4,749	2,887	40	7,676	0.619
1974	1,046	1,393	103	2,542	0.411
1975	469	3,257	398	4,124	0.114
1976	3,468	5,598	622	9,688	0.358
1977	2,486	4,140	310	6,936	0.358
1978	1,852	3,819	14+6	5,691	0.325
1979	1,045	1,589	91+6	2,731	0.383
1980	2,952	3,540	176	6,668	0.443
1981	4,679	4,790	187	9,656	0.485
1982	1,548	3,737	270	5,555	0.279
1983	3,980	2,724	73	6,777	0.587
1984	2,915	3,245	314	6,474	0.450
1985	5,612	4,771	291+12	10,686	0.525
1986	4,437	4,009	141	8,587	0.517
1987	2,963	2,952	148	6,063	0.489
1988	3,151	3,336	50	6,537	0.482
1989	3,199	963	43	4,205	0.761
1990	2,200	1,114	42	3,356	0.656
1991	1,119	1,152	30	2,301	0.486
1992	974	640	33	1,647	0.591
1993	656	153			
1994	157				

App. 3. Freshwater age and number of wild 1SW fish (A) counted at Mactaquac fish passage facilities, Saint John River, 1982-1995, and (B) that would have returned to Mactaquac had they not been exploited within the river, 1983-1997.

Fresh-water age	Number of 1SW fish														
	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994[a]	1995[b]	1996[b]	1997
A															
2	2,348	4,140	1,264	3,196	2,513	5,066	3,922	2,646	2,728	2,743	1,967	1,049	955	601	150
3	1,264	3,132	3,913	3,001	2,349	2,930	4,217	3,580	2,555	2,859	861	1,044	1,129	585	146
4	11	81	144	150	233	66	278	260	122	127	45	40	41	28	32
5			5						10						
6			5												
Total	3,623	7,353	5,331	6,347	5,095	8,062	8,417	6,486	5,415	5,729	2,873	2,133	2,125	1,214	328
B															
2	2,952	4,679	1,548	3,980	2,915	5,612	4,437	2,963	3,151	3,199	2,200	1,119	974	656	157
3	1,589	3,540	4,790	3,737	2,724	3,245	4,771	4,009	2,952	3,336	963	1,114	1,152	640	153
4	14	91	176	187	270	73	314	291	141	148	50	43	42	30	33
5			6						12						
6			6												
Total	4,555	8,311	6,526	7,904	5,909	8,930	9,522	7,263	6,256	6,683	3,213	2,276	2,168	1,326	343

[a]Total count (A) based on external characteristics and interpretation of scales from wild fish; total estimate (B) reflects ratio between count and estimate based only on external characteristics (Table 1).

[b]As in footnote[a] but with counts adjusted by removal of hatchery fish (Table 1).