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Status of Atlantic salmon stocks of southwest New Brunswick, 1996

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TABLE OF CONTENTS

ABSTRACT

Total one-sea-winter (1SW) returns (6,723) destined for above Mactaquac in 1996 were the highest since 1992. The wild component (20% of the total) was the lowest since 1972; hatchery-origin 1SW returns (80% of the total) were the highest since 1981. Multi-sea-winter (MSW) returns (3,321) increased from those of 1994-1995 but remained low. Hatchery-origin MSW fish (1,002; 30% of total) were the highest since 1984. Return rates for hatchery smolts were, in contrast to 1995, the highest of recent years. Spawners numbered 5,476 1SW and 2,518 MSW salmon, 112% and 51% of the respective new conservation requirements. Egg deposition (61% from wild fish) was 57% of the new requirement; the requirement has not been met since 1985.

Below Mactaquac, counts at the Nashwaak fence contributed to an estimated return of 1,829 1SW and 657 MSW salmon, the highest values since monitoring there was re-instituted in 1993. Estimated spawners were 88% and 31% of respective new 1SW and MSW requirements. Egg depositions increased from the levels of 1993-1995 to 48% of the new requirement. Counts at a fence in the headwaters of the Kennebecasis River suggested an escapement above that point of 115 1SW and 63 MSW salmon with potential for egg deposition of 52% of requirement. Redd counts on an 11.75-km stretch of the upper main stem Hammond River were the highest since 1992. Egg deposition within those redds was estimated to be 341% of the requirement for the stretch.

External and scale characteristics of 222 1SW and 41 MSW salmon captured in the Magaguadavic River trap indicated that only 48 1SW and 21 MSW salmon were of wild (non-aquaculture) origin - the lowest of a 9-year record. Unlike 1995, aquaculture fish were released to spawn in the river. The effective female escapement (many aquaculture fish were determined to be immature) indicated that potential egg deposition was 18% of requirement; 41% of the eggs was of aquaculture-origin fish.

Salmon ascending the St. Croix River at Milltown numbered 152 fish of which only 21 were of aquaculture origins. An estimated egg deposition of 4% of requirement was double that of 1995. An additional 2% of requirement was taken for hatching and artificial rearing.

1SW returns destined for Mactaquac in 1997 should number 7,800-9,400 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 1993 and 1994. MSW returns destined for Mactaquac in 1997 could number 3,100- 3,600, i.e., 63%-73% of the 4,900 MSW conservation requirements above Mactaquac.

Qualitative forecasts of returns to the other assessed rivers of Southwest New Brunswick indicate that the proportions of conservation requirements (eggs) that will be met in 1997 are unlikely to exceed those levels observed in 1996.

RÉSUMÉ

Les remontées totales de saumons unibermarins (UBM), de 6 723, se dirigeant en amont de Mactaquac en 1996 ont été les plus élevées notées depuis 1992. La composante sauvage (20 % du total) était la plus faible depuis 1972 tandis que les remontées d'UBM d'origine piscicole (80 % du total) ont été les plus élevées depuis 1981. Les remontées de saumons pluribermarins (PBM), de 3 321 poissons, ont été supérieures à celles de 1994-1995, mais sont demeurées faibles. Les remontées de PBM d'origine piscicole (1 002; 30 % du total) ont été les plus importantes depuis 1984. Contrairement à 1995, les taux de retour des saumoneaux d'élevage ont été les plus élevés des dernières années. Il y avait 5 476 UBM et 2 518 PBM géniteurs, qui représentaient respectivement 112 % et 51 % des nouveaux besoins de conservation. La ponte (61 % de poissons sauvages) correspondait à 57 % des nouveaux besoins, qui n'ont pas été atteints depuis 1985.

En aval de Mactaquac, les remontées à la barrière de dénombrement de Nashwaak représentaient des remontées estimées de 1 829 UBM et de 657 PBM, les plus fortes valeurs obtenues depuis la reprise des contrôles en 1993. Les nombres estimés de géniteurs représentaient respectivement 88 % et 31 % des nouveaux besoins en UBM et PBM. La ponte a augmenté pour passer des valeurs de 1993-1995 à 48 % des nouveaux besoins. Les dénombrements effectués à une barrière située dans les eaux d'amont de la rivière Kennebecasis indiquent des échappées, en amont de ce point, de 115 UBM et de 63 PBM dont la ponte correspondrait à 52 % des besoins. Le dénombrement des nids sur un segment de 11,75 km de la branche d'amont principale de la rivière Hammond a été le plus élevé depuis 1992. La ponte correspondant à ces nids a été estimée à 341 % des besoins du segment.

Les caractéristiques externes et les écailles des 222 UBM et des 41 PBM capturés dans le piège de la rivière Magaguadavic montrent que seulement 48 UBM et 21 PBM étaient d'origine sauvage (non d'élevage), soit la valeur la plus faible de la période d'enregistrement de 9 années Au contraire de 1995, des poisons d'élevage ont été libérés pour le frai en cours d'eau. L'échappée effective de femelles (bon nombre de poissons d'élevage se sont avérés immatures) correspondait à une ponte atteignant 18 % des besoins et 41 % des oeufs provenaient de poissons d'élevage.

On a décompté 152 saumons remontant la rivière St. Croix à Milltown et seulement 21 étaient d'origine piscicole. La ponte estimée, correspondant à 4 % des besoins, était le double de celle de 1995. Un 2 % supplémentaire aux besoins a été prélevé à des fins d'élevage.

Les remontées de saumons UBM se dirigeant vers Mactaquac en 1997 devraient compter entre 7 800 et 9 400 poissons et donc excéder les besoins de la conservation, de 4 900 UBM. Les poissons formant les remontées devraient surtout être d'origine piscicole, que ce soit sous la forme de saumoneaux relâchés directement à Mactaquac ou d'alevins d'âge 0+ libérés en amont de Mactaquac en 1993 et 1994. Les remontées de PBM vers Mactaquac en 1997 pourraient compter entre 3 100- 3 600 poissons, soit entre 63 % et 73 % des 4 900 PBM nécessaires aux besoins de conservation en amont de Mactaquac.

Des prévisions qualitatives des remontées des autres rivières évaluées du sud-ouest du Nouveau-Brunswick indiquent que les proportions des besoins de conservation (oeufs) obtenus en 1997 ne devraient pas être supérieures à celles observées en 1996.

SUMMARY SHEET (PART 1 of 2)

Stock: Saint John River, N.B. (*above Mactaquac*) SFA 23
Conservation requirement: 29.4 million eggs (4,400 MSW and 3,200 1SW fish)
New Conservation requirement: 32.3 million eggs (4,900 MSW and 4,900 1SW fish)

Year	1991	1992	1993	1994	1995	1996	MIN	MAX	Mean
Harvest:									
First Peoples									
Small	657	560	241	250	50	675	50[2]	657[2]	351[2]
Large	957	748	462	90	25	285	25[2]	957[2]	456[2]
Recreational									
Small	1690	2104	852	0	-	0	0[1]	2304[1]	1416[1]
Counts:									
1SW	7575	7664	3907	3313	4970	6155	3313[1]	9587[1]	7127[1]
MSW	4226	4203	2980	2206	2279	3139	2206[1]	4291[1]	3897[1]
Est. Returns:									
1SW	8751	8940	4369	3534	5079	6723	3534[1]	10861[1]	7852[1]
MSW	5215	4898	3389	2375	2355	3321	2375[1]	6925[1]	4219[1]
Est. Spawners:									
1SW	5721	5128	2819	2901	4839	5476	2819[2]	5721[2]	4282[2]
MSW	3481	3269	2149	1647	1887	2518	1647[2]	3481[2]	2487[2]
% of Target met:									
1SW	179	160	88	91	151	171	88[2]	179[2]	134[2]
MSW	79	74	49	37	43	57	37[2]	79[2]	56[2]
Eggs	87	81	51	39	45	62	39[2]	87[2]	61[2]
Eggs(New)	79	74	46	35	41	57	35[2]	79[2]	56[2]

[1]For the period 1986-1995
[2]For the period 1991-1995

Harvests: SFA 23 was closed to recreational and commercial salmon fisheries in 1996. Allocations to First Nations totalled 4,035 1SW fish; estimates of harvest totalled 675 1SW and 285 MSW salmon.

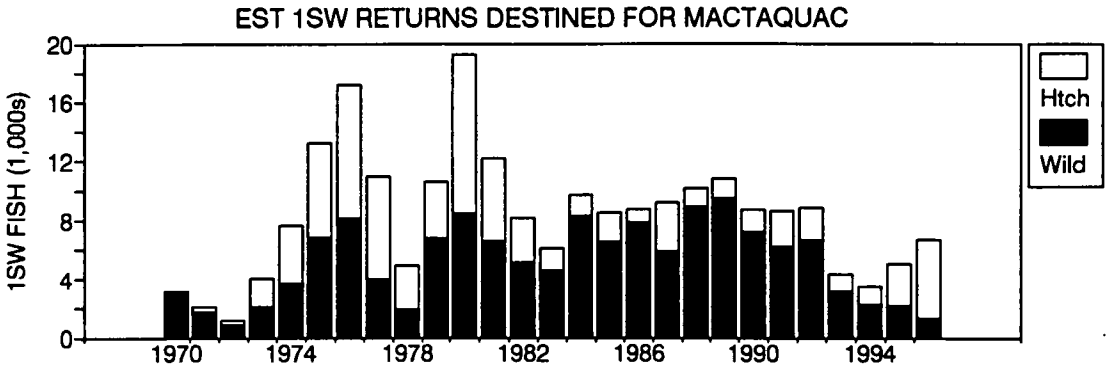
Data and methodology: Counts of fish are obtained from the collection facility at Mactaquac Dam; returns destined for the Dam are the counts plus estimates of down river removals. Spawners equal the releases above Mactaquac minus estimates of upriver removals, not including poaching and disease. Wild 1SW returns are forecast from a relationship between adjusted egg depositions recruiting to 1SW fish; forecasts of wild MSW returns are based on a relationship between MSW returns and their 1SW cohorts (and fork length) in the previous year. New estimates of juvenile production area and biological characteristics of salmon contributed to a 10% increase in egg requirements for conservation.

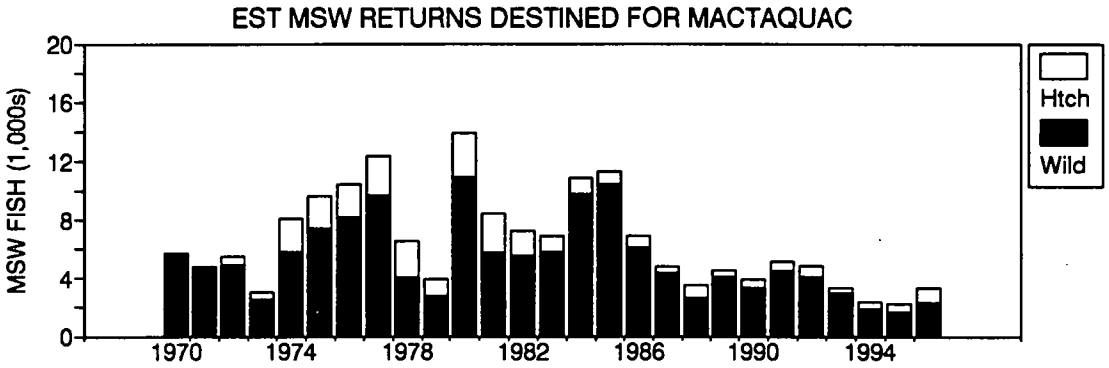
State of the stock: Wild 1SW were the fewest in 24 years; MSW returns increased from those of 1994-1995 but remained low. Hatchery-origin 1SW returns (80% of the total) were the highest since 1981; hatchery MSW returns (30% of the total) were the highest since 1984. Egg deposition (39% from hatchery-origin fish) was 62% of old and 57% of new requirements; the requirement has not been met since 1985. The 1SW return rate for hatchery smolts nearly doubled to 1.2%; MSW return rates increased by 30% to 0.26%.

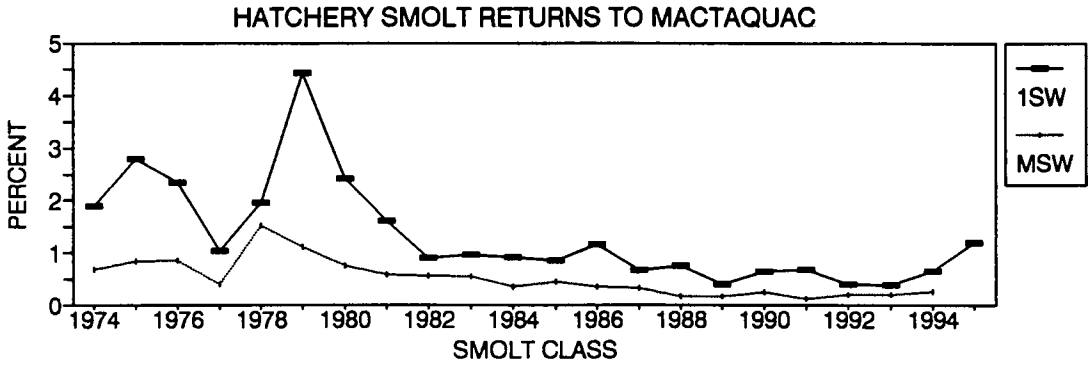
Forecasts: 1SW returns destined for Mactaquac in 1997 could total 7,800-9,400 fish comprised of 1,200-2,700 wild and upwards of 6,600 fish of hatchery origin. Total 1SW returns should exceed the 4,900 1SW conservation requirements. Wild MSW returns destined for Mactaquac in 1997 could number 2,000 to 2,300 fish; hatchery returns could number another 1,100-1,300 fish. Total MSW returns of 3,100-3,600 fish will only be 63%-73% of the MSW requirement.

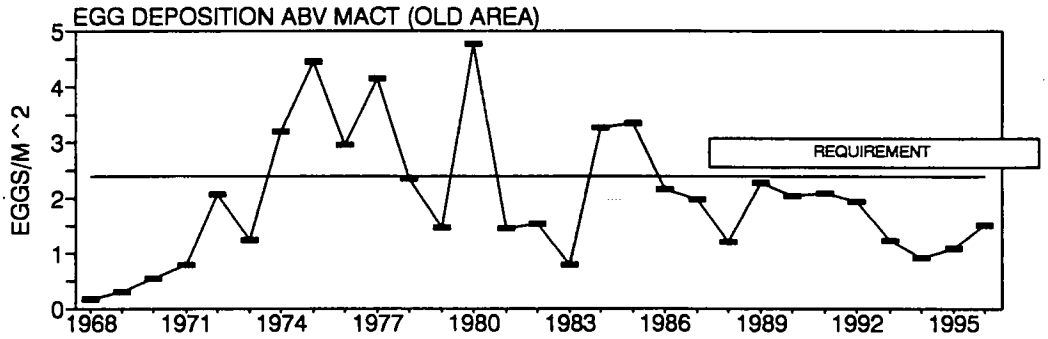
Management Considerations: Early client consultations, a season closure until mid-July, and end-of-July forecasts should be requisite to fishing plans in 1997.

SUMMARY SHEET (PART 2 of 2)









Stock status of Atlantic salmon, Saint John River above Mactaquac, various years to 1996. (Aqua fish excluded from all but eggs.)

SUMMARY SHEET

Stock: Nashwaak River, N.B. (*above counting fence*) SFA 23
Conservation requirement: 10.7 million eggs (1,620 MSW and 1,530 1SW fish)
New Conservation requirement: 12.8 million eggs (2,040 MSW and 2,040 1SW fish)

Year	1991	1992	1993	1994	1995	1996	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]	186	426	137	30[4]	-[6]	-[4]	137[5]	426[5]	250[5]
Partial Counts:									
1SW	-	-	83	403	569	940	83	569	352
MSW	-	-	155	274	308	429	155	308	246
Est. Returns:									
1SW	-	-	954	661	940	1829	661	954	852
MSW	-	-	555	388	436	657	388	555	460
Est. Spawners:									
1SW	-	-	866	610	940	1804	610	940	805
MSW	-	-	555	349	436	641	349	555	447
% of Target met:									
1SW	-	-	57	40	61	118	40	61	53
MSW	-	-	34	22	27	40	22	34	28
Eggs	-	-	37	31	39	58	31	39	36
Eggs(New)	-	-	31	26	33	48	26	33	30

[1]For the period 1993-1995.
[2]For the period 1993-1994.
[3]Catch corresponds to above and below fence.
[4]Mandatory release.
[5]For the period 1991-1993; 1994 and 1996 were mandatory release.
[6] Closed to angling

Harvests: No harvests were reported or allocated. The recreational fishery was restricted to hook-and-release fishing only. 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).

State of the stock: Counts at the fence and a mark-recapture estimate indicate a return of 1,829 1SW and 657 MSW in 1996. Escapement of 1,804 1SW and 641 MSW represents 88% and 31% of the new conservation requirement. Egg deposition was 6.20 million eggs or 48% of the new requirement; 44% came from 1SW fish. The river has not attained more than 50% of target in the past four years. Juvenile densities are consistent with low escapements. Hatchery-origin fish comprised 11% of returns.

Forecasts: There is little expectation for change in the numbers of wild 1SW returns in 1997 from those of the last four years (mean of 1,096 1SW fish). The 1,829 1SW fish in 1996 are again suggestive of an increase of MSW salmon in 1997. No evidence suggests numbers outside the range of the last four years (388-657 fish). With no increase in the numbers of hatchery-origin distributions, their contribution to returns in 1997 will continue to be minimal. In total, it is unlikely that MSW or egg requirements in 1997 will be approached.

INTRODUCTION

This document assesses the status of Atlantic salmon stocks in 1996 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. New to this status report are data from the Kennebecasis and Hammond rivers. Prognoses of returns in 1997 are provided in various levels of detail for all but the Hammond and Kennebecasis. 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) which do not have a significant 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 St Mary's, Kingsclear and Oromocto first nations. Data for the evaluation of the status of stocks in the Kennebecasis and Hammond rivers were provided by N.B. Dept. Natural Resources and Energy; 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 a significant number of hatchery returns undetected by external characteristics.

On the basis of low spawning escapements in four rivers of SFA 23 in 1995, and poor prospects of 1SW returns being surplus to conservation requirements above Mactaquac in 1996, SFA 23 was closed to all salmon fishing until July 15. On that date, food fisheries were opened to Aboriginals. After an in-season assessment at Mactaquac on Aug 1 indicated that conservation requirements for 1SW fish would be exceeded, allocations to Aboriginals were increased and recreational fisheries were opened to hook-and-release.

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 states of the salmon stocks since 1970 were estimated beginning in 1983 (Penney and Marshall MS 1984) and continued through 1995 (Marshall and Jones MS 1996). Pre-season forecasts of 1SW fish for 1996 had suggested that homeriver returns destined for Mactaquac could number 5,800 to 6,900 fish, i.e., 180-215% of conservation requirements. MSW returns were forecasted to be 3,800 to 4,300 fish, i.e., 85-95% of requirements. Conservation requirements were not expected to be met or approached on any of the other systems assessed in SFA 23.

This assessment of stocks above Mactaquac is similar to that of 1995 (Marshall and Jones MS 1996). Differences include the revision of conservation requirements (for the entire Saint John drainage) through use of new measures of area and an update of biological characteristics (eggs per fish). Juvenile densities for tributaries above and below Mactaquac, 1996, are tabled in acknowledgement of client requests to work towards analyses of a data set begun in the late 1960s and as insight to prognoses of wild returns beyond 1997.

Description of fisheries

The entire Saint John River has been closed to commercial fishing for Atlantic salmon; the recreational fishery for spring (black salmon) was, as in 1995, again closed. Aboriginal food fisheries for 1SW salmon on the Saint John drainage (many using unauthorized gill nets) began, in some instances, in advance of the July 15 opening and continued into October. High water discharge in July limited the effectiveness of prescribed trap nets; angling, drifting and seining with gill nets proved effective below Mactaquac, while set gill nets (unauthorized) were deployed with trap nets on the Tobique River. Numbers of 1SW fish allocated for a July 15 opening and increases which followed consultations between governments, First Peoples and commercial and recreational fishery stakeholders at a Zone 23 Management Advisory Committee, July 29, are summarized as follows:

	July 15	Early August	Total
Tobique FN	440	840	1,280
Woodstock FN [1]	140	85	225
Kingsclear FN	150	580	730
St Mary's FN	235	750	985
Oromocto FN	95	300	395
NB Aboriginal Peoples' Council	80	340	420
TOTAL	*1,140*	*2,895*	*4,035*

[1] Allocation based on attainment from Mactaquac.

The recreational fishery was also opened to hook-and-release fishing (only) on July 15. No other changes were effected over the duration of traditional open dates for recreational fishing.

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 continued; Greenland, closed in 1993-94, harvested 85t of a 174t quota in 1996, up from the 70t of a 77t quota in 1995. In Labrador, licensed salmon fishermen harvested 50 t of a 55t quota - down from the 55t of a 77.5t quota harvested in 1995. Two tags (1993 smolt class from Mactaquac) from Saint John River salmon destined for Mactaquac were returned in 1996 from the non-fishery in Greenland in 1994; one tag (Nashwaak R.) was returned from the 1995 fishery and one tag (Mactaquac) has been returned from the Greenland harvest in 1996.

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 facility at the dam was, with the exception of August 9-20, open May 7 - Oct 25; the migration channel at the station was fished May 20 - Oct 31.

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 were identified by "broomtails" (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 about every 5th fish (exceptions included the sampling of all broodstock, earliest-run fish and fish of suspected sea-cage origin) 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. 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 and earliest-run fish) which were completely sampled, provided the basis for "adjusted" counts at Mactaquac (aquaculture fish removed), estimated returns and, return rates for hatchery fish released as age-1 smolts and as age 0+ parr.

Removals by First Peoples fishing below Mactaquac were only partially reported and were therefore estimated on the basis of catches observed by or known to Fishery Officers. By-catch was monitored by Fishery Officers and Native Guardians. As in 1995 assumed catch rates were 1% of the 1SW and 2.5% of the MSW river returns. Catches 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 1996 (Table 1) totalled 6,155 1SW and 3,139 MSW salmon. Unadjusted counts (Table 2) or adjusted counts (Table 1) of wild 1SW fish were down from those of 1995, i.e., only 42% and 21% of the previous 5- or 10- year means, respectively, (Table 2) and the lowest in 20 or more years (Fig. 2). Counts of wild MSW

salmon increased over those of 1995 and were 92% and 84% of the respective 5- and 10-year means (Table 2). Counts adjusted by scale interpretation shifted the hatchery component among 1SW fish from 75% (Fig. 3) to 80% and, among MSW fish (aquaculture fish excluded) from 23 to 30% (Fig. 3 includes fish of aquaculture origin). Proportionate age composition among hatchery and wild components was:

Origin	Age 1.1	Age 2.1	Age 3.1	Age 4.1	Tot	Age 1.2	Age 2.2	Age 3.2	Age 4.2	Age 3.3	P.S.	Tot
Hatch	0.54	0.27	0.18		1.0	0.60	0.23	0.14	<0.01	0.00	0.03	1.0
Wild		0.50	0.48	0.02	1.0		0.52	0.42	<0.01	<0.01	0.04	1.0

Five hundred 1SW and 100 MSW salmon were estimated to have been removed by First Peoples fishing below Mactaquac Dam, including 295 1SW fish taken with hook and line (Table 1). Reporting of 95 1SW fish harvested by NB Aboriginal Peoples' Council was received too late to be included in the assessment. However a Washademoak fishing location would have had minimal impact on stocks destined for Mactaquac. Another 67 1SW fish and 83 MSW fish were ascribed to by-catch in the shad and gaspereau nets in the lower river and Saint John Harbour area (Table 1).

Estimated homewater returns in 1996 totalled 6,723 1SW (Table 1) and 3,321 MSW fish; 1SW returns were the highest since 1992; MSW returns were the 4th lowest of a 27-year record (Table 3). Counts comprised 92 and 95% 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 aquaculture fish; there were no returns to Mactaquac from smolts released to the Nashwaak River) was 0.01203 - nearly double that of 1995 and the highest since 1987 (Table 4a). The adjusted return rate of 1-year smolts as 2SW salmon (Table 4b) was 0.00267 - a 30% increase over that rate of 1995 and the highest since 1987. No allowance has been made for the few age 1.1 fish that originated from stocking of age 0^+ fall parr.

Removals of fish destined for Mactaquac

Methods

Removals include the estimate of salmon retained by First 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 or handling operations at Mactaquac, including a "harvest" of 225 1SW fish for Woodstock FN.

Losses to poaching and disease, exclusive of those fish 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. These rates are 50% of those of 1994 because of the paucity of persons and activity on the river. Fish lost to poaching and disease are considered, by definition, as "spawners". Losses were apportioned to hatchery and 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 First Peoples were approximated at 500 1SW and 100 MSW salmon (Table 5) which contributed to the best Aboriginal fishery since 1992 (Table 6). Transport from Mactaquac to the Aroostook River above Tinker consisted of 100 1SW and 40 MSW salmon. An additional 53 1SW and 12 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 55 1SW and 63 MSW salmon.

Total river removals by all factions were estimated at 1,302 1SW and 866 MSW fish (Table 5) of which 14 1SW and 217 MSW salmon were held at Mactaquac for broodstock. These broodstock yielded 1.67 million eggs (all early-run components); another 1 million eggs were laid down from Serpentine stock reared in sea-cages.

Conservation requirements

Until now, conservation requirements have been based on an accessible salmon-producing substrate of 12,261,000 m^2 above Mactaquac, (exclusive of riverine habitat on the main Saint John below Grand Falls and Beechwood, the Aroostook River and the main Saint John and tributaries above Grand Falls), an assumed requirement of 2.4 eggs m^{-2}, a length-fecundity relationship (Log_e eggs = 6.06423 + 0.03605 Fork length), and biological characteristics of hatchery and wild 1SW and MSW salmon, 1972-1982 (Marshall and Penney MS 1983). On average, approximately 4,400 MSW and 3,200 1SW fish were needed to provide the 29.4 million eggs for that conservation requirement and a 1:1 male: female ratio among spawners. Not all eggs were expected to be contributed by MSW salmon, but 90-95% of eggs were in fact from MSW salmon

New estimates of area, determined from measures of lengths on orthophotographic maps and widths on air photographs (Amiro 1993), are 13,471,600 m^2 (>0.12% and <15.0% grades) including 540,000 m^2 in the mainstem Saint John (Table 8). Wild MSW salmon spawning above Mactaquac, 1988-1995, were, on average, 94 % female (Table 9). Each female was estimated from the length-fecundity relationship to have a capacity of 7,056 eggs, about 550 fewer than in the historical data (selection of larger fish for broodstock from among those returning has tended to reduce the average length of escapement from the average length of returns). To meet a conservation requirement of 32,331,840 eggs above Mactaquac (product of area and 2.4 eggs m^{-2}) requires an average of 4,606 wild female MSW salmon which are, on average accompanied by 294 males, i.e., 4,900 MSW salmon. The deficit males for a 1:1 ratio male:female are 4,288 fish.

1SW characteristics have also changed from the historical data. Grilse are larger and credited with an increase from about a 3,500 to nearly 3,700 egg carrying capacity per female. In addition, the proportion females has increased, on average, from about 5% to 15%. of returns (and escapement) To insure a 1:1 male to female ratio among MSW females, deficit males are accorded from 1SW fish, i.e., 5,073 (inc. 15% females). These females among grilse would have the potential to contribute 2.8 million eggs (requirement + 10%). For simplicity, it is proposed to round the 1SW requirement at 4,900 fish, the same number as for MSW requirements.

Under the revised requirements it is proposed that all eggs be sought from wild MSW salmon Eggs from 1SW fish are additional to requirements, although they are counted with respect to assessing the attainment of requirements. However, the

contribution by 1SW fish will offset a generally lower (1996 excepted) proportion females (0.85-0.90) among generally smaller 1SW and MSW fish of hatchery origin. Fish of hatchery origin are counted as equals to wild fish in assessing the attainment of adult requirements though eggs fish $^{-1}$ are less.

Escapement

Collation of the total returns (Table 1) and total removals (Table 5) indicates that escapement was 2,518 MSW salmon, 57% of the old and 51% of the new requirement above Mactaquac (Table 10). For 1SW fish, 171% of the old and 112% of the new requirement was met above Mactaquac. Biological data for spawners released above Mactaquac are:

Biological parameter	1SW wild	1SW htch	MSW wild	MSW htch
Prop. female	0.132	0.118	0.861	0.921
Mean fork length, female (cm)	58.83	58.81	78.59	77.00

Differences from 1995 were an increase in proportion of females among hatchery 1SW fish (from 0.076) and an increase in lengths of wild and hatchery-origin MSW fish (from 77.02 and 76.48 cm, respectively). Mean lengths, the length-fecundity relationship and estimated escapement indicate that total potential deposition (including estimated losses to poaching and disease) was 18.3 million eggs (1.49 [old] and 1.34 [new] eggs m^{-2}) or 62% and 57%, respectively, of the requirement - up from the 45% [old] of target in 1995. Eggs from 1SW fish comprised 13% of the total deposition; eggs from hatchery-origin fish potentially contributed to 39% of the total deposition. The 13 fish classified as aquaculture escapees made relatively no contribution to egg 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, 1973-1994, on adjusted egg depositions in the Tobique River, 1968-1969 to 1989-1990 [method in Penney and Marshall (MS 1984), with updates on freshwater age composition from wild 1SW fish, App. 1, 2 and 3 in this paper]. The 1992 and 1993 egg depositions, principal contributors to 1SW returns in 1997, were derived using angular-transformed mean proportions for age-2.1 1SW fish in the previous 10-year period. To account for multiplicative effects of environment, competition, variability in recruits etc. the natural logarithms of the observed values were considered in the regression analysis

1SW wild (Forecasts)

Potential returns of wild 1SW fish returning to Mactaquac in 1996 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 11). A regression using natural logs was less significant than the relationship unlogged but the unlogged form 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. From the equation 1SW = 2,515.778+ 17.796 eggs ($R^2_{adj.}$=0.495, p=0.0003, n=21), the estimate for 1SW returns in 1997, is **5,183** 1SW fish (90% CL 2,089 - 8,277). For 1996, the method forecast 5,864 1SW fish; only 1,326 fish or 23% (35% in 1994; 34% in 1995) of the forecast was estimated to have returned. Variations

between forecast and actual values since 1994 (Fig. 4) have contributed to proportionate reductions in stated expectations of returns.

Some observers of the dramatic increase in "hatchery " 1SW returns in 1995 and 1996 have hypothesized that 1SW fish have been misclassified at the Mactaquac sorting facility. Collectively they suggest that i) aquaculture escapees, (frequently showing only 1 year of freshwater growth) could be attributed to a Mactaquac origin and ii) that fish with minimal fin deformation but classified as "hatchery" (freshwater age >1 year), i.e., originating from age-0^+ distributions, principally fall parr, are in fact of wild origins (they ignore the potential of wild returns to originate from fry stocking and eggs deposited in the Aroostook and above Grand Falls). To investigate the possibility that the differences between forecast and observed 1SW returns in the above model were due to misclassification, the ratios of MSW/1SW returns for wild fish, hatchery fish of 1-year smolt origin and hatchery fish believed to have been derived from age-0^+ distributions were examined for similarities and possible combination.

Mean ratios of the respective groups, 1988-1989 to 1995-1996, (n=8) were 0.6125, 0.380 and 0.267 (there was no undo bias from the 1995-1996 pairs, the first year of notable increases from juvenile stocking) Wild ratios were significantly different from each of the hatchery ratios (Bonferroni adjusted critical value of 0.025) and are consistent with past observations that hatchery-smolt origin fish typically returned a higher proportion 1SW fish (low proportion MSW) than their wild counterparts. Thus the populations were not combined and the forecast model was not subjected to further testing. These analyses do suggest, however that even high 1SW returns from juvenile distributions should not be expected to be mirrored by unduly high returns of MSW salmon in the succeeding year. Increased hatchery contributions are discussed further in the section forecasting returns of hatchery 1SW salmon.

MSW wild (Methods)

Forecasts of MSW returns in 1997 were based on multiple regression. The log of MSW returns in year i+1, were estimated from the numbers and fork length of 1SW returns in year i (Marshall and Jones MS 1996. 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).

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 25 of the 26 years used above were added to the MSW returns and examined in the above MSW forecast model.

Finally, selected periods (co-variate "period") within the 25 or 26 years of data were tested by ANCOVA procedures to determine if an abbreviated or modified model would be more responsive in predicting MSW returns from the 1SW fork length and low (lowest in 23 years) 1SW returns of 1996.

MSW wild (Forecasts)

A potential return of **2,051** (90% CL 1,310 - 3,210) wild MSW fish destined for Mactaquac in 1997 was derived from the equation Log_e MSW = 25.9003 + 0.137E-3 1SW - 0.3203 Length ($R^2_{adj.}$=0.796, p<0.0001, n=26, columns 7 on columns 4 and 5, Table 11). For 1996 the method forecast a return of 2,849 MSW salmon; 2,309 (81%) were estimated to have returned. In 1994 and 1995, respective returns were 80% and 103% of forecast. The inclusion of the co-variate "period" in the model for MSW years 1971-1975; 1976-1984 and 1985-1996 and, as well, 1971-1975; 1976-1986 and 1987-1996 when ratios of MSW:1SW (Fig. 4) and lengths (Table 11 appeared to be different, was not significant (p=0.164 and p=0.144, respectively), i.e., no evidence suggests a subset(s) of the data would provide a more appropriate model for forecasting.

Use of the estimated numbers of returning salmon in the absence of commercial fisheries in Newfoundland and Greenland (moratoria model), 1972-1996, (Table 8, one less year than in the above data set) suggests a return of **2,841** (90% CL 1,547- 5,216) wild MSW fish destined for Mactaquac in 1997 (Log_e MSW = 29.57436 + 0.148E-3 1SW - 0.3790 Length; $R^2_{adj.}$=0.737; p<0.0001; n=25). For 1996, the method forecast 4,121 (178%) returns, the method forecast about 200% of returns estimated in 1994 and 135 % of 1995 returns.

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 1985-1996 (p=0.005) or 1987-1996 (p=0.011). The subset model for the period 1985-1996, Log_e MSW = 22.6081 + 0.188E-3 1SW - 0.2644 Length ($R^2_{adj.}$=0.846; n=12) was significant (p=0.0001) and provides a forecast of **2,052** (90% CL 1,208- 3,487) wild fish destined for Mactaquac. For 1996 the method forecasted 121% of returns. The model for the period 1987-1996, Log_e MSW = 18.2764 + 0.180E-3 1SW - 0.1894 Length ($R^2_{adj.}$=0.722; n=10; p=0.005) was slightly less significant. The model for the latter two periods combined, i.e., MSW years 1976-1996, is Log_e = 27.1707 + 0.184E-3 1SW - 0.3418 Length ($R^2_{adj.}$ =0.840; p<0.0001; n=21). The forecast from this model is **2,255** (90% CL 1,370- 3,710) wild MSW salmon; For 1995 and 1996 the latter method forecasted 108% and 141% of respective estimated returns.

1SW hatchery (Methods)

Since the shift to age-1 smolt production at Mactaquac in 1985, forecasts of returns from hatchery-reared smolts have 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 significant relationship between rates of return of hatchery 1SW fish and the March index of winter habitat for salmon in the North Atlantic (r^2=0.604; p<0.001; n=21) and a slight indication that the index may be increasing, suggests the use of the mean (arcsin) survival rates of the most recent years (1995-1996; Table 4a) when the index of winter habitat may be trending upwards (Fig. 5). Age-1.1 returns in 1996 may also be expected at the Mactaquac Dam from smolts reared at Mactaquac but released into the Nashwaak River. The return rate for these smolts was assumed to be the proportion (Nashw return $rate_{95}$/Mactaquac return $rate_{95}$; there were no returns in 1996) of the value used for forecasting returns to Mactaquac in 1997.

Additional 1SW returns of age-3.1 and age-2.1 fish are expected at Mactaquac in 1997 from fall fingerlings (age-0^+) graded from the age-1 smolt program at Mactaquac and released into tributaries above Mactaquac in 1993 and 1994. Selection of return rates for eggs deposited by adults in areas foreign to them is in part constrained by evidence that recent wild recruits do not appear to be replacing spawners (return rate from eggs of 0.0003 should equal

replacement). Thus, selection considered values estimated from returns in 1996 (Table 12) and 1995 (Table 9, Marshall and Jones MS 1996) relative to those used for forecasting the 1996 returns. Returns of age-2.1 fish from fall fingerlings were forecast as the product of a 0.00255 return rate to Mactaquac (the mean of 1995-96) and the numbers released in 1994. Age-3.1 fish were assigned a return rate of 0.00139 (mean of 1995-96). Returns from feeding fry, many of which were reared for stocking above Grand Falls, were assigned a return rate of one-half that of fall fingerlings and eggs were accorded a return rate of one-fifth that of feeding fry. Recruits from eggs and many feeding fry will have "clean" fins and be classified as wild fish at Mactaquac. In total, 4.7 million stocked fish of various life stages will contribute to returns in 1997.

1SW hatchery (Forecasts)

A forecast of hatchery 1SW fish destined for Mactaquac in 1997 is **6,610** fish (Table 13); the same approach with more conservative return rates forecast 3,310 1SW returns in 1996 - the minimum estimate of actual returns was 5,394 fish. Age-1.1 salmon, the most identifiable element, should contribute to 40% of the hatchery-origin recruits. Twenty-five percent of returns are projected (Table 13) to have originated in relatively competition-free environs above Grand Falls.

MSW hatchery (Methods)

Returns as MSW fish from age-1 smolts released at Mactaquac in 1995 were estimated as the product of the number released and the mean return rate for 1995 and 1996 (Table 12 and Table 9, Marshall and Jones MS 1996). 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, at Mactaquac. Use of return rates from the 1-year smolt program (1985 onwards) would be more correct but there is no significant relationship. A return rate based on recent years presumes no dramatic change in distant fisheries. As with 1SW hatchery returns, MSW fish destined for Mactaquac from releases to the Nashwaak River were given the same proportioned rate of return as for 1SW fish.

Selection of return rates for MSW salmon from juveniles and eggs was guided by the average return rate for age 2.2 and age 3.2 returning to Mactaquac in 1995-96. Returns of age-2.2 salmon from fall fingerlings were forecast as the product of their numbers and a return rate to Mactaquac of 0.0003 (Table 13). Age-3.2 hatchery MSW fish, were accorded a 0.00024 return rate. As with 1SW fish, fry were accorded one-half the rate of fall fingerlings and eggs/unfed fry were given a rate of 0.2 of that of feeding fry.

Fish which returned as maiden fish, mainly in 1995-1996, are expected to contribute to the repeat-spawning hatchery MSW component in 1997. The forecast return was based on a 0.00032 return rate estimated for 1996 from 1994-1995 mostly maiden fish (Table 12).

Total hatchery MSW returns were also forecast from a significant regression of MSW returns 1987-1996 on 1SW returns, 1986-1995. Each year except, 1986-87, has an element of hatchery-smolt and juvenile-origin fish.

MSW hatchery (Forecasts)

Total returns of MSW fish of hatchery, including Aroostook and above Grand Falls, origins destined for Mactaquac in 1997 are **1,052** fish, virtually the same as forecast for 1996 (Table 13) Of the 1,033 fish forecast for 1996, 1,002 were identified either by fin deformities or from scale analyses. Returns from age 1.2 hatchery smolts are expected to number 565 or

54% of the total; about 70% of the total should be identifiable among wild fish. Solution of the equation $MSW_{'97} = 302.1165 + 0.1870\ 1SW_{rtns\ '96}$ ($R^2_{adj} = 0.58$; n=10; p= 0.006) provided an estimate of **1,311** MSW returns in 1997.

Ecological considerations

In-river

Discharges at Mactaquac in July and early August were the highest since 1992 (Fig. 8). Weekly plots of salmon counts at the dam, 1993-1996, (Fig. 3) indicate the unprecedented early (late-June) arrival of 1SW fish at the dam. Relatively average discharge rates from the dam during June is unlikely to have influenced either early arrival or entry to the fishway (low discharges would be expected hasten fishway entry; Marshall and Jones MS 1996). The frequency distribution of weekly counts from July onwards, even under high flow regimes, are consistent with previous years, i.e., fish appear to have been able to ascend the river and find the fishway attraction water through the entire season.

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 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 6,155 wild and hatchery 1SW and 3,139 wild and hatchery MSW salmon in 1996 were forecast on dates as:

Sea-age	July 15	July 22	July 29	August 5
1SW	11,787	10,180	8,133	6,588
MSW	2,779	2,692	2,709	2,593

1SW forecasts are not promoted as managerial tools until the end of July; MSW forecasts have usually been near season-end counts 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 broodstock have been selected for early run-timing and, now hatchery returns being the major portion of the 1SW run, merit separate forecasting - probably with a shortened time series to reflect 1-year smolt and juvenile contributions. End-of-season counts and estimates were generally consistent with pre-season forecasts and identified a shortfall of MSW salmon and a surplus of 1SW fish relative to conservation requirements.

A recent synthesis of data with potential to elucidate the potential impact of hydroelectric installations on smolts and their return as adults (Anon MS 1996b) prompted a cursory investigation of the utility of river discharge as a meaningful variable in the MSW forecast models. Interestingly, the proportion of 1SW fish from a smolt class increases with decreasing discharges at Mactaquac ($p<0.001$). High proportions of 1SW fish from a smolt class are correlated with longer average lengths of 1SW fish (Fig. 7; FL1SW in forecast model). A hypothesis that deserves exploration is that increased fork length and "grilsification" is a consequence of delays in downstream migration of smolts - effected by delays (proxied

by river discharge) in headponds and nurtured by seasonally later conditions at sea. Low discharge could delay the arrival of smolts at the Bay of Fundy, expose them to different currents, abundances of food, greater growth or growth perhaps without expenditure of energy in migrating to distant waters (like earlier arriving smolts?). In effect, delayed smolts might have a reduced marine range - perhaps more like that of adjacent inner-Fundy stocks.

Marine

The ICES Working Group on North Atlantic Salmon (Anon MS 1996a) forecasted from an index of overwinter habitat in the North Atlantic that pre-fishery abundance of non-maturing 1SW salmon available to a Greenland fishery in 1996 would be $\geq$ than that of 1995. Reddin et al. (1993) suggested that 2SW fish returning to homewaters in the following year should reflect the relative changes in forecast Greenland pre-fishery abundance. An unimproved habitat index value for 1996 (Anon MS 1996a and Fig. 6), upwards inflection of values over the last three years, and improved return rates for hatchery-origin fish supports the hypothesis that forecast levels of MSW returns in 1997 may be minimal.

For the Saint John River wild stock of Atlantic salmon, indices of winter habitat for the first or second winter of a 2SW fish at sea were either a statistically non-significant addition to the MSW (homewater returns) predictor models or, because of a significant but negative slope, not immediately interpretable (Marshall et al. MS 1993). However, several other relationships with perhaps more robust data from survival of hatchery-reared fish appear to implicate the "index" of over-winter habitat in the well-being of 1SW and MSW hatchery components (Marshall and Jones MS 1996). They included a significant relationship between: i) the March index of habitat and return rates for 1SW salmon from hatchery smolts (Fig. 6), 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 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 (reciprocal of Fig. 7). 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.

In total, the above elements implicate recent low index values of overwinter habitat with low rates of 1SW and MSW marine survival and, as well, large mature 1SW fish. Explanations for reduced survival include potential increases in distance or rigours in reaching that habitat, i.e., a window or gauntlet condition has narrowed. Increased growth among returning 1SW fish could be the result of selective mortality on smaller, later, or earlier-run smolts or the result of above average growth conditions for those fish successfully crossing the threshold and within reach of the overwinter zone albeit reduced in size but not necessarily in quality. As indicated earlier, equally plausible in-river effects may be contributing to the end results.

Forecast summary

1SW salmon

1SW returns destined for Mactaquac in 1997 were forecast to be 11,793 (5,183 wild and 6,610 hatchery) salmon. Forecasts of wild returns in 1993, 1994 ,1995 and 1996 were at best 35, 53, 34 and 23%, respectively, of the realized returns. Because only a portion of 1994 and none of 1995 returns are incorporated in the model for wild fish and because of the linkage between low survival of hatchery fish and a low index of winter habitat, the wild forecasts are likely inappropriate. Forecasts of hatchery fish reflect current influences but for stages other than smolts require several assumptions. Following the approach taken in 1996, discounting wild forecasts by the range of "error" noted in the past four years may be more indicative of wild returns in 1996. Hence, the forecast for total 1SW returns may more realistically be 7,802 (6,610+[5,183*0.23]) to 9,357 (6,610+[5,183*0.53]) or, in general terms, **7,800** to **9,400 fish**. The potential for greater hatchery contribution from the 1996 smolt class and an upturn in sea survival suggests that **returns in 1997 will exceed new (4,900) and old (3,200) 1SW spawning requirements.**

Prognoses for 1SW salmon returns beyond 1997 are, at best, qualitative. Stocking of large numbers of juveniles and smolts, which made significant contributions to returns in 1996, have continued through 1996 and should influence returns through the remainder of the decade. Recent densities of wild juvenile salmon above Mactaquac (Fig. 9 and Tables 14a and b) are presumably reflective of egg depositions 1993-1995 which dipped below 50% of the old conservation requirements. Densities in 1996 were particularly disappointing in the major Tobique production area given that egg depositions in 1995 (1996 age 0+) were estimated to have improved slightly over those of 1994. High densities for the relatively small Shikatehawk production area are believed to be a direct result of fall migration hold-ups at the Beechwood Dam. In total, 1SW fish returning through the remainder of the decade should number between those estimated to have returned in 1996 and those projected to return in 1997, i.e., 6,000 to perhaps 10,000 fish or 120 to 200% of conservation requirements. Estimated returns during the past decade have been low but ranged from 8,000 to 11,000 fish in six of the ten years. A trend towards improving marine survival would enhance projected surpluses to conservation.

MSW salmon

The forecasts of wild MSW fish for 1997 were 2,051 (no effect of the moratoria), 2,052 (11-year subset of the moratoria data) 2,255 for the 19-year subset of moratoria data and 2,814 for the complete moratoria model. Period hypotheses support the rejection of the complete moratoria model. Hatchery returns were forecasted to be 1,052 and 1,311 MSW salmon. Minimum and maximum values for combinations of all estimates are 3,103- 3,566 fish. In general terms, forecasts of MSW returns may be said to be **3,100 to 3,600 MSW salmon, i.e., 63 to 73% of the new and 70 to 82% of conservation requirements.**

The long-term prognoses for MSW salmon are less favourable than for 1SW fish. Hatchery-origin MSW recruits are few relative to their 1SW counterparts. Until 1996, wild-origin MSW returns from a smolt class have also been 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., only a 30% probability that conservation requirements of 4,900 fish will be met (no chance of real surpluses).

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 10). The river is the largest single salmon-producing tributary of the Saint John below Mactaquac - its production area having been estimated at 4.9 million m^2 or 31% of the total below Mactaquac (Marshall and Penney MS 1983). A new estimate of habitat area from orthophoto measurements substantially increases the productive area to 5.69 million m^2 or 28.5% of the total below Mactaquac Dam (Table 8). A salmon counting fence at kilometre 23 (Fig. 10) from the confluence with the Saint John was operated by DFO in 1972, 1973 and 1975 (Francis and Gallop MS 1979), and by First Peoples in 1993, 1994, 1995, and 1996. In 1996, Kingsclear, Oromocto, and St. Mary's First Nations jointly operated the fence.

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. The total runs of 1SW and MSW salmon above the fence in 1996 were estimated using mark-and-recapture techniques. Similar to previous years, seining of pools upriver from the fence was undertaken to sample the relative numbers of caudal-punched and unpunched salmon. These data form the basis of a mark-and-recapture estimate of the numbers of fish above the fence and, by deduction, the number which passed the fence site uncounted.

Results

Unadjusted counts of small and large salmon at the Nashwaak fence during the June 13 -October 18 (washed out on July 9-10 and 14-31) operating dates numbered 885 small and 486 large salmon. Both counts represented the largest catches since fence operation resumed in 1993. After scale analysis, these counts were corrected to 940 1SW and 429 MSW salmon (Table 2; 2 recaptures were also deducted from the original counts). Hatchery returns were 86 1SW and 38 MSW salmon and represented about 9% of the total counts. Unlike run-timing in 1995, 90% and 74% of the counted and estimated 1SW and MSW salmon passed the fence prior to October in 1996 (Fig. 11). Only 47% and 32% of 1SW and MSW salmon ascended during the same time period in 1995 when summer discharges were much lower. Scale samples revealed that sea-ages of the wild fish were 74% 1SW; 20% 2SW and 6% previous spawners. Sea ages from 1993-1996 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

Seining was conducted on August 15 and 16 and the catch can be summarized as follows:

River		1SW salmon		MSW salmon	
Section	Pool	Marked	Unmarked	Marked	Unmarked
Lower	Colters	4	10	4	8
	Cross Creek	4	6	0	3
	Dunbar	0	0	1	0
Upper	Burnt Camp	1	3	0	0
	Little Basin	0	0	1	2
	Big Basin	1	0	2	0
	Sister's	2	2	1	1
	William's Camp	3	4	6	3
Total		15	25	15	17

To estimate the entire run in 1996, it was necessary to determine the number of fish ascending the river prior to fence installation and during two high water periods in July when the fence was less than 100% efficient. Mark-and-recapture data were submitted to a Bayesian estimate procedure (Gazey and Staley 1980) to describe the most probable estimate (mode) among a binomial distribution of less probable solutions. Analyses suggest a population of 1386 (90%CL; 1098-2250) 1SW and 406 (90%CL; 328-640) MSW salmon above the fence as of August 13 (Fig. 12). The sum of these estimates and adjusted fence counts after that period give an entire season estimate of **1,829** 1SW and **657** MSW salmon. No account has been made of by-catch in the Saint John 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

A total of 23 1SW and 12 MSW salmon was reported to have been illegally removed. The Nashwaak River was open to hook-and-release angling but no catch statistics were available with which to estimate hook-and-release mortality. Two 1SW and four MSW mortalities were recovered on the upstream side of the fence; three of the six fish were later confirmed to have furunculosis. As in 1995, no Nashwaak fish were collected for broodstock.

Conservation requirements

Original conservation requirements were calculated using an accessible salmon-producing substrate of 4.938 million m^2. An assumed requirement of 2.4 eggs m^{-2} (11.9 million total), the length-fecundity relationship for Mactaquac-origin 1SW and MSW fish and 1SW:MSW ratios in the Nashwaak recreational fishery, 1974-1983, (Marshall et al. MS 1992) suggested that, on average, approximately 1,700 1SW and 1,800 MSW fish were required for the entire Nashwaak River. As on the Saint John River above Mactaquac, 1SW requirements were set at those which would provide a 1:1 male-to-female ratio for female MSW fish. The spawning requirement above the fence site was 10.7 million eggs (1,530 1SW and 1,620 MSW fish) or 90% of that of the entire Nashwaak drainage (Marshall and Cameron MS 1994).

Orthophotographic and air photo measurements for the Nashwaak River suggest a juvenile salmon production area (>0.12% grade) of 5.692 million m^2 (Table 8). Productive area *above the fence* is estimated to be 5.35 million m^2 and the new conservation requirement is 12.8 million eggs (Table 15). Biological characteristics of salmon at the counting fence, 1993-1996, indicate a requirement of 2,042 MSW salmon (rounded to **2,040**) to provide eggs and 2,466 1SW fish to provide a 1:1 male:female ratio. Requirements for 1SW fish have been arbitrarily reduced to equal those of MSW salmon, i.e., 2,040 fish. Egg deposition and spawners in 1996 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 **1804** 1SW and **641** MSW salmon. Sea-age, origins, female composition and mean fork lengths for spawners above the fence can be summarized as follows:

	1SW salmon		MSW salmon	
Biological parameter	Wild	Hatchery	Wild	Hatchery
Number	1618	186	569	72
Proportion female	0.437	0.512	0.759	0.632
Mean length female (cm)	57.1	58.1	78.7	77.2

Numbers of 1SW and MSW spawners were 118% and 40%, respectively, of the established and 88% and 31% of the new conservation requirements. Egg deposition was estimated at 6.20 million (1.16 eggs m^{-2} or 48% of the new egg requirement); 1SW females contributed 44% of the total estimated egg deposition.

Estimated egg depositions in the previous three years of fence operation were 31%, 26%, and 33% of new conservation requirements. Densities of juvenile salmon in 1996 (Figure 9, Table 14) are consistent with low levels of egg deposition. The average age-1^+ and age-2^+ parr density for the nine sites was 3.8 parr 100 m^{-2}. Elson's (1967) "normal index" of the same parr groupings is 38 fish 100 m^{-2}.

Forecasts

Data are too few to forecast returns to the Nashwaak fence. However, if wild fish recruit in the same manner as those above Mactaquac, there should be little expectation for change in the numbers of wild 1SW fish from those of the last four years (mean of 1,096 1SW fish). The low parr densities (Fig. 9) which would have contributed to the 1996 smolt run and subsequent 1SW returns in 1997 do not suggest an increase in the expectation for wild 1SW returns. As well, recent numbers of juvenile hatchery fish distributed have remained constant, therefore there is no anticipated increase in the hatchery component (Table 16). The 1,829 1SW fish in 1996 is, however, again suggestive of an increase in MSW salmon in 1997. However, as with 1SW fish, the MSW data are too few to suggest that wild MSW returns will vary from those of the last four years (388-657 fish). It is **highly unlikely that MSW or egg requirements will be approached in 1997.** Juvenile densities in 1995 and 1996 are further suggestive of deficits to conservation requirements continuing through the end of this decade.

KENNEBECASIS RIVER

With a drainage area of about 1,422 km^2, the mainstem Kennebecasis River flows approximately 90 km in a northerly then south-westerly 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 13). The drainage is estimated by orthophotographic survey techniques (Table 8; method of Amiro 1993)) to have the third highest quantity of salmon-producing substrate below Mactaquac Dam. In 1996 a counting fence with upstream and downstream traps was installed at McCully Station (Fig. 13), 40 km from tidal waters, by the NB Coop Fish and Wildlife Research Unit at UNB. 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 450,800 m^2 or 15.5% of the total within the drainage.

Returns

Methods

All salmon 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. The count of 1SW and MSW fish past the fence excluded some fish known to have passed during high flows. Later recapture of two unmarked and five marked fish in the downstream trap permitted the estimation of total fish spawning escapement.

Results

Counts of 1SW and MSW fish at the McCully fence during the July 3- October 28 operating dates numbered 82 1SW and 47 MSW salmon. Eighty percent of fish ascended after Sept 15 (Fig. 14); spawning peaked in the first week of November. External characteristics (scales not yet read) suggested that only two 1SW fish were of hatchery origins.

Removals

As in the rest of SFA 23, recreational fisheries were restricted to "hook-and-release", 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 (except for one MSW mortality) 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. As elsewhere on the Saint John River, all eggs are expected from MSW fish, 1SW requirements were set at those which would provide a 1:1 male-to-female ratio for female MSW salmon. Egg deposition was estimated on the basis of lengths, external sexing and counts from fish trapped at the fence.

Escapement

Eighty-two 1SW and 46 MSW salmon were known to have passed above the fence and were presumed to have spawned. Sea-age, origins (all but two were believed to be wild), female composition and mean fork lengths for wild spawners above the fence can be summarized as follows:

Biological parameter	1SW salmon	MSW salmon
Number	82	46
Proportion female	0.316	0.949
Mean fork length female (cm)	58.1	78.5

Counted 1SW and MSW salmon were only 51% and 29% of the respective requirements. Deposition was estimated at 406,500 eggs (0.88 eggs m^{-2}) or **37%** of requirement. 1SW females contributed 22% of the total estimated egg deposition. Recovery of two unmarked fish among 7 in the downstream trap suggested that 52 fish could have passed the fence during high water. If their 1SW:MSW ratio and biological characteristics were the same as those sampled at the fence, depositions could have been as many as 573,000 eggs or **52% of requirement.**

Forecasts

No adult data or indexes exist from which to forecast wild returns to the fence in 1997. Age-1^+ and -2^+ parr densities in 1995 (Fig. 9) which will contribute to 1SW returns in 1997, are similar to a 10.7 parr 100 m^{-2} average for five sites in 1994 and thus no increases in wild 1SW returns would be expected over those of 1996. (Parr densities in 1996, which will contribute to 1SW returns in 1998 are even lower; Table 14 and Fig. 9) Current MSW/1SW ratios from a smolt class are as yet undocumented but might be assumed to approximate the 0.57 value from two smolt classes in 1996 (true if, as elsewhere on the Saint John, stocks have not greatly fluctuated). Under such an assumption MSW counts in 1997 would not vary substantially from those counted in 1996.

Hatchery-origin 1SW fish at the fence in 1997 should increase as a result of releasing about 6,400 of some 16,000 smolts (Kennebecasis origin) above the fence site in 1996. A return rate of 0.0092 forecast for returns to Mactaquac suggests a return of about 60 hatchery 1SW fish to the fence.

A more general prognosis for returns to the fence in 1997 might parallel that of the Nashwaak River population which, despite increased returns of 1SW fish, is only attaining $\leq$ 50% of conservation requirements and which, in 1997, is unlikely to approach MSW and egg conservation requirements.

HAMMOND RIVER

With a drainage area of about 453 km^2, the mainstem Hammond River flows approximately 60 km in a south-westward 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 15). The drainage has an estimated 1.662 million m^2 of salmon-producing habitat (Table 8; including Palmer Br.), about 8% of the total below Mactaquac Dam. Redds and salmon have been counted in most years since 1976 but have not previously been reported in the DFO Stock Assessment Research Document Series. The surveyed area is 11.75 km in length (25.7% of the mainstem length), averages 0.25% grade and contains an estimated 127,869 m^2 (NBDNRE) of salmon-producing substrate. The lower and upper limits are bounded by the Tabor and Hillsdale bridges, respectively.

Returns

Methods

Salmon returns to the 11.75-km surveyed section were not directly assessed but, rather, 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 per MSW salmon (males and females) is summarized as follows:

Rivers	Years and (no. observations)	Method of fish count	No.redds/ MSW (M+F) fish
Tobique	1987-95 (8)	barrier pool	1.33
Upsalquitch, NW, SE, LSE & Main+Patapedia & Main Restigouche	1978-87 (13)	from canoe	2.25
Hammond	1977-83 (6)	from canoe	2.01
Average (unweighted)			1.86

The number of redds per female MSW fish equals the product of redds per MSW fish and the reciprocal of the proportion females in the MSW population. The analysis assumed that the MSW stock was 75% female - 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 17. Counts of large redds (small redds could be false or those of 1SW fish) ranged from 78 to 305; a count of 256 in 1996 was the 4th highest of the 16 observations and the highest since 1992 (Fig. 16).

Removals

As in the rest of SFA 23, recreational fisheries were restricted to "hook-and-release" fishing, 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.

Conservation requirements

The product of the 127,869 m^2 of substrate in the study area and an assumed requirement of 2.4 eggs m^{-2} suggests a conservation requirement of 0.307 million eggs. Required eggs would be met by **42** MSW females ([306,886/7,306]*2.48) or 105 "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 1996, was the highest since 1992. Egg depositions, with respect to a 2.4 eggs m^{-2} requirement for the study area, were virtually exceeded in all years; those of 1996 are 341% of requirement; those of 1995 are about 100% of requirement.

The excesses to conservation requirements for the study area should not, however, be extrapolated to the entire Hammond River. The study area represents prime spawning habitat and is unlikely to be representative of all production area in the drainage. The 2.4 eggs m^{-2} conservation requirement was by contrast, established on the basis of the complete Pollett River subdrainage, i.e., a variety of habitat and gradient types. There is no knowledge of the egg requirements for prime spawning areas but a general belief that egg depositions in prime area might necessarily greatly exceed 2.4 eggs m^{-2} if juveniles are to recruit to non-spawning juvenile-producing substrate.

Densities of juvenile salmon at five sites on the Hammond River in 1995 and 1996 appear to be greater than the those of the Kennebecasis but not unlike the under-escaped areas above Mactaquac (Shikatehawk River, excepted; rationale in earlier section) and of less than the "normal abundance" of juveniles proposed by Elson (1967).

An increase in redds (and presumably returns and escapement) in 1996 over that of the last few years is, however, consistent with recent estimated increases on the Nashwaak and above Mactaquac. Thus, the simplest interpretation and, requirement of the fewest assumptions, is that redd data may be an index of abundance. To test this hypothesis i) age-0^+ and age-1^+ parr at three electrofishing stations on and within the bounds of the redd survey area were regressed on estimated egg depositions in year i-1 and year i-2, and ii) estimates of wild salmon returns at Mactaquac were regressed on total redd counts in the study area. Neither regression of juvenile and egg, nor Mactaquac wild returns and Hammond redd counts were significant ($n=11$ and 10; $p > 0.05$ and $n=16$, $p > 0.05$, respectively).

Forecasts

Data are few and no demonstrated stock and recruit relationships exists with which to forecast numbers of salmon returning to the Hammond River or Hammond River study area. Total redd counts in the study area, 1997, might reasonably be expected to be between the 113 and 344 values observed between 1992 and 1996, i.e., representative of an excess to conservation requirements to the study area. Juvenile data (Fig. 9) suggest that wild returns recruiting to the Hammond could represent a greater proportion of conservation requirements than might be expected to recruit to the Kennebecasis River. As well, 1SW recruits can be expected from 20,000 age-1^+ parr (70-80% smolt) distributed within the drainage in 1996.

MAGAGUADAVIC RIVER

With origins in Magaguadavic Lake, the Magaguadavic River flows south-easterly for 97 km to Passamaquoddy Bay, Bay of Fundy, at St. George, N.B. (Fig 17; Martin MS 1984). A 13.4m-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 1996, the trap was monitored and summary data and analyses were provided by J. Carr[1], Atlantic Salmon Federation. The trap was operated from July 3 to November 22, but some bright salmon were observed in the fishway as early as May.

In 1994 and 1995 the trap had been operated and data provided by the Magaguadavic Watershed Management Association; in 1992 and 1993 it was operated by the Atlantic Salmon Federation (Marshall and Jones MS 1996) Operating dates in each of those years was July through October. Since at least 1992, a decline in wild salmon counted at the dam has been accompanied by an increase in aquaculture escapees.

Returns

Counts of salmon in the trap numbered 69 wild and 194 aquaculture escapees (after analyses of scales; there were also 46 post-smolts), (J. Carr[1] pers comm). 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 in 1996 were the lowest of the short record. Aquaculture escapees were down considerably from those counted in 1994 and 1995. No repeat-spawning fish were observed among the 21 MSW aquaculture fish; one was found among the 21 fish of wild origin. In 1996, unlike, 1994 and 1995, there were no reported losses from the industry in Passamaquoddy Bay.

Of the wild salmon counted, 68% were in the months of July and August; the remainder were in the fall. In contrast, about 65% of aquaculture-origin fish were counted in the fall months. Thus, May-June river entrants that were not trapped are more likely to have been of wild than aquaculture origin.

Removals

Unlike 1995, virtually all fish captured at the fishway in 1996 were released to the river. The exceptions were 3 female and 4 male wild MSW salmon which were removed for broodstock by the Magaguadavic River Salmon Association. Virtually all fish released to the river were tagged with red(wild) and yellow (aquaculture) Floy anchor tags as part of a continuing investigation on the relative distribution and contribution to spawning by fish of wild and aquaculture origins. There has been no commercial fishery since 1983, no aboriginal food fishery and, in 1996, the recreational fishery was restricted to hook-and-release fishing.

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

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 m^{-2} (Anon MS 1978). Spawners necessary to obtain those eggs were estimated at 230 MSW and 140 1SW salmon. Measurements from orthophotgraphic maps and air photos (Amiro 1993) suggest 6.4 million m^2 of substrate >0.12% gradient but their use has been delayed until new ground survey information is integrated into the data base.

Escapement

Two hundred and twenty-two 1SW and 41 MSW fish (3 MSWs and 4 1SW fish were taken for broodstock) were released above the fishway. All wild fish were estimated to be sexually maturing; only a small portion of aquaculture escapees were thought to be maturing. (J. Carr[1] pers comm). Biological characteristics of sexually maturing fish released to the river were as follows:

Biological characteristic	1SW wild	1SW aqua	MSW wild	MSW aqua
Number	44	41	18	4
Proportion female	0.32	0.56	0.78	1.0
Mean fork length female (cm)	56.1	57.2	75.2	71.3

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 by maturing fish of 249,615 eggs or 18% of requirement. Forty-one percent of total eggs was estimated to have been from fish of sea-cage origin. Estimates of escapement and attainment of conservation requirements, 1994-1996, are as follows:

	Escapm't		% Req'm		
Year	1SW	MSW	1SW	MSW	Eggs
1994	639	143	456	62	56
1995	182	105	130	46	22
1996	222	34	159	15	18

Forecasts

If recruitment to the Magaguadavic were based on escapement of wild fish alone, the prospects for MSW returns in 1997 would be minimal. 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 improve beyond current levels. 1SW recruitment has not been strong and potential escapement in 1992-1993 (Table 2) does not offer promise of more 1SW fish in 1997 than those recruited in 1996 from escapements in 1991-1992. Aquaculture fish at the fishway in 1997 will largely be a function of cage losses in the same year.

ST. CROIX RIVER

The St. Croix River, a US/Canada international river bordering the State of Maine and Province of New Brunswick, drains south-easterly 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. 17). 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 three 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 1996, there was no salmon fishery of any description. The river is essentially a development project and, based on 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.

Returns

Salmon were counted at the Milltown fishway, just above tide-head, between May 4 and October 18, 1996. As in recent years, counts, scale samples and external characteristics were provided by L. Sochasky[2] (pers comm). Interpretation of sea-age from scales indicated a total return of 38 1SW and 114 MSW salmon (Table 2). Wild returns numbered only 10 1SW and 32 MSW salmon; the MSW component now numbers <5% of their numbers in the mid-1980s. Eleven of the 13 hatchery-origin 1SW fish originated from 17,541 age 1^+ smolts of St. Croix River origin reared at Saint John Fish Culture Station and released in 1995. Twenty-eight of the 77 hatchery-origin MSW fish originated from Penobscot-origin smolts stocked by the Atlantic Sea-Run Salmon Commission (Maine). Fifteen 1SW and 5 MSW salmon of sea-cage origin were identified on the basis of "broom" tails and fin regeneration.

The majority of the wild and hatchery salmon ascended the fishway by the end of July, only 13% and 6% of the 1SW and MSW respectively entered the fishway after July 31. Run-timing of sea-cage fish was the opposite of the wild and hatchery component, as 93% 1SW and 60% MSW ascended the fishway after August 31. Sea-cage fish were believed to be of the same sources as those entering the Magaguadavic River; both 1SW and MSW fish were judged to be immature.

Removals

Removals were restricted to 41 broodstock delivered to Mactaquac Fish Culture Station. Broodstock were mostly June-, July-run fish of both wild (naturalized stock; preferred) and hatchery (Penobscot; less preferred) origins.

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

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 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. 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 were likely to produce the egg requirement.

Escapement

Effective river escapement in 1996 increased to 70 MSW and 22 1SW salmon from just 23 MSW and 21 1SW fish in 1995. Fifteen 1SW and 5 MSW 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 fork lengths for fish released above the Milltown Dam can be summarized as follows:

Biological characteristics	1SW wild	1SW htch	1SW aqua	MSW wild	MSW htch	MSW aqua
Number	10	12	15	23	47	5
Prop. female	0.56	0.46	0.93	0.65	0.64	0.80
Mean fork length female (cm)	54.7	56.7	60.2	72.8	72.8	69.4

The resultant egg deposition totalled about 302,000 eggs or 4% of requirements. Sixteen hatchery and two wild female broodfish yielded 158,000 eggs that were laid down at Mactaquac Fish Culture Station.

Forecasts

Data are too few to forecast returns to the St. Croix. The St. Croix is a restoration project with little possibility of approaching conservation requirements within the coming decade.

MANAGEMENT CONSIDERATIONS (SFA 23)

Forecast models and forecasts for 1SW returns destined for Mactaquac Dam in 1997 incorporate a significant amount of uncertainty. As well, marine conditions in the North Atlantic, which are not fully accounted for in the forecast models, may be improving. Forecasts of greater 1SW returns in 1997 are based on a greater contribution from hatchery-source fish. MSW returns are not expected to improve. Conservation requirements have been increased; the probability of attaining the new egg requirement through MSW salmon (or 1SW fish) is remote. 1SW escapement is making a slightly greater contribution to egg requirements than previously. Building on the results and experience from 1996, management should consider initial allocations of 1SW fish for a mid-July opening. 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 1994-1996 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 1996 and juvenile salmon densities in tributaries below Mactaquac, 1995-1996, 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 on the Kennebecasis are unlikely to be met in 1997. However, 1SW requirements will be met above Mactaquac and may be approached on the Nashwaak and above the McCully fence on the Kennebecasis River, in part because of projected returns of hatchery-origin fish.

Prospects for wild MSW salmon to the Magaguadavic River in 1997 do not exceed a few dozen fish. Similarly on the St. Croix River (a development project) counts of wild 2SW fish are now 5% 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 in 1997.

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 losses were acknowledged by the industry. Few externally recognizable aquaculture fish were reported at monitoring sites on the Saint John River. There appears to be no commitment on the part of government to control potential swamping of native stocks with other genetic material - most probably that of Saint John River or Penobscot River salmon, or to deter/ penalize/have the industry mitigate for probable loss of unique salmon populations.

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LITERATURE CITED

Amiro, P.G. 1993. Habitat measurement and population estimation of juvenile Atlantic salmon (*Salmo salar*). p. 81-97. *In* R.J. Gibson and R.E. Cutting [ed.]. Production of juvenile Atlantic salmon, *Salmo salar*, in natural waters. Can. Spec. Publ. Fish. Aquat. Sci. 118. 262p.

Anon. MS 1978. Biological Conservation Subcommittee Report. Atlantic Salmon Task Force Review. 203p.

Anon. MS 1988. Long-term management plan for the diadromous fisheries of the St. Croix River. Can. MS Rep. Fish Aquat. Sci. No. 1969. vii + 68p.

Anon. MS 1996a. Report of the North Atlantic Salmon Working Group. ICES C.M. 1996/ Assess:11 Ref. M:228p.

Anon. MS 1996b. Assessment of Atlantic salmon smolt recruitment in the Saint John River, final report. Washburn and Gillis Associates. Ltd., Fredericton NB *for* SALEN Inc., np.

Elson, P.F. 1967. Effects on wild young salmon of spraying DDT over New Brunswick forests. J. Fish. Res. Board Can. 24(4):31-767.

Francis, A.A., and P.A. Gallop. MS 1979. Enumeration of adult Atlantic salmon, *Salmo salar*, runs in 1972, 1973 and 1975 to the Nashwaak River, New Brunswick. Unpubl. Data Rep. Fish. Mar. Serv. Halifax, N.S. np.

Gazey, W.J., and M.J. Staley. 1996. Population estimation from mark-recapture experiments using a sequential Bayes algorithm. Ecology 67:941-952.

Harvie, C.J., and T.L. Marshall. In prep. In-season forecasting of end-of-season counts at the Mactaquac Dam, Saint John River, N.B.

Marshall, T.L. MS 1989.. Assessment of Atlantic salmon of the Saint John River, N.B. CAFSAC Res. Doc. 89/77. vii+29.

Marshall, T.L., and J.D. Cameron. MS 1994. Assessment of Atlantic salmon of the Saint John River above Mactaquac and of the Nashwaak River, N.B., 1993. DFO Atl. Fish. Res. Doc. 94/19. v +24p.

Marshall, T.L., and J.D. Cameron. MS 1995. Assessment of Atlantic salmon stocks of the Saint John River and southwest New Brunswick, 1994. DFO Atl. Fish. Res. Doc. 95/129. iii +49p.

Marshall, T.L., and R. Jones. MS 1996. Status of Atlantic salmon stocks of the Saint John River and southwest New Brunswick, 1995. DFO Atl. Fish. Res. Doc. 96/40. iii + 50p.

Marshall, T.L., and G.H. Penney. MS 1983. Spawning and river escapement requirements for Atlantic salmon of the Saint John River, New Brunswick. CAFSAC Res. Doc. 83/66. iii +17p.

Marshall, T.L., P.G. Amiro, J.A. Ritter, B.M. Jessop, R.E. Cutting and S.F. O'Neil. MS 1992. Perfunctory estimates of allowable harvests of Atlantic salmon in 18 rivers of Scotia-Fundy Region. CAFSAC Res. Doc. 92/16. 28p.

Marshall, T.L., J.A. Ritter and D.G. Reddin. MS 1993. Forecasting multi-sea-winter salmon returns to the Saint John River, N.B., Canada. ICES Doc. C.M.1993/M:29, Ref C+H 10p.

Martin, J.D. MS 1984. Atlantic salmon and alewife passage through a pool and weir fishway on the Magaguadavic River, New Brunswick, during 1983. Can MS Rep. Fish. Aquat. Sci. 1776: iii + 11p.

O'Connell, M.F., D.G. Reddin, P.G. Amiro, F. Caron, T.L. Marshall, G. Chaput, C.C. Mullins, A. Locke, S.F. O'Neil, and D.K. Cairns. MS 1996. Canadian Atlantic salmon 2SW spawner requirements. DFO Atl. Fish. Res. Doc. (In prep.)

Penney, G.H., and T.L. Marshall. MS 1984. Status of Saint John River, N.B., Atlantic salmon in 1983 and forecast of returns in 1984. CAFSAC Res. Doc. 84/47. 34p.

Reddin, D.G., K.D. Friedland, P.J. Rago, D.A. Dunkley, L. Karlsson, and D.M. Meerburg. MS 1993. Forecasting the abundance of North American two-sea winter salmon stocks and the provision of catch advice for the West Greenland salmon fishery. ICES C.M. 1993/M:43, 20p. + Figs & Tables.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Fish. Res. Board Can., Bull. 191: 382p.

Ritter, J.A., T.L. Marshall, and P.R. Boudreau. MS 1990. Model development for predicting multi-sea-winter Atlantic salmon (*Salmo salar* L.) returns to Saint John River, New Brunswick. CAFSAC Res. Doc 90/84. 28p.

PEER REVIEW/OUTSIDE CONSULTATIONS

Vetting of the contents of this document took place during the week of Feb 3-7, 1997, in Moncton, N.B. Reviewers included staff of the Diadromous Division of DFO, biologists from the provinces of Quebec, New Brunswick and Nova Scotia, Atlantic Salmon Federation, Parks Canada and DFO Headquarters (Ottawa) Region, NB Co-op Fish and Wildlife Research Unit, Biology Dept., UNB, NB Wildlife Federation and Universities of Moncton and New Brunswick. Representatives of the Netukulimkewe'l Commission (representing off-reserve Aboriginals in Nova Scotia) were also in attendance. Science Branch also publishes a regional overview, a précis of the assessment, research recommendations and main points raised during the meeting.

Formal consultations re: status of stocks in 1995 and pre-season forecasts for 1996 were presented to the Zone 23 Salmon Management Advisory Committee (ZMAC) on April 3, 1996; stock status (1994) and conservation requirements for the Saint John River were

presented and cross-examined in Provincial Court (Crown vs Knockwood et al.) on April 13 and 15. Science "management" practices (proposed adult and juvenile distributions above Mactaquac), free-swim initiatives and background to client initiatives to investigate downstream passage of smolts at hydro dams above Mactaquac were presented at a "Science Review" facilitated by the NB Salmon Council and Atlantic Salmon Federation in Fredericton on May 25, 1995. Clients represented both Canadian and US (Aroostook River and upper Saint John River) interests.

In-season management measures and available surpluses of 1SW fish were discussed at a full meeting of ZMAC 23 on July 30 in Fredericton. The same topics were presented to the Chief and Council of Woodstock First Nation on August 7 (at Woodstock) and with representatives of the Oromocto First Nation on August 8 (in Fredericton). Several formal (many informal) meetings were held background to shared field investigations, including: Tobique Rec. Fish. (July 11), and Steering Committee of the downstream smolt investigations (July 25, August 6 and August 22). 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 January 9, 1997, in Fredericton.

Table 1. Estimated total arrivals of wild, hatchery and aquaculture 1SW and MSW fish destined for Mactaquac Dam on the Saint John River, N.B., 1996.

Sea-age	Components	Wild	Hatch.	Aqua.	Total
1SW					
	Mactaquac counts(a)	1,552	4,600	3	6,155
	Mactaquac counts adjusted(b)	1,214	4,939	3	6,156
	Angled MS below Mactaquac	0	0	0	0
	Native Food Fishery	99	401	0	500
	By-catch(c)	13	54	0	67
	Totals	1,326	5,394	3	6,723
MSW					
	Mactaquac counts(a)	2,413	716	10	3,139
	Mactaquac counts adjusted(b)	2,181	947	10	3,138
	Native Food Fishery	70	30	0	100
	By-catch(c)	58	25	0	83
	Totals	2,309	1,002	10	3,321

(a) - Hatchery/wild origins per external characteristics in previous assessments;fishway closed Oct 25.

(b) - Adjusted by analyses of scales from sampled fish. (See text p.10 for explanation.)

(c) - Estimated to be 1% of total 1SW returns and 2. 5% total MSW returns, considered to include losses to poaching.

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

	Saint John					Nashwaak					Magaguadavic					St. Croix(e)					
	Wild		Hatchery			Wild		Hatchery			Wild		Aquaculture			Wild		Hatchery		Aquaculture	
Year	1SW	MSW	1SW	MSW		1SW	MSW	1SW	MSW	Dates of Operation	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
Means:																					
1991-95	3,716	2,631	1,770	548		-	-	-	-		96	89	432	91		13	35	18	46		
1986-95	5,300	2,885	1,616	543		-	-	-	-		135	151	432	91		44	90	24	50		
1996 as % of:																					
1991-95	42%	92%	260%	133%		-	-	-	-		50%	24%	40%	22%		80%	93%	72%	169%		
1986-95	29%	84%	285%	134%		-	-	-	-		36%	14%	40%	22%		23%	35%	55%	155%		

a- Small numbers of aquaculture fish, see Tables 3, 4a & 4b. 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, 1970-1996.

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

(a) 1990-1994, 1SW and MSW classification based on lengths and count data; 1995 & 1996, 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, 1975-1996, from **hatchery-reared smolts released at** Mactaquac, 1974-1995. Includes counts of 8, 56, and 34 probable sea-cage fish in 1990, 1991 and 1992, respectively.

Releases			Returns										
			Mactaquac									% return	
Year	Smolts	Prop 1-yr	Year	Mig ch (combined)	Dam	Native fishery	Angled main SJ	By-catch	Commer-cial	Total[a]		Unadj	Adj[b]
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[d]		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[d]		0.686	0.671
95	240,582	1.00	96[c]	(2,649)		215	0	29		2,893		1.203	1.203
96	286,400	1.00											

[a] Includes some returns from smolts stocked downriver of Mactaquac, 1981-1991 and 1993 and in sea-cages (as determined from erosion of margins of upper and lower caudal fins).

[b] Adjusted return rates exclude smolts stocked downriver from Mactaquac (Marshall MS 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; 1996 count yielded no tagged 1SW fish from among 4,000 tagged smolts released to the Nashwaak in 1995 (13,282 smolts total).

[c] Hatchery origin 1SW fish at Mactaquac in 1996, were assigned an origin on the basis of freshwater age (scale reading) and fin condition, i.e., age 1.1 @ 0.5364, age 2.1 @ 0.274, age 3.1 @ 0.176 and age 4.1 @ 0.01.

[d] Adjustments made in 1987 returns (juvenile contribution had been overlooked) and in 1995 (mathematical error: age 1.1 @ 0.5314; age 2.1 @ 0.3099; age 3.1 @ 0.1587).

Table 4b. Estimated total number of **MSW** returns to the Saint John River, 1976-1996, from **hatchery-reared smolts released at** Mactaquac, 1974-1994. Includes counts of 221, 24, 16, 6 and 28 probable sea-cage fish in 1990, 1991, 1992, 1993 and 1994, respectively.

Releases			Returns										
			Mactaquac									% return	
Year	Smolts	Prop 1-yr	Year	Mig ch (Combined)	Dam	Native fishery	Angled main SJ	By-catch	Commer-cial	Total[a]		Unadj	Adj[b]
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		0.364	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	0	23		468		0.229	0.214
93	221,403	1.00	95	(440)		5	0	11		456		0.206	0.205
94	225,037	1.00	96[c]	(567)		18	0	15		600		0.267	0.267
95	240,582	1.00											

[a] Includes some returns from smolts stocked downriver of Mactaquac, 1981-1990 and in sea-cages (erosion of margins of upper and lower caudal fins); sea-cage fish removed in 1995 (Table 1).

[b] Adjusted return rates exclude smolts stocked downriver from Mactaquac (Marshall MS 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 and no returns from 15,059 stocked in the Nashwaak in 1994.)

[c] Hatchery origin MSW fish at Mactaquac in 1996 were assigned an origin on the basis of freshwater age (scale reading) and fin condition, i.e., age 1.2 @ 0.599, age 2.2 @ 0.232, age 3.2 @ 0.144 and repeat spawners @ 0.025.

Table 5. Estimated homewater removals(a) of 1SW and MSW salmon destined for Mactaquac Dam on the Saint John River, N.B., 1996.

	1SW			MSW		
Components	Wild	H+Aq	Total	Wild	H+Aq	Total
Native Food Fishery						
Below Mact.	99	401	500	70	30	100
Above Mact.	49	126	175	144	41	185
Recreational fishery						
Tobique River	-	-	-	-	-	-
Mainstem abv Mact.	-	-	-	-	-	-
Mainstem blw Mact.	-	-	-	-	-	-
Hook-release mort.(b)	22	90	112	89	43	132
Passed abv Tinker	35	118	153	49	3	52
Passed abv Grand F.	-	-	-	-	-	-
Passed blw Mact.	-	-	-	-	-	-
Hatchery broodfish	8	6	14	172	45	217
mortalities, etc.(c)	18	208	226	27	6	33
Poaching/disease(d)	11	44	55	42	21	63
By-catch	13	54	67	58	25	83
Totals	255	1,047	1,302	651	215	866

(a) - Wild:hatchery (+aquaculture) composition per adjusted counts and assumed availability.

(b) - Assumed to be 2% & 5% of all remaining 1SW and MSW fish respectively, above Mactaquac.

(c) - Includes 225 1SW fish for Woodstock FN.

(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, 1970-1996.

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

(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.

(b)- NBDNRE and DFO sources.

(c)- Guesstimates from various sources or assumed proportions (Table 1) of the run; inc. in commercial, 1981-83.

(d)- Not include 225 1SW fish provided from Mactaquac.

Table 7. Numbers of adult salmon released above Tinker Dam [Aroostook River] and Grand Falls [mainstem Saint John] dams, 1983-1996.

	Tinker						Grand Falls			
	Trucked				Fishway(a)		Trucked			
Year	1SW	(F)	MSW	(F)	1SW	MSW	1SW	(F)	MSW	(F)
1983	34		0							
1984	58		29							
1985	65		24						12	(10)
1986	50		0							
1987	77		9							
1988	70		30		17?	39?				
1989	88	(6)	35	(30)	81	22				
1990	0		0		45	18				
1991	50	(3)	50	(47)	39	0	90	(5)	50	(47)
1992	225	(24)	90	(84)	117	6	230	(16)	110	(106)
1993	85	(17)	71	(63)	50	13	109	(12)	64	(53)
1994	105	(6)	16	(12)	14	5	62	(8)	17	(14)
1995	100	(11)	40	(36)	20	2	0		0	
1996	100	(8)	40	(40)	53	12	0		0	

a) - sea-age based on fork length measurements & differs from that ascribed by operator at Tinker fishway.

Table 8. Estimates of juvenile salmon production area in the Saint John River, N.B. (Based on measures from air photos and orthophotographic maps, Amiro, 1993).

	Area (100m^2) units				Percentage		
Tributary	Total	<0.12%	Productive	% Chng[a]	Above	Below	Total
Above Mactaquac							
Salmon R.	13,500	746	12,754	+3	9.47		3.81
Tobique R.	145,730	67,168	78,562	-17	58.31		23.49
Shikatehawk R.	4,540	-	4,540	+32	3.37		1.36
Becaguimec R.	14,110	3,410	10,700	-5	7.94		3.20
	-	-					
Nackawic R.(acces)@0.6	7,656	-	7,656	+566	5.68		2.29
Mainstem Hrt-B'wood	87,640	87,640	-	none	0.00		0.00
Mainstem Aroos-GF	50,900	45,500	5,400	new	4.01		1.61
Little R., Tilley	-	-					
Muniac Str.	-	-					
Mactaquac R.	-	-					
Presquile R.	7,050	240	6,810	new	5.05		2.04
Meduxnekeag R.	13,960	5,660	8,300	new	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)	350,190	210,364	134,722	+10	100.00		40.28
	-	-					
Below Mactaquac	-	-					
Keswick R.	14,200	4,100	10,100	+28		5.06	3.02
Nashwaak R.	77,110	20,190	56,920	+15		28.50	17.02
Little R. Gr. Lk	13,500	3,340	10,160	+247		5.09	3.04
Gaspereau R. Gr. Lk	18,890	650	18,240	+82		9.13	5.45
Salmon R. Gr. Lk	35,970	19,690	16,280	+306		8.15	4.87
Canaan R.	46,600	22,730	23,870	+106		11.95	7.14
Kennebecasis R.	37,290	16,600	20,690	-51		10.36	6.19
Hammond R.	26,400	9,780	16,620	-37		8.32	4.97
Nerepis R.	12,410	5,650	6,760	+33		3.38	2.02
	-	-					
Nashwaaksis R.	3,990	1,420	2,570	new		1.29	0.77
Portabello Cr. Gr. Lk	1,960	610	1,350	new		0.68	0.40
Noonan Br., Gr. Lk	-	-					
Burpe Mill Str., Gr. Lk.	2,190	-	2,190	new		1.10	0.65
Newcastle Cr., Gr. Lk	5,220	-	5,220	new		2.61	1.56
Coal Cr., Gr. Lk.	5,450	1,730	3,720	new		1.86	1.11
Cumberland Bay Gr. Lk	1,150	-	1,150	new		0.58	0.34
Youngs Cove Gr. Lk.	-	-					
Bellisle Cr.	4,360	460	3,900	new		1.95	1.17
Total Below	306,690	106,950	199,740	+25		100.00	59.72
	-	-					
Total Saint John	651,776	317,320	334,462	+19			100.00

[a] -Percentage change from area in Marshall and Penney (MS 1983).

Table 9. Biological characteristics and estimated conservation requirements for the Saint John River salmon above Mactaquac (O'Connell et al. MS 1996).

	1SW Salmon				MSW Salmon			
Year	Prop. returns	Prop. female	Mean FL (cm)	Eggs per female (a)	Prop. returns	Prop. female	Mean FL (cm)	Eggs per female (a)
1988	0.77	0.15	60.7	3,837	0.23	0.95	76.9	6,881
1989	0.70	0.17	61.3	3,921	0.30	0.93	78.8	7,368
1990	0.69	0.27	60.2	3,769	0.31	0.91	77.8	7,108
1991	0.58	0.18	58.3	3,519	0.42	0.91	78.3	7,237
1992	0.62	0.13	59.2	3,635	0.38	0.95	77.7	7,082
1993	0.52	0.06	59.0	3,609	0.48	0.96	77.9	7,133
1994	0.55	0.14	60.1	3,755	0.45	0.94	76.1	6,685
1995	0.57	0.11	58.3	3,519	0.43	0.94	77.2	6,955
Mean	0.63	0.15	59.64	3,695	0.37	0.94	77.59	7,056

a - Eggs per female= 430.19 * exp(0.03605* Fork Length) (Marshall and Penny MS 1983).

MSW requirement (4,900) = area (32,331,840 m^2) /eggs per spawner and equates to 4,606 females and 294 males.

Deficit males are 4606-294 or 4,312 fish.

1SW requirement to attain deficit males = 4,312/0.85 or 5,073 (round down to 4,900).

Table 10. Estimated homewater returns, removals and spawning escapement of 1SW and MSW salmon destined for/above Mactaquac Dam, Saint John River, 1996.

Sea-age	Components	Wild	H+Aq	Total
1SW				
	Homewater returns	1,326	5,397	6,723
	Homewater removals(a)	255	1,047	1,302
	Spawners(b)	1,082	4,394	5,476
	Conservation req'm			3,200
	% of requirement			171
	New requirement			4,900
	% of requirement			112
MSW				
	Homewater returns	2,309	1,012	3,321
	Homewater removals(a)	651	215	866
	Spawners(b)	1,700	818	2,518
	Conservation req'm			4,400
	% of requirement			57
	New requirement			4,900
	% of requirement			51

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

(b) - Excludes Mactaquac broodfish but includes losses to poaching and disease

Table 11. Tobique River egg deposition/100m^2 and recruitment of total wild 1SW and MSW salmon which would have returned to Mactaquac in the absence of homewater removals in yr i+5 and i+6, and absence of removals in Newfoundland (col 8) and Greenland (col 9). Eggs contributing to annual returns derived in App 1-3; mean lengths of 1SW recruits in col 5.

Eggs/100m^2		1SW recruits (wild)			MSW recruits (wild)				Ratio
Years	No.	Year	Number returns	Length (cm)	Year	Number returns	Col 7 + Nfld	Col 8 +Grnld	MSW /1SW
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(7/4)
1965-66		1970	3,057	54.7	1971	4,715			1.54
1966-67		1971	1,709	55.8	1972	4,899	5,724	10,599	2.87
1967-68		1972	908	57.0	1973	2,518	2,595	3,074	2.77
1968-69	42.70	1973	2,070	54.6	1974	5,811	6,411	10,011	2.81
1969-70	32.06	1974	3,656	56.1	1975	7,441	9,138	14,437	2.04
1970-71	66.26	1975	6,858	55.5	1976	8,177	11,913	15,181	1.19
1971-72	122.05	1976	8,147	55.5	1977	9,712	11,068	15,236	1.19
1972-73	82.47	1977	3,977	56.1	1978	4,021	5,637	5,975	1.01
1973-74	80.22	1978	1,902	56.4	1979	2,754	3,303	4,132	1.45
1974-75	391.21	1979	6,828	56.4	1980	10,924	11,684	16,197	1.60
1975-76	348.93	1980	8,482	58.1	1981	5,766	7,062	8,051	0.68
1976-77	267.20	1981	6,614	56.3	1982	5,528	5,934	7,773	0.84
1977-78	287.02	1982	5,174	55.4	1983	5,783	6,537	8,375	1.12
1978-79	173.40	1983	4,555	55.4	1984	9,779	11,484	11,694	2.15
1979-80	248.15	1984	8,311	55.6	1985	10,436	12,335	13,270	1.26
1980-81	229.42	1985	6,526	55.8	1986	6,128	7,803	9,269	0.94
1981-82	181.65	1986	7,904	57.6	1987	4,352	4,636	5,942	0.55
1982-83	99.63	1987	5,909	58.1	1988	2,625	4,132	5,615	0.44
1983-84	248.32	1988	8,930	58.6	1989	4,072	4,072	6,828	0.46
1984-85	362.09	1989	9,522	59.1	1990	3,329	4,333	5,075	0.35
1985-86	274.19	1990	7,263	58.6	1991	4,491	4,491	6,881	0.62
1986-87	208.86	1991	6,256	57.8	1992	4,104	4,104	5,505	0.66
1987-88	205.60	1992	6,683	58.5	1993	2,958	2,958	3,450	0.44
1988-89	154.50	1993	3,213	58.3	1994	1,844	1,844	1,844	0.57
1989-90	148.42	1994	2,276	58.9	1995	1,654	1,654	2,145	0.73
1990-91		1995	2,168	57.1	1996	2,309	2,309	2,309	1.06
1991-92		1996	1,326	57.7	1997	____			
1992-93	149.87	1997	____						

Recent tag returns contributed to minor revisions in column 9 relative to col 9, Marshall and Jones (MS 1996).

Table 12. Hatchery releases contributing to adult returns to Mactaquac in 1996, 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 1996			
Year	Loc	Stage	Number	Age	1SW	MSW	Rate
1995	At	1-yr smolt	240,582	1.1	2,893		0.01203
1995	Bl	1-yr smolt(Nashw)	13,283	1.1	0		
1994	Abv	Fall fing [10.5-14cm]	126,684	1.1			
1994	Abv	Fall fing *Ad-clip ["]f*	253,730	1.1	(16)		
1993	Abv	Feeding fry/sum fing	306,558 c	2.1			
1993	Abv	Fall fing [10.5-13cm]	170,065	2.1	901		0.00530
1993	Abv	Fall fing-*Ad clip ["]f*	99,939	2.1	0		
1993	Abv GF	Fall fing [10-11cm]	173,033	2.1	577		0.00334
1993	Abv GF	Summer fing [5cm]	290,484 c	2.1			
1992	Aroos	Adults(eggs'93)	779,000 c	2.1			
1992	Abv GF	Adults(eggs'93)	809,000 c	2.1			
1992	Abv	Fall fing	508,445 a	3.1	947		0.00186
1992	Abv	Unfed/fry	600,441 ac	3.1			
1991	Aroos	Adults(eggs'92)	370,000 c	3.1			
1991	Abv GF	Adults(eggs'92)	370,000 c	3.1			
	Total juveniles (n/c smolts)		2,529,379				
1994	At	1-yr smolt	225,037	1.2		600	0.00267
1994	Bl	1-yr smolt(Nashw)	15,059	1.2		0	
1993	Abv	Fall fing [10.5-13cm]	170,065	1.2		0	
1993	Abv	Fall fing-*Ad clip ["]f*	99,939	1.2		0	
1992	Abv	Fall fing	508,445 a	2.2		232	0.00046
1992	Abv	Unfed/fry	600,441 ac	2.2			
1991	Aroos	Adults(eggs'92)	370,000 c	2.2			
1991	Abv GF	Adults(eggs'92)	370,000 c	2.2			
1991	Abv	Fall fing	479,458 b	3.2		144	0.00030
1991	Abv	Unfed fry	173,524 bc	3.2			
1990	Aroost	Adults(eggs'91)	105,000 c	3.2			
		Repeat spawners	4,687 d			15	0.00320
	Total juveniles (n/c smolts)		2,036,559				
Totals					5,318 e	991	

a - Includes 135,309 fall fingerlings and 411,678 fry (5.8-6.4cm) to above Grand Falls.
b - Includes 139,323 fall fingerlings and 173,524 fry (5.0-5.6cm) to above Grand Falls.
c - Not expected to be distinguishable from wild fish upon return.
d - Estimated escapement ["spawners" minus losses to poaching/disease] above Mactaquac, 1994-1995.
e - excludes 76 1SW fish classified as age 4.1and 11 MSW aged 4.2
f - ad-clip returns (3 from age-1.1 and 1 each from MSW age 2.2, 3.2 & ?.2 fish [latter releases unknown]) were processed post-assessment; the estimated 16 age 1.1 fish were included among returns from 1-year smolts; a return rate of 0.00334 was used in the assessment for the 170,065 + 99,939 fall fingerlings.

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 1997. (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, and 150,000 in 1994.)

		Release			Returns in 1997			
Year	Loc	Stage	Number		Age	Rate(e)	1SW	MSW
1996	At	1-yr smolt	286,400		1.1	0.00918	2,629	
1996	Bl	1-yr smolt(Nashw)	12,000		1.1	0.00329	39	
1994	Abv	Feeding fry	447,854	c	2.1	0.00128	573	
1994	Abv	Feeding fry-*Ad clip f*	30,000		2.1			
1994	Abv	Fall fing	126,684		2.1	0.00255	323	
1994	Abv	Fall fing-*Ad clip f*	253,730		2.1	0.00255	647	
1994	Abv GF	Fall fing	159,311		2.1	0.00255	406	
1994	Abv GF	Feeding fry	565,717	c	2.1	0.00128	724	
1993	Aroos	Adults(eggs'94)	137,000	c	2.1	0.000256	35	
1993	Abv GF	Adults(eggs'94)	123,630	c	2.1	0.000256	32	
1993	Abv	Feeding fry	306,558	c	3.1	0.00064	196	
1993	Abv	Fall fing	170,065		3.1	0.00139	236	
1993	Abv	Fall fing-*Ad clip f*	99,939		3.1	0.00139	139	
1993	Abv GF	Fall fing	173,033		3.1	0.00139	241	
1993	Abv GF	Feeding fry	290,484	c	3.1	0.00064	186	
1992	Aroos	Adults(eggs'93)	779,000	c	3.1	0.000128	100	
1992	Abv GF	Adults(eggs'93)	809,000	c	3.1	0.000128	104	
		Total juveniles (n/c smolts)	4,472,005					
1995	At	1-yr smolt	240,582		1.2	0.00235		565
1995	Bl	1-yr smolt(Nashw)	13,283		1.2	0.00028		4
1993	Abv	Feeding fry	306,558	c	2.2	0.00014		43
1993	Abv	Fall fing	170,065		2.2	0.0003		51
1993	Abv	Fall fing-*Ad clip f*	99,939		2.2	0.0003		30
1993	Abv GF	Fall fing	173,033		2.2	0.0003		52
1993	Abv GF	Feeding fry	290,484	c	2.2	0.00014		41
1992	Aroos	Adults(eggs'93)	779,000	c	2.2	0.00003		23
1992	Abv GF	Adults(eggs'93)	809,000	c	2.2	0.00003		24
1992	Abv	Fall fing	508,445	a	3.2	0.00024		122
1992	Abv	Unfed/fry	600,441	ac	3.2	0.00012		72
1991	Aroos	Adults(eggs'92)	370,000	c	3.2	0.00003		11
1991	Abv GF	Adults(eggs'92)	370,000	c	3.2	0.00003		11
		Repeat spawners	8,484	d	_._._	0.00032		3
		Total juveniles (n/c smolts)	4,485,449					
Totals							6,610	1,052

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

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

[d] Estimated escapement ["spawners" minus losses to poaching/disease] above Mactaquac, 1995-1996.

[e] Return rates based on synthesis of those derived in Table 9 (this document) and Table 9 in Marshall and Jones (MS 1996); return rates for eggs are 0.2 those accorded to fry - similar to the rate used in 1996.

[f] Ad-clip break-outs done post assessment; sum of separately estimated returns do not differ from original assessment.

Table 14. Results of the electrofishing surveys in the Saint John watershed, 1996.

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+	Density / 100 m² Parr
			Tributaries Below Mactaquac Dam														
Hammond River																	
	Smithtown	2	9	4	1	2887	25	2	0	24	3	1	0.29	3.0	0.2	0.0	0.2
	Hanford Brook - Lower	3	9	4	1	2122	16	27	0	44	29	9	0.25	3.0	4.6	0.5	5.1
	Hanford Brook - Upper	3	9	4	1	915	5	4	0	10	3	2	0.44	1.2	1.0	0.0	1.0
	Hanford Brook - Combined	3	.	.	.	3037	21	31	0	54	32	11	0.27	2.6	3.5	0.3	3.8
	Burke's Farm	4	8	26	1	1255	267	62	1	165	31	23	0.44	48.3	11.2	0.2	11.4
	Hillsdale - Lower	5	8	27	2	1136	187	76	1	163	29	34	0.55	29.9	10.5	1.8	12.3
	Hillsdale - Upper	5	8	27	2	944	63	19	0	87	9	8	0.49	13.7	2.8	1.3	4.1
	Hillsdale - Combined	5	.	.	.	2080	250	95	1	250	38	42	0.53	22.5	7.2	1.5	8.7
	Average												**0.38**	**19.1**	**5.5**	**0.5**	**6.0**
Kennebecasis River																	
	Mt. Pisgah, Smiths Creek	1	8	26	1	1633	42	19	2	31	12	6	0.40	6.5	2.6	0.6	3.2
	Penobsquis - Lower	3	8	27	1	823	142	5	0	139	8	4	0.33	51.8	1.8	0.0	1.8
	Penobsquis - Upper	3	8	27	1	733	148	18	1	126	15	4	0.25	79.7	10.2	0.0	10.2
	Penobsquis - Combined	3	.	.	.	1556	290	23	1	265	23	8	0.29	65.2	5.4	0.0	5.4
	South Branch - Lower	4	8	28	1	600	0	32	0	0	13	15	0.54	0.0	9.8	0.0	9.8
	South Branch - Upper	4	8	28	1	588	1	5	0	0	2	2	0.56	0.3	1.2	0.3	1.5
	South Branch - Combined	4	.	.	.	1188	1	37	0	0	15	17	0.54	0.2	5.6	0.2	5.8
	Goshen - Lower	5	8	27	1	733	61	3	0	49	1	0	0.43	19.4	0.0	1.0	1.0
	Goshen - Upper	5	8	27	1	1173	83	3	0	80	2	0	0.27	25.9	0.0	0.9	0.9
	Goshen - Combined	5	.	.	.	1906	144	6	0	129	3	0	0.22	34.0	0.0	1.4	1.4
	Millstream - Lower	6	8	28	1	741	4	5	0	6	2	2	0.56	0.9	0.9	0.3	1.2
	Millstream - Upper	6	8	28	1	1000	98	19	0	116	7	9	0.58	17.0	2.5	0.8	3.3
	Millstream - Combined	6	.	.	.	1741	102	24	0	122	9	11	0.56	10.5	1.9	0.6	2.5
	Average												**0.40**	**23.3**	**3.1**	**0.6**	**3.7**
Nashwaak River																	
	Penniac Stream	1	8	8	4	1041	35	27	0	22	24	3	0.14	24.3	16.6	2.1	18.7
	Above Durham Bridge*	2	7	2	.	1018	34	0	0	.	.	.	.	9.4	0.0	0.0	0.0
	Tay River	3	8	7	5	1009	28	9	0	49	10	4	0.31	8.9	2.9	0.0	2.9
	MacKenzie Brook	4	8	13	1	1012	7	5	0	4	14	3	0.19	3.6	1.7	0.9	2.6
	Above Nashwaak Bridge*	5	7	2	.	1153	5	0	0	.	.	.	.	1.2	0.0	0.0	0.0
	Below Stanley	7	7	3	5	1212	2	3	0	3	3	1	0.33	0.5	0.7	0.0	0.7
	Above Stanley	8	7	3	2	556	7	2	0	9	0	0	1.00	1.3	0.4	0.0	0.4
	Cedar Bridge	9	8	21	1	1148	19	16	0	22	12	4	0.28	5.9	3.4	1.6	5.0
	Doughboy Brook	10	8	21	1	1500	32	14	0	28	13	3	0.22	9.6	3.1	1.1	4.2
	Average												**0.35**	**7.2**	**3.2**	**0.6**	**3.8**
Keswick River																	
	Jones Forks	1	8	13	1	1144	45	27	0	42	39	7	0.16	23.9	13.3	1.0	14.3
	Stoneridge	3	9	23	1	1090	49	6	0	48	6	3	0.35	12.8	1.6	0.0	1.6
	Hayne	4	8	19	3	965	13	8	0	28	11	4	0.29	4.8	2.8	0.1	2.9
	Barton	5	9	23	1	1324	39	16	0	43	23	5	0.20	14.9	5.5	0.6	6.1
	Average												**0.25**	**14.1**	**5.8**	**0.4**	**6.2**

Table 14. (cont'd)

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+	Density / 100 m² Parr
	Tributaries Above Mactaquac Dam																
Meduxnekeag River																	
	Marven Brook	1	9	3	2	306	134	46	0	143	12	30	0.96	45.8	15.7	0.0	15.7
	North Br. @ Jackson Falls	3	8	26	2	528	27	19	0	37	13	10	0.53	9.7	6.8	0.0	6.8
	Hagerman Brook @ Oakville	4	8	19	2	724	0	7	0	0	2	3	0.64	0.0	1.5	0.0	1.5
	North Br. @ Carter Brook	5	8	27	2	1219	13	30	0	16	21	12	0.38	2.9	6.5	0.1	6.6
	Average												**0.63**	**14.6**	**7.6**	**0.0**	**7.7**
Becaguimec River																	
	Coldstream (Bannon)	1	9	10	2	977	26	14	0	14	5	5	0.70	3.8	2.0	0.0	2.0
	East Coldstream	2	9	10	2	982	34	1	0	40	4	1	0.33	10.4	0.3	0.0	0.3
	South Branch (County Line)	3	9	30	2	679	3	7	0	4	4	3	0.47	0.9	2.0	0.2	2.2
	North Branch (Cloverdale)	4	9	4	2	1212	74	13	0	82	2	8	0.81	7.5	1.3	0.0	1.3
	North Branch (Carlisle)	5	9	11	2	1376	137	31	0	140	25	14	0.49	20.2	4.6	0.0	4.6
	Average												**0.56**	**8.6**	**2.0**	**0.0**	**2.1**
Shikatehawk River																	
	Lockharts Mill - Lower	1	9	3	2	540	45	63	2	32	37	25	0.42	19.8	26.0	2.5	28.5
	Lockharts Mill - Upper	1	9	3	2	660	35	64	2	24	37	23	0.40	13.2	22.0	2.8	24.8
	Lockharts Mill - Combined	1	.	.	.	1200	80	127	4	56	74	48	0.41	16.3	24.1	2.6	26.7
	Gordonsville	2	8	12	2	1200	148	48	0	117	33	16	0.34	36.8	10.1	1.8	11.9
	West Glassville - Lower	3	8	12	2	587	82	35	0	72	32	4	0.13	105.8	36.8	8.3	45.1
	West Glassville - Upper	3	8	12	2	1060	268	47	5	229	40	10	0.23	107.9	18.9	2.0	20.9
	West Glassville - Combined	3	.	.	.	1647	350	82	5	301	72	14	0.18	117.2	25.2	3.9	29.1
	Centre Glassville	4	8	7	1	876	8	28	1	8	15	5	0.29	3.2	10.1	1.4	11.5
	Kenneth	5	8	7	1	902	2	53	3	7	41	12	0.25	0.9	22.9	1.8	24.7
	Average												**0.29**	**34.9**	**18.5**	**2.3**	**20.8**
	Tributaries Above Beechwood and Tobique Narrows Dams																
Tobique River																	
	Fyke Net	1	7	2	2	1457	0	7	5	3	20	1	0.14	0.0	6.0	0.0	6.0
	Ben's Pole Road	2	7	2	2	1869	54	24	0	42	17	3	0.18	15.7	4.5	2.5	7.0
	Saddler Brook Road	3	7	3	2	729	0	25	1	0	21	11	0.37	0.0	8.2	1.5	9.7
	Trouser's Lake Road	4	7	3	2	801	0	17	1	0	12	6	0.38	0.0	4.2	1.8	6.0
	Burma Road	5	7	24	1	1281	0	14	2	0	3	5	0.73	0.0	1.5	0.2	1.7
	Campbell Landing	7	7	9	2	1363	66	7	0	71	9	1	0.16	29.7	3.0	0.2	3.2
	Shingle Gulch	8	8	20	3	1246	1	34	2	1	31	8	0.23	0.3	8.4	4.0	12.4
	Hazelton Landing	9	8	19	3	1500	39	30	1	21	31	5	0.16	15.9	10.2	2.5	12.7
	Anvil Brook	10	8	19	3	1156	21	17	1	10	8	2	0.28	6.6	5.0	0.6	5.6
	Mamozekel Landing	11	7	25	1	1513	0	6	1	0	3	2	0.54	0.0	0.7	0.2	0.9
	Opposite Serpentine Road	12	8	13	2	736	2	2	0	1	2	0	0.25	1.1	0.8	0.3	1.1
	South Branch	13	7	24	1	948	1	29	3	0	21	9	0.35	0.3	5.9	3.8	9.7
	Pat's Crossing	14	8	13	2	1172	47	2	0	34	0	0	1.00	4.0	0.2	0.0	0.2
	Above Lawson Brook	15	8	13	2	855	1	6	1	1	7	1	0.23	0.5	2.6	1.0	3.6
	Nation House	16	6	24	2	777	71	8	4	24	8	5	0.60	15.2	2.4	0.2	2.6
	Bob Barr	17	6	25	.	1665	0	47	6	0	22	11	0.39	0.0	8.0	0.1	8.1
	Rattray's Home	18	6	24	2	1705	0	48	0	0	20	18	0.48	0.0	5.4	0.5	5.9
	Pearl Road	19	6	26	2	1145	0	17	0	0	17	9	0.35	0.0	2.1	2.1	4.2
	Average												**0.38**	**5.0**	**4.4**	**1.2**	**5.6**

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

Table 15. Estimation of new spawner requirements based on new area and updated biological characteristics of Atlantic salmon, Nashwaak River.

Orthophoto Estimate of Habitat Area		7,711,000		(Amiro 1993)
Area with stream gradient < 0.12%		2,019,000		
Area with stream gradient >= 0.12%		5,692,000		
Orthophoto Estimate of Juvenile Production Area (stream gradient >= 0.12%)				
Nashwaak River above counting fence		**5,350,480**		
Conservation Requirements:				
Rearing Units	=	53,505	(100 m²)	
Optimal Egg Deposition	=	240	per unit	(Elson 1975)
Total Egg Requirements	=	**12,800,000**		
Biological Characteristics (Fence Data 1993-96)*:				
Length-Fecundity Relationship				
= (LogeEggs=6.06423+0.03605(fork length))				(Marshall and Penny MS 1983)
1SW % Female	=	40%		
Mean Length (cm)	=	57.6		
Fecundity	=	3431		
MSW % Female	=	86%		
Mean Length (cm)	=	78.4		
Fecundity	=	7263		
Eggs per spawner 1SW	=	fecundity* %female		
	=	3,431* 40%		
	=	1,369		
MSW	=	fecundity* %female		
	=	7,263* 86%		
	=	6,268		
Required number of MSW salmon	=	egg requirements / eggs per MSW salmon		
	=	12,800,000 / 6,268		
	=	2,042		
Females	=	1,762		
Males	=	280		
Deficit Males	=	1,482		
Required number of 1SW salmon	=	deficit males / %male		
	=	1,482 / 60%		
	=	2,466		
Minimum Requirements:	**MSW** =	**2,042**		
	1SW =	**2,042**	**	

**Fence Data - Biological Characteristics, 1993 - 1996:*

		% Female		Mean Length	
Year	%MSW	1SW	MSW	1SW	MSW
1993	0.37	0.279	0.858	57.1	77.8
1994	0.37	0.517	0.850	58.8	78.7
1995	0.31	0.363	0.983	57.2	78.3
1996	0.26	0.437	0.759	57.1	78.7
Mean	0.33	0.399	0.863	57.6	78.4

*** Reduced 1SW requirement to equal MSW requirement.*

Table 16. Historical hatchery distributions to the Nashwaak River, 1976-96.

Year	Stock	0+ Fry		0+ Parr	1+ Parr		1+ Smolt		2+ Smolt		
		No Mark	Ad Clip	No Mark	No Mark	Ad Clip	No Mark	Tagged	No Mark	Ad Clip	Tagged
1976	Mactaquac	203,265	.	18,964	11,117	1,210	.	.	.	.	.
1977	Mactaquac	137,187	650	22,044	7,200	3,196	.	.	.	.	.
1978	Mactaquac	.	.	106,375	1,320	.	.	.	.	.	.
1979	Mactaquac	.	.	85,113	22,476	.	.	.	.	.	.
1980	Mactaquac	134,884	.	.	18,240	.	.	.	.	.	.
1981	Mactaquac	.	.	.	25,254	32,880	.	.	20,336	.	.
1982	Mactaquac	.	.	57,750	.	.	.	.	5,183	12,776	.
1983	Mactaquac	.	.	.	.	.	.	.	.	8,053	7,998
1984	Nashwaak	.	.	10,693	.	.	.	.	.	.	.
	Mactaquac	.	.	36,436	.	.	.	.	.	12,158	8,005
1985	Nashwaak	11,000	.	13,043	.	12,344	.	.	.	.	.
	Mactaquac	.	.	.	46,643	.	.	7,966	.	.	.
1986	Nashwaak	.	.	23,071	.	.	18,734	.	.	.	.
1987	Nashwaak	4,500	.	17,931	.	.	13,205	6,500	.	.	.
	Mactaquac	67,114	.	.	.	.	.	.	.	.	.
1988	Nashwaak	18,515	.	17,114	.	.	16,788	4,001	.	.	.
	Serpentine	7,169	.	.	.	.	.	.	.	.	.
	Mactaquac	96,027	.	.	.	.	.	.	.	.	.
1989	Nashwaak	5,590	.	19,824	.	.	11,914	.	.	.	.
	Serpentine	4,560	.	.	.	.	.	.	.	.	.
	Mactaquac	3,553	.	30,684	.	.	.	.	.	.	.
1990	Nashwaak	9,012	.	25,568	.	.	15,248	3,999	.	.	.
	Mactaquac	38,160	.	.	.	.	.	.	.	.	.
1991	Nashwaak	.	.	16,716	.	.	15,903	4,000	.	.	.
	Mactaquac	16,397	.	1,386	.	.	.	.	.	.	.
1992	Nashwaak	10,288	.	26,553	.	.	9,658	3,995	.	.	.
	Serpentine	13,178	.	.	.	.	.	.	.	.	.
	Mactaquac	2,836	.	.	.	.	.	.	.	.	.
1993	Nashwaak	17,310	.	22,500	.	.	9,270	3,881	.	.	.
1994	Nashwaak	5,887	.	8,163	.	.	11,059	4,000	.	.	.
	Mactaquac	45,433	.	8,654	.	.	.	.	.	.	.
1995	Nashwaak	1,650	.	16,802	.	.	9,281	4,000	.	.	.
	Mactaquac	30,800	.	.	.	.	.	.	.	.	.
1996	Nashwaak	.	.	.	.	.	9,027 (a)	3,004	.	.	.
Total		884,315	650	585,384	132,250	49,630	140,087	45,346	25,519	32,987	16,003

(a) - 3,014 1+ smolt were released from the Mactaquac Migration Channel.
0+ fry - 0 to 14 weeks old.
0+ parr - 14 weeks but less than 1 year old.
1+ parr - 1 year but less than 2 years old.

Table 17. 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 127,869 m^2 of stream habitat.

Year	Date	No. of redds observed			No of fish observed	Percent salmon	Comments
		Large	Small	Total			
1976	Nov-08	-	-	88	30	-	- moderate water levels, good visibility.
1977	Nov- 07-08	-	-	256	160	68.8	- moderate water levels, good visibility.
1978	Nov-08	264	75	339	176	96.6	- low water, excellent visibility.
1979	Nov-09	117	16	133	101	92.1	- moderate water levels, good visibility.
1980	Nov-06	160	31	191	170	94.7	- moderate water conditions, spawning incomplete,
1981	Nov-09	137	28	165	133	71.4	- water moderately high, poor visibility in some pools.
1982	Nov-08	149	33	182	107	86.0	- water moderately high, poor visibility in pools.
1983	Nov-08	162	41	203	104	76.0	- moderate water levels, good visibility except for the three
1984		Survey not done - water too low for canoeing.					largest pools.
1985	Nov-08	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-09	158	102	260	34	52.9	- water low to moderate, good visibility.
1995	Nov-06	78	35	113	8	87.5	- water high, visibility fair to good except in deeper runs & pools.
1996	Nov-07	256	77	333	6	66.6	- water moderate, visibility good to excellent on the bars and flats, good in the runs, and fair to poor in the pools (larger deeper pools - poor to nil visibility).

Note:

* Main stem considered as being from the confluence of the North Hammond downstream to the bar above Steele's Pool (first spawing site above normal head-of-tide). In 1976 and 1977 redds were not differentiated as to small and large.
In 1980 about 15-20% of fish still on or in the vicinity of redds.
In 1993 - 7 female salmon were removed from this stretch on Oct. 28th for broodstock, which theoretically would have reduced the large redd count by 14 to 17 redds.

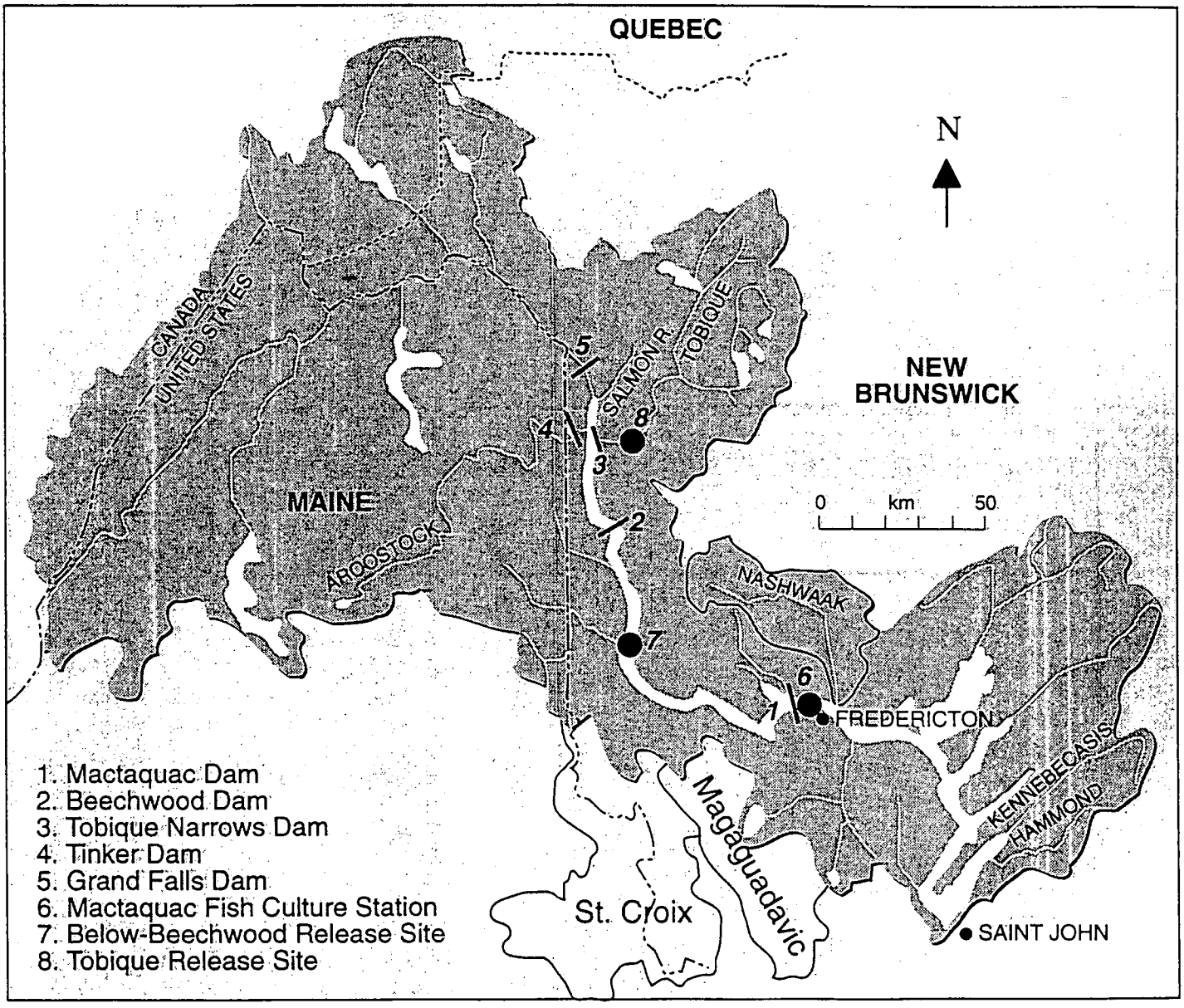


Fig. 1. Magaguadavic, St. Croix and Saint John river drainages including Nashwaak, Kennebecasis and Hammond rivers and major tributaries, dams and principal release sites for Atlantic salmon above Mactaquac. Fish trapping locations on Magaguadavic, St. Croix, Nashwaak and Kennebecasis drainages shown on Figs. 10, 13 and 17.

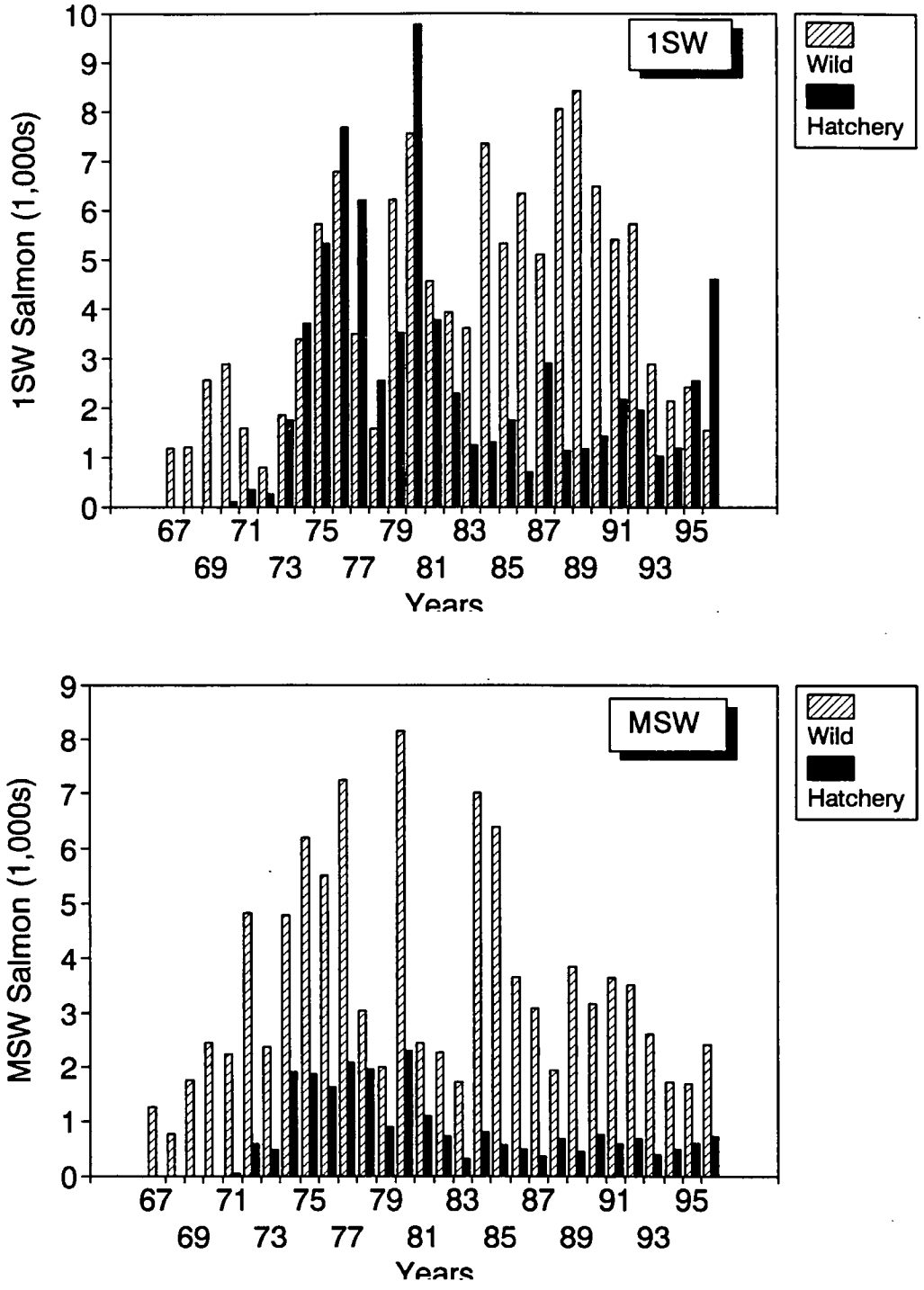


Fig. 2. Unadjusted counts of wild and hatchery 1SW and MSW salmon at Mactaquac, 1967-1996.

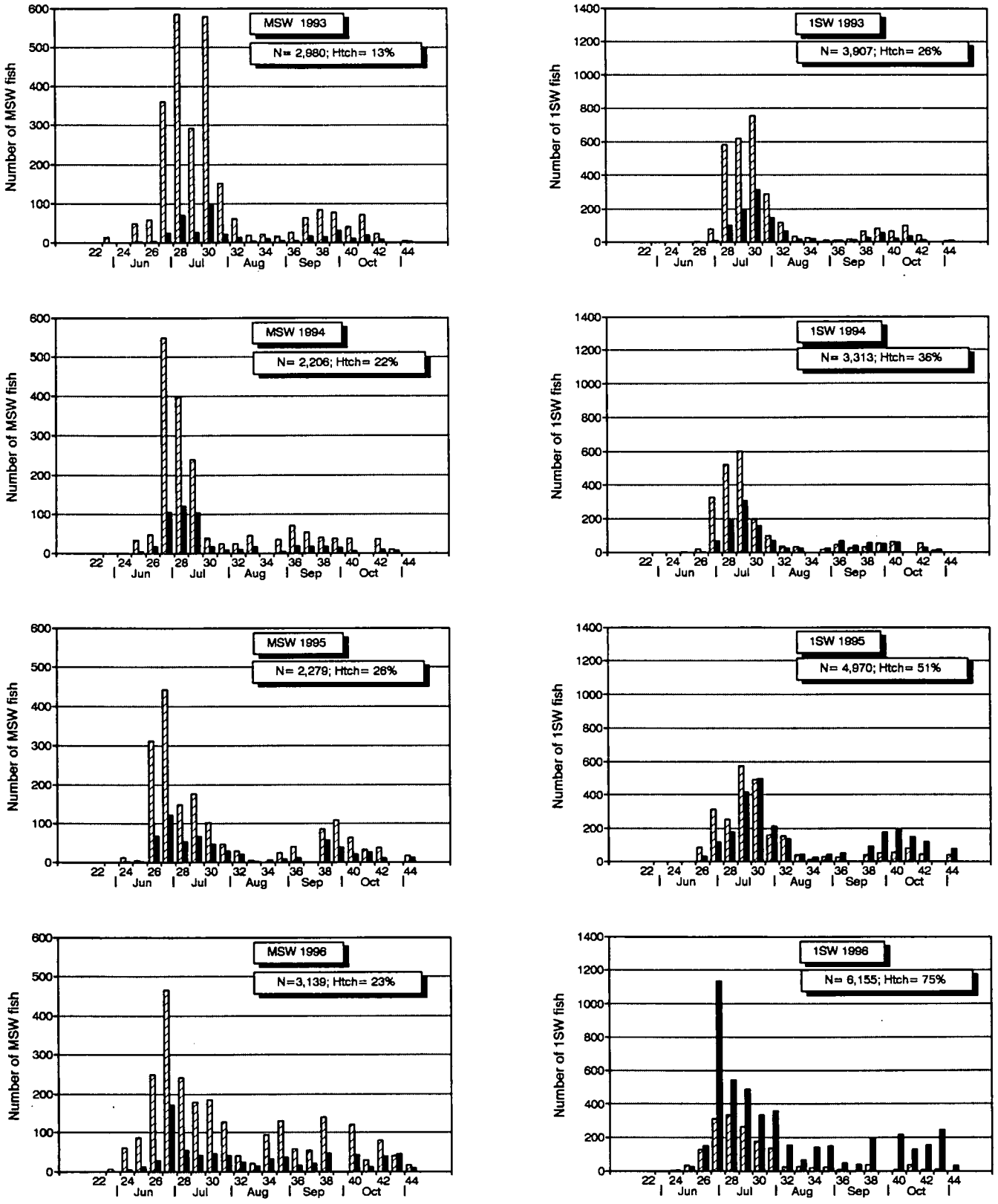


Fig. 3. Weekly unadjusted counts of wild (cross hatch) and hatchery (solid)1SW and MSW salmon at the Mactaquac sorting facilities, 1993-1996. [Note difference in 1SW and MSW Y-axis scales.]

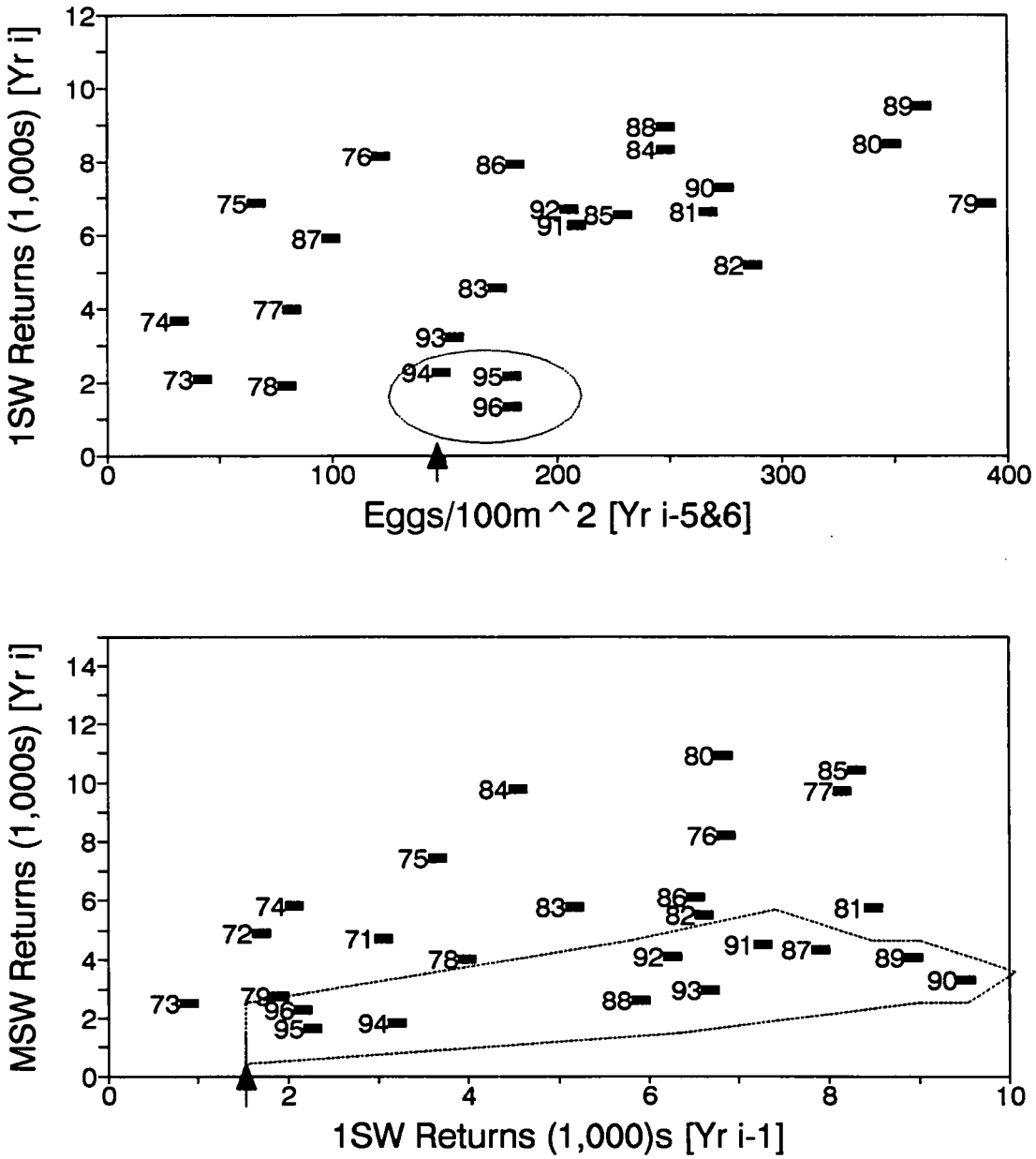


Fig. 4. Upper panel -plot of 1SW returns from egg depositions 5 & 6 years previous (data in Table 11), arrow indicates egg deposition contributory to returns in 1997 and circle identifies most recent data. Lower panel - plot of MSW and 1SW returns without effect of moratoria (data in Table 11), arrow indicates level of 1SW returns to be associated with MSW returns in 1997 and dashed line encloses most recent data.

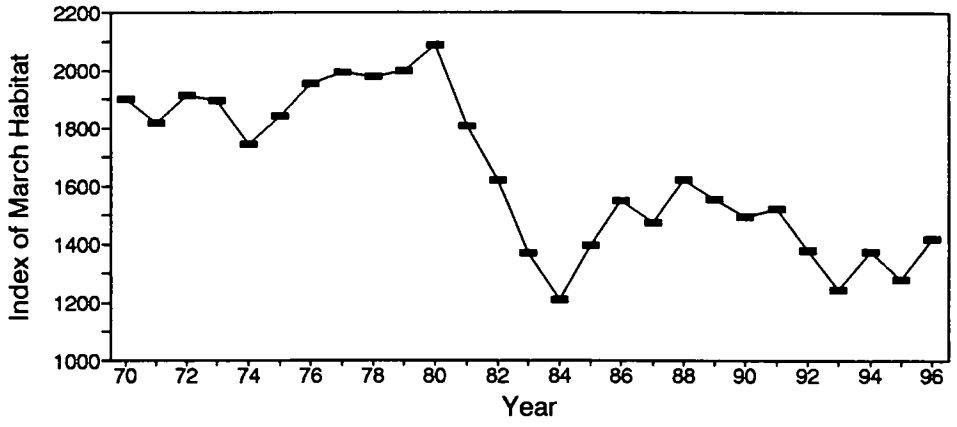


Fig. 5. March index of winter habitat in the N.W. Atlantic,1970-1996 (Anon. 1996a).

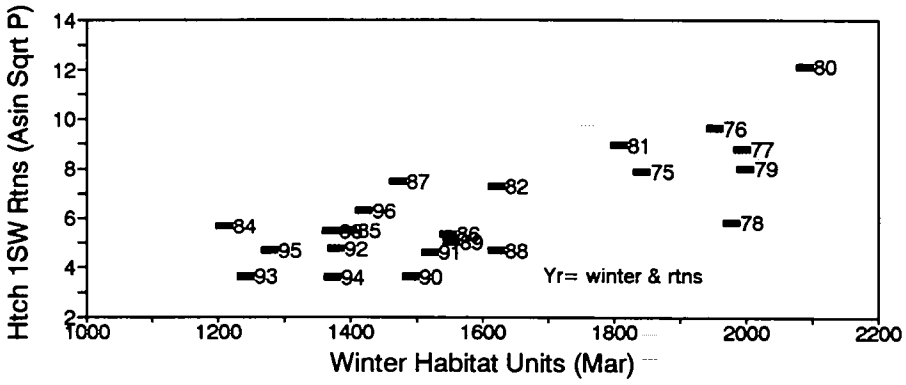


Fig. 6. March index (yr i) and return rate of hatchery 1SW fish (yr i) stocked as smolts from Mactaquac, 1975-1996.

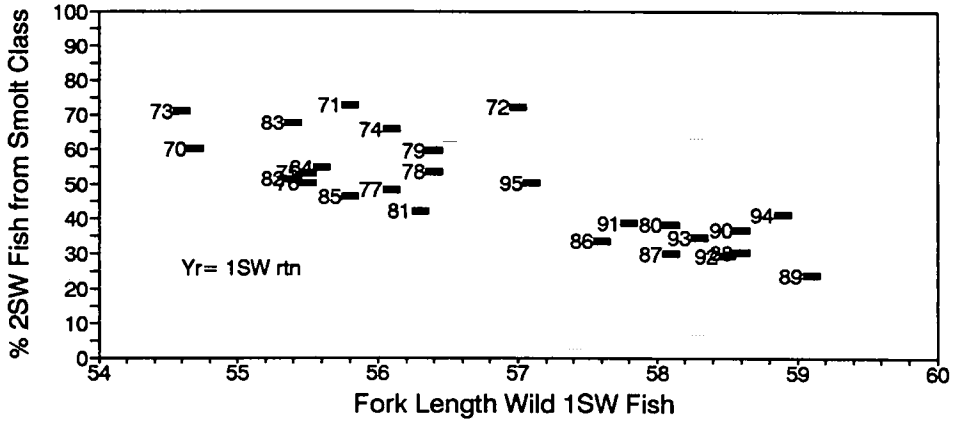


Fig.7 . Mean fork length of wild 1SW fish at Mactaquac and proportion of total recruits from a smolt class that returned as 2SW fish.

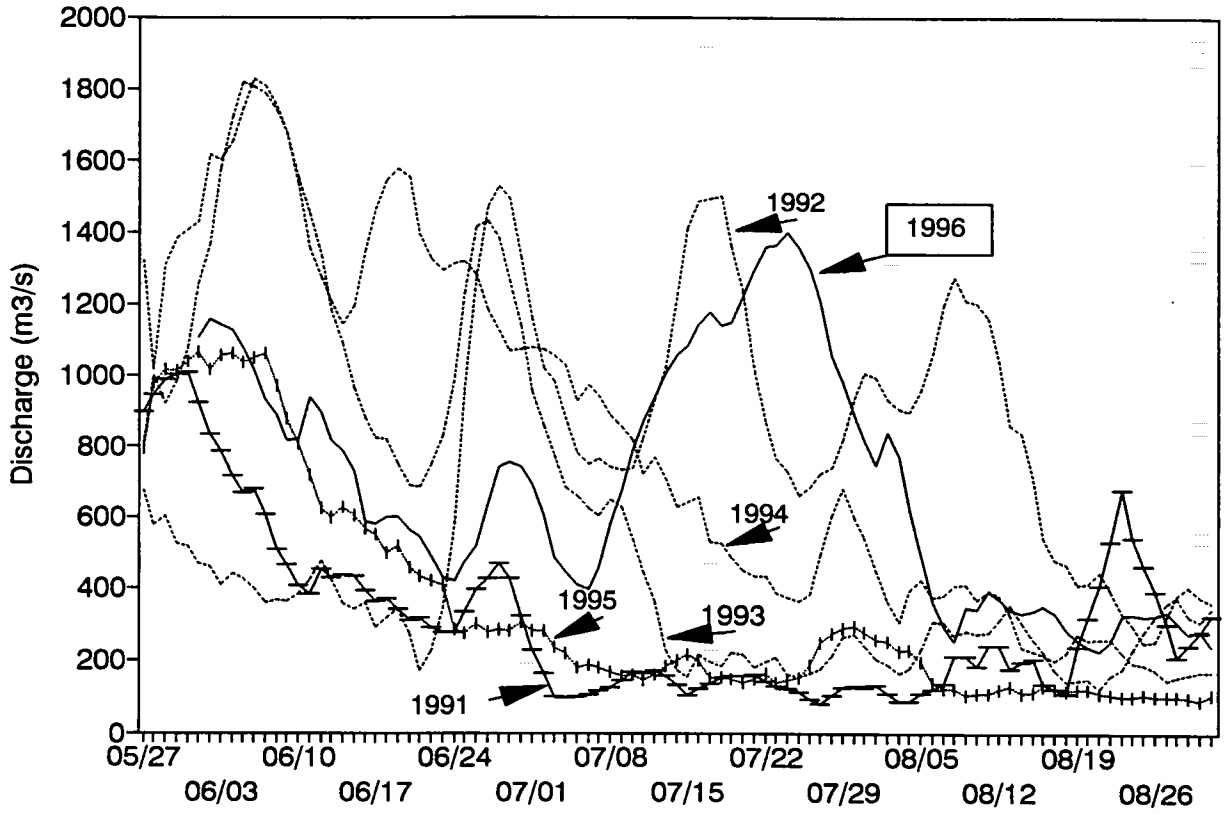


Fig. 8. Five-day moving averages of mean daily river discharge at Mactaquac, June through August, 1991-1996.

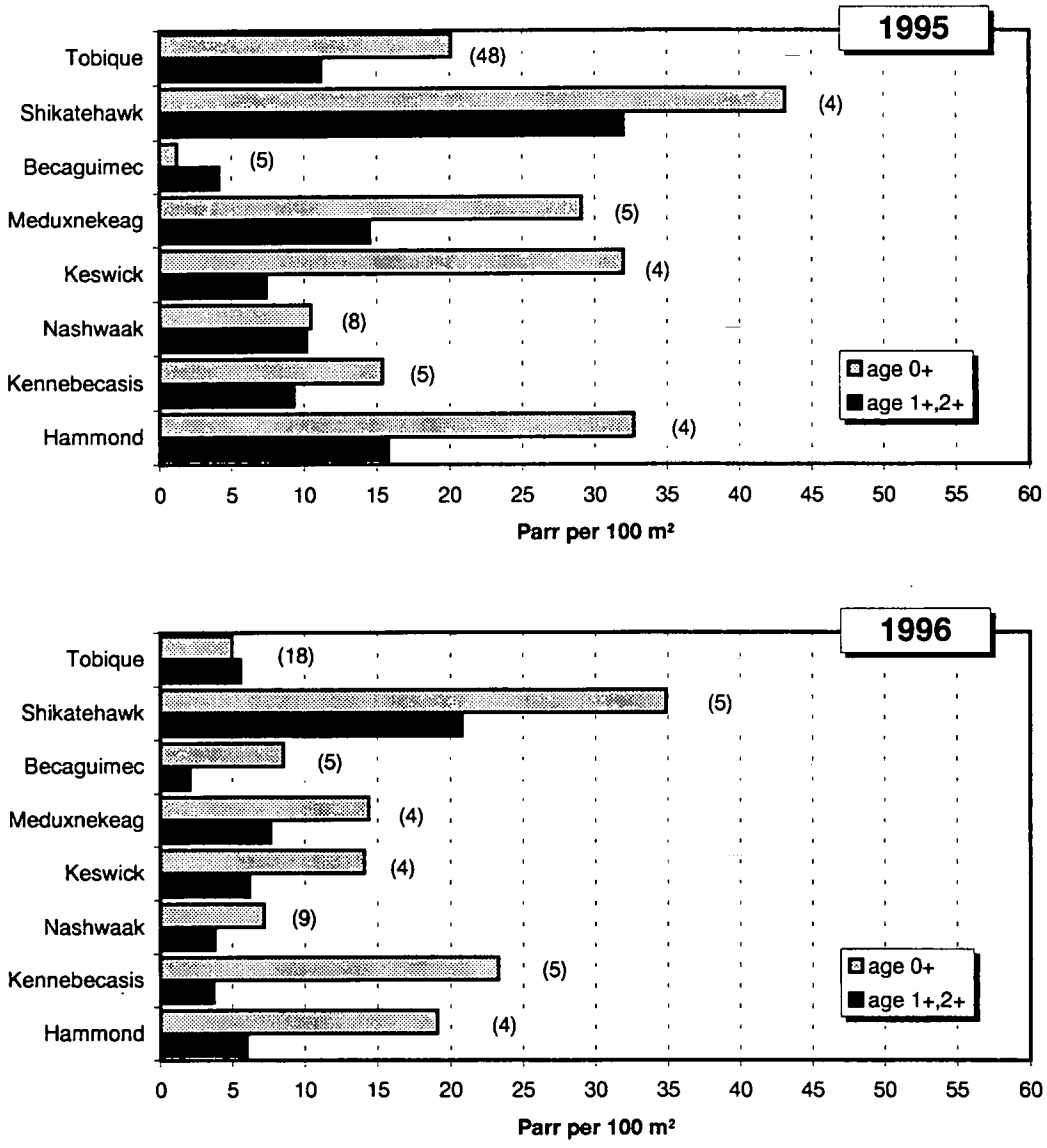


Fig. 9. Estimated average wild parr densities for tributaries of the Saint John River, 1995-1996. (Number of sites.)

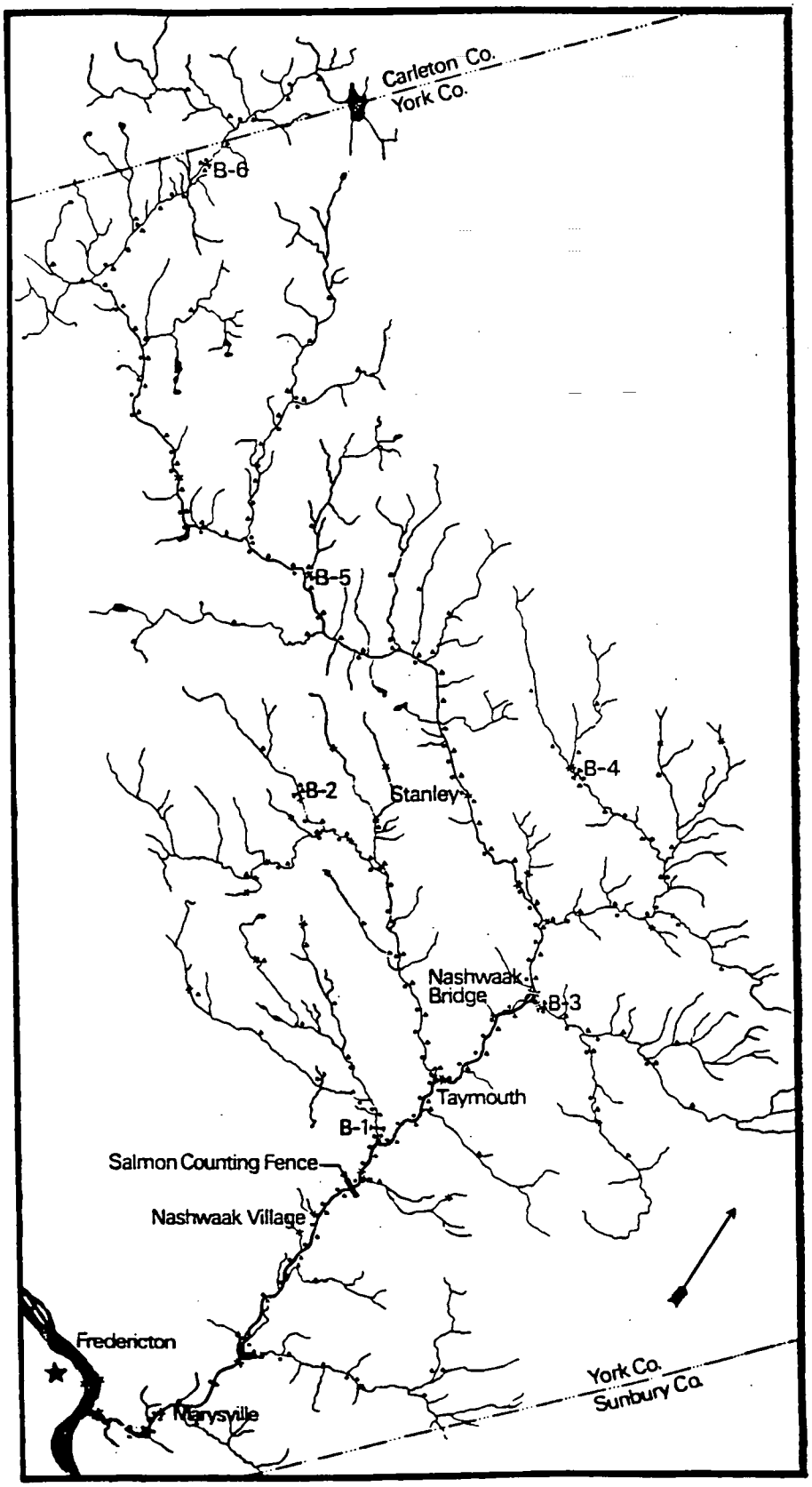


Fig. 10. Nashwaak River, site of counting fence and barriers {B-} to salmon migration.

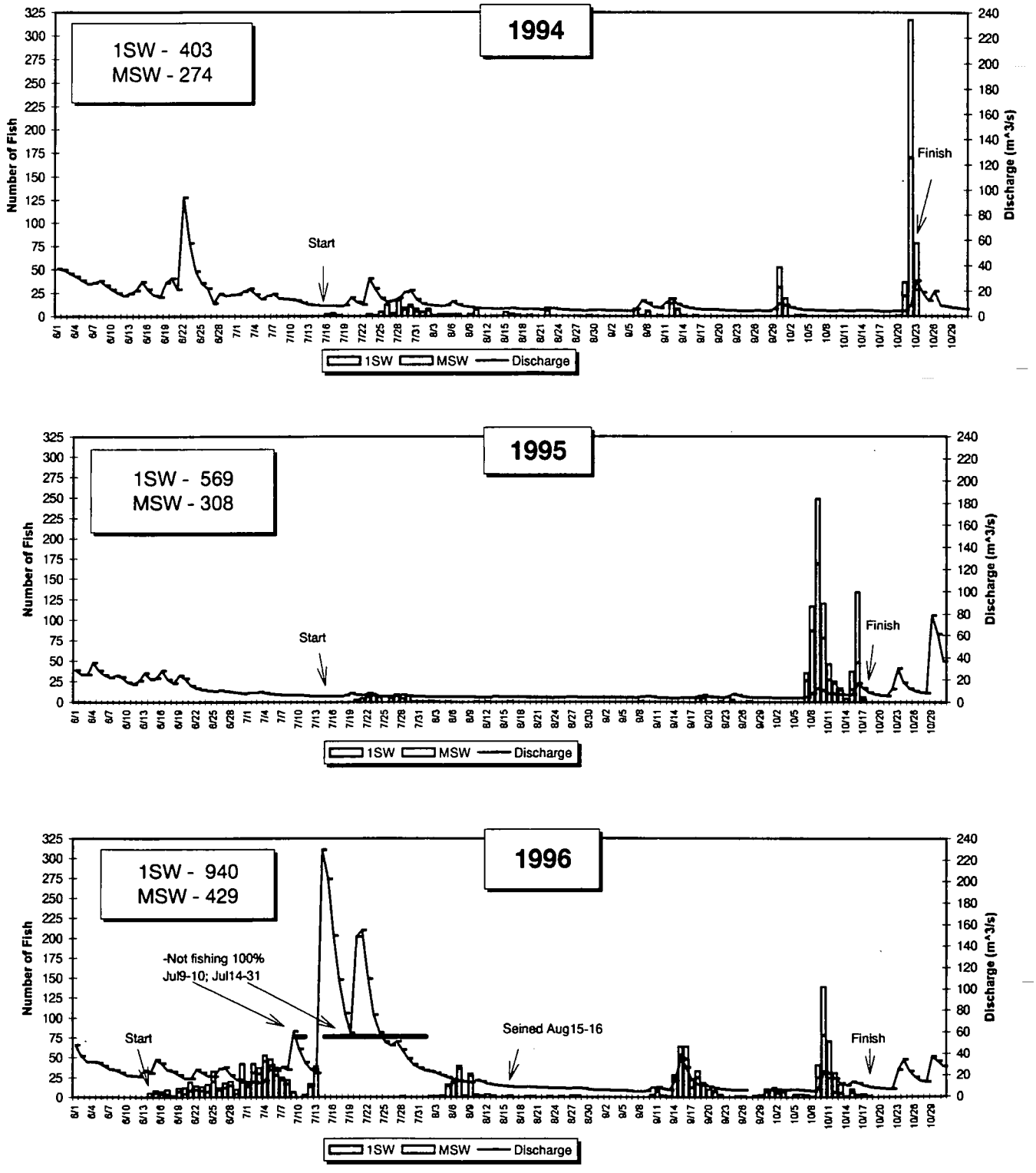
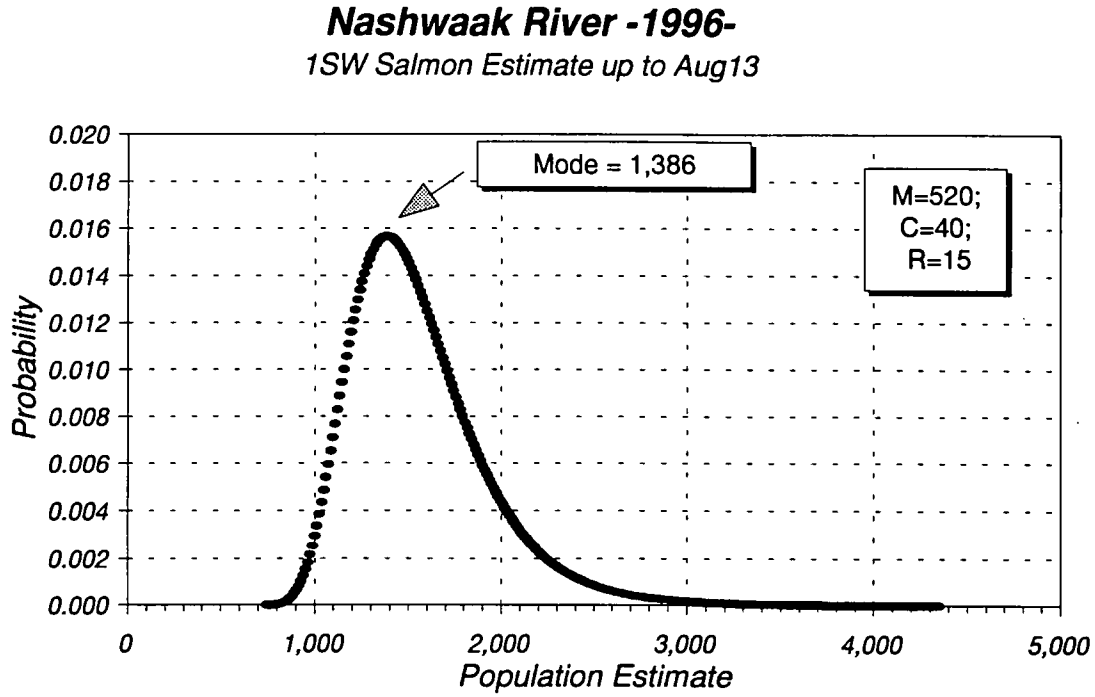


Fig. 11. Average daily discharge (cubic metres/sec) at Durham Bridge and sea-age corrected fence counts of 1SW and MSW salmon, Nashwaak River, 1994, 1995, and 1996.



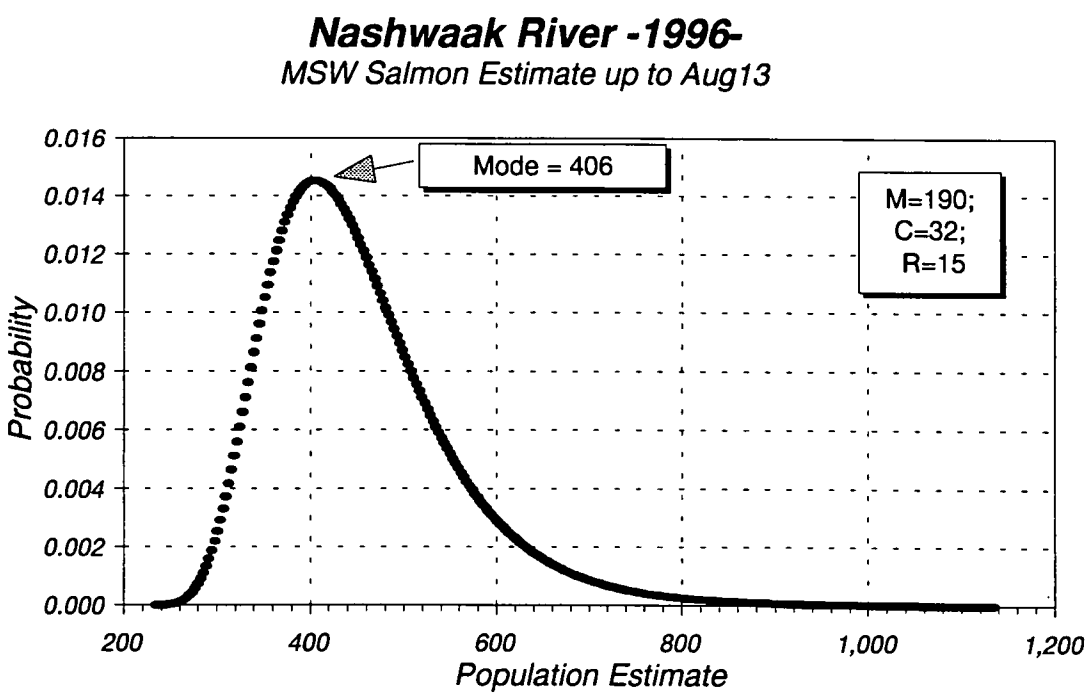


Fig. 12. Estimated returns of 1SW and MSW salmon to the Nashwaak River up to August 13, 1996, based on mark-and-recapture techniques.

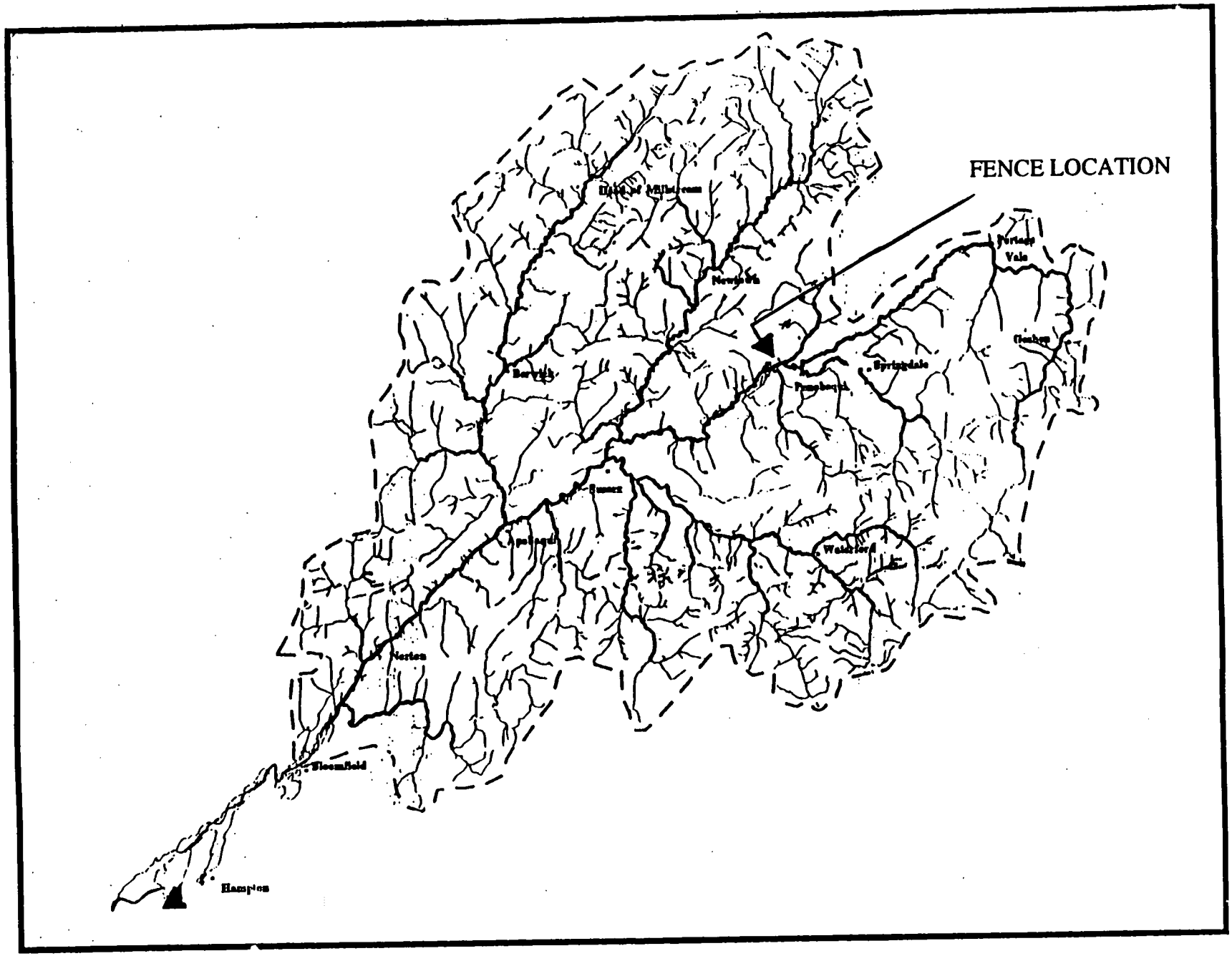


Fig. 13. Kennebecasis River watershed area and location of counting fence.

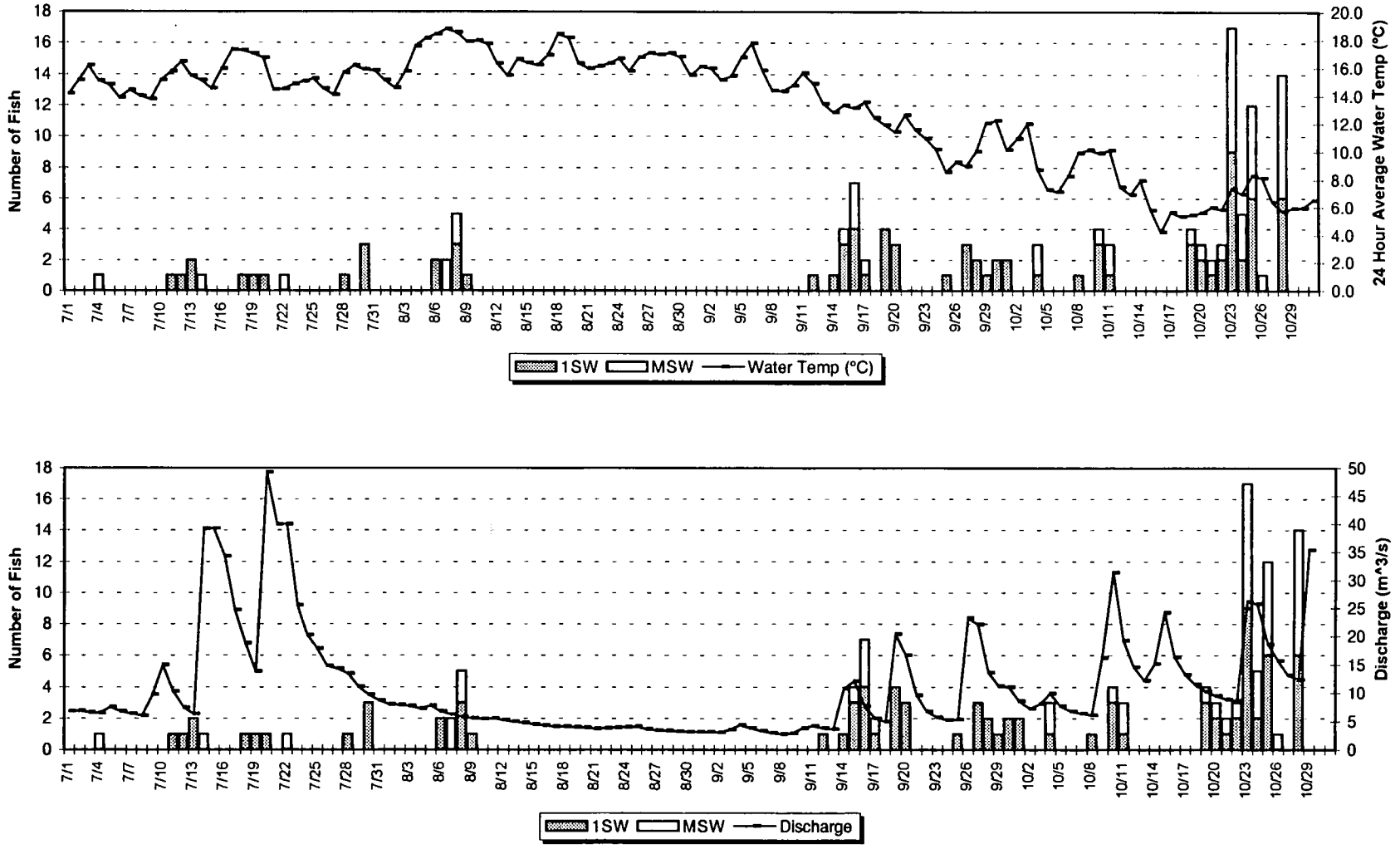


Fig. 14. Average daily water temp (top) and discharge (bottom) and fence counts of 1SW and MSW salmon, McCully Station, South Branch, Kennebecasis River, 1997.

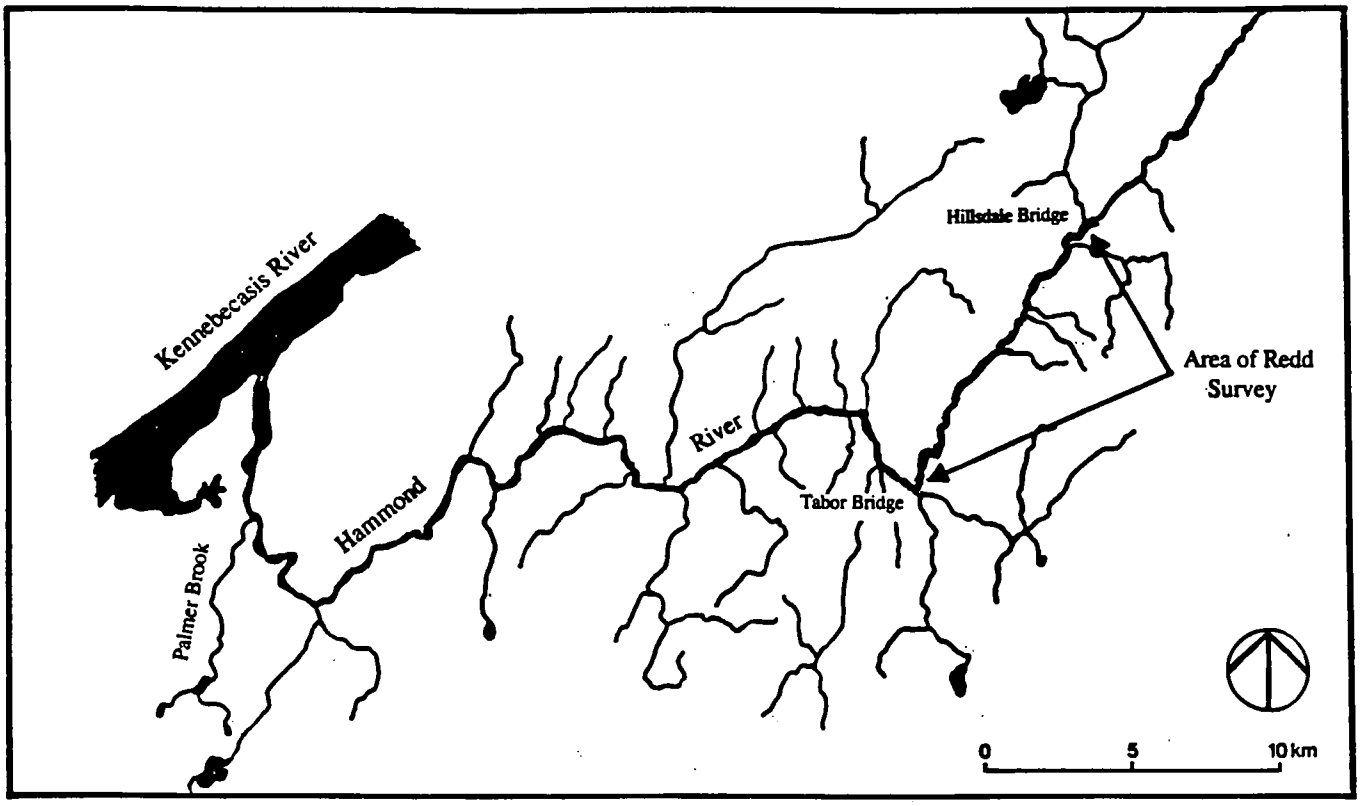


Fig. 15. Hammond River and location of redd survey area.

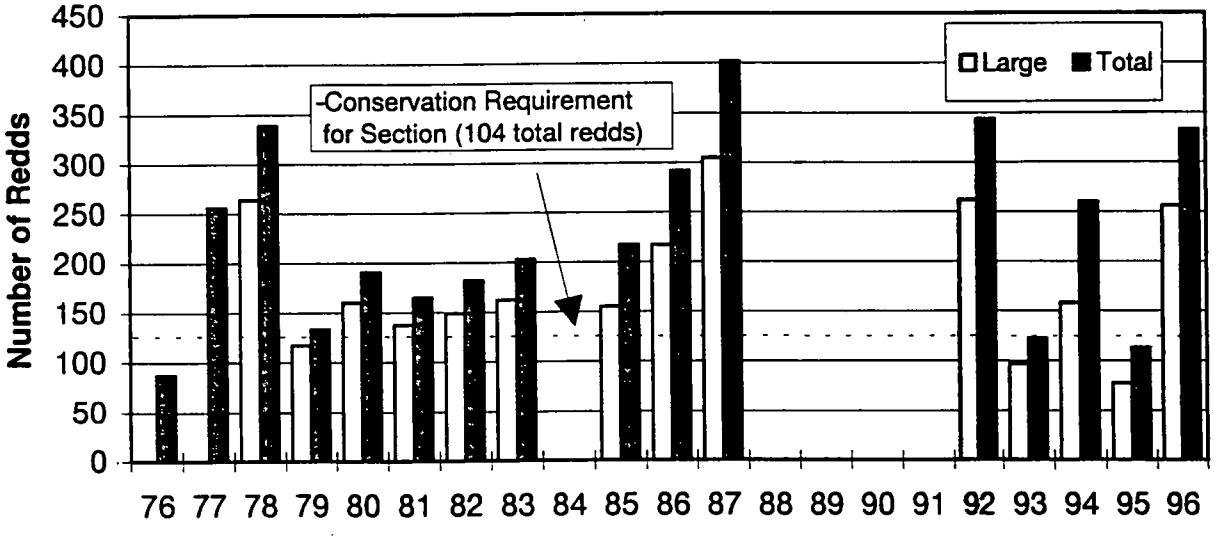
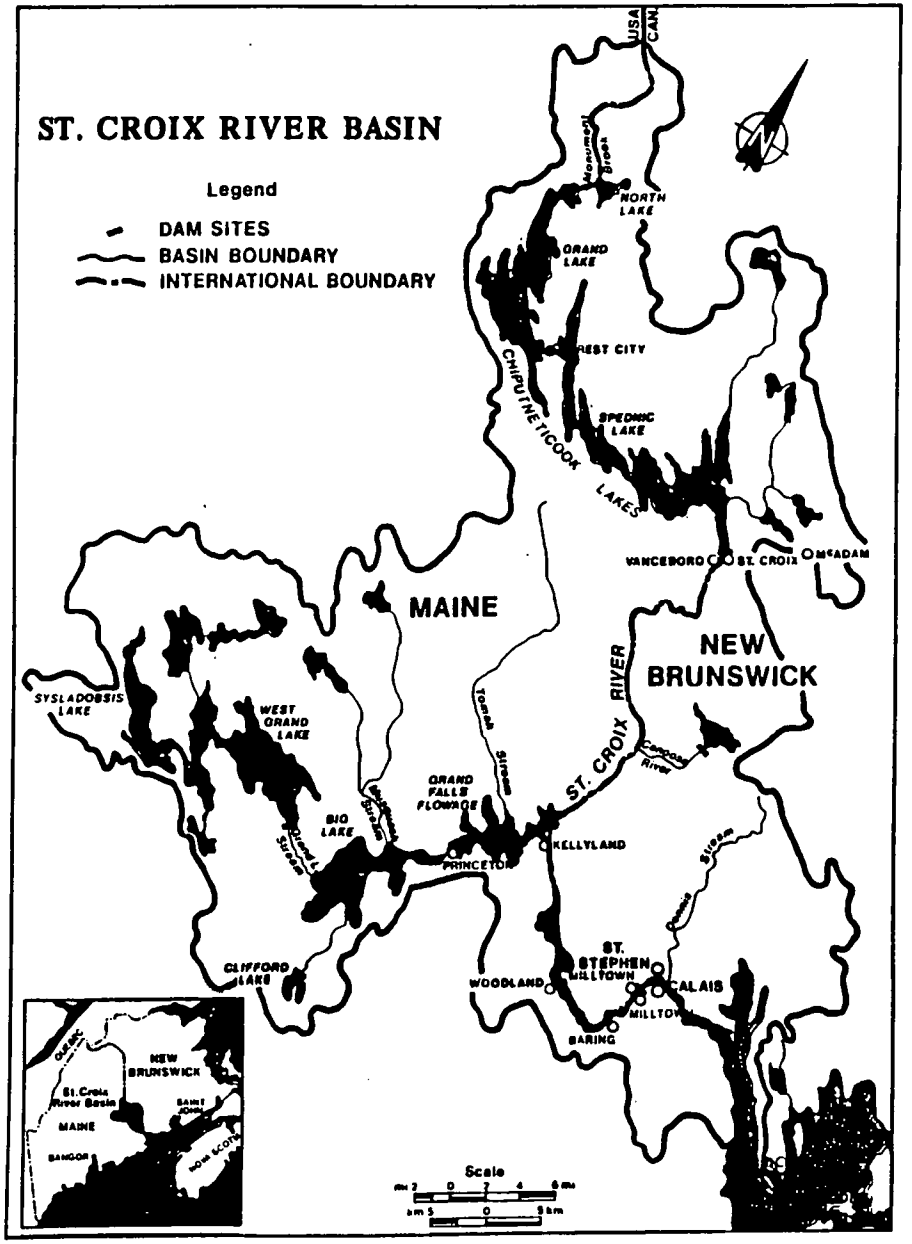


Fig. 16. Atlantic Salmon redd counts on the Hammond River, 1976-96. Requirement based on 2.5 redds per female MSW and 7,306 eggs/female.



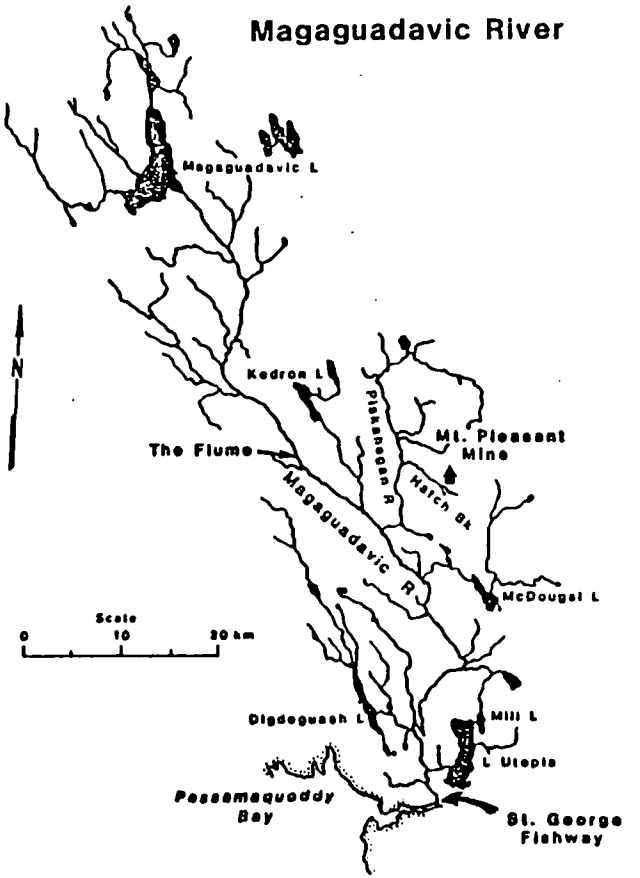


Fig. 17. St. Croix and Magaguadavic river systems of southwest New Brunswick.

App. 1. Number of eggs 100^-2 deposited in the Tobique River, 1968-1992, and derivation of weighted number of eggs contributing to annual returns of wild 1SW fish at Mactaquac, 1973-94 and 1997 (explanation in Penney and Marshall MS1984).

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 @ Mact (year)
Year	Number	Age 2	Age 3	Yr i	Yr i+1	
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					
1992	191.9					
			0.476		91.33	
1993	111.7	0.524		58.54		149.87 (1997)

(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 1969-1991 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				Prop. 2:1's of total
	2:1 (i+3)	3:1 (i+4)	4:1 (i+5)	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			
1993	656				

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, 1983-1996.

Fresh-water age	Number of 1SW fish													
	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994[a]	1995[b]	1996[b]
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
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
4	11	81	144	150	233	66	278	260	122	127	45	40	41	28
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
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
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
4	14	91	176	187	270	73	314	291	141	148	50	43	42	30
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

[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).