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Status of Atlantic salmon stocks of the Saint John River and southwest New Brunswick, 1995

by

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ABSTRACT

Total 1SW (5,079) returns destined for above Mactaquac in 1995 increased over those of 1993 and 1994 but were the third lowest since 1978. MSW returns (2,355) were the lowest of a 26-year record but were comparable with 1994. The proportion of the run identifiable as hatchery fish increased to 57% of 1SW and 27% of MSW returns; return rates for hatchery smolts improved but were among the lowest of record. Spawners numbered 4,839 1SW fish and 1,887 MSW salmon, 151% and 43% of the respective targets. Egg deposition (70% from wild fish) was 45% of requirement; the target has not been met since 1985.

Counts at the Nashwaak fence contributed to an estimated return and spawning escapement of 940 1SW and 436 MSW salmon, up from 1994. Estimated spawners were 61% and 28% of respective 1SW and MSW targets. Egg depositions increased to 37% from 31% in 1994.

External and scale characteristics of 555 1SW and 194 MSW salmon captured in the Magaguadavic River trap indicated that only 49 1SW and 30 MSW salmon were of wild origin - the lowest of an 8-year record. The effective female escapement was estimated at 31 1SW and 28 MSW fish because many aquaculture fish were removed and most of the remainder were determined to be immature. Potential egg deposition was 22% of target; 52% of the eggs were of aquaculture-origin fish.

Sixty salmon ascended the St. Croix River at Milltown - the lowest of a 13-year record. Only 7 1SW and 14 MSW fish were of wild origin. Egg deposition was 2% of requirement.

1SW returns destined for Mactaquac in 1996 should number 5,800 to 6,900 fish thereby exceeding the 3,200 1SW spawning requirements. More than half the returns will be of hatchery origin - either smolts released directly from Mactaquac or age-0+ fish released upriver of Mactaquac in 1992 and 1993.

MSW returns destined for Mactaquac in 1996 could number 3,800 to 4,300, i.e., 85 to nearly 100% of the 4,400 target spawning requirements for MSW fish above Mactaquac. The forecast is dependent on an increase, from recent smolt classes, in the proportion of wild MSW returns from the 1994 smolt class and an increasing contribution by fish of hatchery origin.

Returns to the Nashwaak River in 1995 should at least equal those of 1995; hatchery stocking has not, in the last few years, been as significant an activity in any of the areas below Mactaquac as it has been above. Trends in the returns of wild fish to both the Magaguadavic and St. Croix rivers have been downward; there is no evidence to suggest that wild fish will equal or exceed the few dozen fish that returned in 1995.

RÉSUMÉ

Bien que les remontées totales de saumons unibermarins (5 079) vers l'amont de Mactaquac aient augmenté par rapport à 1993 et 1994, elles ont été les troisièmes plus basses depuis 1978. Les remontées de saumons pluribermarins (2 355) ont été les plus basses depuis 26 ans, mais se comparaient à 1994. La contribution identifiable des saumons d'écloserie aux remontées a augmenté et s'est établie à 57 % des unibermarins et à 27 % des pluribermarins; les taux de remontée des saumoneaux d'écloserie ont augmenté, mais se situaient encore parmi les plus bas enregistrés. Le nombre de géniteurs s'établissait à 4 839 unibermarins et 1 887 pluribermarins, soit 151 % et 43 % des cibles respectives. La ponte (70 % provenant de saumons sauvages) correspondait à 45 % des besoins, lesquels n'ont pas été comblés depuis 1985.

D'après les dénombrements effectués à la barrière de Nashwaak, on a estimé le nombre de saumons amontants à 940 unibermarins et 436 pluribermarins, une augmentation par rapport à 1994. Le nombre estimé de géniteurs était de 61 % et de 28 % des cibles respectives d'unibermarins et de pluribermarins. On a chiffré la ponte à 37 % des besoins, ce qui représente une augmentation de 6 % par rapport à 1994.

D'après les caractéristiques externes et scalimétriques de 555 unibermarins et de 194 pluribermarins capturés au piège de la Magaguadavic, seuls 49 unibermarins et 30 pluribermarins étaient d'origine sauvage; ces chiffres sont les plus bas enregistrés depuis huit ans. On a estimé à 31 parmi les unibermarins et à 28 parmi les pluribermarins les échappées réelles de femelles, compte tenu du retrait de nombreux poissons provenant de cages marines et du fait que la plupart des poissons restants ont été jugés immatures. La ponte potentielle se situait à 22 % de la cible, tandis que 52 % des oeufs provenaient de poissons d'élevage.

On a dénombré 60 saumons dans la rivière Ste-Croix à Milltown, soit le plus faible nombre enregistré depuis 13 ans. Seuls 7 unibermarins et 14 pluribermarins étaient d'origine sauvage. La ponte ne correspondait qu'à 2 % des besoins.

Les remontées d'unibermarins dans la Mactaquac en 1996 devraient se situer entre 5 800 et 6 900 saumons, dépassant ainsi les besoins en géniteurs de 3 200 unibermarins. Plus de 50 % des saumons amontants proviendront d'écloseries - soit des saumoneaux relâchés directement à Mactaquac ou des saumons de 0+ an relâchés en amont de Mactaquac en 1992 et 1993.

Il se pourrait que les remontées de pluribermarins vers Mactaquac en 1996 atteignent entre 3 800 et 4 300 poissons, c'est-à-dire de 85 % à presque 100 % des besoins-cibles en géniteurs, chiffrés à 4 400 pluribermarins, en amont de Mactaquac. Elles dépendent d'une augmentation du pourcentage de pluribermarins sauvages amontants issus de la classe 1994 de saumoneaux et d'une augmentation du nombre de saumons provenant d'écloseries.

Les remontées dans la rivière Nashwaak en 1995 devraient au moins se comparer à 1995. Dans les dernières années, les opérations d'empoisonnement dans les eaux en aval de Mactaquac n'ont pas atteint la même ampleur qu'en amont. Les remontées de saumons sauvages dans les rivières Magaguadavic et Ste-Croix montrent une tendance à la baisse; rien n'indique qu'elles seront comparables ou supérieures aux quelques douzaines de saumons qui sont remontés en 1995.

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)

Year	1990	1991	1992	1993	1994	1995	MIN	MAX	Mean
Harvest:									
First Peoples									
Small	273	657	560	241	250	50	241[2]	657[2]	396[2]
Large	247	957	748	462	90	25	90[2]	957[2]	501[2]
Recreational:									
Small	2110	1690	2104	852	0	-	852[1]	3580[1]	2065[1]
Counts:									
1SW	7907	7575	7664	3907	3313	4970	3313[1]	17314[1]	8290[1]
MSW	3919	4226	4203	2980	2206	2279	2010[1]	10451[1]	4907[1]
Returns:									
1SW	8804	8751	8940	4369	3534	5079	3534[1]	19275[1]	9731[1]
MSW	4125	5215	4898	3389	2375	2355	2375[1]	13916[1]	7085[1]
Spawners:									
1SW	6057	5721	5128	2819	2901	4812	2819[2]	6057[2]	4525[2]
MSW	3202	3481	3269	2149	1647	1919	1647[2]	3481[2]	2750[2]
% of Target met:									
1SW	189	179	160	88	91	151	88[2]	189[2]	141[2]
MSW	73	79	74	49	37	43	37[2]	79[2]	62[2]
Eggs	85	87	81	51	39	45	39[2]	87[2]	69[2]

[1] For the period 1975-1994.
[2] For the period 1990-1994.

Harvests: Salmon Fishing Area 23 was closed to recreational and commercial salmon fisheries in 1995. Fishing Agreements with requesting First Nations were begun on September 7 after the declaration of 1SW surpluses; only a few individuals exercised their right to fish.

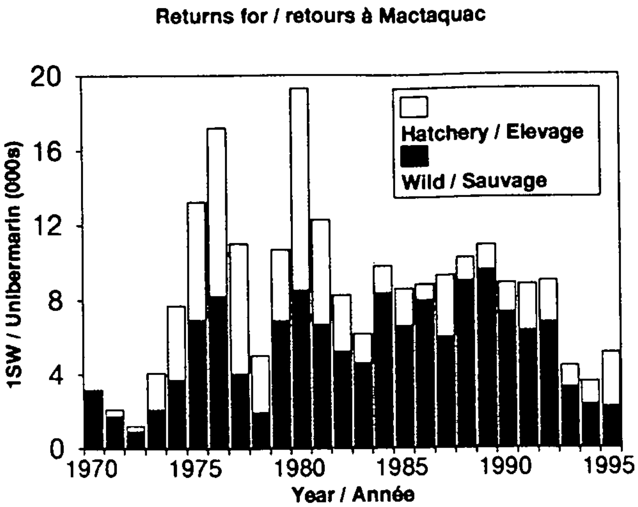
Data and methodology: Counts of fish are obtained from the collection facility at Mactaquac Dam; returns destined for the Dam are the counts plus estimates of down river removals. Spawners equal the releases above Mactaquac minus estimates of upriver removals, not including poaching and disease. 1SW returns are forecast from a relationship between adjusted egg depositions recruiting to 1SW fish; forecasts of MSW returns are based on a relationship between MSW returns and their 1SW cohorts and their fork length, in the previous year.

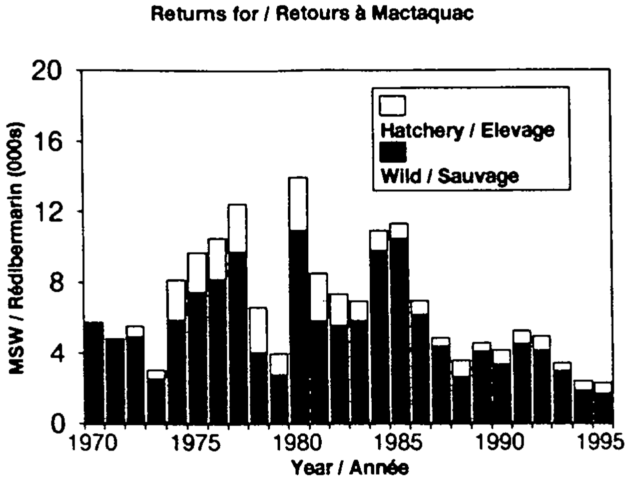
State of the stock: Wild 1SW and MSW returns were the fewest in 17 and 25 years, respectively. Hatchery origin 1SW returns (57% of the total) were the highest since 1987; hatchery MSW returns (27% of the total) were the fourth highest since 1987. Egg deposition (30% from hatchery-origin fish) was 45% of requirement; the target has not been met since 1985. 1SW return rates for hatchery smolts increased to 0.6% from 0.4% in 1993 and 1994.

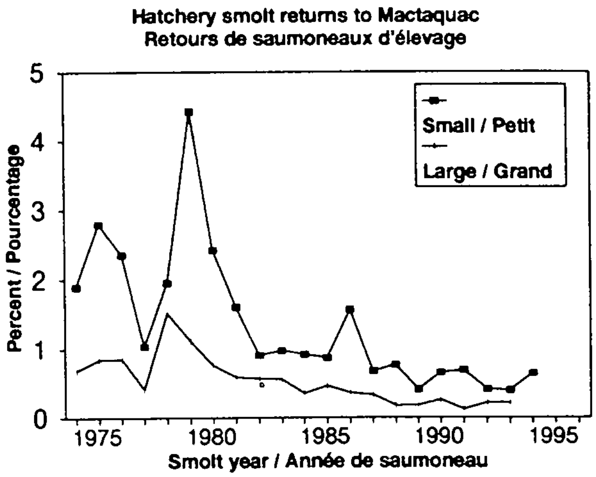
Forecasts: 1SW returns destined for Mactaquac in 1996 could total 5,800-6,900 fish comprised of 2,000-3,100 wild and upwards of 3,800 fish of hatchery origin. Total 1SW returns should exceed the 3,200 1SW conservation requirements. Wild MSW returns destined for Mactaquac in 1996 could number 2,800 to 3,300 fish (64-75% of the 4,400 fish conservation requirements); hatchery returns could number another 1,000 fish. Total MSW returns could approach 85-98% of the MSW requirement.

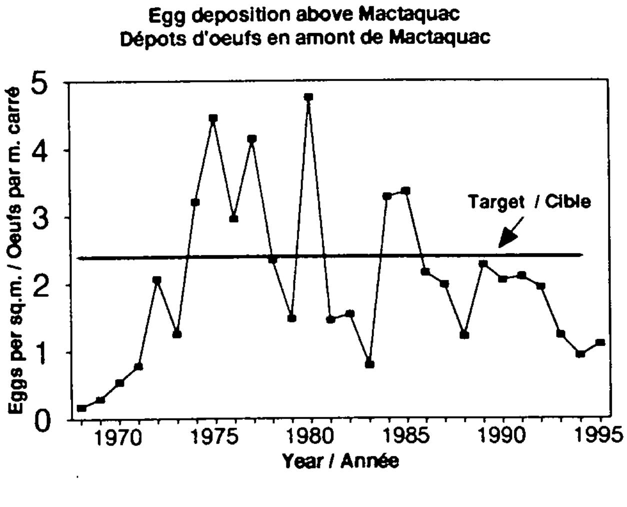
Management Considerations: Early client consultations and mid- and end-of-July forecasts should be requisite to any fishing plan in 1996.

SUMMARY SHEET (PART 2 of 2)









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)

Year	1990	1991	1992	1993	1994	1995	MIN[1]	MAX[1]	Mean[1]
Harvest:									
First Peoples									
Small	-	-	-	2	40	-	2	40	21
Large	-	-	-	5	30	-	5	30	18
Angling harvest (retained):									
Small[2]	196	186	426	137	30[3]	-	137[4]	426[4]	236[4]
Partial Counts:									
1SW	-	-	-	83	403	569	83	403	243
MSW	-	-	-	155	274	308	155	274	215
Returns:									
1SW	-	-	-	954	661	940	661	954	808
MSW	-	-	-	555	388	436	388	555	472
Spawning:									
1SW	-	-	-	866	610	940	610	866	738
MSW	-	-	-	555	349	436	349	555	452
% of Target met:									
1SW	-	-	-	57	40	61	40	57	49
MSW	-	-	-	36	23	28	23	36	30
Eggs	-	-	-	37	31	39	31	37	34

[1] For the period 1993-1994.
[2] Catch corresponds to above and below fence.
[3] Mandatory release.
[4] For the period 1990-1993; 1994 was mandatory release.

Harvests: With the exception of a 150-fish allocation to Kingsclear and St. Mary's First Nations, Sep 7 - Oct 16, there were no legal fisheries for salmon on the Saint John River and tributaries in 1995. No salmon were known or reported to have been removed above the Nashwaak River fence.

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 two different methods. Mark-and-recapture techniques and a proportional method which uses the run timing of previous years when entire runs were estimated or monitored (1972, 1973 and 1975).

State of the stock: Counts at the fence indicate an estimated return and escapement of 940 1SW and 436 MSW representing 61 and 28% of the target. Egg deposition was 4.22 million eggs or 39% of the target of which 28% came from 1SW fish. The river has not attained more than 40% of target in the three past years. Target numbers of MSW salmon were attained above the fence in 1973.

Forecasts: There is little expectation for change in the numbers of wild 1SW fish in 1996 from those of the last three years (mean of 852 1SW fish). The 940 1SW fish in 1995 are suggestive of an increase of MSW salmon in 1996. However there is no evidence to suggest numbers outside the range of the last three years (388-555 fish). The contribution of hatchery-origin fish to returns in 1996 has been, and will continue to be, minimal. In total, it is unlikely that target 1SW or MSW requirements in 1996 will be approached.

INTRODUCTION

This document assess the status of Atlantic salmon stocks in 1995, and provides prognoses of returns in 1996, for the **Saint John River above Mactaquac**, the **Nashwaak River** (tributary to the Saint John just below Mactaquac), and the **Magaguadavic** and the **St. Croix** rivers of south and western New Brunswick. These rivers 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 conponent 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 cooperative agreements with the St Mary's, Kingsclear and Oromocto First Nations. Data for the evaluation of the status of stocks in the Magaguadavic River were provided by the Magaguadavic Watershed Management Committee; data for the St. Croix River were provided by the St. Croix Recreational Fisheries Development Program. Counts at Mactaquac were adjusted on the basis of age determination of fish to account, for the first time, for a significant number of hatchery returns undetected by external characteristics.

On the basis of low spawning escapements (< 50% of requirement) in four rivers of SFA 23, 1994, and prospects for similar returns in 1995, SFA 23 was closed to commercial and, for the first time, recreational fishing for salmon. Only two First Nations requested and attained a food fishery allocation on the Saint John River after target 1SW escapements had been met.

SAINT JOHN RIVER ABOVE MACTAQUAC

Physical attributes of the Saint John River drainage (Fig. 1), salmon production area[1], barriers to migration, fish collection and distribution systems, the role of fish culture operations and biology of the stocks have been previously described (Marshall and Penney MS 1983). The state of the salmon stocks since 1970 were estimated beginning in 1983 (Penney and Marshall MS 1984) and continued through 1994 (Marshall and Cameron MS 1995). Pre-season forecasts of 1SW fish for 1995 had suggested that homeriver returns destined for Mactaquac could number 4,000 to 5,000 fish. MSW returns were forecast to be as few as 2,200 to 2,500 MSW fish. Thus, the conservation requirement of 3,200 1SW fish could be met or exceeded; the conservation requirement of 4,400 MSW salmon, which provides most of the egg depositon, was unlikely to be met (Marshall and Cameron MS op cit).

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[1] The area used herein for above Mactaquac is 12,261,000 m^2; it excludes all of the flow-controlled mainstem Saint John River. Recent measurements from orthophotographic maps and air photos (Amiro 1993), indicate an area of 12,931,600 m^2 (>0.12% and <15%) exclusive of the mainstem, and an additional 540,000 m^2 in the mainstem Saint John.

This assessment for stocks above Mactaquac is similar to that of 1994 (Marshall and Cameron MS 1995). Differences include the adjustment, based on age determination, of counts at Mactaquac to account for increasing numbers of adult returns from hatchery age-1 smolts that had "clean" fins, i.e., externally classified by Mactaquac staff as wild fish. This adjustment was also applied to freshwater age-2 and age-3 "wild" adults on the premise that fin condition among hatchery age-0+ fish released above Mactaquac was $\geq$ than that of smolts, i.e., a minimum adjustment. Also, forecasting with non-parametric models (Harvie and Amiro MS 1991; Marshall and Cameron MS 1995) was again discontinued because of the large difference between predicted returns and actual returns relative to predicted returns from parametric models.

Description of fisheries

The entire Saint John River was closed to commercial and recreational, inc. spring (black salmon), fishing for Atlantic salmon. On August 29, after the spawning target for 1SW fish above Mactaquac had been attained, the opening of a 1SW food fishery for First Peoples and possible opening of a hook-and-release recreational fishery were discussed by government, First Peoples and commercial and recreational fishery stakeholders at a meeting of the Zone 23 Management Advisory Committee. Thereafter, St. Mary's and Kingsclear First Nations requested, and obtained, on Sep 7, a combined allocation of 150 1SW fish. One trapnet was deployed for a few days but the few fish estimated to have been harvested were taken by hook-and-line in the vicinity of Mactaquac. Some salmon of sea-cage origin were provided to each First Nation according to an agreement between the First Nations and the Atlantic Salmon Federation.

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 70t of a 77t quota. In Labrador, licensed salmon fishermen harvested 55t of a 73.5t quota (quota was down from 92t in 1994 and 178t in 1993). No tags from Saint John River salmon destined for Mactaquac had been returned from any 1995 fishery at the time of the assessment.

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 a week in mid August, open May 20 - Oct 27; the migration channel at the Station was open May 20 - Oct 30.

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 every 5th fish (exceptions included the sampling of all broodstock, earliest-run fish and fish of suspected sea-cage origin) suggested that, for the first time, 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. (Weights of 4,3, and 2 allowed more regenerated scales to originate from hatchery-produced age-1 smolts, than age-2 or age-3 smolts which had spent one or two years in the wild). 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, hatchery return rates.

Removals by First Peoples fishing below Mactaquac were not formally reported but, were estimated on the basis of catches observed by or known to Fishery Officers. By-catch was closely monitored by Fishery Officers and Native Guardians. Assumed catch rates were 1% of the 1SW and 2.5% of the MSW river returns - values which are half of those used in 1994. 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 1995 (Table 1) totalled 4,970 1SW and 2,279 MSW salmon. Unadjusted counts (Table 2) or adjusted counts (Table 1) of wild fish were similar to those of 1994, i.e., only 50% or less of the previous 5- or 10- year means (Table 2) and among the lowest in the last 20 years (Fig. 2). Counts adjusted by scale interpretation shifted the hatchery component among 1SW fish from 51% (Fig. 3) to 57% and, among MSW fish (aquaculture fish excluded) from 23 to 27% (Fig. 3 includes aquaculture). 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	0.51	0.33	0.16		1.0	0.76	0.14	0.07			0.03	1.0
Wild		0.45	0.53	0.02	1.0		0.62	0.31	0.02	0.01	0.04	1.0

Fifty 1SW and 25 MSW salmon were estimated to have been removed by First Peoples fishing below Mactaquac Dam. Another 51 1SW fish and 59 MSW fish were ascribed to by-catch in the shad and gaspereau nets in the lower river and Saint John Harbour area.

Estimated homewater returns in 1995 totalled 5,079 1SW (Table 1) and 2,355 MSW fish; 1SW returns exceed those of 1993 and 1994 but MSW returns were the lowest in the 25 year record (Table 3; Fig. 4). Counts comprised 98 and 97% 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 and returns from smolts released to the Nashwaak River [on the basis of tag recaptures at Mactaquac and in the Nashwaak]) was 0.00644, a 57% increase over those rates of 1993 and 1994 (Table 4a). The adjusted return rate of 1-year smolts as 2SW salmon (Table 4b) was 0.00205 - similar to that rate of 1994 and the fourth lowest of a 20-year data set.

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. The lack of support by the State of Maine for salmon development initiatives above Grand Falls resulted in the discontinuation of adult (and juvenile) distributions above Grand Falls.

Losses to poaching and disease, exclusive of those estimated to have been taken in the net fishery at Tobique, the sport fishery or passed into the Aroostook or above Grand Falls, were 1% for 1SW and 2.5% for 2SW fish. These rates are reduced by 50% from 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 /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 by First Peoples were approximated at 50 1SW and 25 MSW salmon (Table 5) -the lowest in the 20-year record (Table 6). Transport from Mactaquac to the Aroostook River above Tinker consisted of 100 1SW and 40 MSW salmon. An additional 20 1SW and 2 MSW fish ascended the Tinker fishway (only closed for 2 weeks in August). Losses to poaching and disease were estimated at 95 fish which includes 8 salmon that died while being held in the Half-Mile Barrier Pool, Tobique River.

Total river removals by all factions were estimated at 288 1SW fish, of which 120 were placed above Tinker Dam 2 (external to the production area for which conservation requirements are assessed) and 515 MSW salmon, of which 305 were held at Mactaquac for broodstock.

Conservation requirements

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), and an assumed requirement of 2.4 eggs/m^2, yields a requirement of 29.4 million eggs. A length-fecundity relationship (Log_e Eggs = 6.06423 + 0.03605 Fork Length) applied to 1SW and MSW fish data, 1972-1982, and the 1SW:MSW ratios in those years suggested that, on average, approximately 4,400 MSW fish are required above Mactaquac (Marshall and Penney MS 1983). Because 1SW fish contribute few eggs relative to MSW salmon, a management philosophy limits 1SW requirements to that number which provides males for MSW females unaccompanied by MSW males, i.e., 3,200 fish (Marshall and Penney op cit).

Escapement

Collation of the total returns (Table 1) and total removals (Table 5) indicates that 1,887 (43%) of the required 4,400 MSW spawners was attained above Mactaquac (Table 7). For 1SW fish, 151% of 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	0.114	0.076	0.942	0.805
Mean length, female(cm)	58.32	58.94	77.02	76.48

Differences from 1994 were a reduction from 0.144 to 0.114 in the proportion of females among 1SW fish and reductions of just over 1 cm in mean length of female wild and hatchery 1SW fish. Mean lengths, the length-fecundity relationship and estimated escapement indicate that total potential deposition was 13.3 million eggs (1.1 eggs/m^2) or 45.2% of the target - up from the 38.6% of target in 1994. Eggs from 1SW fish comprised 12% of the total deposition; eggs from hatchery fish potentially contributed to 30% of the total deposition. Aquaculture fish, most likely the progeny of Mactaquac seed stock, potentially contributed to about 4% of the total 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, 1973-1992, on adjusted egg depositions in the Tobique River, 1968-1969 to 1988-1989 [method in Penney and Marshall (MS 1984), with updates on freshwater age composition from wild 1SW fish, App. 1, 2 and 3 this paper]. The 1991 and 1992 egg depositions, principal contributors to 1SW returns in 1996, were derived using angular-transformed mean proportions for age-2.1 1SW fish in the previous 10-year period.

To make multiplicative effects of environment, competition, variability in recruits etc. amenable to linear regression analysis, the natural logarithms of the observed values were used. 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).

1SW wild (Forecasts)

Potential returns of wild 1SW fish returning to Mactaquac in the absence of homewater removals 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 8). From the equation Log_e 1SW = 6.4275 + 0.4350 Log_e eggs ($R^2_{adj.}$=0.426, p=0.0008, n=21), the estimate for 1SW returns in 1996 is **5,864** 1SW fish (90% CL 3,185-10,795). There was no significant first order auto-correlation (0.303) but the Durbin-Watson "D" statistic (1.182) was "inconclusive". For 1995, the method forecast 6,408 1SW fish; only 2,168 fish or 34% (35% in 1994) of the forecast was estimated to have returned. The model, however, does not yet include egg depositions and low 1SW returns in 1993 and 1994 (estimated position of eggs in Fig.5) which reflect a recent downturn in survival.

MSW wild (Methods)

Forecasts of MSW returns in 1996 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 Cameron MS 1995). As with the forecast of 1SW salmon, the resultant GM value of MSW salmon (and confidence limits) was converted to an AM value (Ricker 1975).

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 1996 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 22 of the 24 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 24 or 25 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 17 years) 1SW returns of 1995.

MSW wild (Forecasts)

A potential return of **2,849** (90% CL 1,833-4,428) wild MSW fish destined for Mactaquac in 1996 was derived from the equation Log_e MSW = 25.7402 + 0.133E-3 1SW - 0.3170 Length ($R^2_{adj.}$=0.784, $p<0.0001$, n=25 columns 5 and 7 on column 4, Table 8). For 1995, the method forecast 1,613 returns; 1,654 fish (103% compared to 80% in 1994) were estimated to have returned. The inclusion of the co-variate "period" in the model for MSW years 1971-1975; 1976-1984 and 1985-1995 and, as well, 1971-1975; 1976-1986 and 1987-1995 when ratios of MSW:1SW (Fig. 5) and lengths (Table 8) appeared to be different, was not significant (p=0.224 and p=0.194, respectively), i.e., there was no evidence to suggest 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), 1972-1995, (Table 8, one less year than in the above data set) suggests a return of **4,121** (90% CL 2,326- 7,302) wild MSW fish destined for Mactaquac in 1996 (Log_e MSW = 30.01686 + 0.143E-3 1SW - 0.3862 Length; $R^2_{adj.}$=0.752; $p<0.0001$; n=24). For 1995, the method forecast 2,240 returns - about 135% (about 200% in 1994) of the actual 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 1985-1995 (p=0.010) or 1987-1995 (p=0.022). The subset model for the period 1985-1995, Log_e MSW = 24.1443 + 0.193E-3 1SW - 0.2917 Length ($R^2_{adj.}$=0.861; n=11) was significant (p=0.0002) and provides a forecast of **2,788** (90% CL 1,623-4,790) wild fish destined for Mactaquac. The model for the period 1987-1995, Log_e MSW = 26.3627 + 0.194E-3 1SW - 0.3298 Length ($R^2_{adj.}$=0.757; n=9; p=0.006) was slightly less significant. The model for the latter two subsets combined, i.e., MSW years 1976-1995, is Log_e = 27.9280 + 0.183E-3 1SW - 0.3549 Length ($R^2_{adj.}$ =0.851; $p<0.0001$; n=20). The forecast from this model is **3,257** (90% CL 2,035- 5,214) wild MSW salmon; for 1995 this method forecasted 1,782 returns or 108% of the actual returns.

1SW hatchery (Methods)

Since the shift to age-1 smolt production from Mactaquac in 1985, forecasts of hatchery returns have been simply the product of the mean return rate of recent years and the number of smolts (i.e., >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 (Anon. MS 1995) (r^2=0.604; p<0.001; n=21) and the absence of any indication that the index is increasing, suggests the use of the mean (arcsin) survival rates of the last four years (Table 4a) when the index of winter habitat was low (Fig. 8). 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 $rate_{95}$) of the 4-year mean value calculated for forecasting 1996 returns to Mactaquac.

Additional 1SW returns of age-3.1 and age-2.1 fish are expected at Mactaquac in 1996 from fall fingerlings (age-0^+) graded from the age-1 smolt program at Mactaquac and released into tributaries above Mactaquac in 1992 and 1993. 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 for returns in 1995 or 1994 relative to those used for forecasting the 1995 returns. Returns of age-2.1 fish were forecast as the product of a 0.002 return rate to Mactaquac (the value for returns in 1995; Table 9) and the numbers released in 1993. Age-3.1 fish were assigned a return rate of 0.001. Returns from unfed fry were accorded a return rate of one-half of that given the fall fingerlings but most are likely to be indistinguishable from wild fish upon return to Mactaquac.

1SW hatchery (Forecasts)

A forecast of hatchery 1SW fish destined for Mactaquac in 1996 is **3,810** fish (Table 10); the approach forecast 1,900 1SW returns in 1995 - the minimum estimate of actual returns was 2,900. Age-1.1 salmon, perhaps the best forecast element, would contribute to only 33% of the hatchery-origin recruits.

MSW hatchery (Methods)

Returns as MSW fish from age-1 smolts released at Mactaquac in 1993 were estimated as the product of the number released and a forecast return rate. The return rate was derived from a relationship between survival to home waters of 1SW and 2SW salmon originating from smolt releases, 1974-1993, at Mactaquac. Hatchery smolt return rates used in forecasting hatchery MSW salmon exclude potential gains from the moratoria on commercial fishing in insular Newfoundland and the buy-out in Greenland. This effect is disregarded because moratoria models would have little effect at the origin (XY) in raising estimates and, values at the origin are mostly unaffected by the moratoria. 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 0.5 ratio of MSW/1SW during the last 9 return years (Table 8) and by values estimated for returns in 1995 or 1994 relative to those used for forecasting 1995 returns. Returns of age-2.2 salmon were forecast as the product of their numbers and a return rate to Mactaquac of 0.0002, approximately the same as that observed in 1995 (Table 9) and 1993-1994. Age-3.2 hatchery MSW fish, theoretically less abundant because of the generally large size of stocked fall fingerlings, were accorded a 0.002 return rate exhibited by returns in 1995.

Fish which returned as maiden fish, mainly 1994-1995, are expected to comprise the repeat-spawning hatchery MSW component in 1996. The forecast return was based on a 0.002 return rate estimated for 1995 from 1993-1994 mostly maiden fish (Table 9).

MSW hatchery (Forecasts)

Total returns of MSW fish of hatchery-, Aroostook- and above Grand Falls- origins destined for Mactaquac in 1996 are **1,033** fish (Table 10) - 70% more than were identified in 1995. Returns from age 1.2 hatchery smolts are expected to number 668 or 65% of the total. They were estimated from the product of the number of smolts and a return rate of 0.00297 derived from the regression Arcsin sqrt (MSW return rate) = 0.790 + 0.507 Arcsin sqrt(1SW return rate), where $R^2_{adj.}=0.73$, $p<0.001$ and $n=20$.

Ecological considerations

In-river

Discharges at Mactaquac June through August were among the lowest of record; the pattern was little different from that of 1991 (Fig. 6). Weekly plots of counts at the Dam, 1992-1995, (Fig. 3) suggest if anything, the predicted earlier arrival of salmon in the fishway. The effect of below average mid-June to early-July river discharges, for example, is to increase the proportion of the eventual total run seen to date (Marshall and Cameron MS 1995). The interpretation is that fish arrive in the reaches below the Dam at about the same time annually but that, for example, low discharges from turbines allow fish to find the attraction water from the fish collection facility more easily; high discharge from turbines/spill delays salmon in locating and entering the collection facility.

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 Jul 2-14, Jul 2-21 and Jul 2-29 for respective forecast dates of July 15, 22, and 29, and for MSW models, mean daily discharge Jun 18-Jul 7, Jun 18-Jul-14, Jun 18-Jul 21 and Jun 18-Jul 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 4,970 1SW and 2,279 MSW salmon were forecast as:

Sea-age	July 15	July 22	July 29	August 5
1SW	4,400	4,190	4,990	5,010
MSW	1,830	1,895	2,020	2,160

Estimates were consistent with pre-season forecasts and identified a significant shortfall of MSW salmon and a surplus of 1SW fish relative to conservation reqirements.

Turbine induced mortality on smolt-sized parr at the Tobique Narrows facility was estimated to be about 15% (MacEachern MS 1961). The cumulative mortality through turbines at the Tobique, Beechwood and Mactaquac facilities then has the potential to be as much as 40% Plots of discharge at Mactaquac and the "level" at which river flow is spilled, are illustated in Fig. 7. Spill, or the window of opportunity to by-pass turbines, has been variable in April and early-May of the last 8 years and was suggested (Marshall and Cameron MS 1995) as having an influence on smolt survival. However, recent synthesis of available data

(J. Bagnall[2] pers comm) suggests that smolts do not arrive at Mactaquac until early- to mid- June when there is virtually no spill.

Marine

The ICES Working Group on North Atlantic Salmon (Anon MS 1995) 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 would be as low as that of recent years and, require a conservative management strategy. Reddin et al. (1993) suggested that in years following low abundance in Greenland that there should be low numbers of 2SW salmon returning to homewaters. An unimproved habitat index value for 1995 (Anon MS 1995 and Fig. 8) and probable continuation of low marine survival, supports the forecasts that MSW returns to the Saint John will be inadequate to meet target requirements in 1996.

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.

A significant relationship between the March index of habitat and return rates for 1SW salmon from hatchery smolts (Arcsin sqrt[1SW return rate]= 0.006 March - 4.043; $R^2_{adj.}$=0.604; $p<0.001$; n=21) indicates decreasing 1SW returns with a declining index of habitat (Fig. 9). Similar relationships exist between return rates of hatchery 2SW salmon originating from hatchery smolts and the index of habitat for the first year at sea ($R^2_{adj.}$=0.500; $p<0.001$; n=20); the second year at sea ($R^2_{adj.}$=0.439; p=0.001; n=20) and first and second years together (R^2=0.483; p=0.001; n=18). Further, the length of wild 1SW returns (hatchery not tested) and April index of habitat are also negatively correlated ($R^2_{adj.}$=0.168; p=0.024; n=25) as is the fork length and proportion of 1SW salmon from a smolt class (Arcsin sqrt[prop. 1SW] = 4.475 Length - 209.610; $R^2_{adj.}$=0.510; $p<0.001$; n=25;[Fig. 10 - 2SW fish]). 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. This hypothesis will in part be challenged in 1996 given that the increased forecast of MSW returns over those forecast for 1995 is the result of a decrease from 1994 in the mean length of wild grilse returning in 1995.

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.

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[2] Washburn and Gillis Ltd., 25 Waggoners Ln, Fredericton, N.B. E3B 2L2.

Forecast summary

1SW salmon

1SW returns destined for Mactaquac were forecast to be 9,674 (5,864 wild and 3,810 hatchery) salmon. Forecasts of wild returns in 1993, 1994 and 1995 were at best 35, 53 and 34%, respectively, of the realized returns. Because only a portion of 1993 and none of 1994 returns are incorporated in the model for wild fish and because of the linkage between low survival of hatchery fish and a continuing low index of winter habitat, the wild forecasts are likely inappropriate. Forecasts of hatchery fish better reflect recent trends in low survival but for stages other than smolts require several assumptions. As done in 1995, discounting wild forecasts by the range of "error" noted in the past 3 years may be more indicative of wild returns in 1996. Hence, the forecast for total 1SW returns may more realistically be 5,804 (3,810+[5,864*0.34]) to 6,918 (3,810+[5,864*0.53]) or, in general terms **5,800** to **6,900 fish**. The greater potential for hatchery contribution to the 1995 smolt class and an upturn in sea survival could mean that returns in 1996 will be no worse than those of 1995 and that **spawning requirements of 3,200 1SW fish will be exceeded.**

MSW salmon

The forecasts of wild MSW fish for 1996 were 2,849 (no effect of the moratoria), 2,788 (11-year subset of the moratoria data, 3,257 for the 19-year subset of moratoria data and 4,121 for the complete moratoria model. Total wild and hatchery MSW returns destined for Mactaquac were forecast to be 3,882, 3,821, 4,290 and 5,154 fish. Unlike 1SW models, MSW models including forecasts of hatchery-source returns indicate low survival of 1SW returns in recent years. Wild MSW returns have been on average 90% (1993-1995) of the model without the effects of the moratoria; the complete moratoria model was the least accurate - 165% of returns. Disregarding the complete moratoria model leaves estimates that range from 2,788 to 3,257 wild MSW fish and, total returns that range from 3,821 to 4,290 MSW fish. In general terms, forecasts of MSW returns are **3,800** to **4,300** MSW salmon, i.e., **85 to nearly 100% of conservation requirements.**

NASHWAAK RIVER

With a drainage area of about 1,700 km^2, the Nashwaak River flows approximately 110 km in an easterly and southerly direction from Nashwaak Lake on the York/Carleton county line to its confluence with the Saint John River in Fredericton North (Figs. 1 and 11). The river is the largest single salmon-producing tributary of the Saint John below Mactaquac - its production area[3] having been estimated at 4.9 million m^2 or 31% of the total below Mactaquac (Marshall and Penney MS 1983). A salmon counting fence at kilometre 23 (Fig. 11) 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 and 1995 - principally those of the St. Mary's and Kingsclear First Nations.

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[3] Recent measurements from orthophotographic maps and air photos but not used in this assessment indicate an area of 5,692,000 m^2 >0.12% grade.

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 fish above the fence in 1995 were estimated as the product of the counts in 1995 and the reciprocal of the proportion that 1994 counts were of the total estimated run (Marshall and Cameron MS 1995). This analysis assumed, on the basis of river discharge and to a lesser extent, water temperature, that run-timing of salmon in 1995 was more similar to that of 1994 than 1973 or 1975 (Fig 12).

As in 1994, seining of pools upriver from the fence was undertaken to sample the relative numbers of caudal punched and unpunched salmon above the fence. These data were to 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

Counts of 1SW and MSW fish (adjusted by scale analyses) at the Nashwaak fence during the Jul 12 - Oct 18 operating dates numbered 569 1SW and 308 MSW salmon (Table 2; Fig. 13). Nearly all, i.e., 87% of 1SW and 96% of the MSW salmon moved through the fence after Oct 7, (Fig 13). Scale samples revealed that sea-ages of the wild fish were 65% 1SW; 33% 2SW and 2% previous spawners. Sea ages from 1993-1995 are as follows:

Year	n	Prop 1SW	Prop 2SW	Prop 3SW	Prop previous spawners(PS)	PS as p of MSW*
1993	92	0.33	0.53	0.02	0.12	0.18
1994	204	0.59	0.32	0.01	0.08	0.19
1995	159	0.65	0.33	0.00	0.02	0.06

Seining was conducted on three separate occasions and catch can be summarized as follows:

Date	Pools seined	Marked 1SW	Marked MSW	UnMarked 1SW	UnMarked MSW
Sep 1*	2	0	0	10	8
Oct 25	4	1	1	1	3
Nov 1-2	8	1	0	0	0

* a swim-thru of 9 pools before seining revealed that only 2 pools held salmon.

Distribution of the effort (Sep 1) and small sample sizes (Oct 25 and Nov 1-2) discouraged estimation of the proportion of the run that ascended the fence site prior to July 12 or possibly, after Oct 18, 1995.

A mark-and-recapture estimate of the entire run in 1994 (Marshall and Cameron MS 1995) suggested that the fence, which operated over approximately the same period as in 1995, accounted for 60.5% of 1SW and 70.6% of MSW returns. Raising the adjusted 1995 counts by the respective proportions through the fence suggests that the total run past the fence in 1995 could have been **940** 1SW and **436** MSW salmon.

Removals

With the exception of a 150 fish allocation to Kingsclear and St. Mary's First Nations, Sep 7 - Oct 16, there were no legal fisheries for salmon on the Saint John River and tributaries in 1995. No salmon were known or reported to have been removed above the Nashwaak River fence. Also because of the sparse availability of summer-run fish, no broodstock were collected in the Nashwaak by staff of the Mactaquac Fish Culture Station.

Conservation requirements

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, suggest that, on average, approximately 1,700 1SW and 1,800 MSW fish are required for the entire Nashwaak River (Marshall et al. MS 1992). 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 target for spawning requirements above the fence site is 10.7 million eggs (1,530 1SW and 1,620 MSW fish) or 90% of that of the entire Nashwaak (Marshall and Cameron MS 1994). Egg deposition and spawners were estimated on the basis of lengths, external sexing and interpretation of age from scales collected from fish passing through the fence.

Escapement

All 940 1SW and 436 MSW salmon estimated to have passed above the fence were presumed to have spawned. Sea-age, origins, female composition and mean lengths for spawners above the fence can be summarized as follows:

Biological parameter	One-Sea-Winter Salmon		Multi-Sea-Winter Salmon	
	Wild	Hatchery	Wild	Hatchery
Number	899	41	416	20
Proportion female	0.363	0.435	0.983	0.692
Mean length female (cm)	57.2	61.0	78.3	75.3

Numbers of 1SW and MSW salmon were only 61 and 28% of the respective targets. Egg deposition was estimated at 4.22 million (0.95 eggs m^{-2} or 39% of the egg requirement). 1SW females contributed 28% of the total estimated egg deposition. Estimated egg deposition in the previous two years of fence operation were 37 and 31% of target (Marshall and Cameron MS 1995). Counts in 1973 (Table 2), the first complete year of an announced 5-year ban on commercial salmon fishing in the Saint John River and Bay of Fundy approaches, suggest that egg deposition exceeded target.

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 three years (mean of 852 1SW fish). The 940 1SW fish in 1995 is, however, suggestive of a marginal increase in MSW salmon in 1996. However, as with 1SW fish, the MSW data are too few to suggest that wild MSW returns will vary from those of the last three years (388-555 fish). The contribution of hatchery-origin fish to returns has been, and in 1996, will continue to be minimal. In total, it is **highly unlikely that target 1SW or MSW requirements will be approached.**

MAGAGUADAVIC RIVER

With origins in Magaguadavic Lake, the Magaguadavic River flows southeasterly for 80 km to the Bay of Fundy at St. George, N.B. (Fig 14; 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 top pool of the fishway. In July through October, 1995, as in 1994, the trap was operated and data were collected by the Magaguadavic Watershed Management Association (J. Carr[4] pers comm). In 1992 and 1993 the trap was operated and data were collected by the Atlantic Salmon Federation (ASF). 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 79 wild and 666 aquaculture salmon (after analyses of scales; the latter including 6 post smolts), (J. Carr[4] 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 returns in 1995 were less than 20% of the average count for the previous 5 years (inc 1985 and 1988).

Of the wild returns, 63% were in the month of July, 22% were in August and the remainder were in September and October. Fish of aquaculture origin arrived at the fishway in similar proportions in the months of July, September and October. Seventy-eight percent of escapees released to the river were from among July arrivals - prior to a management decision to exclude further aquaculture fish from the River. The remaining releases contributed to ongoing research on the interactions between wild and aquaculture Atlantic salmon.

Removals

Three hundred and sixty-three (363) 1SW, 89 MSW and 6 post-smolt salmon externally identified as being of aquaculture origin were removed from the trap in the fishway (J. Carr[4] pers comm). These fish were in part disposed of, taken alive to the ASF, sampled for disease or tagged and released below the trap in the

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[4] Magaguadavic Watershed Management Association, c/o General Delivery, St. George, N.B. E0G 2YO.

fishway. There was no commercial or recreational fishery of any description in 1995.

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)[5]. Spawners necessary to obtain those eggs were estimated at 230 MSW and 140 1SW salmon.

Escapement

External characteristics and scale analyses indicate that 182 1SW and 105 MSW fish were released above the fishway (J. Carr[4] pers comm). Biological characteristics of the spawners were as follows:

Biological characteristic	1SW wild	1SW aqua	MSW wild	MSW aqua
Number	49	133	30	75
Prop. female	0.31	0.55	0.50	0.17
Mean length female (cm)	55.6	67.1	74.8	72.6

Only 16 (22%) of the female 1SW aquaculture escapees were believed to be sexually mature (J. Carr[4] pers comm). Mean lengths, the mean length fecundity relationship for Saint John River salmon of $Y=430.19e^{0.03605X}$ (Marshall and Penney MS 1983) and estimated number of females suggest a potential egg deposition of 297,000 eggs or 22% of target. Fifty-two percent of that total was estimated to have been of sea-cage origin.

Forecasts

If recruitment to the Magaguadavic were based on escapement of wild fish alone, the prospects for returns in 1996 would be minimal. 1SW fish have diminished annually at a rate of 0.3 to 0.4. Based on the relationship MSW = 2.48 1SW - 194.49 (n=5; R^2= 0.96; p=0.01) from count data, wild MSW salmon could be virtually non-existent in 1996. However, potential recruitment from escaping MSW aquaculture fish in 1991 and 1992, may act to stabilize wild-looking returns at existing levels of wild fish.

ST. CROIX RIVER

The St. Croix River, a US/Canada international river bordering the State of Maine and Province of New Brunswick, drains southeasterly into Passamaquoddy Bay of the Bay of Fundy. Approximately 1,619 km^2 of the drainage basin is in New Brunswick and 2,616 km^2 is in Maine (Fig. 14). Once a significant producer of Atlantic salmon, the river and stocks succumbed to industrial development - initially cotton mills, then pulp

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[5] Other estimates of juvenile production area are under review and, to date, suggest that the current estimate of substrate area is a minimum.

mills, and now, dams and headponds at 3 hydroelectric facilities. The main stem and East Branch (84 km), the Chiputneticook lakes (66 km) and Monument Brook (19 km) determine 169 km of the international boundary (Anon MS 1988), the fluvial portions of which comprise the bulk of the potential rearing area for Atlantic salmon.

In 1995, 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

Counts of salmon have been made at the Milltown fishway just above tide-head - most recently under the St. Croix Recreational Fisheries Development Program (Table 2). Counts, scale samples and external characteristics provided by L. Sochasky[6] (pers comm), in 1995, indicate a return comprised of only 14 and 7 wild 1SW and MSW salmon, respectively. Wild MSW fish have declined steadily since the late 1980s and now number < 5% of their numbers in the mid 1980s. Seven 1SW and 19 MSW fish of hatchery origin can be accredited to a smolt stocking program conducted by the Atlantic Sea-Run Salmon Commission (Maine). Seven 1SW fish and 6 MSW fish of sea-cage origin were identified on the basis of "broom" tails and gross fin degeneration. Sea-cage fish were believed to be of the same sources as those entering the Magaguadavic River; 1SW fish were judged to be immature.

Removals

Removals were restricted to 16 broodstock delivered to Mactaquac Fish Culture Station. Broodstock were mostly June-, July-run fish of both wild (naturalized stock) and hatchery (Penobscot) origins.

Conservation requirements

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

Escapement

Effective river escapement in 1995 was limited to a total of 17 MSW and 11 1SW female fish. Eleven fish of sea-cage origins were assumed to be non-contributors. Eggs were estimated from the length-fecundity relationship ($Y=430.19e^{0.03605X}$) for salmon of the Saint John River. Sea-age, origin,female composition and mean lengths for fish released above the Milltown Dam can be summarized as follows:

[6] St. Croix International Waterway Commission, St Stephen, N.B., E3L 2Y7.

Biological characteristics	1SW wild	1SW htch	1SW aqua	MSW wild	MSW htch	MSW aqua
Number	7	7	7	8	11	4
Prop. female	0.43	0.14	1.0	0.75	0.82	0.50
Mean length female (cm)	58.0	55.5	58.1	75.7	72.9	69.7

The resultant egg deposition totalled about 142,000 eggs or 2% of requirements. Eight hatchery females and 3 wild females contributed to 87,000 eggs that were laid down at Mactaquac Fish Culture Station.

MANAGEMENT CONSIDERATIONS (SFA 23)

Forecast models and forecasts for 1SW returns destined for Mactaquac Dam in 1996 incorporate a significant amount of uncertainty. As well, poor marine conditions, not fully accounted for in the forecast models, continue to persist in the North Atlantic. Forecasts of total greater returns in 1996 are based on a greater contribution from hatchery-source fish and a relationship that suggests that smaller 1SW fish are an indication of an increase in MSW returns from the same smolt class. Building on the results and experience from 1995, managers should consider allocations of 1SW fish once a significant proportion of the run is available (mid-July). In-season assessments of end-of-season counts at Mactaquac should be maintained to ensure that conservation targets for MSW salmon, in particular, are maximized.

The significant shortfalls in egg deposition in 1994 and 1995 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 1995). Egg deposition requirements above Mactaquac may be approached in 1996, but requirements for the Nashwaak and, possibly, other tributaries below Mactaquac are unlikely to be met, because none have received the same level of hatchery support. However, T. Pettigrew (pers comm[7]) suggests that requirements, as indicated by redd counts, were met for an 11.75 km section of the main Hammond River.

Prospects for wild MSW salmon to the Magaguadavic River in 1996 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 reasonable to expect that MSW salmon requirements may be approached above Mactaquac in 1996, but that requirements are unlikely to be met in any other outer Bay of Fundy rivers.

Escapement of aquaculture-origin fish to outer-Fundy rivers has the potential of swamping native stocks with other genetic material - most probably that of Saint John River or Penobscot River salmon. This was the case in the Magaguadavic River in 1994 and 1995. Selective harvests of these fish in the

[7] NBDNRE, P.O. Box 150, Hampton, N.B. E0G 1Z0.

Passamaquoddy Bay area are largely impractical except at fishways.

ACKNOWLEDGEMENTS

Compilation and synthesis of these assessments have been made possible only with the support of many co-workers. Counts of salmon essential to the assessment on the Saint John were provided by the staff, particularly B. Ensor, at Mactaquac FCS and field supervisors J. Mallery and C. Fitzherbert. Counts of salmon at Tobique Narrows were provided by Maliseet First Nation, counts of salmon at Beechwood were provided by NB Power and counts of salmon at Tinker Dam were provided by Maine Public Service. The St. Mary's, Kingsclear and Oromocto First Nations installed and operated the salmon counting fence on the Nashwaak River. D. MacPhail, Silvacare Inc., determined ages for salmon scales sampled at Mactaquac; P. Swan, DFO Moncton aged and tabulated salmon from the St. Croix River. J. Carr, Magaguadavic Watershed Management Committee provided fishway counts, biological data, and estimates of escapement at the St. George fishway; L. Sochasky and D. McLean, St. Croix Recreational Fisheries Development Program, provided counts and scales from salmon ascending the Milltown fishway. C.J. Harvie, DFO, Halifax, advised on and assisted with statistical procedures.

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.

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

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 1995. Report of the North Atlantic Salmon Working Group. ICES C.M. 1995/Assess:14 Ref. M:191p.

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

Harvie, C.J., and P.G. Amiro. MS 1991. Forecasts of MSW salmon returns to the Saint John River using non-parametric and parametric models. CAFSAC Res. Doc. 91/22. 19p.

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.

MacEachern, N. MS 1961. Mortality tests at Tobique Narrows Dam, 1959 and 1960. Unpubl. MS Can. Dept. Fish., Halifax, N.S. 24p.

Marshall, T.L. MS 1989. Assessment of Atlantic salmon of the Saint John River, N.B., 1988. CAFSAC Res. Doc. 89/77. vii + 24p.

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.

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.

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.

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 5-9, 1996, in Moncton, N.B. Reviewers included staff of the Diadromous Division of DFO, biologists from the provinces of New Brunswick and Nova Scotia, State of Maine, Atlantic Salmon Federation, Parks Canada and Headquarters (Ottawa) Region, UNB Wildlife Co-op Unit, NB Wildlife Federation and University of Moncton. 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 precis of the assessment, research recommendations and main points raised during the meeting.

Formal consultations re: status of stocks in 1994, pre-season forecasts for 1995 and, in particular, management practices and scenarios above Mactaquac (without the prospect of salmon development above Grand Falls) were conducted in a "Science Review" at the Florenceville Motel on Sat. June 3, 1995. Clients represented both Canadian and US (Aroostook River and upper Saint John River) interests. Minutes were distributed and are on file in Halifax.

Formal consultations on prospects for 1995 and in-season management measures were discussed at a full meeting of the Salmon Management Advisory Committee (ZMAC 23), [press in attendance] April 21 in Fredericton. A meeting/teleconference between chiefs or their representatives of First Nations of the Saint John River Valley to discuss in-season stock status and the utilization of surplus 1SW fish took place on Aug 9 at Woodstock First Nation. A second meeting of ZMAC 23, Aug 29 in Fredericton, reviewed in-season status of salmon, extent of the surplus 1SW fish, and plans by First Peoples to deal with surplus 1SW salmon and possibly open the door to a hook-and-release recreational fishery. 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" as prescribed within a recent Science Branch mandate were included in the agenda of a third ZMAC 23 held Jan 4, 1996, in Fredericton. Attendees included the authors and Phil Atwin (Kingsclear FN), J.-C. Thibodeau (Northwest Salmon Assoc.), Lewis Brooks (St Mary's FN), Alex Bielak (NBDNRE, Fish and Wildl Br.), Frank Palmater (NB Aboriginal Peoples Council), Doug Clay (Parks Canada), Ben Macaulay (Kennebecasis Salmon Assoc.), John Mallery (Concerned Citizen), Richard Michaud (ASF), Jennifer Cameron (DFO, Rec. Sec.), Stuart Shaw (Central Branch, SJRSA), Greg Stevens (DFO, Halifax), Carl Urquhart (Fredericton Branch, SJRSA), Jack Davis (DFO, Fredericton), John Kearney (Fundy N. Fisherman's Assoc.), Rex Hunter (DFO, St. Andrews, Chairperson), Frank Wilson (NB Wildlife Federation) and Jim Gillespie (NB Salmon Council).

DFO reviewed the status in 1995 of salmon stocks in the Saint John River above Mactaquac, Nashwaak, Magaguadavic and St. Croix rivers. The presentation focused on data for (1) target conservation requirements, particularly those above and below Mactaquac, (2) counts of adults and background information to each of the assessments and (3) the need to adjust counts of externally classified hatchery and wild fish on the basis of scale reading. The availability and need to assess juvenile densities from electroseining as potential indicators of the past status of stocks in tributaries for which there are no assessments of adult salmon was also recognized. Estimates of spawning escapement and egg deposition were shown to again be less than 50% of requirements in each of the four assessments; 20+ year low discharges and associated warm summer water temperatures on the Saint John River were not believed to have adversely affected returning adults or the estimates of their numbers returning.

Pre-season and in-season forecasting of adult returns was reviewed and, despite the absence of statistically strong forecast models, were no worse than 20% of actual returns. In-season forecasts of end-of-season counts at Mactaquac were also shown to be, at worst (July 14), 20% of the final count. Uncertainties in forecasting adult returns in 1996, as in 1995, were reviewed and it was suggested that returns of 1SW and MSW salmon in 1996 would equal or perhaps slightly exceed those of 1995. Full Minutes of the meeting can be obtained from the Secretary at the above address.

Client input ranged beyond specifics of spawning requirements, stock status and forecasts to the larger issues of (1) hatchery divestiture, (2) the pros and cons of current/past stocking practices in maintaining/building stocks, (3) failure of DFO to promote adequate upstream/downstream passage, (4) need for "free-swim" above Mactaquac to encourage integrity of distinct stock components, (5) the need for a better understanding of the causes of low marine survival, (6) strategies to allow fishing for species other than salmon in the event of a continued closure of the recreational fishery for salmon, and (7) concern over an alleged change in the size of the openings in the trash racks which may or may not impede the passage of salmon through the turbines. Comments fitting the prescribed headings and relevant to the assessment process are as follows:

Fisheries - (essentially there were none)

Target - There was a concern that the Saint John could not be rebuilt to historic levels if targets were not elevated to better utilize existing and unutilized juvenile rearing areas above Mactaquac.

Data - The reliability and consistency of adult count data was raised. It was pointed out that count data at facilities in rivers reflect what is left after most fisheries and that increased counts over the last 25+ years can frequently be attributed to reductions in exploitation. NBDNRE presented a series of estimated escapements relative to targets for a 11.75 km stretch of the Hammond River (<10% of the total production area; escapement exceeded target in most years since 1976.) It was mentioned that these data would be evaluated by DFO relative to wild adult returns to Mactaquac and juvenile densities above and below Mactaquac.

Status - Salmon in rivers of SFA 23 have been below target for many years. Discussion ensued on broader issues (see above) of similarity/differences with other under-escaped Atlantic coast rivers.

Prospects - No significant discussion.

Other - It was suggested that i) more emphasis should be placed on the assessment of stocks below Mactaquac and the assumption that the above-Mactaquac stocks were an appropriate index of stock strength below Mactaquac, ii) more insight should be acquired on the impact of marine conditions on the current low status of salmon stocks and, iii) DNA microsatellite markers (using archived scale material) be considered to investigate the impact of stocking on the genetics of Saint John River salmon.

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., 1995.

Sea-age	Components	Wild	Hatch.	Aqua.	Total
1SW					
	Mactaquac counts(a)	2,429	2,533	8	4,970
	Mactaquac counts adjusted(b)	2,125	2,849	4	4,978
	Angled MS below Mactaquac	0	0	0	0
	Native Food Fishery	21	29	0	50
	By-catch(c)	22	29	0	51
	Totals	2,168	2,907	4	5,079
MSW					
	Mactaquac counts(a)	1,681	504	94	2,279
	Mactaquac counts adjusted(b)	1,595	578	98	2,271
	Native Food Fishery	18	6	1	25
	By-catch(c)	41	15	3	59
	Totals	1,654	599	102	2,355

(a) - Hatchery/wild origins per external characteristics in previous assessments;fishway closed Oct.27 (counts unadjusted to any other date).

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

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

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

	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	f	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	f	69	61	995	167	cf	24	19	23	18	97	-	f
1995	2,429	1,681	2,541	598	a	544	294	25	14	7/12-10/18	f	49	30	496	164	cf	7	14	7	19	7	6	
Means:																							
1990-94	4,527	2,928	1,546	579		-	-	-	-			112	108	391	94		13	44	17	52			
1985-94	5,590	3,356	1,537	541		-	-	-	-			159	238	391	94		48	118	24	51			
1995 as % of:																							
1990-94	54%	57%	164%	103%		-	-	-	-			44%	28%	127%	175%		53%	32%	42%	36%			
1985-94	43%	50%	165%	111%		-	-	-	-			31%	13%	127%	175%		15%	12%	30%	37%			

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

Table 3. Estimated river returns of wild, hatchery and aquaculture 1SW and MSW salmon destined for Mactaquac Dam, Saint John River, 1970-1995.

	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

(a) 1990-1994, 1SW and MSW classification based on lengths and count data; 1995 , 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, 1975-1995, from **hatchery-reared smolts released at** Mactaquac, 1974-1994. 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	Dam	Native fishery	Angled main SJ	By-catch	Commer-cial	Total[a]	Unadj	Adj[b]
				(combined)								
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	198	2,679	96	288	67		3,328	1.738	1.570
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		18		883	0.399	0.393
94	225,037	1.00	95[c]	(1,456)		14		15		1,485	0.659	0.644
95	240,582	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 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; 1995 count yielded 9 tagged 1SW from among 4,000 tagged smolts released to the Nashwaak in 1994 (15,060 smolts total) - potential return was 35 1SW fish to the Dam.)

[c] Hatchery origin 1SW fish at Mactaquac in 1995, were assigned an origin on the basis of freshwater age (scale reading) and fin condition, i.e., age 1.1 @ 0.511, age 2.1 @ 0.325, age 3.1 @ 0.164.

Table 4b. Estimated total number of **MSW** returns to the Saint John River, 1976-1995, from **hatchery-reared smolts released at** Mactaquac, 1974-1993. 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		23		468	0.229	0.214
93	221,403	1.00	95[c]	(440)		5		11		456	0.206	0.205
94	225,037	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 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.)

[c] Hatchery origin MSW fish at Mactaquac in 1995 were assigned an origin on the basis of freshwater age (scale reading) and fin condition, i.e., age 1.2 @ 0.761, age 2.2 @ 0.137, age 3.2 @ 0.067 and repeat spawners @ 0.035.

Table 5. Estimated homewater removals(a) of 1SW and MSW salmon destined for Mactaquac Dam on the Saint John River, N.B., 1995.

	1SW			MSW		
Components	Wild	H+Aq	Total	Wild	H+Aq	Total
Native Food Fishery						
Below Mact.	21	29	50	18	7	25
Above Mact.	-	-	-	-	-	-
Recreational fishery						
Tobique River	-	-	-	-	-	-
Mainstem abv Mact.	-	-	-	-	-	-
Mainstem blw Mact.	-	-	-	-	-	-
Hook-release mort.	-	-	-	-	-	-
Passed abv Tinker	49	71	120	30	12	42
Passed abv Grand F.	-	-	-	-	-	-
Passed blw Mact.	-	-	-	-	-	-
Hatchery broodfish	3	1	4	251	54	305
mortalities, etc.	14	1	15	26	11	37
Poaching/disease(b)	21	27	48	32	15	47
By-catch	22	29	51	41	18	59
Totals	130	158	288	398	117	515

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

(b) - Assumed to be 1% and 2.5% of all remaining 1SW and MSW fish respectively, above Mactaquac (0.5 of values used in 1994 assessments when there was a token angling effort).

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, 1970-1995.

	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

(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.

(b)- NBDNRE and DFO sources.

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

Table 7. Estimated homewater returns, removals and spawning escapement of 1SW and MSW salmon destined for/above Mactaquac Dam, Saint John River, 1995.

Sea-age	Components	Wild	H+Aq	Total
1SW				
	Homewater returns	2,168	2,911	5,079
	Homewater removals(a)	130	158	288
	Spawners(b)	2,059	2,780	4,839
	Target spawners			3,200
	% of target spawners			151
MSW				
	Homewater returns	1,654	701	2,355
	Homewater removals(a)	398	117	515
	Spawners(b)	1,288	599	1,887
	Target spawners			4,400
	% of target spawners			43

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

(b) - Excludes Mactaquac broodfish but includes losses to poaching and disease (Table 5).

Table 8. 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 (1)	No. (2)	Year (3)	Number returns (4)	Length (cm) (5)	Year (6)	Number returns (7)	Col 7 + Nfld (8)	Col 8 +Grnld (9)	MSW /1SW (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	14,326	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	8,021	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		1994	2,276	58.9	1995	1,654	1,654	1,654	0.73
1990-91		1995	2,168	57.1	1996	___			
1991-92	189.19	1996	___						

Table 9. Hatchery releases contributing to adult returns to Mactaquac in 1995, and estimates (based on external characteristics and age interpretation from scales) of 1SW and MSW returns and their return rates. Numbers do not include contributions from about 50,000 eggs to client incubators in 1991 and 1992

Release					Returns in 1995			
Year	Loc	Stage	Number		Age	1SW	MSW	Rate
1994	At	1-yr smolt	225,037		1.1	1450		0.00644
1994	Bl	1-yr smolt(Nashw)	15,059		1.1	35		0.00232
1992	Abv	Fall fing	508,445	a	2.1	946		0.00186
1992	Abv	Unfed/fry	600,441	ac	2.1	-		
1991	Aroos	Adults(eggs'92)	370,000	c	2.1	-		
1991	Abv GF	Adults(eggs'92)	370,000	c	2.1	-		
1991	Abv	Fall fing	479,458	b	3.1	476		0.00099
1991	Abv	Unfed fry	173,524	bc	3.1	-		
1990	Aroost	Adults(eggs'91)	105,000	c	3.1	-		
1993	At	1-yr smolt	221,403		1.2		453	0.00205
1993	Bl	1-yr smolt(Nashw)	12,516		1.2		3	0.00024
1992	Aroos	1-yr parr	16,400		2.2			
1991	Abv	Fall fing	479,458	b	2.2		82	0.00017
1991	Abv	Unfed/fry	173,524	bc	2.2			
1990	Aroos	Adults(eggs91)	105,000	c	2.2		-	
1990	Abv	Fall fing	219,314		3.2		40	0.00018
1990	Abv	Unfed/fry	314,007	c	3.2		-	
		Repeat spawners	9,516	d	_._._		21	0.00221
Totals						2,907	599	

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 - Total estimated escapement above Mactaquac, 1993-1994.

e - Includes the 1-year parr.

Table 10. 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 1996. (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	Rate(e)	1SW	MSW
1995	At	1-yr smolt	240,582		1.1	0.00524	1261	
1995	Bl	1-yr smolt(Nashw)	13,283		1.1	0.00188	25	
1993	Abv	Feeding fry	306,558	c	2.1	0.00100	307	
1993	Abv	Fall fing	270,035		2.1	0.00200	540	
1993	Abv GF	Fall fing	173,033		2.1	0.00200	346	
1993	Abv GF	Feeding fry	290,484	c	2.1	0.00100	290	
1992	Aroos	Adults(eggs'93)	779,000	c	2.1	0.00010	78	
1992	Abv GF	Adults(eggs'93)	809,000	c	2.1	0.00010	81	
1992	Abv	Fall fing	508,445	a	3.1	0.00100	508	
1992	Abv	Unfed/fry	600,441	ac	3.1	0.00050	300	
1991	Aroos	Adults(eggs'92)	370,000	c	3.1	0.00010	37	
1991	Abv GF	Adults(eggs'92)	370,000	c	3.1	0.00010	37	
1994	At	1-yr smolt	225,037		1.2	0.00297		668
1994	Bl	1-yr smolt(Nashw)	15,059		1.2	0.00035		5
1992	Abv	Fall fing	508,445	a	2.2	0.00020		102
1992	Abv	Unfed/fry	600,441	ac	2.2	0.00010		60
1991	Aroos	Adults(eggs'92)	370,000	c	2.2	0.00010		37
1991	Abv GF	Adults(eggs'92)	370,000	c	2.2	0.00010		37
1991	Abv	Fall fing	479,458	b	3.2	0.00020		96
1991	Abv	Unfed fry	173,524	bc	3.2	0.00010		17
1990	Aroost	Adults(eggs'91)	105,000	c	3.2	0.00010		11
		Repeat spawners	11,039	d	-.-.-	0.00200		22
Totals							3,810	1,033

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 - Return rates based on synthesis of those derived in Table 9; Marshall and Cameron (1995) and App.5 Marshall and Cameron (1994); Return rates for eggs are based on natural egg deposition above Mactaquac in 1989 (about 75% of target) and a total return rate for 1SW fish of ~0.0002.

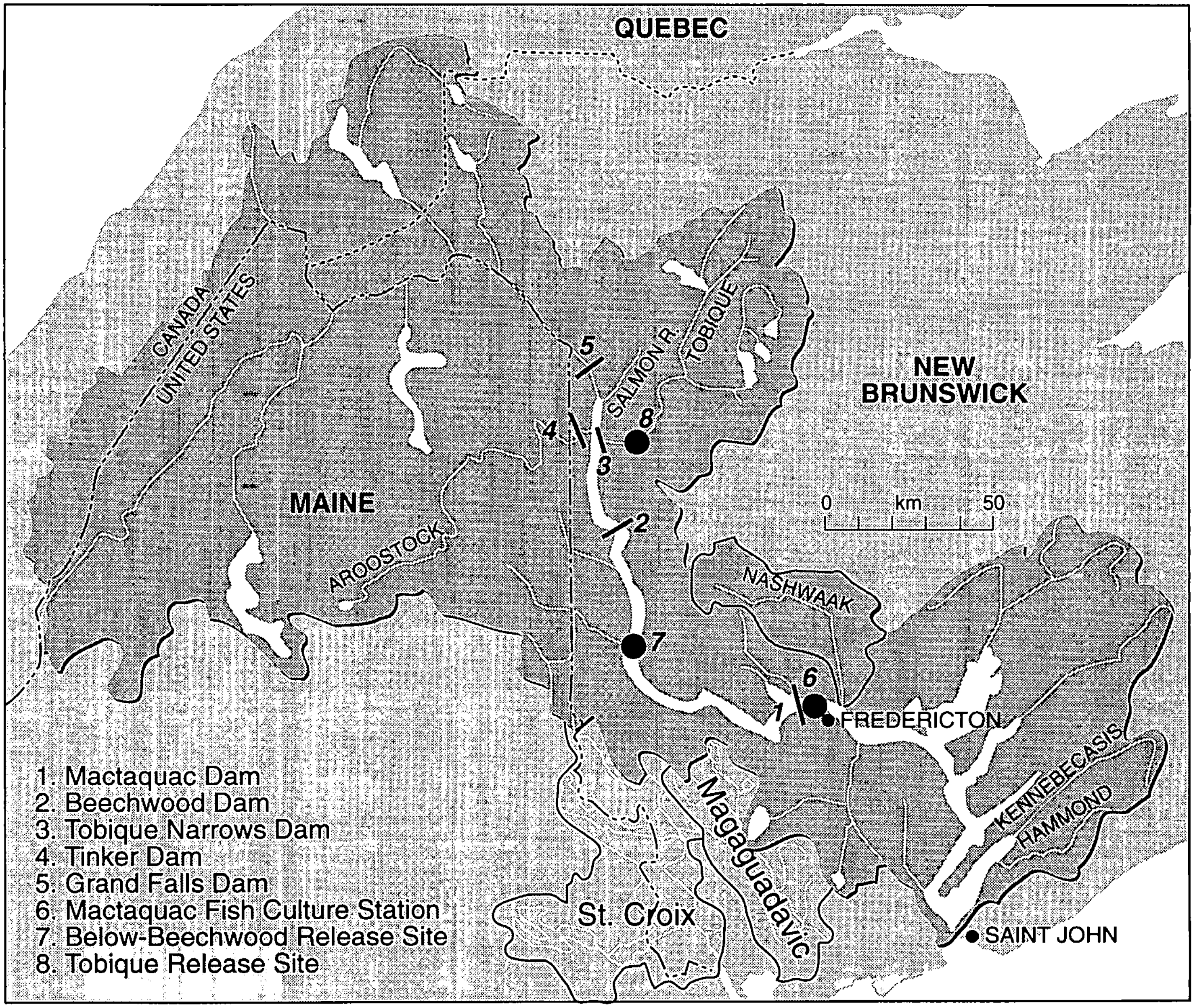
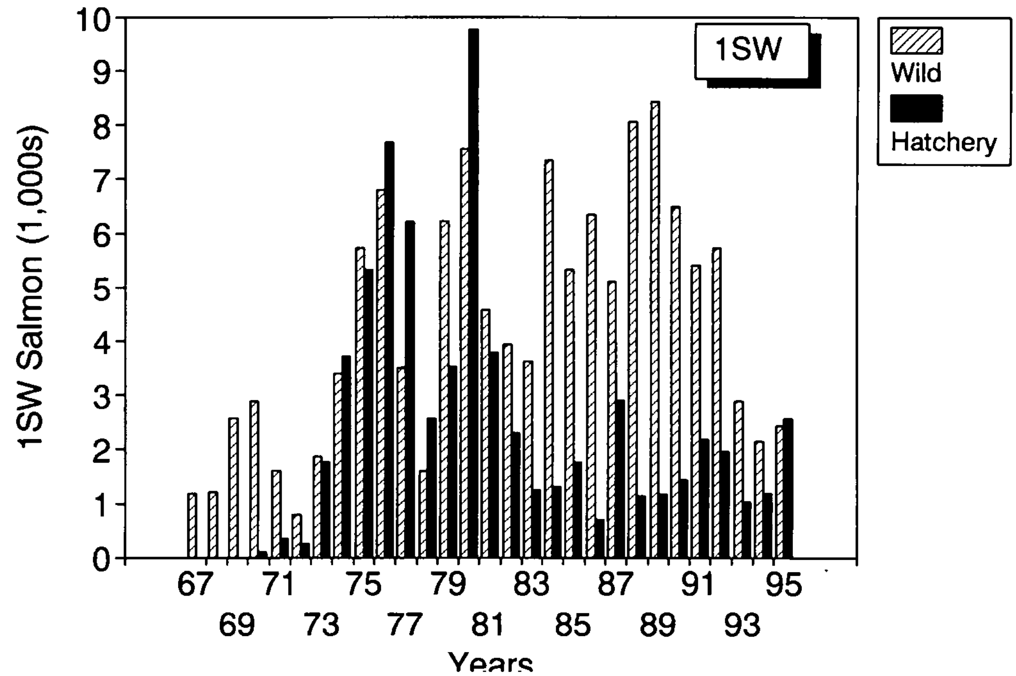


Fig.1. Magaguadavic, St. Croix, and Saint John river drainages including Nashwaak River and major tributaries, dams and principal release sites for Atlantic salmon above Mactaquac. Fish trapping locations on Magaguadavic, St Croix and Nashwaak drainages shown on Figs. 11, 14.



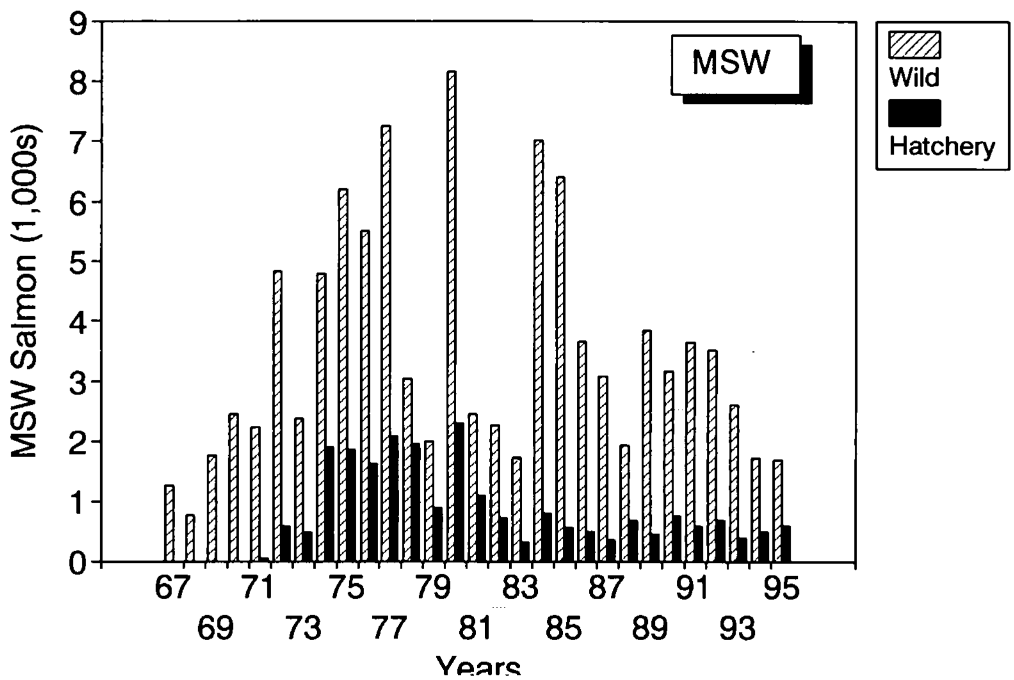


Fig. 2. Counts of wild and hatchery 1SW and MSW salmon at Mactaquac, 1967-1995.

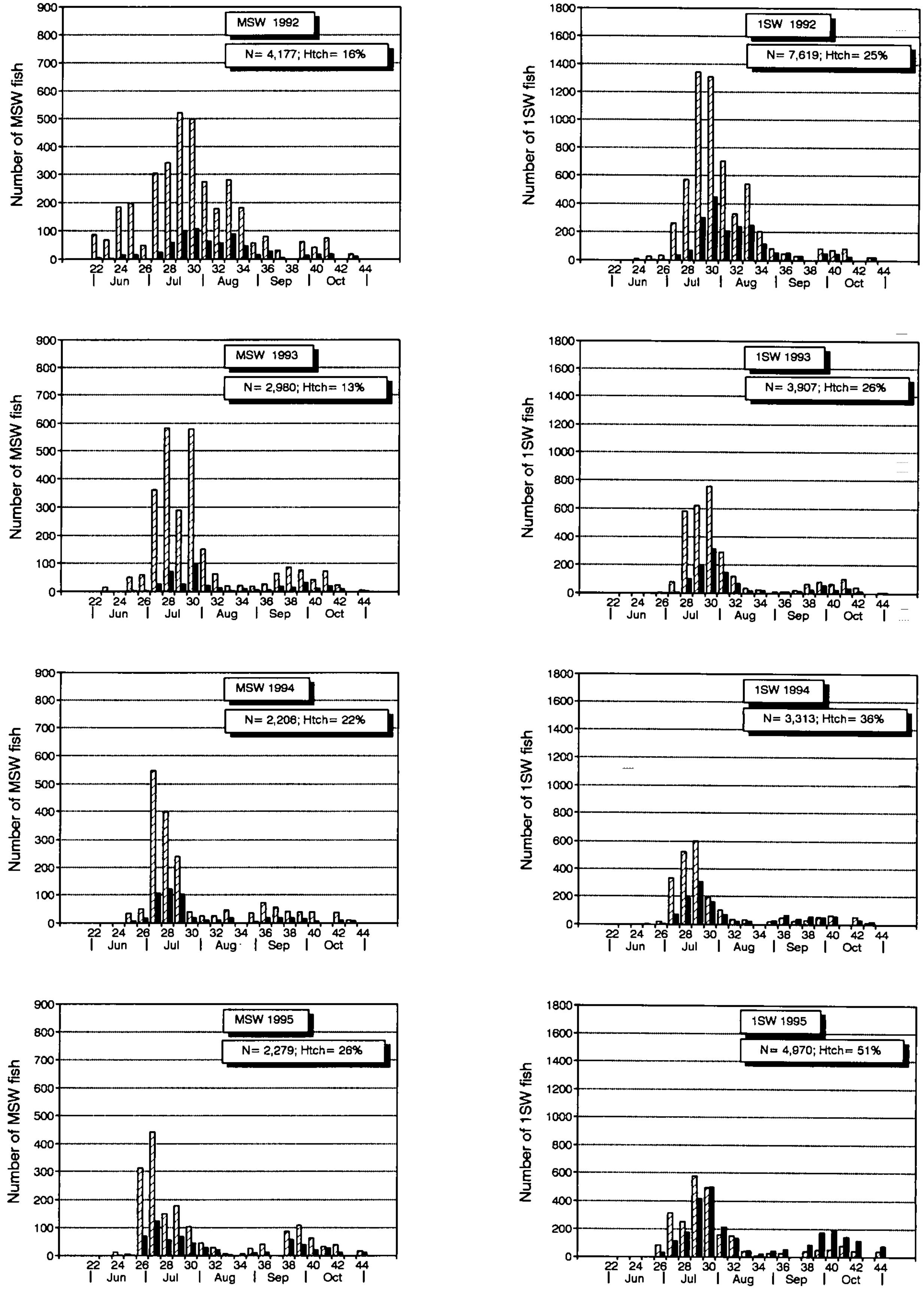


Fig. 3. Weekly counts of wild (cross hatch) and hatchery (solid)1SW and MSW salmon at the Mactaquac sorting facilities, 1992-1995. [Note difference in 1SW and MSW Y-axis scales.]

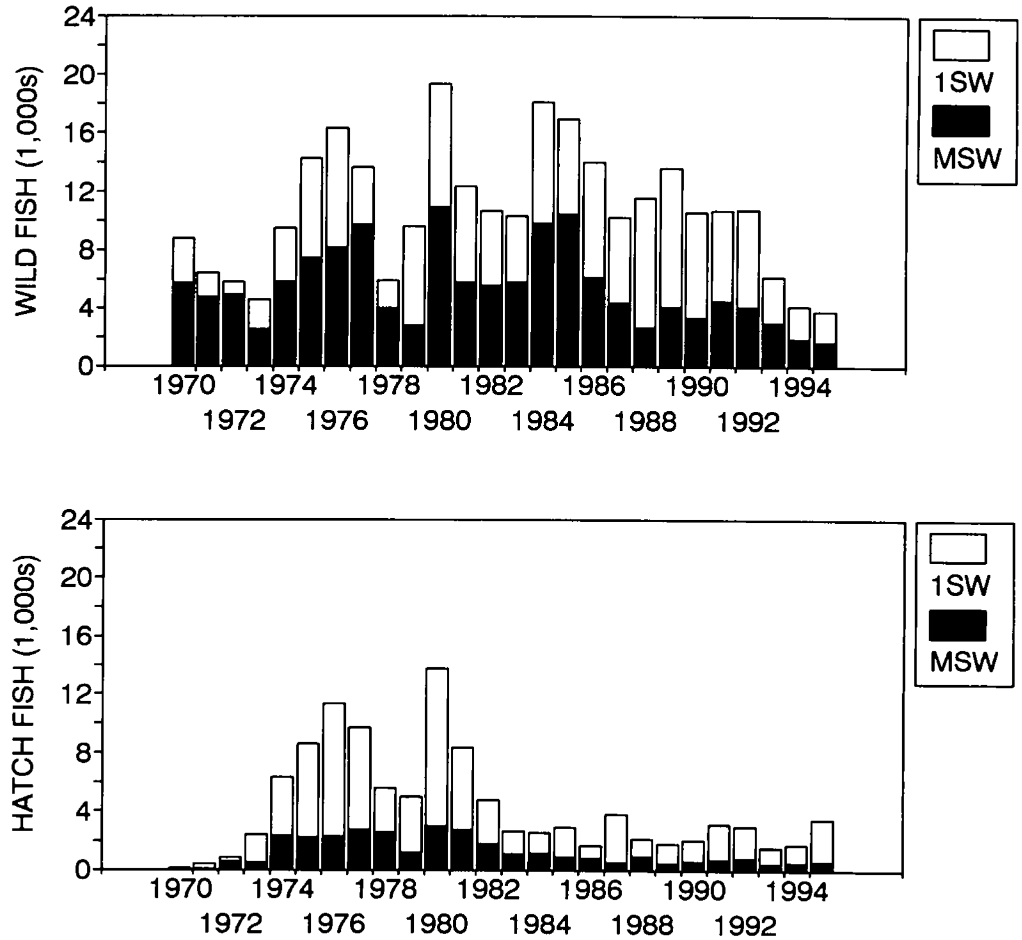
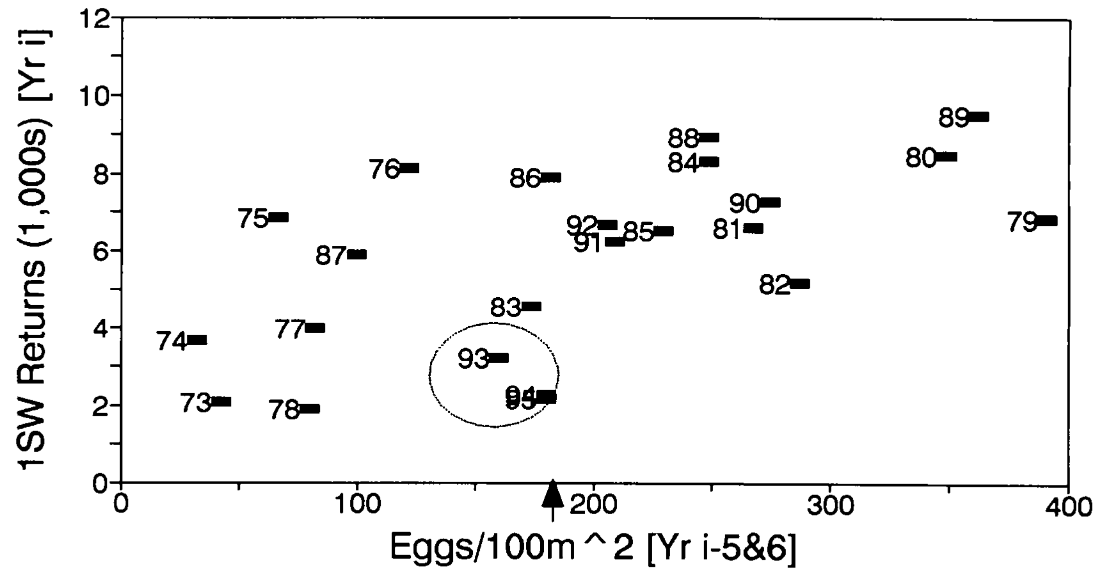


Fig. 4. Estimated numbers of wild and hatchery 1SW and MSW fish that returned to the Saint John River and were destined for Mactaquac, 1970-1995.



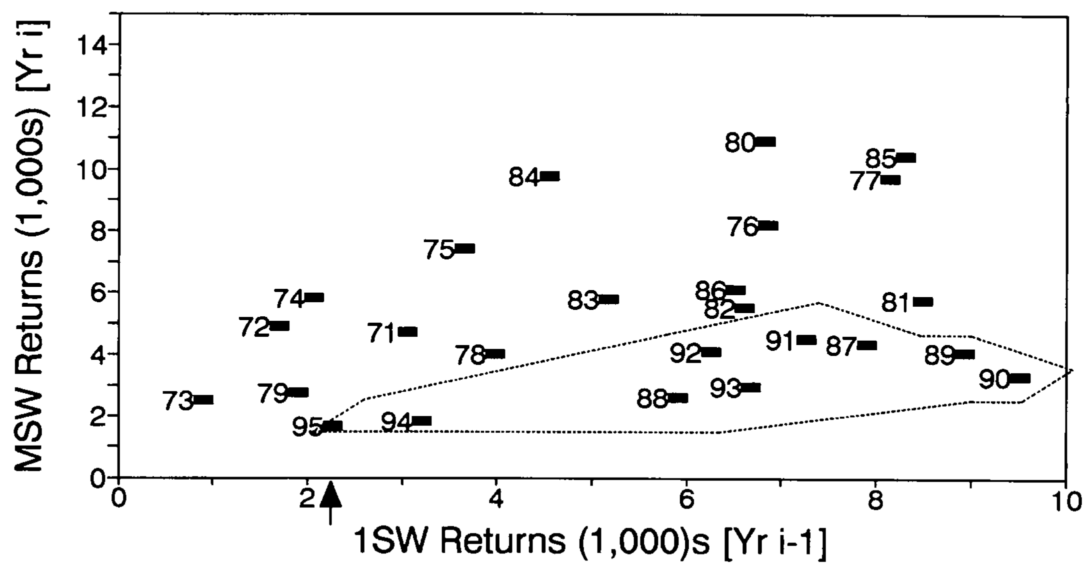


Fig. 5. Upper panel -plot of 1SW returns from egg depositions 5 & 6 years previous (data in Table 8), arrow indicates egg deposition contributory to returns in 1996 and circle identifies most recent data. Lower panel - plot of MSW and 1SW returns without effect of moratoria (data in Table 8), arrow indicates level of 1SW returns to be associated with MSW returns in 1996 and dashed line encloses most recent data.

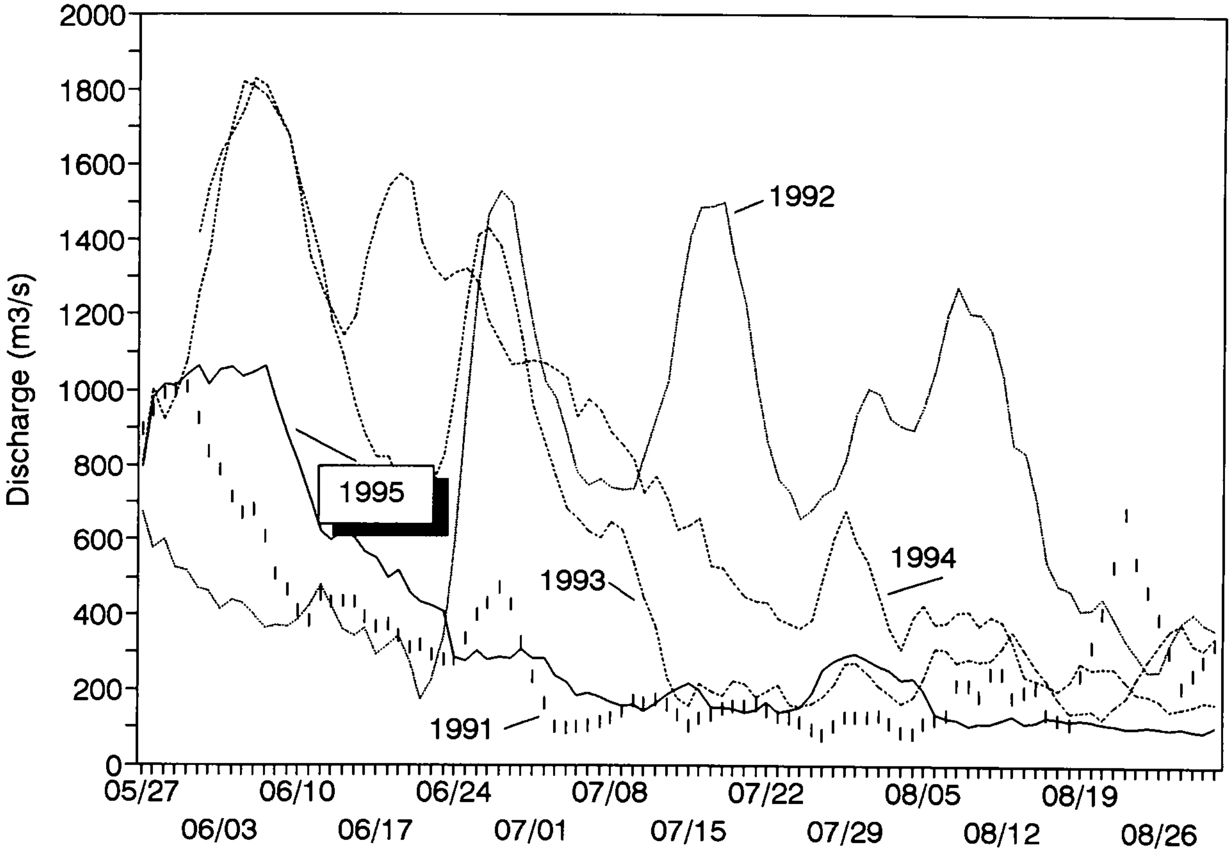


Fig. 6. Five-day moving averages of mean daily river discharge at Mactaquac, June through August, 1991-1995.

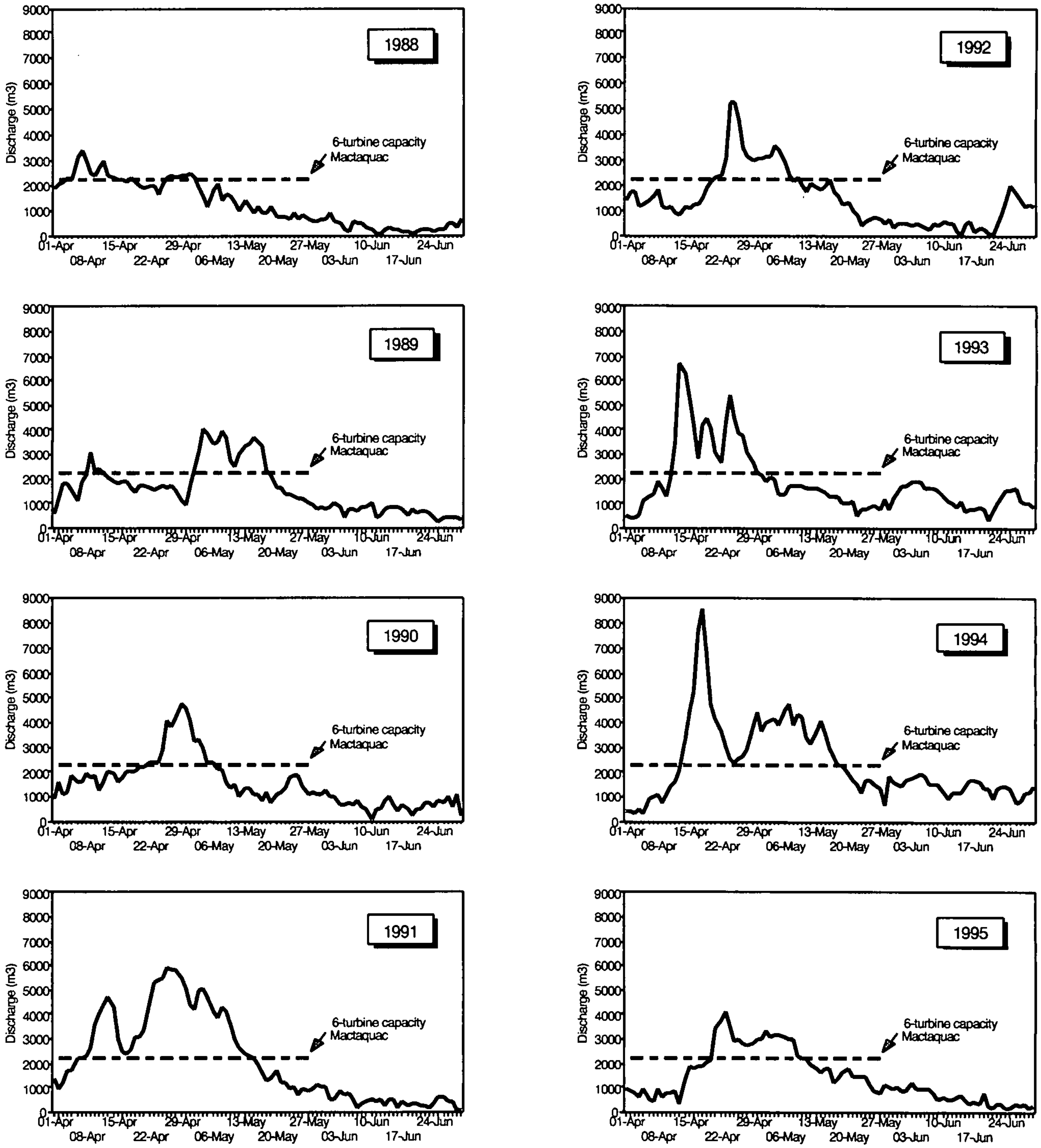


Fig. 7. Discharge of the Saint John River at Mactaquac, April through June, relative to the 6-turbine capacity of the generators, 1985-1995.

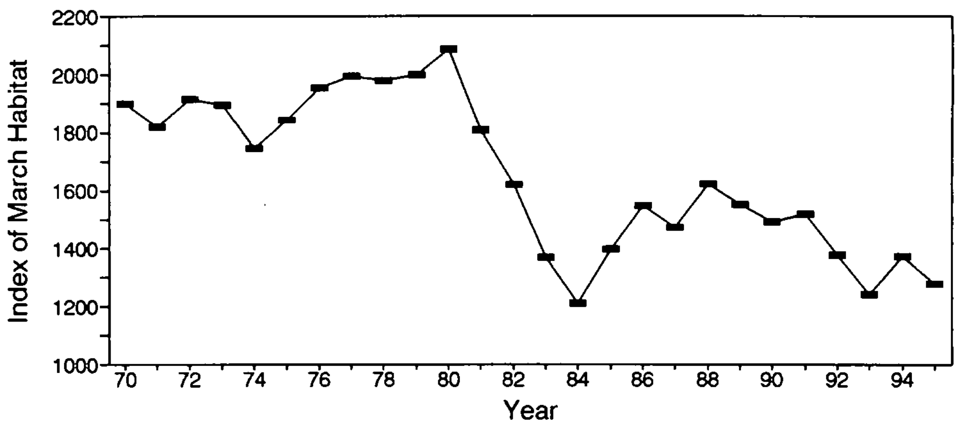


Fig. 8. March index of winter habitat in the N.W. Atlantic,1970-1995 (Anon. 1995).

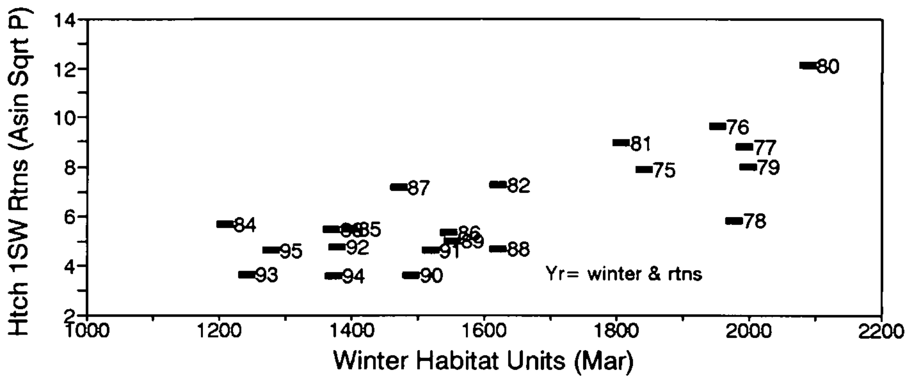


Fig. 9. March index (yr i) and return rate of hatchery 1SW fish (yr i) stocked as smolts from Mactaquac, 1975-1995.

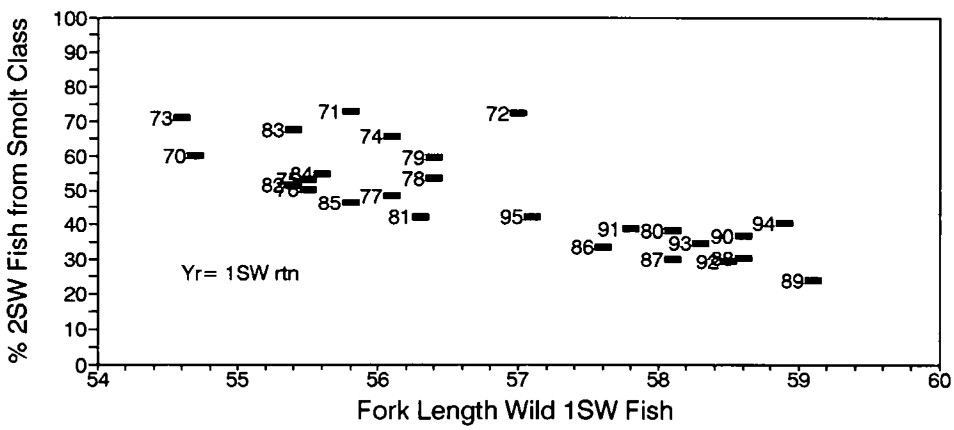


Fig. 10. Mean fork length of wild 1SW fish at Mactaquac and proportion of total recruits from a smolt class that returned as 2SW fish.

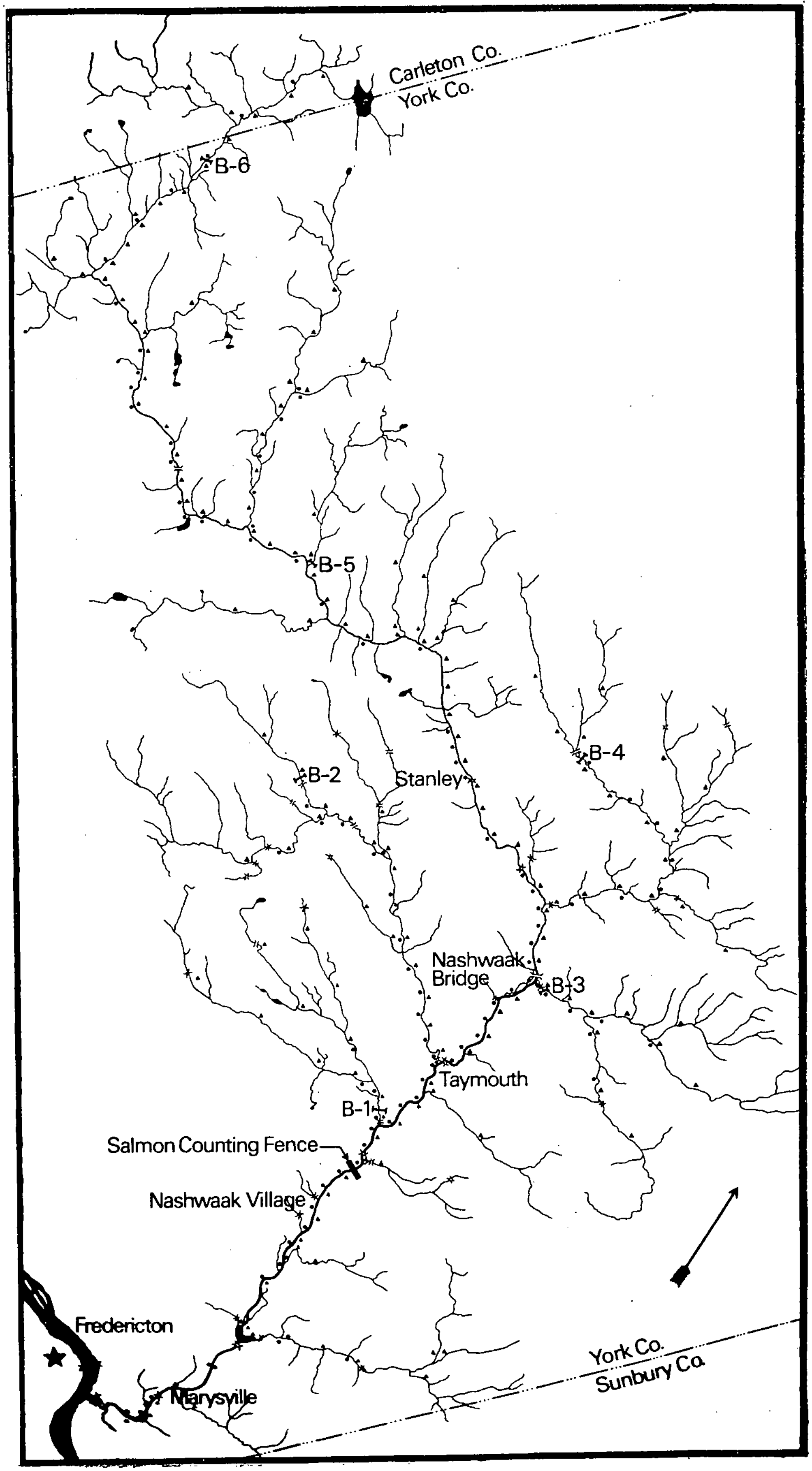
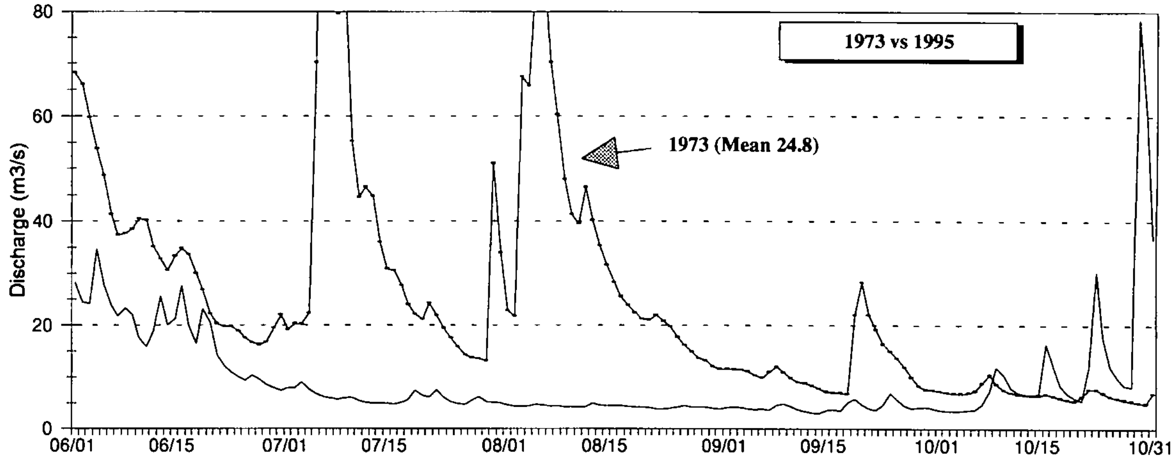
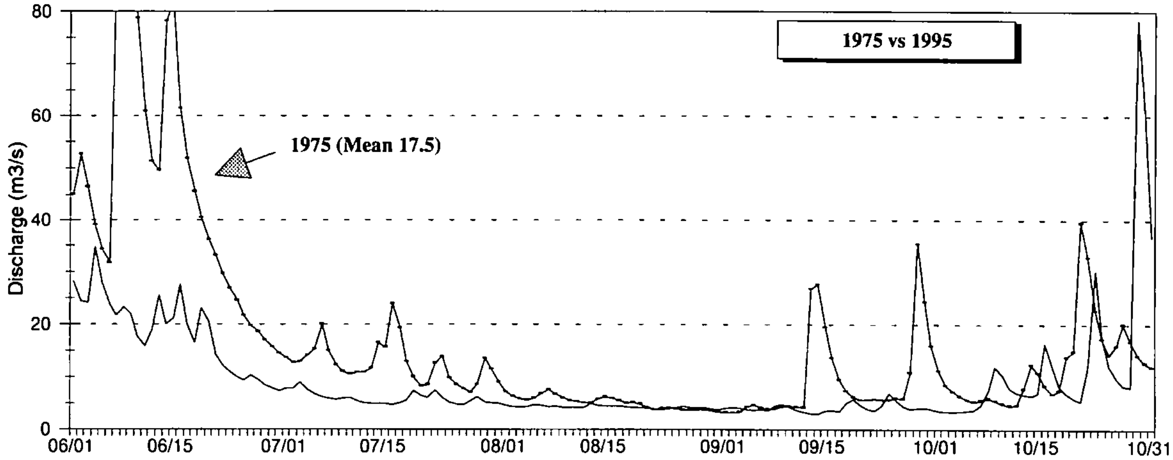


Fig. 11. Nashwaak River, site of counting fence and barriers [B-] to salmon migration.





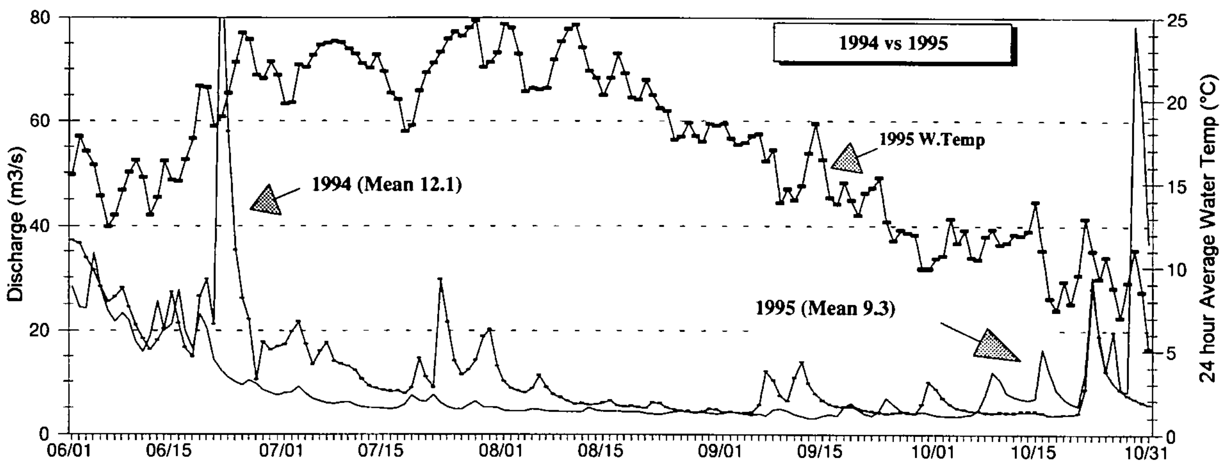


Fig. 12. Average daily discharge (m3/s) at Durham Bridge, Nashwaak River, 1973,1975, and 1994 compared to 1995. Lower graph also indicates the average daily water temperatures at the counting fence in 1995.

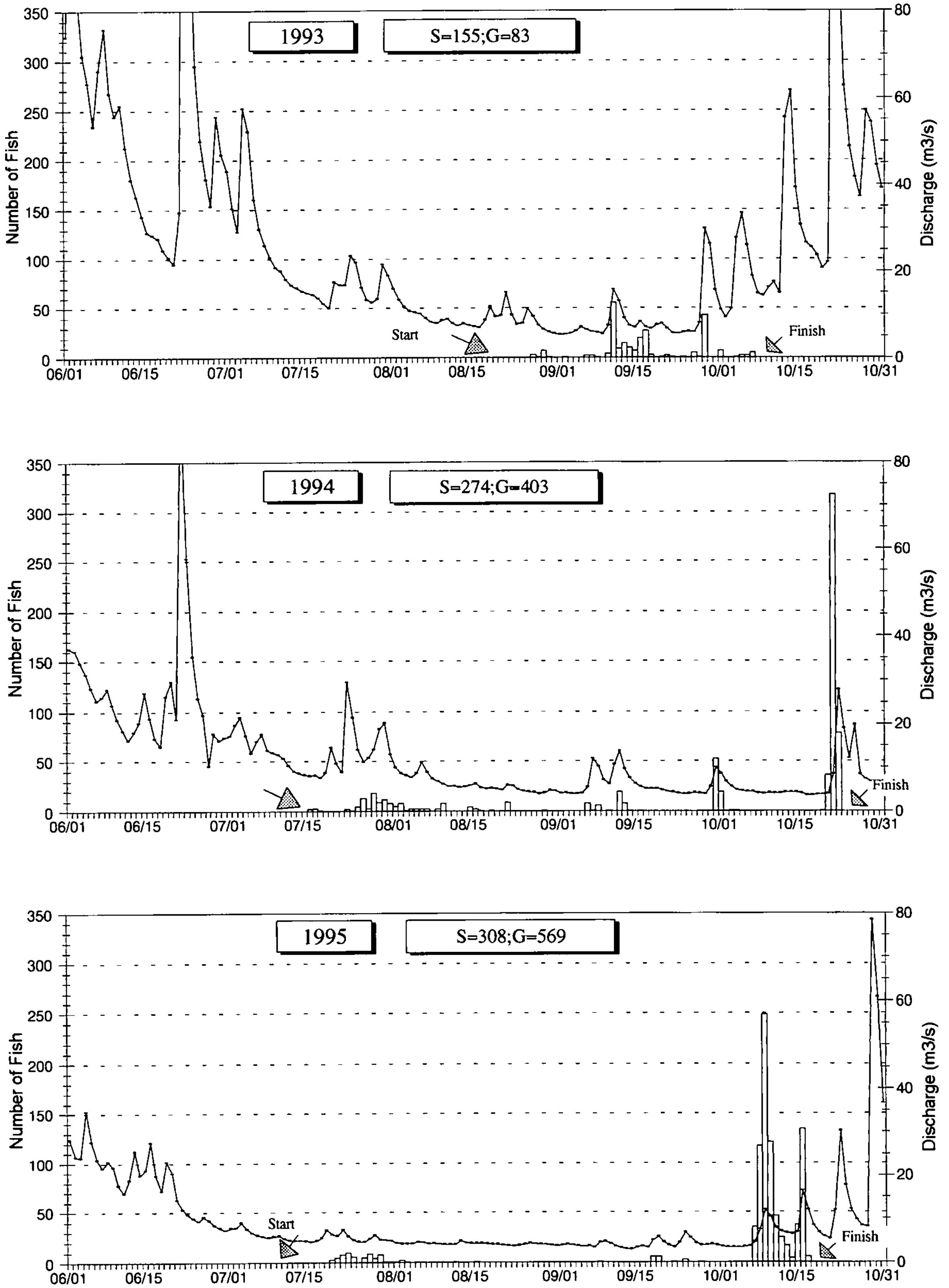
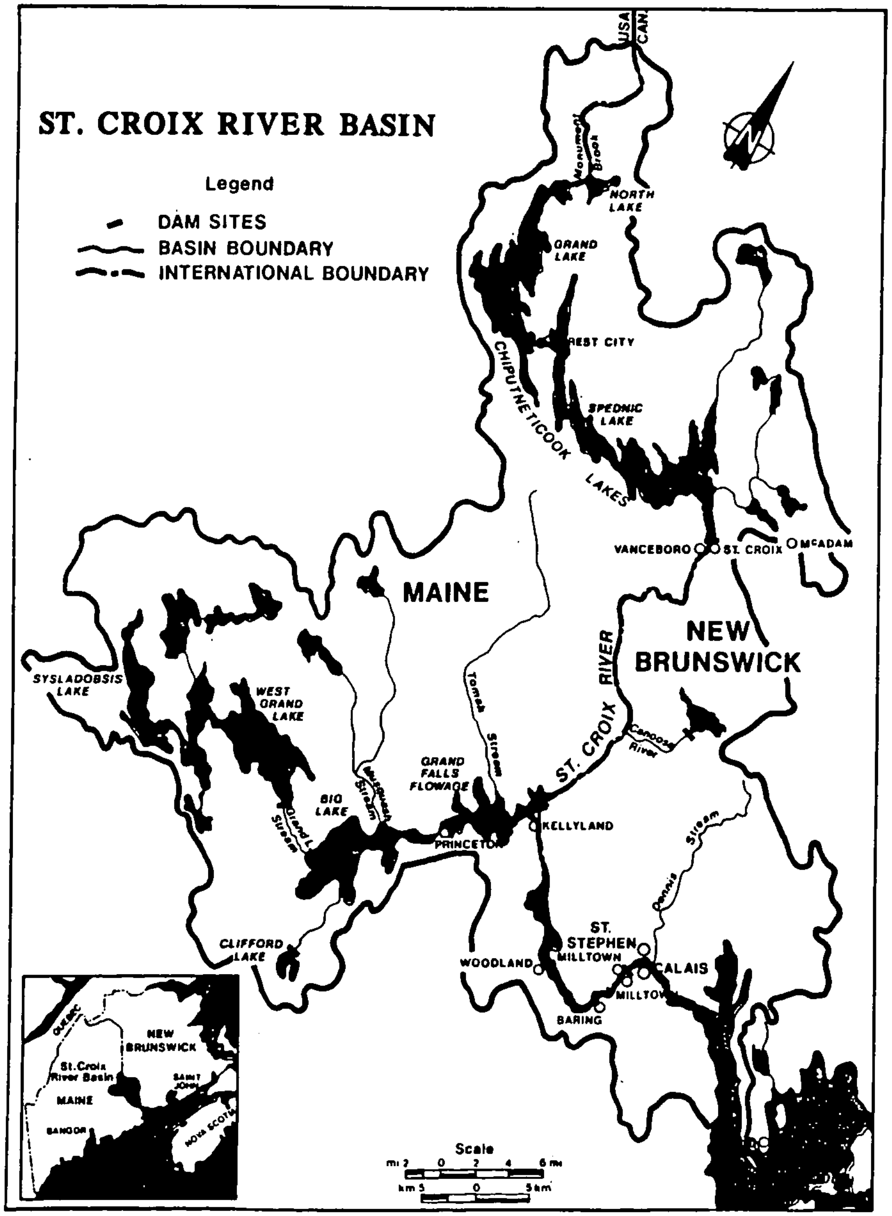


Fig. 13. Average daily discharge (m3/s) at Durham Bridge and fence counts of salmon, Nashwaak River, 1993,1994 and 1995.



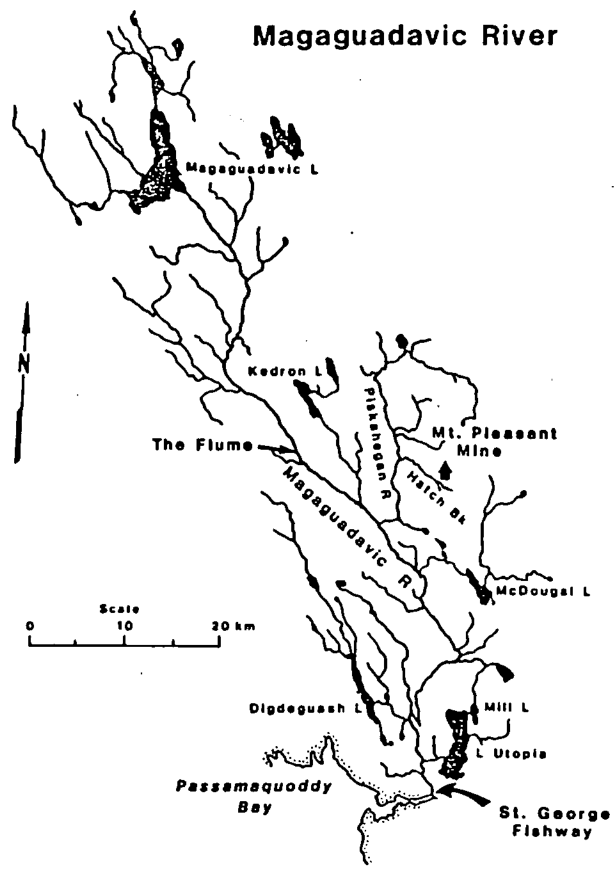


Fig. 14. St. Croix and Magaguadavic river systems of southwest N.B.

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, 1973-93 and 1996 (explanation in Penney and Marshall 1984).

Egg depostion		Proportion age at smoltification (a)		Eggs/100m^2 contributing to 1SW fish		Total wt'd egg contrib/ 100 m^2 to 1SW fish	
Year	Number	Age 2	Age 3	Yr i	Yr i+1	@ Mact	(year)
1968	34.6	0.207					
			0.793		27.44		
1969	34.3	0.445		15.26		42.70	(1973)
			0.555		19.04		
1970	48.4	0.269		13.02		32.06	(1974)
			0.731		35.38		
1971	73.7	0.419		30.88		66.26	(1975)
			0.581		42.82		
1972	128.0	0.619		79.23		122.05	(1976)
			0.381		48.77		
1973	82.0	0.411		33.70		82.47	(1977)
			0.589		48.30		
1974	280.0	0.114		31.92		80.22	(1978)
			0.886		248.08		
1975	399.8	0.358		143.13		391.21	(1979)
			0.642		256.67		
1976	257.7	0.358		92.26		348.93	(1980)
			0.642		165.44		
1977	313.1	0.325		101.76		267.20	(1981)
			0.675		211.34		
1978	197.6	0.383		75.68		287.02	(1982)
			0.617		121.92		
1979	116.2	0.443		51.48		173.40	(1983)
			0.557		64.72		
1980	378.2	0.485		183.43		248.15	(1984)
			0.515		194.77		
1981	124.2	0.279		34.65		229.42	(1985)
			0.721		89.55		
1982	156.9	0.587		92.10		181.65	(1986)
			0.413		64.80		
1983	77.4	0.450		34.83		99.63	(1987)
			0.550		42.57		
1984	391.9	0.525		205.75		248.32	(1988)
			0.475		186.15		
1985	340.3	0.517		175.94		362.09	(1989)
			0.483		164.36		
1986	224.6	0.489		109.83		274.19	(1990)
			0.511		114.77		
1987	195.2	0.482		94.09		208.86	(1991)
			0.518		101.11		
1988	137.3	0.761		104.49		205.60	(1992)
			0.239		32.81		
1989	185.5	0.656		121.69		154.50	(1993)
			0.344		63.81		
1990	174.1						
1991	186.2						
			0.476		88.64		
1992	191.9	0.524		100.55		189.19	(1996)

(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 1969-1990 year classes in the Saint John River destined for Mactaquac. Data from App. 3.

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

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, 1982-1995.

Fresh-water age	Number of 1SW fish													
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994[ab]	1995[c]
A														
2	794	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
3	2,902	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
4	236	11	81	144	150	233	66	278	260	122	127	45	40	41
5					5					10				
6					5									
Total	3,932	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
B														
2	1,045	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
3	3,819	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
4	310	14	91	176	187	270	73	314	291	141	148	50	43	42
5					6					12				
6					6									
Total	5,174	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

[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] Adjusted from App. 3, Marshall and Cameron (1995).

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