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Assessment of Atlantic salmon of the Saint John River, N.B., above Mactaquac, 1991

by

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ABSTRACT

Estimated river returns destined for Mactaquac, Saint John River, 1991, were 8,751 1SW and 5,215 MSW salmon. Homewater removals/losses of about 3,300 1SW fish indicate that 179 percent of the target number of 1SW spawners was met above Mactaquac. Returns and removal of just under 2,100 MSW fish resulted in an estimated spawning escapement above Mactaquac of 79 percent of the MSW target. Target egg requirements, which are largely dependent on MSW fish have been met only three times in the last 14 years (i.e., 1980, 1984 and 1985).

Combined wild and hatchery 1SW returns in 1991 were 95 percent of the preseason parametric forecast. MSW returns were 112 percent of the preseason forecast. Since 1986, returns of 1SW fish have equalled or somewhat exceeded forecast values; before use of the revised forecast model for 1991, returns of MSW salmon had been fewer than forecast.

A relationship between egg depositions and wild 1SW returns indicates fewer returns in 1992: 5,800 or 7,600 wild 1SW fish, depending on the forecast model. Another relationship between wild 1SW returns, their fork length and MSW returns suggests that the 6,300 1SW returns in 1991 will provide 3,900 or 4,200 wild MSW returns in 1992, depending on forecast model. The product of the numbers of hatchery releases and recent return rates suggest hatchery returns in 1992 of 2,000 1SW and 1,200 MSW salmon.

Total 1SW returns in 1992 could be 7,800 or 9,600 1SW fish; total MSW returns could be 5,100 or 5,400 MSW salmon. Spawning requirements are 3,200 1SW and 4,400 MSW salmon and do not include approximately 400 MSW broodstock required to seed Mactaquac Hatchery.

RÉSUMÉ

En 1991, les remontées en direction de la Mactaquac, fleuve Saint-Jean, ont été estimées à 8 751 saumons unibermarins (ayant passé un hiver en mer) et à 5 215 saumons pluribermarins (ayant passé plusieurs hivers en mer). Les récoltes et pertes en eaux natales de 3 300 saumons unibermarins environ montrent que l'objectif de géniteurs unibermarins en amont de Mactaquac a été atteint à 179 pour cent. Le retour et la récolte de près de 2 100 pluribermarins ont donné lieu à une échappée de géniteurs en amont de Mactaquac estimée à 79 pour cent du nombre cible de pluribermarins. Les besoins cibles de la ponte, dont l'atteinte est largement fonction du nombre de pluribermarins, n'ont été satisfaits qu'à trois reprises seulement au cours des 14 dernières années (1980, 1984 et 1985).

Les remontées confondues d'unibermarins d'élevage et sauvages de 1991 se sont élevés à 95 pour cent de la valeur de la prévision paramétrique de pré-saison. Les remontées de pluribermarins correspondaient à 112 pour cent de la prévision de pré-saison. Depuis 1986, les remontées d'unibermarins ont égalé ou dépassé légèrement les valeurs prévues; avant l'utilisation du modèle de prévision révisé, en 1991, les remontées de pluribermarins étaient inférieures aux valeurs prévues.

Une relation établie entre la ponte et la remontée d'unibermarins sauvages indique une remontée plus faible en 1992, qui s'élève à 5 800 ou 7 600 unibermarins sauvages, tout dépendant du modèle de prévision. Une autre relation entre les remontées d'unibermarins sauvages, leur longueur à la fourche et les remontées de pluribermarins porte à croire que la remontée de 6 300 unibermarins de 1991 donnera lieu à une remontée de 3 900 ou de 4 200 pluribermarins sauvages en 1992, tout dépendant du modèle de prévision. Le produit du nombre de poissons d'élevage relâchés et du taux des remontées récentes porte à croire que les remontées de poissons d'élevage de 1992 atteindront 2 000 unibermarins et 1 200 pluribermarins.

Les remontées totales d'unibermarins de 1992 pourraient s'élever à 7 800 ou 9 600 poissons tandis que les valeurs correspondantes de pluribermarins seraient de 5 100 ou de 5 400 poissons. Les besoins en géniteurs sont de 3 200 unibermarins et de 4 400 pluribermarins; ces valeurs ne comprennent pas les 400 géniteurs pluribermarins qui ont été nécessaires à la mise en marche de la pisciculture de la Mactaquac.

INTRODUCTION

This document is background to the management of Atlantic salmon stocks of the Saint John River above Mactaquac, New Brunswick, and, as such, provides data and analyses relevant to stock status in 1991 and forecasts for 1992.

BACKGROUND

Physical attributes of the Saint John River drainage, salmon production area, barriers to migration, fish collection and distribution systems, the role of fish culture operations and status of the salmon stocks since 1970 have previously been described by Marshall (1989). Forecasts made in 1990 suggested that 1991 homewater returns to Mactaquac would number approximately 9,900 or 11,000 1SW and 4,700 or 5,200 MSW salmon, depending on forecasting technique (Marshall 1991).

The Management Plan for 1991 was identical to that of 1990 in that there was a total ban on homewater commercial fisheries, a prohibition on the retention of MSW salmon captured in the sport fisheries and the same open seasons for sport fishing. The Kingsclear Indian Band guided a sport fishery as in the previous few years and reported catch statistics.

New, however, was a native fishery with gill nets on the main Saint John between Mactaquac and Fredericton, near Gagetown and in the lower reaches of the Nashwaak River. No catch statistics were provided. The Oromocto Band fished two trap nets on the main river near Oromocto under an "Agreement" with DFO and reported catch statistics. A food fishery with gill nets was also conducted above and below the Tobique Narrows Dam on the Tobique River. Catch statistics for that fishery were provided, but are, in part, known to be erroneous.

Mean daily river discharges at Mactaquac in June, July and August, 1991, were among the lowest of the last 20 years (Fig. 1). 1SW returns to Mactaquac were later than usual (Fig. 2). The low discharge, lateness of 1SW returns, in-season predictions that MSW spawning requirements above Mactaquac would not be met, unexplained scale loss/ fishing gear-like injuries to 68% of MSW and 22% of 1SW salmon collected at Mactaquac and the concern about the impact of the new in-river net fisheries contributed to the convening of SFA 23 salmon management advisory meetings (ZMACs) in each of July and August.

METHODS

Returns destined for Mactaquac

Total returns of 1SW and MSW salmon of both wild and hatchery origin from and above Mactaquac Dam consist of the summation of Mactaquac counts, estimated angling (including Kingsclear Indian Reserve) and native netting in the mainstem below the Mactaquac Dam and estimated by-catch in downriver shad, gaspereau and "other" species net fisheries.

Mactaquac counts consist of those fish captured at the fish collection facilities at the Mactaquac Dam and at the smolt migration channel at the Mactaquac Fish Culture Station. As in 1990, fish collection facilities were open a "full" season. The identification of 1SW and MSW returns from 1-year and a smaller number of 2-year smolts released at Mactaquac and juveniles released above Mactaquac was dependent on fin clips (adipose) and fin erosion (principally dorsal fin). By-catch was estimated to be 2% of the 1SW and 5% of the MSW river returns - values which approximate the mean estimates for the years 1981-1984. The by-catch, sport and native catches below Mactaquac were assumed to consist of fish of hatchery and wild origins in the same proportions as those counted at Mactaquac.

Removals of fish originating at/above Mactaquac

Removals include calculated numbers of fish taken in the native fishery on the mainstem below Mactaquac and on the Tobique River; provincial, federal and native statistics for sport catch on the mainstem below Mactaquac, on the mainstem above Mactaquac (inc. Salmon River, Victoria Co.,) and the Tobique River; and a by-catch in the estuary.

Estimates of the numbers of salmon harvested by natives in up to 14 nets, mostly 5.0-5.5 in (127-140 mm) mesh below Mactaquac, i.e., Hartts and Savage islands and at McKinley Ferry (all between 2-9 km below the Dam) were based on 89 MSW and 35 1SW fish observed by Fishery Officers who visited the sites on 14 mornings between July 7 and Sept 30 and daily counts at Mactaquac Dam.

Native fisheries also operated at the mouth of and within the Nashwaak River. Landings were estimated by Fishery Officers to have been 100-150 "salmon" which I attributed to a below-Mactaquac origin. The harvest from trap nets at Oromocto and Upper Gagetown were reported by Fishery Officers and apportioned to an above- (0.68) and below- (0.32) Mactaquac origin in accordance with the production area estimated for above Mactaquac relative to that of the Nashwaak and Keswick rivers below Mactaquac (Marshall and Penney 1983).

The estimated gill net catch by the Tobique Band, June - Sept, was based on the total catch compiled by the Band after an "Agreement" was signed with DFO in late October. Fishing was conducted below the Tobique Narrows Dam (2-3 nets) and in the Tobique Headpond (6-8 nets). The reported ratio of 1SW:MSW was found to be inconsistant with ratios developed from adult releases and fishway counts and was therefore discarded in favor of the ratio reported by the Band in 1991 when catch statistics were compiled during the fishery.

Other removals include: fish monitored through the fish-lift at Tinker Dam on the Aroostook River, trucked from Mactaquac to above Tinker Dam and from Mactaquac to above Grand Falls, retained at Mactaquac for broodstock, and mortalities encountered during collection-handling operations or sacrificed for analysis. Losses of MSW fish to hook-and-release mortality were estimated at 2% of the run placed above Mactaquac (exclusive of those estimated to have been taken in the Tobique net fishery or passed into the Aroostook and above Grand Falls) i.e., similar to a previously used 10% loss on estimated MSW sport catch. Losses to poaching and disease ascribed in recent assessments, i.e., 4% of 1SW and 10% of MSW fish placed above Mactaquac (exclusive of those estimated to have been taken in the net fishery at Tobique or passed into the Aroostook or above Grand Falls) were calculated in 1991 but regarded as "spawners". For the most part, losses were apportioned to hatchery/wild components on the basis of estimated stock composition.

Required Spawners

An accessible salmon-producing substrate of 12,261,000 m^2 above Mactaquac, (exclusive of the main Saint John below Grand Falls, the Aroostook River and main Saint John and tributaries above Grand Falls), an assumed requirement of 2.4 egg/m^2, a length-fecundity relationship ($\log_e$ Eggs = 6.06423 + 0.03605 Fork Length) applied to MSW and 1SW fish, 1972-1982, and the 1SW:MSW ratios in those years suggest that, on average, approximately 4,400 MSW fish are required above Mactaquac (Marshall and Penney 1983). Because 1SW fish normally contribute so few eggs (usually fewer than 5% females) 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.).

Stock Forecasts

1SW Wild

One forecast of wild 1SW returns originating above Mactaquac was derived from a regression of total wild 1SW fish returning to the Saint John River which were produced above Mactaquac, 1973-1989, on adjusted (method in Penney and Marshall 1984, with updates on freshwater age composition from wild 1SW fish, App. 1, 2 and 3 this paper) egg depositions in the Tobique River, 1968-1969 to 1984-1985. The 1987 and 1988 egg depositions, principal contributors to 1SW returns in 1992, were derived using angular-transformed mean proportions for age 2.1 and age 3.1 1SW fish in the previous decade. Previous use of the entire 18 years included two years with values quite different from those of the last 10 years.

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 (Ricker 1975). 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). A second forecast of wild 1SW returns in 1992 was derived with a nonparametric probability density function described by Noakes (1989) and the above logged egg and grilse data.

MSW Wild

Recent approaches to forecasting MSW returns have focused on the use of parametric and nonparametric statistics and three variables: log MSW returns in year i+1, 1SW returns and fork length of 1SW returns in year i (Marshall 1991). This assessment provides forecasts of MSW returns in 1992 using current data, the regression of logged MSW returns on 1SW returns and fork length of 1SW returns, and a joint probability density function for three variables in steps, each using only two variables, i.e., the first step constructs the joint probability density function of MSW salmon returns and 1SW returns, the second step uses the residuals from step 1 and the 1SW lengths to produce the forecast and confidence limits. Harvie and Amiro (1991) detail the steps in constructing a joint probability density function using two variables and the procedure by which the multivariate smoothing parameters were determined.

1SW Hatchery

Since the deployment of 1-year smolts 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. The return rate for age 1.1 fish returning to Mactaquac in 1991 was assumed to be the same as the mean (arcsine) of the 1988-1991 'adjusted' return rates (App.4). Age 1.1 returns were adjusted by removal of the estimated returns to Mactaquac from smolts released in tributaries below Mactaquac (Marshall 1990). A 7-year mean ratio (return rate of tagged 1SW fish to Mactaquac from smolts released at Mactaquac: return rate of tagged 1SW fish to Mactaquac from smolts reared at Mactaquac but released below Mactaquac) of 1:0.21 was used for the 1992 returns.

Additional 1SW returns of age 3.1 and age 2.1 are expected at Mactaquac in 1992 from fall fingerlings (age 0^+) graded from the 1-year smolt program at Mactaquac and released in tributaries above Mactaquac in 1988 and 1989. Similarily, returns are expected from fall fingerlings acquired by others for release to the Aroostook River and main Saint John above Grand Falls. Returns of age 2.1's were forecast as the product of a 0.0006 return rate to Mactaquac (an intermediate value from releases of marked and unmarked fall fingerlings above Mactaquac in 1988) and the numbers released in 1989. Age 3.1's were assigned a return rate of 0.5 that given the age 2.1's. Returns from unfed fry were accorded a return rate of 0.5 of that given the fall fingerlings but are unlikely to be distinguishable from wild fish upon return to Mactaquac.

MSW Hatchery

Returns as MSW fish from 1-year smolts released at Mactaquac in 1990 were estimated as the product of the number released and the adjusted mean (arcsine) return rate for 1-year smolts released from Mactaquac 1986-1989 (App.4). As with 1SW hatchery returns, MSW fish destined for Mactaquac from releases to tributaries below were proportioned (0.24) on the basis of MSW tag returns to Mactaquac from six different smolt classes.

As well, MSW returns of age 3.2 and age 2.2 are expected from fall fingerlings released above Mactaquac in 1987 and 1988. Returns of age 2.2 salmon were forecast as the product of their numbers and a return rate to Mactaquac of approximately 0.5 of that exhibited by those fish which returned as 1SW fish in 1991 (App. 5). Age 3.2 hatchery MSW fish, a rarity (App.5) because of the generally large size of stocked fall fingerlings, were accorded a liberal rate of approximately 0.5 of that of age 2.2 fish.

Hatchery fish which returned as maiden fish, principally 1988-1991, are expected to comprise the repeat-spawning MSW component in 1992. This return, which has in the past been less than 0.5 of the forecast, was simplified and assumed to equal the proportion that repeat spawners comprised of all MSW returns in 1991, i.e., 0.07 (App. 4).

RESULTS

Returns destined for Mactaquac

Estimated homewater returns in 1991 totalled 8,951 1SW and 5,255 MSW fish (Table 1). Returns included 450 1SW and 728 MSW fish estimated to have been taken in the Native fishery, 551 1SW fish taken in the sport fishery and 175 1SW and 261 MSW fish allotted to by-catch, all below Mactaquac. Counts of fish at Mactaquac in 1991 comprised 87% of 1SW and 81% of MSW returns estimated to have been destined for Mactaquac. Hatchery fish comprised 28% and 14% of those 1SW and MSW counts, respectively (Fig. 3).

Landings in the net fishery just below Mactaquac were based in part on the regression of MSW catch on MSW counts at Mactaquac the following day (MSW $H_{arvest} = 0.1654\ F_{ishway\ count(day+1)} + 1.879$; $r^2 = 0.343$; n=14: $p < 0.05$) for the 14 mornings for which there were observations of net catch. Regression of MSW catch per net on fishway counts was not significant. A MSW harvest of 701 fish was estimated by substitution of the season-end count at Mactaquac in the above equation. The observed numbers of net-caught 1SW salmon alone or per net did not correlate with counts at the fishway. An estimated harvest of 341 1SW fish was based on a ratio of observed catch to fishway count of 0.045:1.0. Exploitation rates implied by these estimates of 1SW and MSW salmon approximate the average values of 0.04 and 0.22 estimated for the Kingsclear net fishery in the early 1980's (Marshall 1985). An estimated harvest by Natives of 160 1SW and 40 MSW fish in the vicinity of Oromocto was interpreted as a removal of 109 1SW and 27 MSW fish originating above Mactaquac.

Removals

Sport 1SW removals additional to those reported by the Kingsclear Band and NBDNRE in the lower main stem consist of 1,139 fish above Mactaquac (Table 2). The Tobique Indian Band reported a net harvest of 436 salmon, estimated to be comprised of 207 1SW and 229 MSW salmon. The catch was assumed to consist of hatchery and wild 1SW and MSW fish in proportions similar to those estimated to have been available to the fishery.

MSW losses above Mactaquac to poaching and disease combined were set at 10% (exclusive of those taken in the net fishery and passed above Tinker Dam and Grand Falls) as in recent years. No special account was given to the fact that 68% of all MSW salmon observed at Mactaquac had some scale loss/injury, river discharge was unusually low and water temperatures somewhat high. 1SW losses to poaching and disease were set at 4% (exclusive of those taken in the Tobique net fishery and passed above Tinker Dam and Grand Falls). Known losses were similar to those of 1990; furunculosis was again detected in mortalities recovered by NBDNRE from Half Mile Pool on the Tobique River.

Removals by all factions were estimated at 3,304 1SW fish of which 179 made their way above Tinker Dam and Grand Falls and 2,089 MSW salmon of which 100 were transferred above Tinker Dam and Grand Falls. Hatchery broodstock retained at Mactaquac numbered 321 MSW salmon; 329 1SW salmon were sacrificed, mostly to recover nose wire tags, check on external sexing or have disease tested. Most of the carcases were distributed on two Indian Reserves close to Mactaquac.

Spawning Escapement

Collation of the total returns (Table 1), total removals (Table 2) and numbers of fish required on average to meet an egg deposition of 2.4 eggs/m^2 indicate that 3,481 (79%) of the required 4,400 MSW spawners were attained above Mactaquac (Table 3). For 1SW fish, 179% of requirements were met above Mactaquac. An estimated 15% of wild (based on internal sexing of 80 fish in July and external sexing from September onwards) and 7% of hatchery 1SW fish (based on Sept-Oct) were female and with respective mean lengths of 57.8 and 58.7 cm had the potential to deposit about 2.5 million eggs. This number of eggs is 8% of the 2.4 egg/m^2 target or the equivalent of about 320 MSW females.

Stock Forecasts

1SW Wild

A 1992 forecast of wild 1SW fish returning to Mactaquac in the absence of homewater removals was based on the regression of returns to homewaters of 1SW fish which originated above Mactaquac on estimated Tobique River egg depositions adjusted for smolt age. The AM estimate for 1SW returns in 1992 is 5,786 1SW fish (90% C.L. 4,983-6,717; Table 4). For 1991, the method had forecast 6,481 (5,470-7,680) 1SW fish; 6,256 fish were estimated to have returned.

A forecast of 7,603 (90% C.L. 2,105-10,262) 1SW fish was obtained from the probability density function in which maximum likelihood smoothing parameters were 0.80 (eggs) and 0.38 (1SW fish) (Table 4). This forecast is virtually identical to the 1991 forecast.

MSW Wild

A forecast of 3,931 (90% C.L. 2,252-6,863; Table 4) wild MSW fish destined for Mactaquac in 1991 was derived from the equation $\log_e$ MSW = 24.013 + 0.127E-3 1SW - 0.286 Length (R^2=0.547; p<.001). For 1991, the method forecast 3,415 returns in 1991; 4,491 fish were estimated to have returned. The probability density estimator (3-variables in two steps) for the same data provides a forecast of 4,211 (90% C.L. 0-16,271) MSW fish (Table 4) - higher than the forecast of 3,985 fish for 1991.

1SW Hatchery

The forecast of hatchery 1SW fish destined for Mactaquac in 1992 was in part calculated as the product of an estimated 178,127 one- and two-year smolts (25% less than the number contributing to 1991 returns) released at Mactaquac and an adjusted 0.0062 return rate (Table 5), i.e., 1,104 fish. Another 154 and 48 should return from smolts placed above and below Mactaquac, respectively. In addition, it was estimated that fall fingerlings released above Mactaquac, and in the Aroostook River in particular, in 1988 and 1989 would contribute another 511 1SW fish (Table 5) - about one-third of the number forecast to return in 1991. The total forecast of hatchery 1SW returns to Mactaquac is 2,027 1SW fish. The 1991 forecast by these methods exceeded returns by about 25%, principally because fall fingerlings, especially those placed above Grand Falls, returned at only about one-quarter of the forecast 0.0017 return rate (App.4 and Marshall 1991, Table 5)

MSW Hatchery

MSW returns destined for Mactaquac in 1992 were calculated as the sum of the product of an estimated return rate of 0.0029 and 241,078 smolts released at Mactaquac in 1990 (699 fish) and 0.24 of returns from 48,105 smolts released below Mactaquac in 1989 (33 fish). Additional returns are expected from fall fingerlings released in 1987 and 1988 and low (lower than previously used) 0.0001 and 0.00025 survival/return rates (Table 5). The forecast of total hatchery MSW returns to Mactaquac, including repeat spawners, is 1,205 MSW fish (Table 5).

Forecast Summary

The forecast of total homewater returns to Mactaquac, Saint John River in 1992 is 7,813 or 9,630 1SW (5,786 or 7,603 of wild and 2,027 hatchery origin) and 5,136 or 5,416 MSW fish (3,931 or 4,211 of wild and 1,205 of hatchery origin). Forecast returns minus the spawning requirements of 3,200 1SW and 4,400 MSW salmon result in potential surpluses of 4,613 to 6,430 1SW and 736 to 1,016 MSW salmon.

DISCUSSION

Estimated returns in 1991 of 8,751 wild and hatchery 1SW and 5,215 wild and hatchery MSW salmon were 95% and 112% of returns predicted by parametric methods. Comparisons of predicted and actual (estimated) returns for each of wild and hatchery fish since 1985 are as follows:

Sea-age	Returns	1985	1986	1987	1988	1989	1990	1991
Wild								
1SW	Predicted	7,063	5,075	4,989	6,054	8,197	7,393	5,786
	Returned	6,526	7,904	5,909	8,930	9,522	7,263	6,256
	Ret/Pred	0.92	1.56	1.18	1.48	1.16	0.98	1.08
MSW	Predicted	8,413	7,702	8,327	6,983	6,232	6,325	3,415
	Returned	10,436	6,128	4,352	2,625	4,072	3,329	4,491
	Ret/Pred	1.24	0.80	0.52	0.38	0.65	0.53	1.32
Hatchery								
1SW	Predicted	4,292	117	2,319	2,165	2,080	2,710	3,400
	Returned	2,018	862	3,328	1,250	1,339	1,541	2,495
	Ret/Pred	0.47	7.37[a]	1.44	0.58	0.64	0.57	0.74
MSW	Predicted	873	1,134	2,654	1,023	882	750	1,262
	Returned	875	797	480	912	469	796	724
	Ret/Pred	1.00	0.70	0.18[a]	0.89	0.53	1.06	0.57

[a] First returns from 1-year smolts.

MSW returns, including fish of hatchery origin, were the seventh lowest of a 17-year data set, but the highest since 1986 (Table 6). Returns of wild 1SW fish above Mactaquac were 108% of predicted; wild MSW fish above were 132% of the predicted value. Hatchery 1SW and MSW returns were 74% and 57% of forecasts.

Estimated harvests in the various net fisheries increased to pre- 1987 levels (Table 7) before a cooperative "Agreement" was reached with the Kingsclear Band. Indeed, new net removals immediately below Mactaquac in 1991 were variously rumored to have been as many as 3,000 fish - a number that would seriously jeopardize the on going estimation of adult returns and forecasts of returns. Whatever the level of removal, spawning escapement of MSW fish, including estimated losses to poaching and disease, was 79% of requirement - the same as in 1989 and the best since 1986, if mortality of the many "scaled" fish did not exceed that allowed in the assessment. Deficits in MSW spawning escapement, 1986-1991 (80, 63, 39, 79, 73, and 79% of requirements), and likely losses to net fisheries should deter managers from allocating predicted surpluses during the next several years.

For the first time in five years, wild MSW returns have equalled/exceeded those predicted. Investigations by Ritter et al. (1990) determined that the inclusion of fork length of returning 1SW salmon (perhaps the most overlooked and best measured potential expression of annual variation in growth conditions - likely marine but not excluding freshwater) in the original 1SW:MSW forecast models permitted prediction of recent declines in MSW returns. MSW returns declined as 1SW returns and their length increased, i.e., better early growth at sea may lead to earlier maturation and return of normally non-maturing salmon.

A measure of "crossover" had been annually sought through changes in the sex ratio of mature 1SW fish but changes were not found to be significant, perhaps because external sexing of early-run 1SW fish was inaccurate. Internal sexing of 80 1SW fish in July 1991 indicates that external sexing of summer-run 1SW fish may miss some females and that Sept-Oct external sexing may more adequately reflect the male:female ratio of the entire 1SW run. A second year of testing may well contribute to a reexamination of 1SW sex information available for inclusion in the forecast model. Other hypotheses for the decline in MSW returns include proportionately greater exploitation of non-maturing 1SW fish in distant fisheries, proportionately less exploitation on maturing 1SW fish and sea conditions contributing to more/less natural mortality.

Forecasting of hatchery returns continues to be problematic, although in most recent years, the predicted and actual returns have comprised less than 20% of the run. Returns in 1991 were at least not complicated by the identification of potential sea-cage escapees - none were recorded. Of particular difficulty, however, is the forecasting of returns from juveniles originating in other hatcheries and stocked in a less discriminating manner than products from DFO hatcheries.

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SUMMARY

STOCK: Saint John River, N.B. (above Mactaquac) SFA 23
LIFE STAGE: 1SW, MSW salmon (wild and hatchery origin)
TARGET: 29.4 million eggs (4,400 MSW and 3,200 1SW fish)

Year	1986	1987	1988	1989	1990	1991	MIN	MAX	Mean
Harvest:									
Native									
- 1SW	600	280	190	560	273	657	190[2]	657[2]	381[2]
- MSW	2400	1120	760	240	247	957	240[2]	2400[2]	953[2]
Recreational:									
- 1SW	1692	1650	1755	2304	2110	1690	1151[1]	3580[1]	2291[1]
Counts:									
- 1SW	7046	7972	9191	9587	7907	7575	4140[1]	17314[1]	8939[1]
- MSW	4143	3430	2600	4291	3919	4226	2010[1]	10451[1]	5283[1]
Returns:									
- 1SW	8766	9237	10180	10861	8804	8751	4946[1]	19275[1]	10408[1]
- MSW	6925	4832	3537	4541	4125	5215	3537[1]	13916[1]	7644[1]
Spawning:									
- 1SW	5887	7020	7810	7533	6057	5721	5887[2]	7810[2]	6861[2]
- MSW	3519	2758	1704	3491	3202	3481	1704[2]	3519[2]	2936[2]
% of Target Met:									
- 1SW	184	219	244	235	189	179	179[2]	244[2]	214[2]
- MSW	80	63	39	79	73	79	39[2]	80[2]	67[2]

[1]For the period 1975-1990.
[2]For the period 1986-1990.

Harvests: MSW salmon have not been retained since 1984; up to 1990, 1SW landings have ranged from 311 in 1972 to 3,580 in 1976. In 1991 the native fishery had the highest total landings since 1986; the absence of complete catch statistics seriously hampers the stock assessment and forecasting processes.

Data and methodology: Counts of fish obtained from the collection facility at Mactaquac Dam; returns to Dam equal counts plus estimates of down river removals. Spawners equal releases above Mactaquac minus estimates of upriver removals.

State of the stock: Target egg requirements have been met only three times in the last 14 years (1980, 1984, 1985); 1SW escapement contributed to only 8% of the target egg deposition; hatchery fish comprised 14.5% and 28.5% of 1SW and MSW returns in 1991.

Forecast: A relationship between egg depositions and wild 1SW returns indicates a return of 5,800 or 7,600 wild 1SW fish, depending on the forecast model. Another relationship between wild 1SW returns, their fork length and MSW returns suggests that the 6,300 1SW returns in 1991 will provide 3,900 or 4,200 wild MSW returns, depending on forecast model. The product of the numbers of hatchery releases and recent return rates suggest hatchery returns in 1992 of 2,000 1SW and 1,200 MSW salmon. Total 1SW returns could be 7,800 or 9,600 1SW fish; total MSW returns could be 5,100 or 5,400 MSW salmon. Target spawning requirements do not include 400 MSW broodstock required to seed Mactaquac Hatchery.

Table 1. Estimated total returns of wild and hatchery 1SW and MSW salmon destined for Mactaquac Dam on the Saint John River, N.B., 1991.

Sea-age	Components	Wild	Hatch.	Total
1SW				
	Mactaquac counts(a)	5415	2160	7575
	Angled MS below Mactaquac	394	157	551
	Native Food Fishery	322	128	450
	By-catch(b)	125	50	175
	Totals	6256	2495	8751
MSW				
	Mactaquac counts	3639	587	4226
	Native Food Fishery	627	101	728
	By-catch(b)	225	36	261
	Totals	4491	724	5215

(a) - Fishway closed Oct.29, and counts not adjusted.

(b) - Proportions of 2% total 1SW returns and 5% total MSW returns.

Table 2. Estimated homewater removals(a) of 1SW and MSW salmon destined for Mactaquac Dam on the Saint John River, N.B., 1991.

	1SW			MSW		
Components	Wild	Hatch.	Total	Wild	Hatch.	Total
Native Food Fishery						
Below Mact.	322	128	450	627	101	728
Above Mact.(b)	155	52	207	206	23	229
Recreational fishery						
Tobique River	519	185	704	-	-	-
Mainstem abv Mact.	323	112	435	-	-	-
Mainstem blw Mact.	394	157	551	-	-	-
Hook-release mort.(c)	0	0	0	62	9	71
Passed abv Tinker	39	50	89	32	18	50
Passed abv Grand F.	0	90	90	31	19	50
Hatchery broodfish	0	0	0	269	52	321
mortalities, etc.	120	209	329	20	4	24
Poaching/disease(d)	197	77	274	305	50	355
By-catch	125	50	175	225	36	261
Totals	2194	1110	3304	1777	312	2089

(a) - Wild:hatchery composition per estimated returns, unless known.

(b) - Reported by Tobique Band as 334 1SW and 102 MSW; 1SW:MSW ratio adjusted to reflect net selectivity reported in 1991.

(c) - Estimated at 2% of MSW salmon released above Mactaquac (excl. of those to food fishery abv. Mact., Aroostook and Grand Falls).

(d) - Estimated at 4% of all 1SW and 10% of all MSW fish placed abv Mact. (excl. of those to those to food fishery abv. Mact., Aroostook and Grand Falls).

Table 3. Estimated homewater returns, removals and spawning escapement of 1SW and MSW salmon destined for/above Mactaquac Dam, Saint John River, 1991.

Sea-age	Components	Wild	Hatch.	Total
1SW				
	Homewater returns	6256	2495	8751
	Homewater removals(a)	2194	1110	3304
	Spawners(b)	4259	1462	5721
	Target spawners			3200
	% of target spawners			179
MSW				
	Homewater returns	4491	724	5215
	Homewater removals(a)	1777	312	2089
	Spawners(b)	3019	462	3481
	Target spawners			4400
	% of target spawners			79

(a) - Includes Mactaquac broodfish and losses to poaching and disease (Table 2).

(b) - Excludes Mactaquac broodfish but includes losses to poaching and disease (Table 2).

Table 4. Adjusted Tobique River egg deposition[a]/100 m^2 (yr i & i+1) recruiting to total wild 1SW (and their mean fork length in cm) and MSW salmon which would have returned to Mactaquac in the absence of homewater removals in yr i+5 and i+6, resultant MSW:1SW salmon ratios, and parametric and non-parametric forecast numbers of 1SW and MSW fish to Mactaquac in the absence of homewater removals in 1992.

Eggs/100 m^2		Recruits					
		1SW			MSW		
Years (1)	Number (2)	Year	Number (3)	Length (4)	Year	Number (5)	MSW/1SW (6)
1965-66		1970	3,057	54.7	1971	4,715	1.54
1966-67		71	1,709	55.8	72	4,899	2.87
1967-68		72	908	57.0	73	2,518	2.77
1968-69	23.95	73	2,070	54.6	74	5,811	2.81
1969-70	40.58	74	3,656	56.1	75	7,441	2.04
1970-71	74.35	75	6,858	55.5	76	8,177	1.19
1971-72	122.34	76	8,147	55.5	77	9,712	1.19
1972-73	85.39	77	3,977	56.1	78	4,021	1.01
1973-74	81.66	78	1,902	56.4	79	2,754	1.45
1974-75	371.61	79	6,828	56.4	1980	10,924	1.60
1975-76	330.50	1980	8,482	58.1	81	5,991	0.71
1976-77	244.80	81	5,782	56.3	82	5,001	0.86
1977-78	288.96	82	4,958	55.4	83	3,447	0.69
1978-79	167.00	83	4,309	55.4	84	9,779	2.27
1979-80	239.74	84	8,311	55.6	85	10,436	1.26
1980-81	219.60	85	6,526	55.8	86	6,128	0.94
1981-82	167.64	86	7,904	57.6	87	4,352	0.55
1982-83	88.97	87	5,909	58.1	88	2,625	0.44
1983-84	240.56	88	8,930	58.6	89	4,072	0.46
1984-85	338.79	89	9,522	59.1	1990	3,329	0.35
1985-86		1990	7,263	58.6	91	4,491	0.62
1986-87		91	6,256	57.8	92	____[d,e]	
1987-88	138.28	92	____[b,c]				

[a] See App. 1, 2 and 3 for derivation.

[b] Based on regression of 1SW returns to Mactaquac, 1973-1989, (col. 3) on adjusted egg deposition in Tobique River, 1968-1969 to 1984-1985, (col. 2): $\log_e$ 1SW = 6.457 + 0.436 $\log_e$ Eggs; n=17, r^2=0.506, ($p<0.01$), $1SW_{1992}$ = 5,786 (AM); 90% C.L. = 4,983 to 6,717.

[c] Probability distribution: Ln 1SW returns: Ln eggs; most probable value = 7603; 90% C.L. = 2,105-10,262.

[d] Based on regression of MSW returns to Mactaquac, 1971-1991, (col. 5) on 1SW returns to Mactaquac 1970-1990 (col. 3) and their length (col. 4): $\log_e$ MSW = 24.013 + 0.123E-3 1SW - 0.286 LEN; n = 21, R^2 = 0.547 ($p<.001$) MSW_{1992} = 3,931(AM); 90% C.L. = 2,252 to 6,863.

[e] Probability density function: Ln MSW returns: 1SW returns and fork length; most probable value = 4,211; 90% C.L. = 0-16,271.

Table 5. Forecasts of hatchery 1SW and MSW returns to Mactaquac, Saint John River, 1992, as estimated from numbers of various juveniles released at (At), above (Abv) or below (Bl), Mactaquac and estimated return rates.

Release				Returns in 1992			
Year	Loc.	Stage	Number	Rate	Age	1SW	MSW
1991	At	1-,2-yr smolt	178,127	0.0062[c]	1-,2.1	1,104	
1991	Bl[a]	1-yr smolt	37,106	0.0062[c] @ 0.21	1.1	48	
1991	Abv	1-,2-yr smolt	49,836	0.0031	1-,2.1	154	
1990	Abv	1^+ parr (SALEN)	9,900	0.0020	2.1	20	
1989	Abv	Fall fing.	398,691[f]	0.0006	2.1	239	
1989	Abv	Unfed/fry	528,978[f]	0.0003	2.1	159	
1988	Abv	Fall fing.	906,039[b]	0.0003	3.1	272	
1988	Abv	Unfed/fry	209,882[b]	0.00015	3.1	31	
1990	At	1-,2-yr smolt	241,078	0.0029[c]	1-,2.2		699
1990	Bl[a]	1-yr smolt	48,105[c]	0.0029[c] @ 0.24[d]	1.2		33
1990	Abv	1-,2-yr smolt	71,403[b]	0.00145	1-,2.2		104
1989	Abv	1+ parr	9,400	0.0010	2.2		9
1988	Abv	Fall fing.	906,093[b]	0.00025	2.2		227
1988	Abv	Unfed/fry	209,882[b]	0.0001	2.2		21
1987	Abv	Fall fing.	145,428	0.0001	2.2		15
1987	Abv	Unfed/fry	266,257	0.00005	3.2		13
		Repeats	Forecast	0.07[e]			84
Totals						2,027	1,205

[a] Mactaquac origin, only.

[b] Inc. 727,400 fall fings. and 167,600 fry distributed by SALEN and 42,282 fry and 27,350 1-yr smolts distributed by Maine to Aroostook River.

[c] Arcsine mean 1988-1991 adjusted return rate.

[d] Marshall (MS 1990) App. 5, 1SW = mean of 1984-1989 and 1991 ratios; MSW = mean of 2SW 1985-1990.

[e] App. 4.

[f] Inc. 242,245 fall fing. and 312,594 fry to Aroostook; 66,000 fry to above Grand Falls.

Table 6. Estimated river returns of Saint John wild and hatchery 1SW and MSW salmon destined for Mactaquac Dam, 1970-1991.

Year	Wild		Hatchery		Total	
	1SW	MSW	1SW	MSW	1SW	MSW
1970	3057	5712				
1971	1709	4715				
1972	908	4899				
1973	2070	2518				
1974	3656	5811				
1975	6858	7441	6374	2210	13232	9651
1976	8147	8177	9074	2302	17221	10479
1977	3977	9712	6992	2725	10969	12437
1978	1902	4021	3044	2534	4946	6555
1979	6828	2754	3827	1188	10655	3942
1980	8482	10924	10793	2992	19275	13916
1981	5782	5991	4730	2612	10512	8603
1982	4958	5001	2846	1531	7804	6532
1983	4309	3447	1445	581	5754	4028
1984	8311	9779	1451	1115	9762	10894
1985	6526	10436	2018	875	8544	11311
1986	7904	6128	862	797	8766	6925
1987	5909	4352	3328	480	9237	4832
1988	8930	2625	1250	912	10180	3537
1989	9522	4072	1339	469	10861	4541
1990	7263	3329	1541	796	8804	4125
1991	6256	4491	2495	724	8751	5215

Table 7. Estimated numbers of native, sport, commericial and by-catch 1SW and MSW salmon landed which originated at or above Mactaquac on the Saint John River, 1970-1991.

	Native[a]		Sport[b]		Commercial		By-catch[c]		Total	
Year	1SW	MSW	1SW	MSW	1SW	MSW	1SW	MSW	1SW	MSW
1970			392	333	105	3204			497	3537
1971			319	357	57	2391			376	2748
1972			311	770			41	6	352	776
1973			704	420			37	60	741	480
1974	27	569	2034	2080			26	8	2087	2657
1975	73	739	3490	1474			70	56	3633	2269
1976	526	2038	3580	2134			61	90	4167	4262
1977	64	1070	2540	3125			109	156	2713	4351
1978	92	1013	1151	899			114	129	1357	2041
1979	328	771	2456	589			55	69	2839	1429
1980	713	2575	3260	2409			105	211	4078	5195
1981	361	891	2454	1085	855	1228	165	485	3835	3689
1982	235	2088	1880	921	554	469	58	212	2727	3690
1983	203	588	1453	637	378	1152	43	162	2077	2539
1984	353	2135	1824				338	896	2515	3031
1985	471	2526	3060				412	1771	3943	4297
1986	600	2400	1692				175	346	2467	2746
1987	280	1120	1650				185	242	2115	1362
1988	300	1200	1755				204	177	2259	1377
1989	560	240	2304				217	227	3081	467
1990	273	247	2110				176	206	2559	453
1991	657	957	1690				175	261	2522	1218

[a] Kingsclear, 1974-88, Tobique 1988-90, and Kingsclear, St. Mary's, Oromocto and Tobique in 1991.

[b] DNRE and DFO sources.

[c] Guesstimates from various sources or assumed proportions of the run.

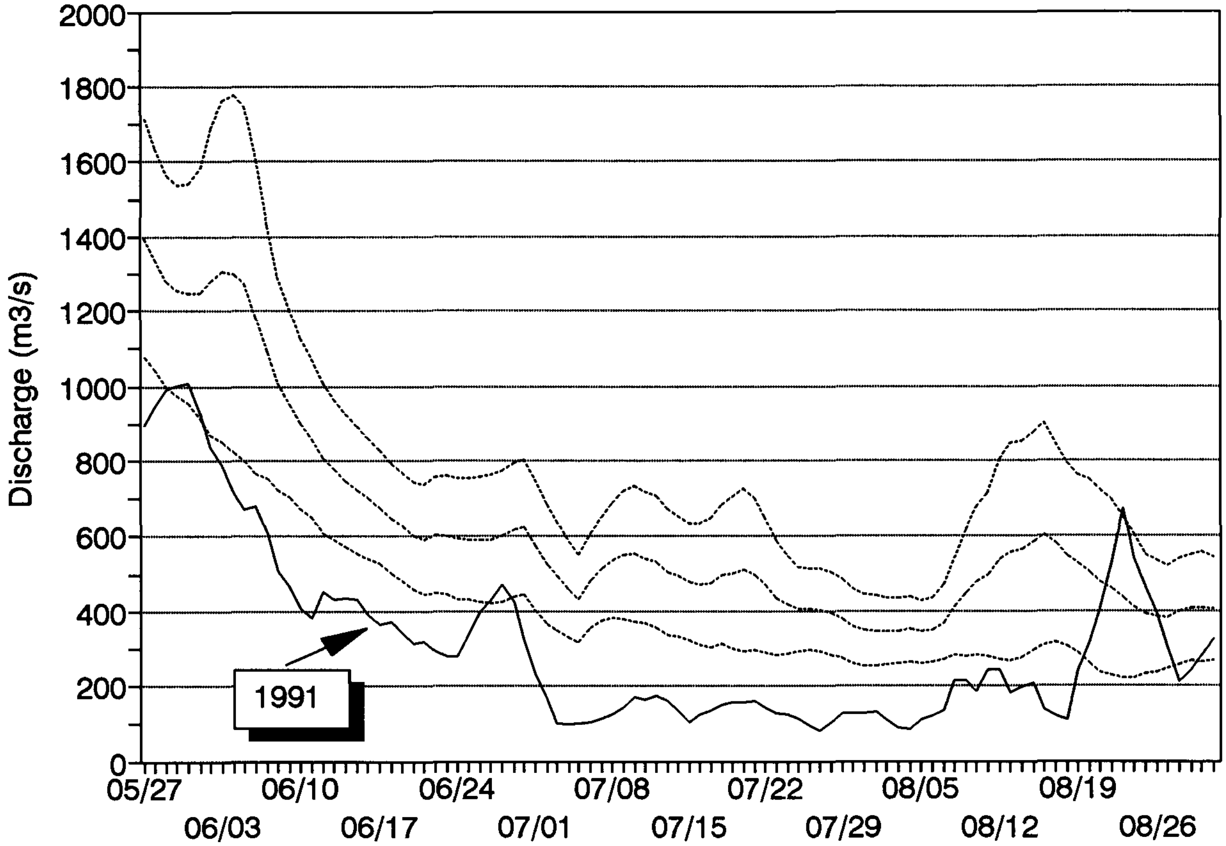

Fig. 1. Five-day moving averages of mean daily river discharge at Mactaquac, June through August, 1991, (solid line) and mean +/- 95% C.L. for daily discharges, 1972-1990 (dashed lines).

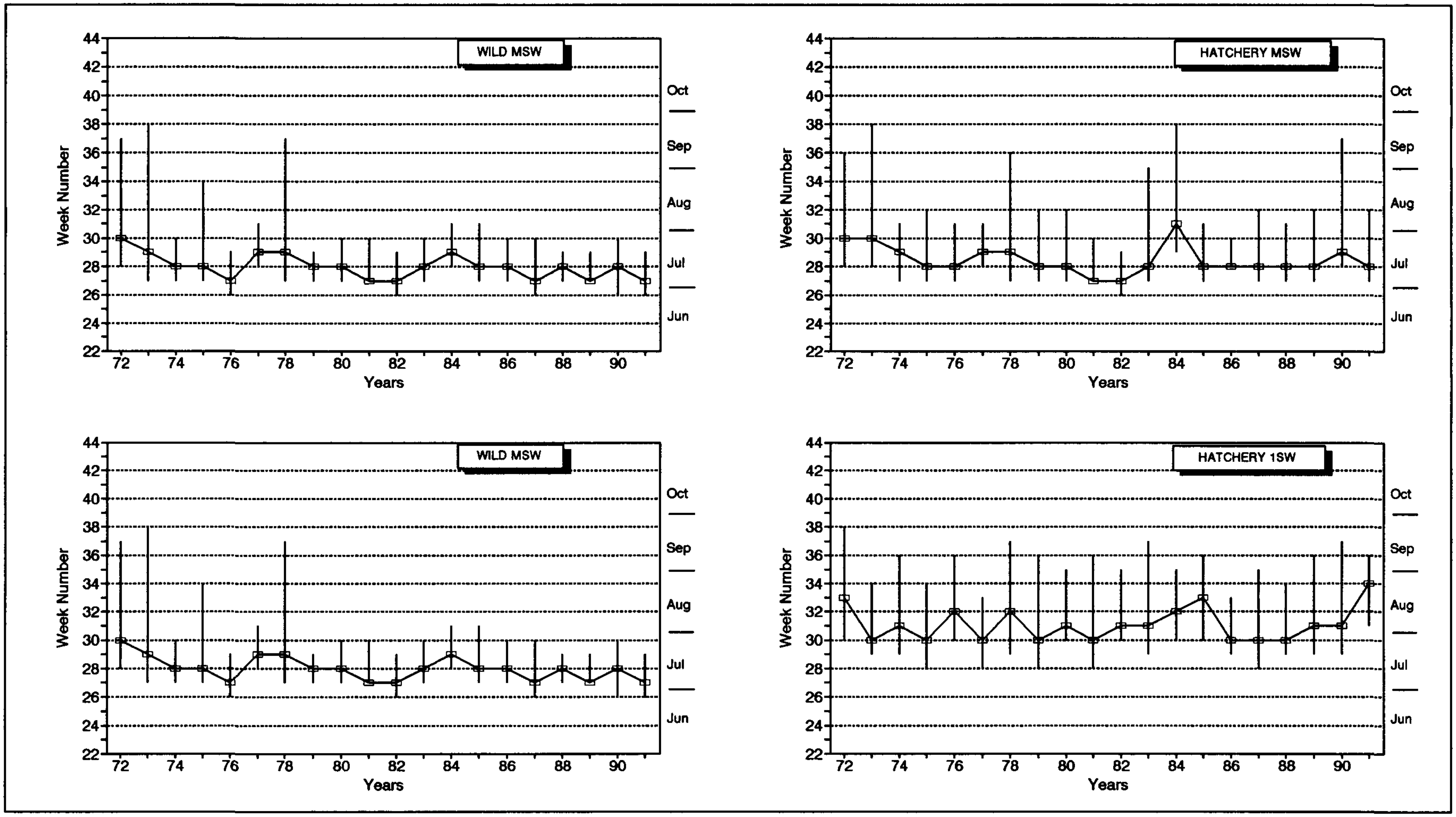

Fig. 2. Weeks in which 50% (open squares), 25% and 75% (bar extremities) of cumulative season counts of wild and hatchery MSW and 1SW salmon were tallied at the Mactaquac sorting facilities, 1972-1991.

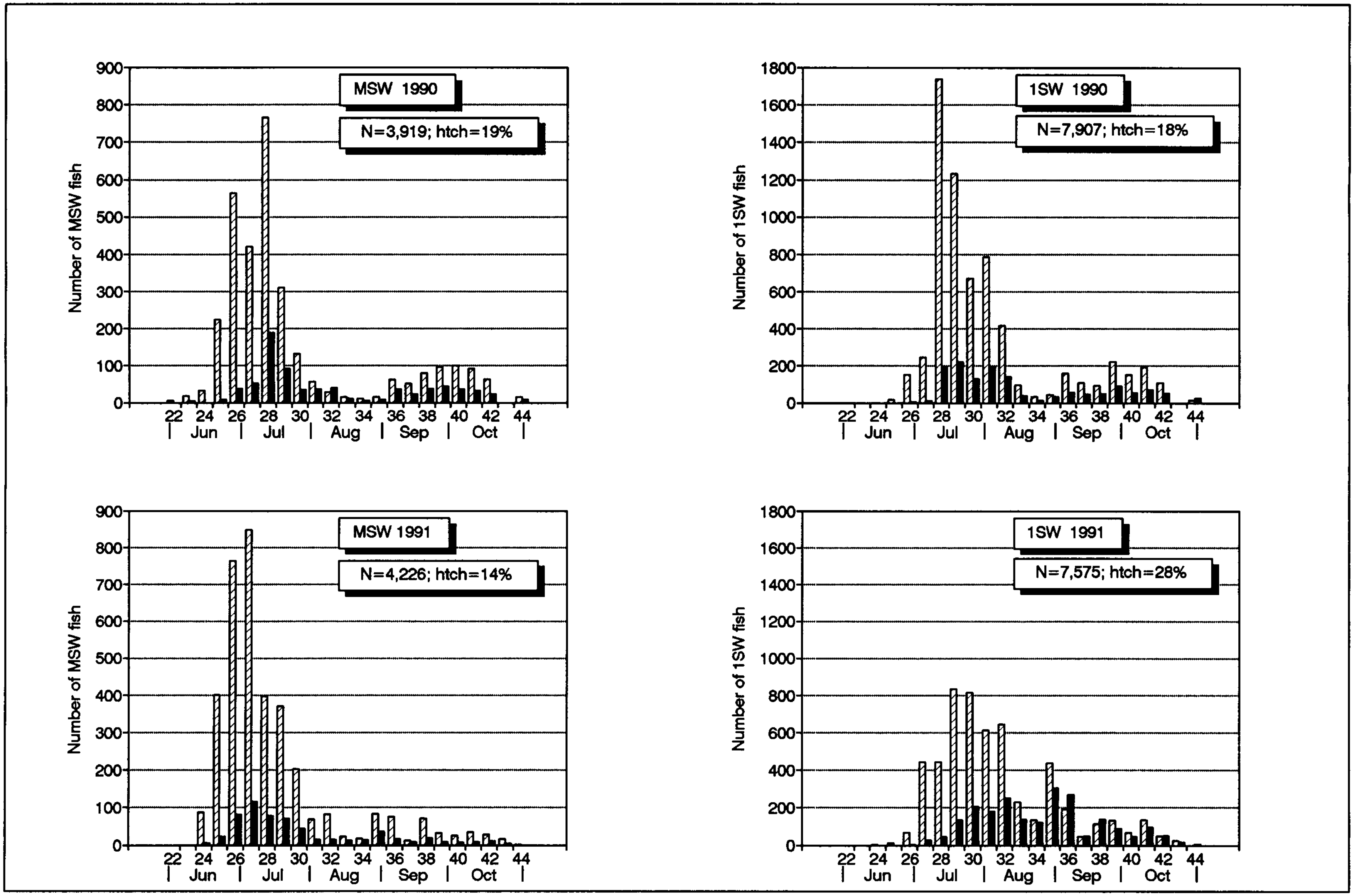

Fig. 3. Weekly counts of wild (cross hatch) and hatchery (solid) 1SW and MSW salmon at the the Mactaquac sorting facilities in 1990 (above) and 1991 (below).

App. 1. Number of eggs/100 m^2 deposited in the Tobique River, 1968-1988, and derivation of weighted number of eggs contributing to annual returns of wild 1SW fish at Mactaquac, 1973-1989 and 1992 (explanation in Penney and Marshall 1984).

Egg deposition		Proportion age at smoltification[a]		Eggs/100 m^2 contributing to 1SW fish		Total wt'd egg contrib/100 m^2 to 1SW fish @ Mact. (yr)
Year	Number	Age 2	Age 3	Yr i	Yr i+1	
1968	5.7	0.207				
			0.793		4.55	
1969	43.6	0.445		19.40		23.95 (1973)
			0.555		24.20	
1970	60.9	0.269		16.38		40.58 (1974)
			0.731		44.52	
1971	71.2	0.419		29.83		74.35 (1975)
			0.581		41.37	
1972	130.8	0.619		80.96		122.33 (1976)
			0.381		49.84	
1973	86.5	0.411		35.55		85.39 (1977)
			0.589		50.95	
1974	269.4	0.114		30.71		81.66 (1978)
			0.886		238.69	
1975	368.2	0.361		132.92		371.61 (1979)
			0.639		235.28	
1976	245.4	0.388		95.22		330.50 (1980)
			0.612		150.18	
1977	309.2	0.306		94.62		244.80 (1981)
			0.694		214.58	
1978	193.2	0.385		74.38		288.96 (1982)
			0.615		118.82	
1979	112.3	0.429		48.18		167.00 (1983)
			0.571		64.12	
1980	362.1	0.485		175.62		239.74 (1984)
			0.515		186.48	
1981	118.7	0.279		33.12		219.60 (1985)
			0.721		85.58	
1982	139.8	0.587		82.06		167.64 (1986)
			0.413		57.74	
1983	69.4	0.450		31.23		88.97 (1987)
			0.550		38.17	
1984	385.5	0.525[c]		202.39		240.56 (1988)
			0.475		183.11	
1985	301.7	0.516		155.68		338.79 (1989)
			0.484		146.02	
1986	200.2					
1987	159.8					
			0.566		90.45	
1988	110.2	0.434[b]		47.83		138.28 (1992)

[a] Derived from App. 2 and 3.
[b] Mean (of last 10 years) calculated with angular transformation.
[c] Revised from Marshall (1991).

App. 2. Number of wild 1SW salmon and proportion of age 2:1's of the total that would have returned to Mactaquac for the 1969-1986 year-classes.

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	544	9,610	0.361
1977	2,486	3,619	298	6,403	0.388
1978	1,619	3,659	13+6	5,296	0.306
1979	1,001	1,503	91+6	2,601	0.385
1980	2,793	3,540	176	6,509	0.429
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+13	10,687	0.525
1986	4,437	4,009	158	8,604	0.516
1987	2,963	2,911			
1988	3,174				

App. 3. Freshwater age and number of wild 1SW fish (A) counted at Mactaquac fish passage facilities, Saint John River, 1978-1991, and (B) that would have returned to Mactaquac had they not been exploited within the river, 1978-1991.

Fresh-water age	Number of 1SW fish													
	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
A														
	391	3,166	2,214	1,280	794	2,348	4,140	1,264	3,196	2,513	5,066	3,922	2,646	2,747
3	1,160	2,974	4,986	2,861	2,902	1,264	3,132	3,913	3,001	2,349	2,930	4,217	3,580	2,520
4	33	94	355	430	236	11	81	144	150	233	66	278	260	137
5									5					11
6									5					
Total	1,584	6,234	7,555	4,571	3,932	3,623	7,353	5,331	6,347	5,095	8,062	8,417	6,486	5,415
B														
2	469	3,468	2,486	1,619	1,001	2,793	4,679	1,548	3,980	2,915	5,612	4,437	2,963	3,174
3	1,393	3,257	5,598	3,619	3,659	1,503	3,540	4,790	3,737	2,724	3,245	4,771	4,009	2,911
4	40	103	398	544	298	13	91	176	187	270	73	314	291	158
5									6					13
6									6					
Total	1,902	6,828	8,482	5,782	4,958	4,309	8,311	6,526	7,904	5,909	8,930	9,522	7,263	6,256

App. 4. Estimated total number of 1SW and MSW returns to the Saint John River from hatchery-reared smolts released at Mactaquac, 1974-1991. (MSW returns in 1990 not corrected for 221 age 1.2 fish likely of sea-cage origin).

Releases			Returns (1SW/MSW)									
		Prop		Mactaquac		Native	Angled	By-	Commer-		% return	
Year	Smolts	1-yr	Year	Mig ch	Dam	fishery	main SJ	catch	cial	Total[a]	Unadj	Adj
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	74	385	4,730	2.037	
81	189,090	0.08	82	828	1,464	64	267	21	202	2,846	1.505	1.445
82	172,231	0.06	83	374	857	39	69	11	95	1,445	0.839	0.776
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	0.405
90	241,078	0.98	91[b]	(1,490)		88	108	35		1,721	0.714	0.688
91	178,127	0.97										
1974	337,281		1976	310	1,313	392	267	20		2,302	0.683	
75	324,186		77	341	1,727	206	417	34		2,725	0.841	
76	297,350		78	223	1,728	368	165	50		2,534	0.852	
77	293,132		79	145	747	210	65	21		1,188	0.405	
78	196,196		80	302	1,992	506	146	46		2,992	1.525	
79	244,012		81	126	963	252	125	147	999	2,612	1.070	
80	232,258		82	88	640	462	181	50	110	1,531	0.659	
81	189,090		83	44	255	76	17	23	166	581	0.307	0.285
82	172,231		84	84	722	201	5	103		1,115	0.647	0.559
83	144,549		85	73	492	189	5	116		875	0.605	0.553
84	206,462		86	16	471	266	4	40		797	0.386	0.346
85	89,051		87	4	338	110	4	24		480	0.539	0.453
86	191,495		88	(511)		150	0	35		696	0.364	0.354
87	113,439		89	(379)		0	0	20		399	0.352	0.330
88	142,195		90	(480)		0	0	25		505	0.355	0.333
89	238,204		91[b]	(359)		62	0	46		467	0.196	0.186
90	241,078											

[a] Includes returns from downriver stocking of smolts, 1981-1991; adjusted return rate excludes downriver returns to Mactaquac (Marshall 1989). (Marginal numbers of returns from approx. 5,000 age 2.1 smolts not inc., 1989-'91.)

[b] 1SW hatchery fish at Mactaquac were approximated at 0.690, 0.106, 0.172 and 0.032 from smolts released "at" and above and age 2.1 and 3.1 fall fingerlings released above, respectively. MSW hatchery fish at Mactaquac were estimated at 0.645, 0.077, 0.198, 0.008 and 0.072 from smolts "at" and "above", and age 2.2, 3.2 fall fingerlings and 'repeats', respectively.

App. 5. Estimates of hatchery 1SW and MSW returns to Mactaquac, Saint John River, 1991, as estimated from numbers of various juveniles released at (At), above (Abv) or below (Bl), Mactaquac and estimated returns to Mactaquac.

Release Year	Loc.	Stage	Number	Returns in 1991 Rate	Age	1SW	MSW
1990	At	1-,2-yr smolt	241,078[a]	0.00668[e]	1-,2.1	1,610	
1990	Bl	1-yr smolt	48,105	0.00668 @ 0.346	1.1	111	
1990	Abv	1-,2-yr smolt	71,403[b,c]	0.00371	1-,2.1	265	
1989	Abv	1+ parr	9,400[f]	unknown	2.1	-	
1988	Abv	Fall fing.	906,093[c]	0.00047[g]	2.1	428	
1988	Abv	Unfed/fry	209,882[c,f]	unknown	2.1	-	
1987	Abv	Fall fing.	145,428	0.00056[g]	3.1	81	
1987	Abv	Unfed/fry	266,257[f]	unknown	3.1	-	
1989	At	1-,2-yr smolt	238,204	0.00186[e]	1-,2.2		444
1989	Bl	1-yr smolt	34,994	0.00186 @ 0.346[d]	1.2		23
1989	Abv	1-,2-yr smolt	52,893	0.00106[g]	1-,2.2		56
1987	Abv	Fall fing.	145,428	0.00098	2.2		143
1987	Abv	Unfed/fry	266,257[f]	unknown	2.2		-
1986	Abv	Fall fing.	220,176	0.00003[g]	3.2		6
		Repeat spawners					52
Totals						2,495	724

[a] Inc. two groups of CWT Ad-clipped fish released at Mactaquac.

[b] Downstream passage trials above Mactaquac.

[c] Inc. 727,400 fall fings. and 167,600 fry distributed by SALEN and 42,282 fry and 27,350 1-yr smolts distributed by Maine to Aroostook River.

[d] See Marshall (1990) App. 5 and footnote d, Table 5 this document; 2SW value set equal to 1SW value.

[e] App. 4.

[f] Not distinguishable from wild smolts.

[g] Based on proportions, footnote App. 4.