DFO Atlantic Fisheries Research Document 93/65

MPO Document de recherche sur les pêches dans l'Atlantique 93/65

Assessment of Atlantic salmon of the Saint John River, N.B., above Mactaquac, 1992

by

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ABSTRACT

Estimated river returns destined for Mactaquac, Saint John River, 1992, were 8,940 1SW and 4,898 MSW salmon. Homewater removals/losses of about 4,000 1SW fish indicate that 160 percent of the target number of 1SW spawners was met above Mactaquac. Returns and removal of just under 2,000 MSW fish resulted in an estimated spawning escapement above Mactaquac of 74 percent of the MSW target. Target egg requirements, which are largely dependent on MSW fish have been met only three times in the last 15 years (i.e., 1980, 1984 and 1985).

Combined wild and hatchery 1SW returns in 1992 were 114 percent of the preseason parametric forecast. MSW returns were 95 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 significantly fewer than forecast.

A relationship between egg depositions and wild 1SW returns indicates about the same number of returns for 1993: 6,100 or 7,500 wild 1SW fish, depending on the forecast model. Another relationship between wild 1SW returns, their fork length and MSW returns which accounts for the effect of the moratorium on the commercial fishery in insular Newfoundland suggests that the 6,600 1SW returns in 1992 will provide 3,800 or 4,400 wild MSW returns in 1993, depending on forecast model. The product of the numbers of hatchery releases and recent return rates suggest hatchery returns in 1993 of 1,900 1SW and 1,000 MSW salmon.

Total 1SW returns in 1993 could be 8,000 or 9,400 1SW fish; total MSW returns could be 4,800 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 or spawners required for salmon development in the Aroostook River or above Grand Falls.

RÉSUMÉ

Les estimations de remontées de saumons vers Mactaquac, dans le Saint-Jean, en 1992 étaient de 8 940 unibermarins et 4 898 pluribermarins. Compte tenu de retraits/pertes dans les eaux d'origine d'environ 4 000 unibermarins, l'échappée de reproducteurs unibermarins en amont de Mactacquac correspondait approximativement à 160 p. 100 de la cible. Quant aux pluribermarins, leurs remontées et le retrait de presque 2 000 d'entre eux situent l'échappée estimée de reproducteurs en amont de Mactacquac à 74 p. 100 de la cible. En ce qui concerne la ponte, qui dépend largement des pluribermarins, le nombre cible n'a été atteint que trois fois au cours des 15 dernières années (en 1980, 1984 et 1985).

Les remontées combinées d'unibermarins sauvages et d'écloserie atteignaient 114 p. 100 de la prévision paramétrique de présaison pour 1992, tandis que celles de pluribermarins se situaient à 95 p. 100 de la prévision présaisonnière. Depuis 1986, les remontées d'unibermarins sont égales ou légèrement supérieures aux prévisions; avant la révision du modèle de prévision, en 1991, les remontées de pluribermarins étaient bien inférieures aux prévisions.

En se fondant sur un rapport entre les oeufs déposés et les remontées d'unibermarins sauvages, on s'attend à ce que ces dernières soient inchangées en 1993, se situant à 6 100 ou à 7 500 saumons, selon le modèle prévisionnel utilisé. Un autre rapport entre les remontées d'unibermarins sauvages, leur longueur à la fourche et les remontées de pluribermarins, qui tient compte des effets du moratoire sur la pêche commerciale dans l'île de Terre-Neuve, semble indiquer que les 6 600 remontées d'unibermarins de 1992 produiront 3 800 ou 4 400 remontées de pluribermarins sauvages en 1993, selon le modèle utilisé pour la prévision. Par ailleurs, le produit du nombre de saumons d'écloserie relâchés et des taux de remontées récents donne pour 1993 des remontées de saumons d'écloserie composées de 1 900 unibermarins et de 1 000 pluribermarins.

Les remontées totales d'unibermarins et de redibermarins en 1993 pourraient être de 8 000 ou de 9 400 poissons pour les premières et de 4 800 ou de 5 400 poissons pour les secondes. Les besoins en géniteurs s'établissent à 3 200 unibermarins et à 4 400 pluribermarins, outre les quelque 400 géniteurs pluribermarins nécessaires à la reproduction dans l'écloserie de Mactacquac ou les géniteurs dont on a besoin pour développer les stocks en amont de Grand-Sault ou dans la rivière Aroostook.

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 1992 and forecasts for 1993.

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 1991 suggested that 1992 homewater returns to Mactaquac would number approximately 7,800 or 9,600 1SW and 5,100 or 5,400 MSW salmon, depending on forecasting technique (Marshall 1992).

The Management Plan for 1992 was identical to that of recent years 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.

A native fishery with gill nets, which began in earnest in 1991, was again conducted on the main Saint John between Mactaquac (McKinley Ferry) and Fredericton, near Gagetown and in the lower reaches of the Nashwaak River. The Oromocto Band again fished a trap net on the main river near Oromocto. A food fishery with both gill and trap nets was conducted above and below the Tobique Narrows Dam on the Tobique River. Natives provided catch statistics for only the few fish captured at Oromocto.

Mean daily river discharges at Mactaquac in June, July and August, 1992, were, in contrast to 1991, among the highest of the last 20 years (Fig. 1). The high discharge was generally perceived to have limited the effectiveness of the net fisheries below Mactaquac and tended to defuse the concern that MSW target spawning requirements, as indicated by weekly in-season forecasts, mid-July through August, would not be met.

This assessment follows the same basic approach as those taken in recent years. Minor revisions have been made to the estimates of harvest, 1981-1983, (Marshall 1993; and therefore estimated returns and contribution by year-class) and egg depositions (Marshall 1994) used in the traditional forecasting of MSW returns. As well, tag data were used to derive "MSW return" data that would reflect returns to homewaters had the moratorium on the insular Newfoundland commercial fishery been in effect for the last two decades. These data were then submitted to the previously used forecast models.

METHODS

Returns destined for Mactaquac

Total returns of 1SW and MSW salmon of both wild and hatchery origin from 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 assumed 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 1991, 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). Returns from hatchery origin unfed and feeding fry would not be expected to be distinguishable from wild fish. By-catch was assumed to be 2% of the 1SW and 5% of the MSW river returns - values which approximate the original mean of reports and 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 numbers of fish recorded by Fishery Officers who monitored the native fishery on the mainstem below Mactaquac and numbers estimated from tag recoveries to have been netted 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.

The number 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) are largely the 153 1SW and 419 MSW fish observed or known to Fishery Officers who visited the sites on 66 mornings between May 30 and Sept 1. Observed numbers of fish correlated with daily counts at the Mactaquac fishway ($r^2 = 0.07$; $n=65$; $p< 0.05$) but the relationship was not useful in deriving estimates of catch in Sept or Oct. or for mornings when there was assumed to be no fishing because of high water conditions. Because interviews/conventional observations were impractical at night (22:00 to 02:00hr) when fishing and "coming-and-going" were observed by residents to be the most active, use of the observed numbers of fish assumes that morning surveys accounted for the accumulated catch for the previous night. Activity was thought to be less than in 1991 because of high water events and employment of a few fishermen in DFO-First Nations "partnership" programs.

Native fisheries also operated at the mouth of and within the Nashwaak River. Landings were estimated by Fishery Officers to have been about 70 "salmon" which I attributed to a below-Mactaquac origin. The harvest of another six 1SW and 18 MSW salmon from the main Saint John downriver of the Nashwaak, inc. Oromocto and Upper Gagetown were also 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).

Unlike previous years, the estimated net catch by the Tobique Band, June - Sept, was based on an exploitation rate derived with 29 Carlin tags recovered from the fishery (mostly from 1SW fish intended for determination of fishway efficiences), an assumed non-reporting rate and an estimate of fish available to the fishery from releases below and above the Tobique Narrows Dam. The availability of fish to netting above the dam was enhanced by the monitoring of 20 ultrasonic-tagged wild and hatchery fish released at the Arthurette dump site, about 18 km above the dam. Fishing was conducted with up to 18 gill nets below the Tobique Narrows Dam and in the Tobique Headpond. Two DFO-provided trap nets were installed in the Headpond for purposes of a 1SW-selective food fishery in early August and were rumored to have taken about 200 fish.

Other removals include fish: monitored through the fish-lift at Tinker Dam on the Aroostook River, trucked from Mactaquac to the Tinker Headpond 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 MSW salmon released above Mactaquac, exclusive of those to the native fishery at Tobique and losses to the Aroostook River and above Grand Falls. 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, the sport fishery or passed into the Aroostook or above Grand Falls) were calculated as in 1991 but are considered as "spawners" for purposes of evaluating the attainment of target spawning escapement. For the most part, losses were apportioned to hatchery/wild components on the basis of known or estimated stock composition in the vicinity of the event.

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 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.).

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, 1973-1990, 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 1985-1986. The numbers of adjusted eggs in this assessment reflect revisions (avg +6% per year) to the estimates of egg depositions (Marshall 1994). An increase in the estimated numbers of 1SW recruits, 1981-83, reflect revisions (15% in 1981) to the commercial harvest, 1981-83 (Marshall 1993). The 1988 and 1989 egg depositions, principal contributors to 1SW returns in 1993, were derived using angular-transformed mean proportions for age 2.1 and age 3.1 1SW fish in the previous decade.

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 1993 was derived with a nonparametric probability density function described by Noakes (1989) and the above logged egg and 1SW 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 firstly, forecasts of MSW returns in 1993 using current data, i.e., the regression of logged MSW returns (inc. revised estimates of returns, 1981-83, Marshall 1993) 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. The first step constructs the joint probability density function of MSW salmon returns and 1SW returns while 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.

Secondly, Saint John River MSW salmon are known to frequent distant waters and contribute to distant water fisheries as non-maturing 1SW fish. The moratorium on the commercial fishery of insular Newfoundland, 1992, could therefore result in returns in 1993 that are not reflected in the "MSW return" data submitted to either forecast model. Hence, tag return data from Insular Newfoundland, a tag reporting rate of 0.7, a non- catch survival

of 0.9, tag retention rate of 0.9 and survival to home waters of 0.88 were used to estimate potential gains in 2SW salmon to the Saint John River as a result of the moratorium. Estimates of the potential gains in 21 of the 22 years used above were added to the MSW returns and submitted to both parametric and non parametric MSW forecast models. For comparative purposes the forecasts based on returns without potential gains from Newfoundland were re-run for the same 21 years of data.

1SW Hatchery

Since the deployment of 1-year smolts from Mactaquac began 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 1993 was assumed to be the same as the mean (arcsine) of the 1988-1992 'adjusted' return rates (App.4). Age 1.1 returns in 1992 were adjusted by removal of the estimated returns to Mactaquac from smolts released in tributaries below Mactaquac (Marshall 1990) and above Mactaquac (clipped adipose fin). An 8-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 1993 returns.

Additional 1SW returns of age 3.1 and age 2.1 fish are expected at Mactaquac in 1993 from fall fingerlings (age 0^+) graded from the 1-year smolt program at Mactaquac and released in tributaries above Mactaquac in 1989 and 1990. Similarily, returns are expected from 150,000 fall fingerlings released by SALEN Inc. from their station at Florenceville to the main Saint John above Grand Falls. Returns of age 2.1 fish were forecast as the product of a 0.001 return rate to Mactaquac (value from returns in 1992) and the numbers released in 1990. Age 3.1 fish were assigned a return rate of 0.0003 (1992 return rate). 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 1991 were estimated as the product of the number released and the adjusted mean (arcsine) return rate for 1-year smolts released from Mactaquac 1986-1990 (App.4). As with 1SW hatchery returns, MSW fish destined for Mactaquac from releases to tributaries below were proportioned (0.21) 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 1988 and 1989. Returns of age 2.2 salmon were forecast as the product of their numbers and a return rate to Mactaquac of twice that exhibited in 1992 (App. 5). Age 3.2 hatchery MSW fish, a rarity (App.5) because of the generally large size of stocked fall fingerlings, were accorded 0.5 of that of age 2.2 fish.

Hatchery fish which returned as maiden fish, principally 1989-1992, are expected to comprise the repeat-spawning MSW component in 1993. The forecast return was simplified to be the product of the estimated escapement of hatchery fish in 1992 and a return rate of 0.03.

Because return rates used in forecasting hatchery MSW salmon exclude potential gains from the moratorium on commercial fishing in insular Newfoundland, forecasts were raised in proportion to the difference between the parametric forecast of wild MSW returns with and without potential gains from Newfoundland.

RESULTS

Returns destined for Mactaquac

Estimated homewater returns in 1992 totalled 8,940 1SW and 4,898 MSW fish (Table 1). Returns included 175 1SW and 450 MSW fish estimated to have been taken in the Native fishery, 922 1SW fish taken in the sport fishery and 179 1SW and 245 MSW fish allotted to by-catch, all below Mactaquac. Counts of fish at Mactaquac in 1992 comprised 86% of respective 1SW and MSW returns estimated to have been destined for Mactaquac (Fig. 2). Hatchery fish comprised 25% and 16% of 1SW and MSW counts, respectively (Fig. 3).

Landings in the net fishery below Mactaquac were essentially those 153 1SW and 419 MSW salmon recorded by Fishery Officers. Proportioning of the salmon reported captured below the Nashwaak and allowance for a few fish to have been captured in Sept.-Oct. provided an estimated total of 175 1SW and 450 MSW salmon. These landings provide exploitation rates of 0.02 and 0.092 for respective 1SW and MSW captures or only about one-half of the value derived for 1991 and of the average 0.04 and 0.22 values estimated for the Kingsclear net fishery in the early 1980's (Marshall 1985).

Removals

In addition to the 1SW sport removals reported by the Kingsclear First Nation and NBDNRE in the lower main stem, 1,182 fish were reported caught above Mactaquac (Table 2). Tag returns and a 0.8 tag reporting rate suggested a net fishery exploitation rate at Tobique of 0.123 for 1SW fish and 0.301 for MSW salmon. These rates were applied equally to fish known to have had access to the fishery below Tobique Narrows Dam (counted over Beechwood or dumped directly at Andover) and 10% of wild and 60% of hatchery fish released above the Tobique Narrows Dam at Arthurette (dropback estimated from tracking of ultrasonic tagged fish). That net catch (Table 2) was estimated to be 385 1SW and 298 MSW salmon.

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. MSW salmon observed at Mactaquac in 1993 again had some scale

loss/injury but high river discharge and generally cooler summer conditions than in 1991 should have contributed to a greater survival than in 1992. 1SW losses to poaching and disease were set at 4% (exclusive of those taken in the recreational and Tobique net fisheries and passed above Tinker Dam and Grand Falls). Unlike recent years, only one salmon was lost (badly injured) at the Half Mile Barrier Pool on the Tobique River. No other mortalities were available to NBDNRE from that location for disease analysis (furunculosis in particular).

Removals by all factors were estimated at 4,019 1SW fish of which 572 made their way above Tinker Dam or Grand Falls and 1,958 MSW salmon of which 206 were transferred above Tinker Dam or Grand Falls. MSW hatchery broodstock retained at Mactaquac numbered 347 fish; 397 1SW salmon were sacrificed for recovery of coded nose-wire tags, checking on external sexing or testing for disease. Most of the carcasses were distributed to First Nations.

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 3,269 (74%) of the required 4,400 MSW spawners were attained above Mactaquac (Table 3). For 1SW fish, 160% of requirements were met above Mactaquac. An estimated 11.5% of wild (internal sexing of 75 fish in July largely confirmed external assessments) and 5.7% of hatchery 1SW fish (internal sexing of 256 fish through the season largely confirmed external assessments) were female and with respective mean lengths of 58.5 and 58.7 cm had the potential to deposit about 1.85 million eggs. This number of eggs is 6% of the 2.4 egg/m^2 target or the equivalent of about 245 MSW females.

Stock Forecasts

1SW Wild

A 1993 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 1993 is 6,105 1SW fish (90% C.L. 5,292-7,034; Table 4). For 1992, the method had forecast 5,786 (4,983-6,717) 1SW fish; 6,683 fish were estimated to have returned.

A forecast of 7,483 (90% C.L. 2,910-10,506) 1SW fish was obtained from the probability density function in which maximum likelihood smoothing parameters were 0.6813 (eggs) and 0.4066 (1SW fish) (Table 4). This forecast is virtually the same as the 7,603 1SW fish forecast for 1992.

MSW Wild

A forecast of 3,361 (90% C.L. 2,091-5,401; Table 4) wild MSW fish destined for Mactaquac in 1993 was derived from the equation $\log_e$ MSW = 24.907 + 0.128E-3 1SW - 0.302 Length (n = 22; R^2 = 0.661; p<.001). For 1992, the method forecast 3,931 returns (R^2 = 0.547); 4,104 fish were estimated to have returned. The probability density estimator (3-variables in two steps) for the same data provides a forecast of 4,551 (90% C.L. 0-15,082) MSW fish (Table 4) - higher than the forecast of 4,211 fish for 1992.

Substitution of the estimated numbers of returning salmon in the absence of a commercial fishery in insular Newfoundland 1971-1991, (Table 5, one less year than in the above data set) provided a parametric forecast of 3,785 (90% C.L. 2,415-5,932) wild MSW fish destined for Mactaquac in 1993 ($\log_e$ MSW = 26.913 + 0.129E-3 1SW - 0.334 Length; n = 21; R^2 = 0.725; p<.001; Table 4). This is 14.7% greater than the parametric forecast of 3,299 (90% C.L. 2,080-5,232) wild MSW fish ($\log_e$ MSW = 25.919 + 0.125E-3 1SW - 0.319 Length; n = 21; R^2 = 0.696; p<.001) using return data lacking a Newfoundland component, 1972-92. Log_e estimated return attributable to the closure was not a significant variable when incorporated into the basic model forecasting 3,299 MSW returns.

The probability density estimator for the enhanced MSW returns provides a forecast of 4,362 (90% C.L. 1,322-16,786; n = 21) fish, i.e., 5% less than the forecast which excluded potential returns from Newfoundland (MSW_{1993} = 4,606; 90% C.L. 0-15,241; n = 21; Table 4).

1SW Hatchery

The forecast of hatchery 1SW fish destined for Mactaquac in 1993 was in part calculated as the product of an estimated 204,836 one-year smolts released at Mactaquac in 1992 and an adjusted 0.0064 return rate (Table 6), i.e., 1,311 fish. Another 18 fish should return from smolts released to tributaries below Mactaquac. Fall fingerlings released above Mactaquac in 1989 and 1990 should contribute another 339 1SW fish (Table 6). The total forecast of hatchery 1SW returns to Mactaquac is 1,904 1SW fish of which an estimated 236 would not be discernable from wild fish. The 1992 pre-season forecast by these methods was 90% of the identifed hatchery return. (Unidentified fish of hatchery origin [accorded "wild" status] could have numbered 100 - 200 individuals, i.e., the forecast may have been about 80% of the return).

MSW Hatchery

MSW returns destined for Mactaquac in 1993 were calculated as the sum of the product of an estimated return rate of 0.0029 and 178,127 smolts released at Mactaquac in 1991 (517 fish) and 0.21 of returns from 37,106 smolts released below Mactaquac in 1991 (23 fish). Additional returns are expected from releases of fall fingerlings in 1988 and 1989 and 0.0002 and 0.00015 survival/return rates (Table 6). The conventional forecast, i.e., without gains from the moratorium in insular Newfoundland, of total hatchery MSW

returns to Mactaquac, including repeat spawners, is 905 MSW fish (Table 6). Application of a 0.872 raising factor, a value which reflects the 14.7 % difference between parametric forecasts for wild MSW salmon, (n = 21), and approximates the 0.865 raising factor to account for removals in Newfoundland since the 1984 salmon management plan (Table 5; 1985-1992) suggests a return of 1,038 hatchery origin MSW salmon.

Forecast Summary

The forecast of total homewater returns to Mactaquac, Saint John River, in 1993 is 8,009 or 9,387 1SW (6,105 [parametric] or 7,483 [non-parametric] of wild and 1,904 hatchery origin) and 4,823 or 5,400 MSW fish (3,785 [parametric inc. Newfoundland] or 4,362 [non-parametric inc. Newfoundland] of wild and 1,038 of hatchery origin) including those affected by the moratorium in the Newfoundland commercial fishery in 1992. Forecast returns minus the spawning requirements of 3,200 1SW and 4,400 MSW salmon result in potential surpluses of 4,809 or 6,187 1SW and 423 or 1,000 MSW salmon.

DISCUSSION

Estimated returns in 1992 of 8,940 wild and hatchery 1SW and 4,898 wild and hatchery MSW salmon were 114% and 95%, respectively, of returns predicted by parametric methods. Comparisons of predicted and estimated returns for each of wild and hatchery fish since 1986 are as follows:

Sea-age	Returns	1986	1987	1988	1989	1990	1991	1992
Wild								
1SW	Predicted	5,075	4,989	6,054	8,197	7,393	5,786	5,786
	Returned	7,904	5,909	8,930	9,522	7,263	6,256	6,683
	Ret/Pred	1.56	1.18	1.48	1.16	0.98	1.08	1.16
MSW	Predicted	7,702	8,327	6,983	6,232	6,325	3,415	3,931
	Returned	6,128	4,352	2,625	4,072	3,329	4,491	4,104
	Ret/Pred	0.80	0.52	0.38	0.65	0.53	1.32	1.04
Hatchery								
1SW	Predicted	117	2,319	2,165	2,080	2,710	3,400	2,027
	Returned	862	3,328	1,250	1,339	1,541+	2,495+	2,257+
	Ret/Pred	7.37[a]	1.44	0.58	0.64	0.57+	0.74+	1.11+
MSW	Predicted	1,134	2,654	1,023	882	750	1,262	1,205
	Returned	797	480	912	469	796	724+	794+
	Ret/Pred	0.70	0.18[a]	0.89	0.53	1.06	0.57+	0.66+

[a] First returns from 1-year smolts; + = returns from juveniles which would have been credited to "wild" fish.

MSW returns, including fish of hatchery origin, were the sixth lowest of an 18-year data set, down 6% from 1991 (Table 7). Returns of wild 1SW fish above Mactaquac were 116% of predicted; wild MSW fish were 104% of the predicted value. Hatchery 1SW and MSW returns were 111+% and 66+% of respective forecasts.

Estimated harvests in the various net fisheries approached the 1991 levels but were considerably below pre-1987 levels (Table 8) before a cooperative "Agreement" was reached with the Kingsclear Band. As in 1991, net removals immediately below Mactaquac were variously rumored to have been several times the observed number of fish. Unusually high water levels (Fig. 1) which discouraged fishing activity and diminished net efficiencies through most of the summer do not, however, support a significant underestimation of removals. The spawning escapement of MSW fish, including estimated losses to poaching and disease, was 74% of requirement - below the 79% average for the period 1987-91, and an extension to 12 years out of the last 15 years in which the target for MSW spawners has not been met.

For the second consecutive year, 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.

ACKNOWLEDGEMENTS

Compilation and synthesis of this assessment has been made possible only with the support of provincial and federal co-workers. Fish count and removal information was provided by the staff at Mactaquac FCS, Fishery Officers in Fredericton, Plaster Rock and St. Leonard and P. Cronin, Regional Biologist, NBDNRE, Kingsclear. C.J. Harvie, DFO, Halifax, provided forecasts from non-parametric probability functions, J. Cameron, DFO, Halifax derived native exploitation rates and assisted in data compilation, D. MacPhail, Silvacare Inc. determined ages from scales.

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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	1987	1988	1989	1990	1991	1992	MIN	MAX	Mean
Harvest:									
Native									
- 1SW	280	300	560	273	657	560	273[2]	657[2]	414[2]
- MSW	1120	1200	240	247	957	748	240[2]	1200[2]	753[2]
Recreational:									
- 1SW	1650	1755	2304	2110	1690	2104	1151[1]	3580[1]	2256[1]
Counts:									
- 1SW	7972	9191	9587	7907	7575	7664	4140[1]	17314[1]	8859[1]
- MSW	3430	2600	4291	3919	4226	4203	2010[1]	10451[1]	5221[1]
Returns:									
- 1SW	9237	10180	10861	8804	8751	8940	4946[1]	19275[1]	10311[1]
- MSW	4832	3537	4541	4125	5215	4898	3537[1]	13916[1]	7501[1]
Spawning:									
- 1SW	7020	7810	7533	6057	5721	5128	5721[2]	7810[2]	6828[2]
- MSW	2758	1704	3491	3202	3481	3269	1704[2]	3491[2]	2927[2]
% of Target met:									
- 1SW	219	244	235	189	179	160	179[2]	244[2]	213[2]
- MSW	63	39	79	73	79	74	39[2]	79[2]	67[2]

[1]For the period 1975-1991.
[2]For the period 1987-1991.

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. The native fishery, lower than that of 1991, approximated the mean of the previous five years.

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 15 years (1980, 1984, 1985); 1SW escapement contributed to about 6% of the target egg deposition; hatchery fish comprised 25% of 1SW and 16% of MSW returns in 1992.

Forecast: A relationship between egg depositions and wild 1SW returns indicates a return of 6,100 or 7,500 wild 1SW fish in 1993, depending on the forecast model. Another relationship between wild 1SW returns, their fork length and MSW returns including those predicted to have benefited by the moratorium on the Nfld. commerical fishery suggests that the 6,680 1SW returns in 1992 will provide 3,800 or 4,400 wild MSW returns in 1993, depending on forecast model. The product of the numbers of hatchery releases and recent return rates suggest hatchery returns in 1993 of 1,900 1SW and 1,000 MSW salmon. Total 1SW returns could be 8,000 or 9,400 1SW fish; total MSW returns could be 4,800 or 5,400 MSW salmon. Zero to 15% of the forecast MSW returns could be the result of the moratorium on the Newfoundland commercial fishery. Target spawning requirements do not include approximately 400 MSW broodstock required to seed Mactaquac Hatchery or spawners required for salmon development in the Aroostook River or above Grand Falls.

Table 1. Estimated total returns of wild and hatchery 1SW and MSW salmon destined for Mactaquac Dam on the Saint John River, N.B., 1992.

Sea-age	Components	Wild	Hatch.	Total
1SW				
	Mactaquac counts(a)	5,729	1,935	7,664
	Angled MS below Mactaquac	689	233	922
	Native Food Fishery	131	44	175
	By-catch(b)	134	45	179
	Totals	6,683	2,257	8,940
MSW				
	Mactaquac counts(a)	3,522	681	4,203
	Native Food Fishery	377	73	450
	By-catch(b)	205	40	245
	Totals	4,104	794	4,898

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

(b) - Proportions of 2% total 1SW returns and 5% total MSW returns, inc. unrecorded MSW losses to angling.

Table 2. Estimated homewater removals(a) of 1SW and MSW salmon destined for Mactaquac Dam on the Saint John River, N.B., 1992.

	1SW			MSW		
Components	Wild	Hatch.	Total	Wild	Hatch.	Total
Native Food Fishery						
Below Mact.	131	44	175	377	73	450
Above Mact.(b)	300	85	385	138	160	298
Recreational fishery						
Tobique River	658	175	833	-	-	-
Mainstem abv Mact.	261	88	349	-	-	-
Mainstem blw Mact.	689	233	922	-	-	-
Hook-release mort.(c)	0	0	0	59	8	67
Passed abv Tinker	286	56	342	68	28	96
Passed abv Grand F.	173	57	230	96	14	110
Hatchery broodfish	0	0	0	270	77	347
mortalities, etc.	75	322	397	14	2	16
Poaching/disease(d)	159	48	207	288	41	329
By-catch	134	45	179	205	40	245
Totals	2,866	1,153	4,019	1,515	443	1,958

(a) - Wild:hatchery composition per estimated availability.

(b) - Based on recovery of tags, assumed reporting rates and availability of fish (see text).

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

(d) - Assumed to be 4% and 10% of all remaining 1SW and MSW fish respectively, above Mactaquac.

Table 3. Estimated homewater returns, removals and spawning escapement of 1SW and MSW salmon destined for/above Mactaquac Dam, Saint John River, 1992.

Sea-age	Components	Wild	Hatch.	Total
1SW				
	Homewater returns	6,683	2,257	8,940
	Homewater removals(a)	2,866	1,153	4,019
	Spawners(b)	3,976	1,152	5,128
	Target spawners			3,200
	% of target spawners			160
MSW				
	Homewater returns	4,104	794	4,898
	Homewater removals(a)	1,515	443	1,958
	Spawners(b)	2,877	392	3,269
	Target spawners			4,400
	% of target spawners			74

(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/100m^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, and absence of removals in Newfoundland (col 8), resultant MSW: 1SW ratios, and parametric and non-parametric forecast numbers of 1SW and MSW fish to Mactaquac in the absence of home water removals. See App. 1, 2 & 3 for derivation of col 2 and Table 5 for derivation of col 8.

Eggs/100m^2		1SW recruits			MSW recruits			Ratios	
Years	No.	Year	No. rtn	Length	Year	No. rtn	Rtn + Nfld	MSW/1SW	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(7/4)	(8/4)
1965-66		1970	3,057	54.7	1971	4,715		1.54	
1966-67		1971	1,709	55.8	1972	4,899	5,724	2.87	3.35
1967-68		1972	908	57.0	1973	2,518	2,595	2.77	2.86
1968-69	42.70	1973	2,070	54.6	1974	5,811	6,411	2.81	3.10
1969-70	32.06	1974	3,656	56.1	1975	7,441	9,138	2.04	2.50
1970-71	66.26	1975	6,858	55.5	1976	8,177	11,913	1.19	1.74
1971-72	122.05	1976	8,147	55.5	1977	9,712	11,068	1.19	1.36
1972-73	82.47	1977	3,977	56.1	1978	4,021	5,637	1.01	1.42
1973-74	80.22	1978	1,902	56.4	1979	2,754	3,303	1.45	1.74
1974-75	391.21	1979	6,828	56.4	1980	10,924	11,684	1.60	1.71
1975-76	348.93	1980	8,482	58.1	1981	5,766	7,062	0.68	0.83
1976-77	267.20	1981	6,614	56.3	1982	5,528	5,934	0.84	0.90
1977-78	287.02	1982	5,174	55.4	1983	5,783	6,537	1.12	1.26
1978-79	173.40	1983	4,555	55.4	1984	9,779	11,484	2.15	2.52
1979-80	248.15	1984	8,311	55.6	1985	10,436	12,335	1.26	1.48
1980-81	229.42	1985	6,526	55.8	1986	6,128	7,803	0.94	1.20
1981-82	181.65	1986	7,904	57.6	1987	4,352	4,636	0.55	0.59
1982-83	99.63	1987	5,909	58.1	1988	2,625	4,132	0.44	0.70
1983-84	248.32	1988	8,930	58.6	1989	4,072	4,072	0.46	0.46
1984-85	362.09	1989	9,522	59.1	1990	3,329	4,333	0.35	0.46
1985-86	274.19	1990	7,263	58.6	1991	4,491	4,491	0.62	0.62
1986-87		1991	6,256	57.8	1992	4,104	4,104	0.66	0.66
1987-88		1992	6,683	58.5	1993	____	____		
1988-89	158.85	1993	____						

Forecast results:

Sea-age	Method	Column	N	R^2	p	Number	90% C.L.
1SW	Ln reg'n	4 on 2	18	0.486	<.01	6,105	5,292- 7,034
1SW	Ln PDF	"	18			7,483	2,910-10,506
MSW	Ln reg'n	7 on 5&4	22	0.661	<.01	3,361	2,091- 5,401
MSW	Ln PDF	"	22			4,551	0- 15,082
MSW	Ln reg'n	"	21	0.696	<.01	3,299	2,080- 5,232
MSW	Ln PDF	"	21			4,606	0- 15,241
MSW	Ln reg'n	8 on 5&4	21	0.725	<.01	3,785	2,415- 5,932
MSW	Ln PDF	"	21			4,362	1,322-16,786

Table 5. Tag recoveries from non-maturing 1SW salmon in distant fisheries and 2SW salmon in homewaters; estimates of the raising factor for Saint John River 2SW returns in the absence of insular Newfoundland commercial fisheries and estimates of MSW returns in the absence of the Newfoundland fishery.

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Smolt year	2S retn year	No. tag recoveries in smolt year + 1 Nfld	Labr	Grnl	Grnl tag rept rate	No. 2SW tags recov'd at home	Raise fact for home 2SW rtns to inc Nfld	Home 2SW returns(a)	Home 2SW returns + gain fr Nfl (7/6)	Gain fr Nfld (8-7)	MSW rtn inc. Nfld [Tab4(7)+ Tab5(9)]
1970	1972	2	0	12	0.8	14	0.8478	4,595	5,421	825	5,724
1971	1973	3	1	19	0.8	116	0.9685	2,362	2,439	77	2,595
1972	1974	3	0	16	0.7	32	0.8946	5,090	5,690	600	6,411
1973	1975	31	4	93	0.8	156	0.8001	6,972	8,714	1,742	9,183
1974	1976	23	5	23	0.9	60	0.6748	7,752	11,487	3,736	11,913
1975	1977	21	8	41	0.5	160	0.8584	8,216	9,572	1,356	11,068
1976	1978	44	11	7	0.6	127	0.6966	3,711	5,328	1,616	5,637
1977	1979	24	5	23	0.5	120	0.7991	2,184	2,733	549	3,303
1978	1980	19	7	86	0.6	316	0.9297	10,050	10,810	760	11,684
1979	1981	66	7	31	0.5	337	0.8023	5,259	6,554	1,296	7,062
1980	1982	8	3	23	0.5	120	0.9226	4,843	5,249	406	5,934
1981	1983	7	3	13	0.6	64	0.8798	5,517	6,271	754	6,537
1982	1984	8	2	1	0.8	56	0.8478	9,495	11,201	1,705	11,484
1983	1985	6	0	3	0.8	40	0.8413	10,071	11,970	1,899	12,335
1984	1986	9	1	8	0.8	38	0.7706	5,626	7,300	1,675	7,803
1985	1987	3	2	14	0.8	53	0.9336	3,995	4,279	284	4,636
1986	1988	17	3	17	0.8	36	0.6275	2,538	4,045	1,507	4,132
1987	1989	0	0	8	0.8	14	1.0000	3,897	3,897	0	4,072
1988	1990	4	2	3	0.8	15	0.7489	2,996	4,001	1,004	4,333
1989	1991	0	0	5	0.8	11	1.0000	4,248	4,248	0	4,491
1990	1992	0	0	4	0.8	11	1.0000	3,962	3,962	0	4,104
						Mean, 1985-92 =	0.8652				

where: Nfld tag rept rate= 0.7
Labr tag rept rate = 0.9
Survival home = 0.88
Tag retention= 0.9
Nfld/Lab n-ctch surv 0.9
Grnl non-ctch surv= 0.8

(a) - Marshall 1994

Table 6. Forecasts of hatchery 1SW and MSW returns to Mactaquac, Saint John River, 1993, as estimated from numbers of various juveniles released at (At), above (Abv) or below (Bl) Mactaquac and estimated return rates.

Release				Returns in 1993			
Year	Loc.	Stage	Number	Rate	Age	1SW	MSW
1992	At	1-yr smolt	204,836[a]	0.0064[f]	1.1	1,311	
1992	Bl[a]	1-yr smolt(Nashw)	13,645	0.0064 @ 0.21[e]	1.1	18	
1990	Abv	Fall fing.	219,314[c]	0.0010[h]	2.1	219	
1990	Abv	Unfed/fry	314,007[cg]	0.0005?	2.1	157	
1989	Abv	Fall fing.	398,691	0.0003[h]	3.1	120	
1989	Abv	Unfed/fry	528,978[fg]	0.0001?	3.1	79	
1991	At	1-,2-yr smolt	178,127[a]	0.0029[f]	1-,2.2		517
1991	Bl[a]	1-yr smolt	37,106	0.0029 @ 0.21[e]	1.2		23
1991	Abv	1-,2-yr smolt	49,836[b]	0.0010[h]	1-,2.2		75
1990	Abv	1+ parr (SALEN)	9,900		2.2		10
1989	Abv	Fall fing.	398,691[d]	0.0002[h]	2.2		80
1989	Abv	Unfed/fry	528,978[dg]	0.0001?	2.2		53
1988	Abv	Fall fing.	906,039[c]	0.0001[h]	3.2		91
1988	Abv	Unfed/fry	209,882[cg]	0.0000?	3.2		10
		Repeat spawners		0.03			46
Totals						1,904	905

[a] Mactaquac origin, only; 1991 inc. two groups of CWT Ad-clipped fish.

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

[e] Marshall 1990, App. 5, 1SW = mean of 1984-1989, 1991-'92 ratios; MSW = mean of 2SW 1985-1990 and 1992.

[f] Arcsine mean of last 5- and 6-year adjusted return rates, App 4.

[g] Not distinguishable from wild smolts.

[h] Assumed on basis of rates estimated in recent years.

Table 7. Estimated river returns of Saint John River wild and hatchery 1SW and MSW salmon destined for Mactaquac Dam, 1970-1992.

	Wild		Hatchery		Total	
Year	1SW	MSW	1SW	MSW	1SW	MSW
1970	3,057	5,712				
1971	1,709	4,715				
1972	908	4,899				
1973	2,070	2,518				
1974	3,656	5,811				
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	1,541	796	8,804	4,125
1991	6,256	4,491	2,495	724	8,751	5,215
1992	6,683	4,104	2,257	794	8,940	4,898

Table 8. 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, 1970-1992.

	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

(a)- Kingsclear, 1974-88, Tobique 1988-90, Kingsclear, St. Mary's, Oromocto and Tobique in 1991-92.

(b)- NBDNRE and DFO sources.

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

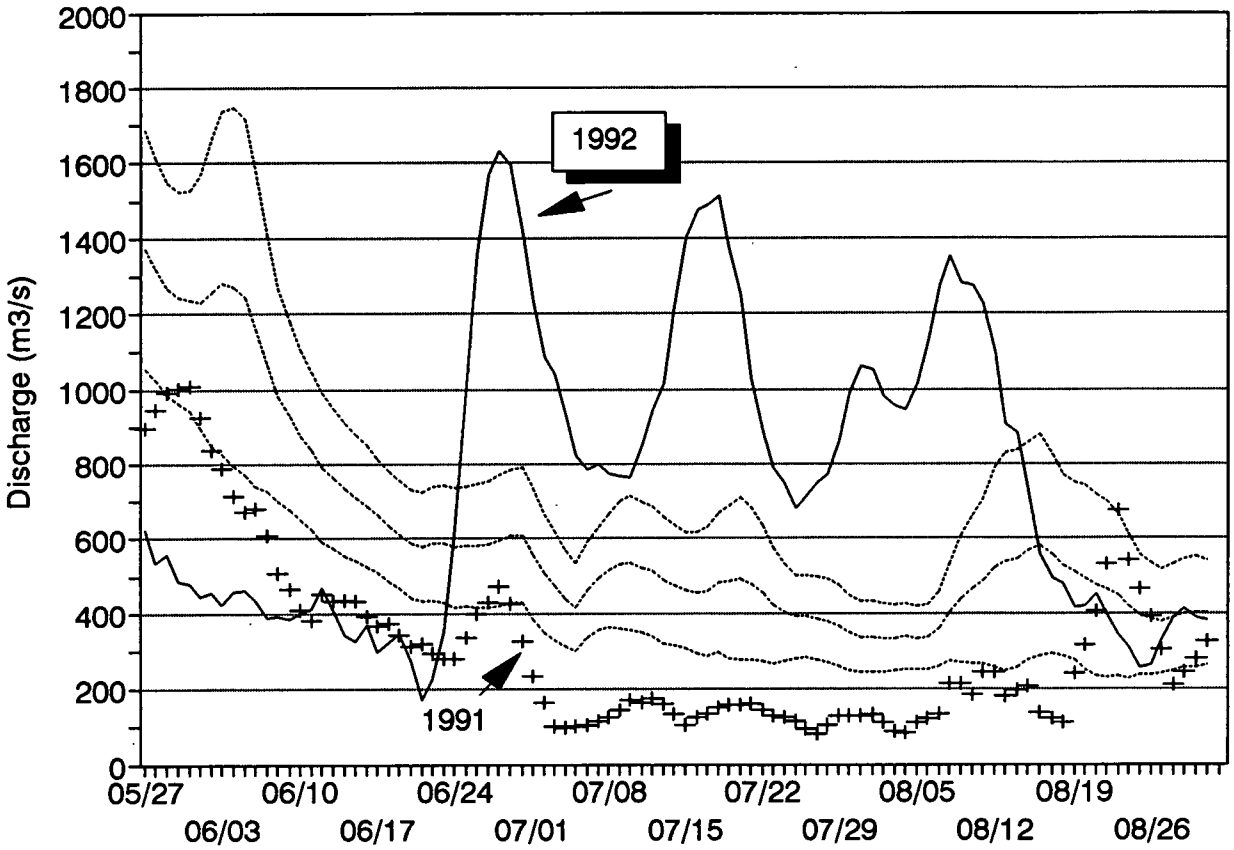

Fig. 1. Five-day moving averages of mean daily Saint John River discharge at Mactaquac, June through August,1992, (solid line), 1991 (++ line) and mean +/- 95% C.L. for daily discharges, 1972-1990 (dashed lines).

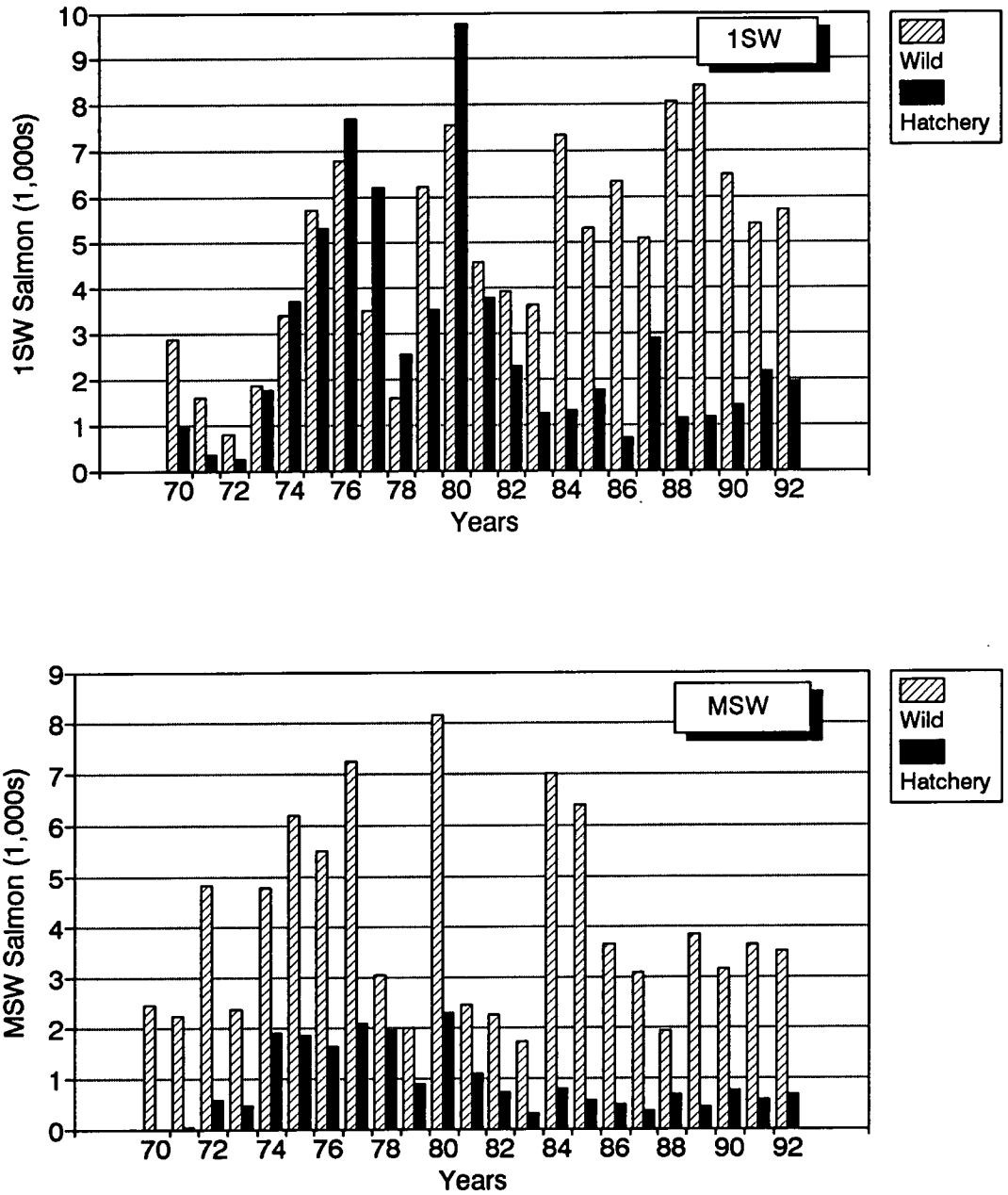

Fig. 2. Counts of wild and hatchery 1SW and MSW salmon at Mactaquac, 1970-1992.

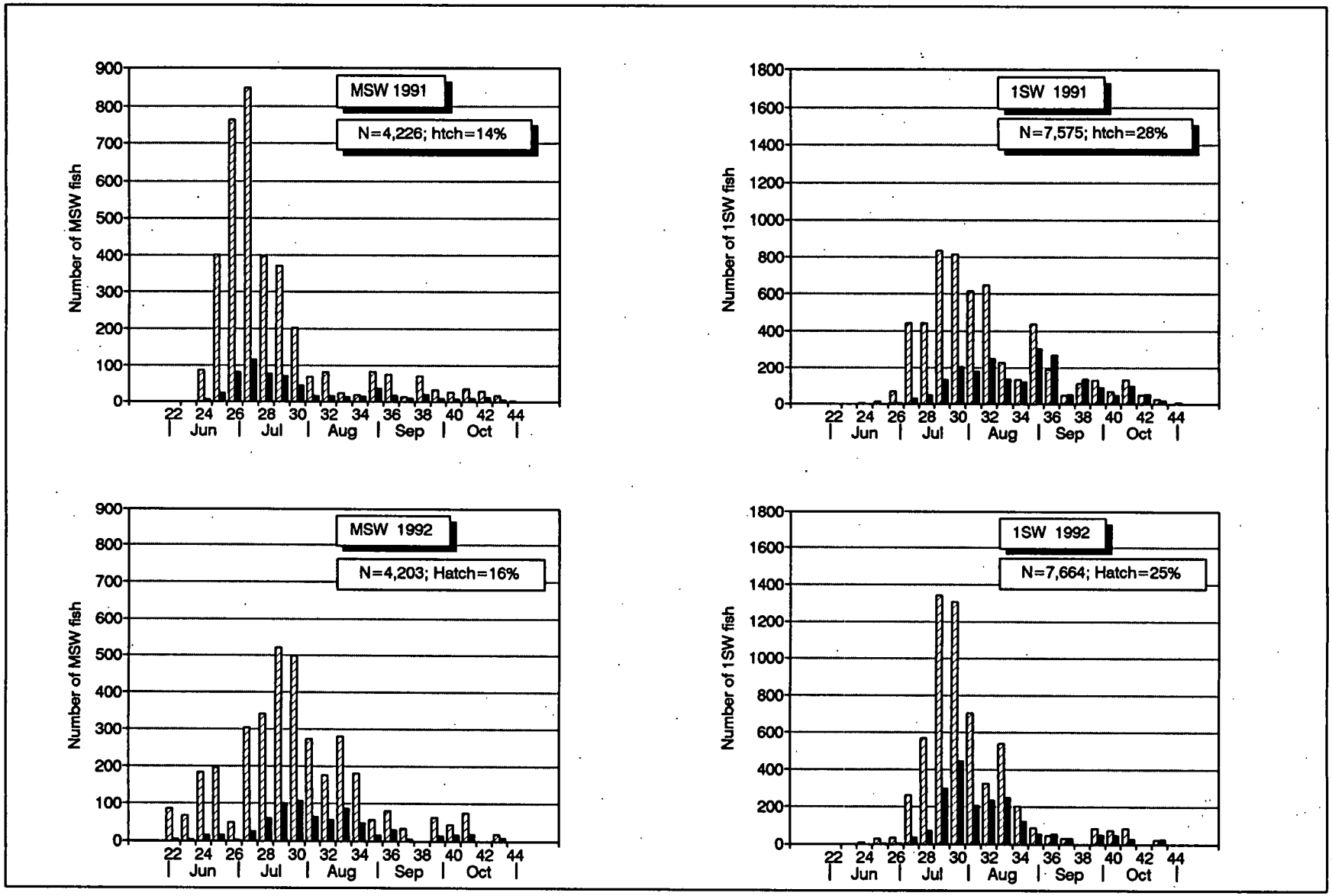

Fig. 3. Weekly counts of wild (cross hatch) and hatchery (solid) 1SW and MSW salmon at the Mactaquac sorting facilities in 1991 (above) and 1992 (below).

App. 1. Number of eggs/100^2 deposited in the Tobique River, 1968-1989, and derivation of weighted number of eggs contributing to annual returns of wild 1SW fish at Mactaquac, 1973-1990 and 1993 (explanation in Marshall and Penney 1984; revisions per Marshall 1993).

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						
1988	137.3						
			0.553		75.93		
1989	185.5	0.447		82.92		158.85	(1993)

(a) Derived from App.2 and 3.
Underscored value is mean of last 10 years (angular transformation).

App. 2. Number of wild 1SW salmon and proportion of age 2:1 of the total of all ages that would have returned to Mactaquac for the 1969-1987 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	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			
1989	3,199				

Year-classes 1976-80 revised, Marshall (1993).

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, 1978-1992.

Fresh-water age	Number of 1SW fish													
	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
A														
2	3,166	2,214	1,280	794	2,348	4,140	1,264	3,196	2,513	5,066	3,922	2,646	2,728	2,743
3	2,974	4,986	2,861	2,902	1,264	3,132	3,913	3,001	2,349	2,930	4,217	3,580	2,555	2,859
4	94	355	430	236	11	81	144	150	233	66	278	260	122	127
5								5					10	
6								5						
Total	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	5,729
B														
2	3,468	2,486	1,852	1,045	2,952	4,679	1,548	3,980	2,915	5,612	4,437	2,963	3,151	3,199
3	3,257	5,598	4,140	3,819	1,589	3,540	4,790	3,737	2,724	3,245	4,771	4,009	2,952	3,336
4	103	398	622	310	14	91	176	187	270	73	314	291	141	148
5								6					12	
6								6						
Total	6,828	8,482	6,614	5,174	4,555	8,311	6,526	7,904	5,909	8,930	9,522	7,263	6,256	6,683

1981-83 adjusted (Marshall, 1993).

App. 4. Estimated total number of 1SW and MSW returns to the Saint John River from hatchery-reared smolts released at Mactaquac, 1974-1992. (inc. potential sea-cage fish numbering 8, 56 and 34 of age 1.1 and 221, 24 and 16 of age 1.2 in 1990, 1991 and 1992, respectively).

Releases			Returns (1SW/MSW)									
			Mactaquac								% return	
Year	Smolts	Prop 1-yr	Year	Mig ch	Dam	Native fishery	Angled main SJ	By-catch	Commer-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		1,356[c]	5,627	2.423	
81	189,090	0.08	82	828	1,464	64	267		415[c]	3,038	1.607	
82	172,231	0.06	83	374	857	39	69		225[c]	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	0.405
90	241,078	0.98	91	(1,490)		88	108	35		1,721	0.714	0.676
91	178,127	0.97	92[b]	(1,123)		26	135	26		1,310	0.735	0.711
92	204,836	1.00										
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		1,262[c]	2,728	1.118	
80	232,258		82	88	640	462	181		398[c]	1,769	0.762	
81	189,090		83	44	255	76	17		712[c]	1,104	0.584	
82	172,231		84	84	722	201	5	103		1,115	0.647	0.560
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	(359)		62	0	46		467	0.196	0.186
90	241,078		92[b]	(546)		58	0	32		636	0.264	0.264
91	178,127											

[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 and MSW hatchery fish at Mactaquac were assigned an origin on the basis of freshwater age (scale reading) and fin clips, ref. App. 4, Marshall (1992).

[c] Adjusted, Marshall (1993).

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

Release				Returns in 1992			
Year	Loc.	Stage	Number	Rate	Age	1SW	MSW
1991	At	1-,2-yr smolt	178,127	0.0071	1-,2.1	1,266	
1991	Bl[a]	1-yr smolt	37,106	0.0071 @ 0.17[c]	1.1	44	
1991	Abv	1-,2-yr smolt	49,836	0.0058	1-,2.1	290	
1990	Abv	1+ parr (SALEN)	9,900	I	2.1	I	
1989	Abv	Fall fing.	398,691[d]	I0.0011	2.1	I428	
1989	Abv	Unfed/fry	528,978[d]	unknown	2.1	-	
1988	Abv	Fall fing.	906,039[b]	0.0003	3.1	229	
1988	Abv	Unfed/fry	209,882[b]	unknown	3.1	-	
1990	At	1-,2-yr smolt	241,078	0.0026	1-,2.2		636
1990	Bl[a]	1-yr smolt	48,105[d]	0.0026 @ 0.00[c]	1.2		0
1990	Abv	1-,2-yr smolt	71,403[b]	0.0008	1-,2.2		59
1989	Abv	1+ parr	9,400	I	2.2		I
1988	Abv	Fall fing.	906,093[b]	I0.0001	2.2		I69
1988	Abv	Unfed/fry	209,882[b]	unknown	2.2		-
1987	Abv	Fall fing.	145,428	0.0001	2.2		13
1987	Abv	Unfed/fry	266,257	unknown	3.2		-
		Repeats					17
Totals						2,257	794

[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. (Aroostook returns credited to release 'At', but smolts not inc. 'At')

[c] Ratio derived per App. 5, Marshall (1990).

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