Status of Saint John River, N.B. Atlantic Salmon in 1983 and Forecast of Returns in 1984

by

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Abstract

Estimated total returns to the Saint John River in 1983 were 10,778 1-SW and 9,110 M-SW salmon. Homewater removals of 4,030 1-SW and 5,532 M-SW fish led to an estimated 1983 spawning escapement only 35 percent of the target number of M-SW spawners. The forecast of 1984 homewater returns is 15,683 1-SW fish (8,050 more than the target escapement) and 10,410 M-SW salmon (10 fish more than the target escapement and hatchery broodstock requirements). Homing tendencies of the M-SW salmon to 'above' and 'below' Mactaquac origins will result in a deficit to spawning requirements of 1,528 fish 'below' Mactaquac and a surplus of 1,538 fish 'above' Mactaquac.

Résumé

On a estimé à 10 778 unibermarins (1 hiver en mer) et 9 110 redibermarins (plusieurs hivers en mer) le nombre des saumons qui sont revenus dans la rivière Saint-Jean en 1983. Des captures, dans les eaux d'origine, de 4 030 unibermarins et de 5 532 redibermarins ont conduit à une estimation de l'échappement en vue de la reproduction de seulement 35 % du nombre cible de redibermarins reproducteurs en 1983. Les prévisions de retours dans les eaux d'origine en 1984 sont de 15 683 unibermarins (soit 8 050 de plus que l'échappement cible) et 10 410 redibermarins (soit 10 poissons de plus que l'échappement cible et le nombre de géniteurs requis pour la pisciculture). Les tendances de retour des redibermarins dans les eaux d'origine en "amont" ou en "aval" du barrage de Mactaquac résulteront en un déficit de 1 528 reproducteurs en "aval" et un surplus de 1 538 poissons en "amont" de Mactaquac.

Introduction

This document is the basis of advice for managing Atlantic salmon stocks of the Saint John River, New Brunswick (CAFSAC Advisory Document 83/24)[1] and, as such, documents data and analyses relevant to both stock status (1983) and forecasts (1984).

Background

Physical attributes of the Saint John River drainage, salmon production area, barriers to migration (Fig. 1), fish collection and distribution systems and role of fish culture operations have previously been described by Marshall and Penney (MS 1983).

Saint John River salmon of both wild and hatchery origin are commercially exploited away from home in West Greenland, Newfoundland and Nova Scotia waters. In New Brunswick, Saint John River salmon stocks are harvested in the Bay of Fundy by commercial fishermen and within the Saint John River by commercial fishermen, Indian Bands and anglers.

Methods

Total River Returns, 1983

Total returns of 1-SW and M-SW salmon of both wild and hatchery origins from both 'above' and 'below' Mactaquac Dam consist of the summation of Mactaquac counts, catches by the Kingsclear Indian Band located between the Mactaquac Dam and Mactaquac Fish Culture Station, angling catches in the mainstem area immediately below the Mactaquac Fish Culture Station, commercial and by-catches and returns to tributaries below Mactaquac Dam.

Mactaquac counts consist of those fish captured at the fish collection facilities at the Mactaquac Dam and head of the smolt migration channel (MC) at the Mactaquac Fish Culture Station.

Kingsclear landings were estimated from mean exploitation rates of that fishery, 1978-1982, and counts of salmon at Mactaquac Dam (not including migration channel), 1983. Exploitation rates were derived from the numbers of tags returned from the Reserve (unadjusted for non-reporting) and from Mactaquac Dam. Tags had originally been applied to smolts of hatchery origin. Exploitation rates were therefore derived for 1-SW and M-SW salmon of hatchery origin and applied to wild salmon counted at the Dam.

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[1]Reanalysis of the data as suggested by ACFF Subcommittee and independent reviewers rendered slightly different numbers of 1-SW and M-SW salmon than appear in the Advisory Document as having returned or being harvested in 1983 and forecast to return in 1984. Advice on available harvests in 1984 remains unaffected.

Commercial catches were adjusted logbook values for Fishery Statistical Districts 48, 49, 55, 56 and 57 being prepared for inclusion in the 1983 Redbook[2]. The proportions of hatchery and wild fish were determined from sampling of the commercial fishery. Numbers of hatchery fish in the catch resulting from smolts released 'below' Mactaquac were based on the proportions of smolts released 'above' and 'below' Mactaquac. Partitioning of wild 1-SW and M-SW fish to 'above' and 'below' Mactaquac origins was based on the ratio of the total wild fish at Mactaquac + Kingsclear + the main river sport fishery to the number of hatchery fish in the same locations, and the number of hatchery fish designated as originating 'above' or 'below' Mactaquac in the commercial fishery.

Total by-catch for 1983 was assumed to equal the estimate of wild by-catch taken in 1982. Hatchery salmon were separated as a proportion equal to the ratio of all homewater hatchery returns to the sum of all wild homewater returns and hatchery returns. Division of hatchery fish to 'above' or 'below' Mactaquac origins was based on the proportion of smolts released to the respective areas which would contribute to 1-SW and M-SW returns. Division of wild fish to 'above' and 'below' origins was based on the ratio of the total wild fish at Mactaquac + Kingsclear + main river sport fishery + those designated as from 'above' in the commercial fishery, to the total wild fish designated as from 'below' in the commercial fishery + returns to tributaries below Mactaquac.

Angling catches in the main stem below Mactaquac are from unofficial estimates obtained from the New Brunswick Dept. Natural Resources. Proportions of 1-SW and M-SW fish and hatchery and wild are assumed to be the same as for the total fish counted at Mactaquac and estimated in the Kingsclear fishery.

Returns of wild salmon to tributaries 'below' Mactaquac in 1983 were based on angler harvests in the Nashwaak, Hammond and Kennebecasis rivers (estimated as the mean numbers of 1-SW and M-SW fish reported in the Provincial angling statistics, 1970-1982), derived angler exploitation rate of 0.35 (ref. forecast methods), return rates for Mactaquac hatchery smolts to Mactaquac + Kingsclear + main stem sport fishery as 1-SW and M-SW fish, numbers of smolts released to the Nashwaak, Hammond and Kennebecasis rivers (ref. footnotes, Tables 10 & 11), an expansion of Nashwaak River returns by 0.16 to account for Keswick River production area (Marshall and Penney, MS 1983) and an expansion of the Hammond + Kennebecasis returns by 0.49 to account for remaining production area 'below' Mactaquac. Total wild 1-SW or M-SW were then written as, Total = a + 0.16a + b + 0.49b where

$a = \bar{X}_{\text{Nashw. sport ctch}} \times 0.35^{-1} - (\text{hatch. smolts} \times \text{return rate})$ and

$b = \bar{X}_{\text{Ham.+Kenneb. sport ctch}} \times 0.35^{-1} - (\text{hatch. smolts} \times \text{return rate})$.

Hatchery returns to all tributaries 'below' Mactaquac were calculated as the product of the number of smolts released and the return rate for fish of Mactaquac origin returning to Mactaquac + Kingsclear + the main stem sport fishery.

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[2]Atlantic salmon Sport Catch Statistics, Maritime Provinces, annual series beginning 1970. Published by Department of Fisheries and Oceans and its precursors.

Total River Removals, 1983

Total removals include those fish to the Kingsclear Indian Reserve, mainstem sport fishery 'below' Mactaquac, Nashwaak, Hammond and Kennebecasis sport catches and the commercial and by-catch fisheries. Additional removals include hatchery- returning 1-SW fish captured in the Mactaquac collection facilities and granted to the Oromocto Indian Band, hatchery-returning fish transferred to the Aroostook River, salmon retained at Mactaquac for broodstock, mortalities encountered during collection-handling operations and some fish sacrificed for analysis. In the absence of angling statistics for the Tobique River, 1983, harvests of 1-SW and M-SW were calculated as the product of 0.19 (M-SW) or 0.24 (1-SW)(mean angler exploitation rates based on fish released to the Tobique River counted through the Tobique fishway and Provincial sport catch statistics 1977-1982) and the numbers of fish released from either the Tobique fishway trap and the tank truck into the Tobique River. Estimates of hatchery fish were based on the proportion of hatchery/wild salmon released to the fishery. Angling catches for the main stem 'above' Mactaquac are the mean of Provincial catches determined for 1979, 1981 and 1982, with hatchery proportions determined from numbers trucked to the area.

Required Spawners

An accessible salmon-producing substrate of 12,261,000 m^2 'above' Mactaquac and 15,928,000 m^2 'below', an assumed requirement of 2.4 eggs/m^2, a length- fecundity relationship ($\log_e Y = 6.06423 + 0.03605X$) applied to M-SW and 1-SW fish 1972-1982 and the 1-SW:M-SW ratios in those years suggested that, on average, approximately 4,400 and 5,700 M-SW fish are required 'above' and 'below' Mactaquac (Marshall and Penney, MS 1983). Because 1-SW fish contribute so few eggs ($\leq$ 5% female) a management philosophy was proposed that limited 1-SW requirements to that number which provided males for M-SW females unaccompanied by M-SW males, i.e., 3,200 above and 4,000 below (Marshall and Penney, op. cit.)

Stock Forecasts

a) Wild 1-SW salmon 'above' Mactaquac

The forecast of wild 1-SW returns originating 'above' Mactaquac was derived from a regression of total wild 1-SW fish returning to the Saint John River which were produced 'above' Mactaquac, 1975-1981, on adjusted egg depositions in the Tobique River, 1968-1969 to 1976-1977.

Total returns of 1-SW fish since 1970 were estimated in a manner generally similar to that of 1983. Variations elaborated upon in the following paragraphs include the derivation of specific values for Kingsclear, mainstem angling, returns to tributaries 'below' Mactaquac and 'above'/'below' designation of the adjusted Redbook values for commercial landings 1970-1971.

Counts of wild salmon to Mactaquac have been tabulated by Ingram (1980; 1984).

Estimates of sport catch in the mainstem 'below' Mactaquac have been provided by the Province in 1979, 1981 and 1982 and by the federal government,

1970-1982. To comply with usage of Provincial statistics on all tributaries, federal data, 1972-1982, were converted to Provincial equivalents by factors of 0.145^{-1} amd 0.394^{-1} for 1-SW and M-SW fish, respectively. Hatchery fish were estimated and discounted by assuming that the ratio of wild:hatchery fish was the same as at Mactaquac Dam.

Kingsclear landings, 1974-1975 and 1977-1982, were based on returns of tagged hatchery fish from that fishery and from the Dam. As in 1983, the mean rate for 1978-1982 was applied to 1976.

Commercial fish originating 'above' and 'below' Mactaquac in 1981 and 1982 were, like 1983, based on Redbook values and commercial sampling in each year. Numbers of 1-SW and M-SW fish taken in 1970 and 1971 were based on Redbooks and relative proportions of 1-SW fish (illegal) noted by Wykes (MS 1972) during sampling of salmon trap nets (12.1%) and drift nets (1.6%), 1968, 1969 and 1970. Hatchery fish in 1970 and 1971 were deducted on the basis of proportions at Mactaquac.

Estimates of by-catch were reported in the Redbooks, 1970-1982, and divided into 1-SW and M-SW fish on the basis of numbers and reported mean weights and an assumed mean weight of 2.4 kg, 6.1 kg and 10.2 kg for 1-SW, 2-SW and 3^{+}-SW fish, respectively. Hatchery fish were estimated (and deducted) as a proportion equal to the ratio of all homewater hatchery returns to the sum of all wild homewater returns and hatchery returns. Separation to 'above'/'below' categories was the same as in 1983.

Derivation of returns to tributaries below Mactaquac (required to proportion 'above' Mactaquac returns in early-commercial and by-catch) was, in general, similar to that described for 1983 except that returns to the Nashwaak River, 1970-1982, were for each year the total of Provincial angling statistics and estimated spawning escapement. Smolts of hatchery origin were first introduced in 1981 and thus first returns in 1982 were removed in a fashion similar to 1983. Introductions of hatchery underyearlings particularly in 1971 and 1976-1978 (Francis, 1980) were assumed to have neither contributed to hatchery returns nor biased juvenile densities determined by electroseining.

Estimates of spawning escapement in the Nashwaak River, 1970-1978 and 1980-1982, were based on a relationship between egg deposition and resultant fry density established for the Tobique River for the egg-deposition-years 1969-1978 and 1980-1982 and on the similarity of both the estimated egg deposition and resultant fry densities in the Nashwaak River, 1972-1973 and 1973-1974. The 1972 and 1973 estimates of egg deposition were based on counts at the Nashwaak River fence, Nashwaak angler returns of tags applied in the Bay of Fundy and at Westfield and subsequently captured by anglers on the Nashwaak and Provincial angling statistics for the Nashwaak River.

Returns in 1970, 1971, 1974-1978 and 1980-1982 were estimated by substituting mean fry densities for eight sites on the Nashwaak River into a transposed Tobique egg-on-fry relationship, exclusive of the 1980-1981 value and solving for egg deposition. The eggs were then used to reconstruct the spawning populations on the assumption that the sport catch represented the 1-SW:M-SW

ratio in the escapement, that the sex ratio of each sea-age was adequately represented by the mean of data collected at the fence in 1972-1973 and in 1974 at Westfield (but recaptured by anglers in the Nashwaak River) and that the egg-carrying capacity of females was the same as for females at Mactaquac (Marshall and Penney, MS 1983). Escapement plus sport catch provided total returns to the Nashwaak River. Exploitation rates were the proportion that the reported angling catch was of the estimated escapement plus angling. The 12-year mean exploitation rate was used with the sport catch in 1979 and, as earlier mentioned, 1983 to derive the number of returns to the Nashwaak River in those years. As well, this exploitation rate was used with the sport catches for the Hammond and Kennebecasis rivers to derive their respective escapements.

Summation of all returns on the basis of 'above' or 'below' Mactaquac origins allowed the final proportioning of by-catch into 'above' and 'below' origins and the final summation of fish originating 'above'/'below' Mactaquac.

The 1984 forecast of wild 1-SW returns to homewaters which originated above Mactaquc was based on the regression of estimated 1-SW returns to Mactaquac, 1973-1981, on adjusted egg depositions in the Tobique River, four and five years previous. 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) $\bar{Y}$ resultant of the logarithm 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 variates (Ricker, 1975, p.274).

The adjusted egg depositions on the Tobique River used to forecast 1-SW returns 'above' Mactaquac were derived in the following manner. Scales of wild 1-SW fish sampled at Mactaquac, 1972-1983 ($n \simeq 190$/year), were read to determine their freshwater age. The proportion of each age was then used to estimate the age composition of the 1-SW fish counted at Mactaquac and the estimated total homewater returns of 1-SW fish destined for Mactaquac. These fish were then accorded to their respective year-classes for derivation of proportions of age 2:1's and 3^+:1's which were in turn used to adjust the estimated egg depositions in the Tobique River, 1968-1977, to the number of eggs which contributed to those grilse returns in each of the years 1973 through 1981. Adjustment of the 1979 and 1980 egg depositions, principal contributors to 1-SW returns in 1984, was done with the use of angular-transformed mean proportions for age 2:1's and age 3^+:1's in the year-classes, 1969-1978 (n=10).

b) Wild M-SW salmon 'above' Mactaquac

The 1984 forecast of M-SW returns to homewaters which originated 'above' Mactaquac was based on the regression of the estimated M-SW returns to Mactaquac 1976-1983 on the estimated numbers of 1-SW fish originating 'above' Mactaquac and returning to the Saint John River in the previous year. As in the forecasting of 1-SW salmon, analyses included the use of natural logarithms and conversion of the GM to AM.

c) Wild 1-SW salmon 'below' Mactaquac

The 1984 return to homewaters of 1-SW fish which originated 'below' Mactaquac was estimated from the regression of the estimated numbers of 1-SW fish originating 'below' Mactaquac on the estimated number of 1-SW fish originating 'above' and returning to Mactaquac in the same years. Because the data were independent of each other, they were not transformed.

d) Wild M-SW salmon 'below' Mactaquac

The 1984 return to homewaters of M-SW salmon which originated 'below' Mactaquac was based on the 1984 estimate for 'above' Mactaquac and the mean proportion of the total M-SW fish which were produced 'below' Mactaquac, 1970-1983.

e) Hatchery returns

Forecasts of hatchery returns in 1984 were derived by applying an average return rate for smolts returning as 1-SW fish, 1975-1983, and for smolts returning as M-SW fish, 1976-1983, to the number of smolts released in 1983 and 1982 respectively. Designation of returning hatchery fish to 'above' or 'below' Mactaquac origins in 1982 was as for 1983.

Results

Total River Returns, 1983

Estimated homewater returns in 1983 totalled 10,778 1-SW fish (5,753 originating 'above' and 5,025 originating 'below' Mactaquac) and 9,110 M-SW fish (4,012 originating 'above' and 5,098 originating 'below' Mactaquac)(Table 1). Hatchery returns comprised 19.7 percent and 8.6 percent of the total 1-SW and M-SW returns, respectively.

Counts at Mactaquac were 84.4% of the 1-SW and 50.1% of the M-SW fish estimated to have originated at or above Mactaquac (Table 1).

Landings of 203 1-SW and 588 M-SW fish were estimated as the product of the respective 0.0433 and 0.2301 exploitation rates for hatchery fish at Kingsclear, 1978-1982 (Table 2), and counts of 3,620 wild and 857 hatchery 1-SW fish and 1,712 wild and 255 hatchery M-SW fish at Mactaquac Dam (exclusive of the migration channel counts).

Sampling of the commercial fishery in 1983 (n=150 1-SW and 972 M-SW fish) revealed that 9.3 percent and 6.5 percent of 1-SW and M-SW fish respectively, were marked (Table 3). Accounting for unmarked hatchery fish and location of smolt releases with respect to 'above' or 'below' Mactaquac (Table 3) it was estimated that the 1983 commercial landings consisted of 140 hatchery 1-SW fish of which 95 came from 'above' and 45 from 'below' Mactaquac and 224 M-SW fish of which 166 came from 'above' and 58 from 'below' Mactaquac (Table 4). Wild fish numbered 1,091 1-SW and 2,651 M-SW salmon (Table 1). Proportioning (Table 5) indicated that 283 and 808 1-SW wild fish were of 'above' and 'below' origins respectively and that 986 and 1,665 M-SW wild fish were of respective 'above' and 'below' Mactaquac origins.

Total by-catch in 1983 was assumed to equal 79 1-SW and 332 M-SW fish (Table 1). Mainstem angling yielded an estimated 276 1-SW and 115 M-SW fish. Hatchery composition was assumed to be proportionate to the combined Mactaquac count and Kingsclear catch.

Returns to tributaries below Mactaquac were based on an estimated angler harvest of 884 1-SW and 680 M-SW fish in the Nashwaak River (Table 6). Expansion to all tributaries 'below' Mactaquac (see Table 11) and allowance for hatchery smolts released 'below' Mactaquac in 1981-1982 provided an estimated return of 3,507 wild and 628 hatchery 1-SW fish and 3,050 wild and 139 hatchery M-SW fish (Table 1).

Total River Removals, 1983

Total river removals, already established as a major component of the estimated returns, numbered 4,030 1-SW and 5,532 M-SW fish (Table 6). The totals were comprised of nearly equal proportions of fish originating 'above' and 'below' Mactaquac. Hatchery fish comprised 17.9 percent of 1-SW removals and 10.4 percent of the M-SW fish. The commercial and by-catch fisheries together accounted for 3,189 fish or 58 percent of the M-SW harvest and 1,310 fish or 33 percent of the 1-SW fish. The estimated angling catch was 1,409 M-SW salmon and 2,389 1-SW fish. Kingsclear Indian Reserve took an estimated 588 M-SW and 203 1-SW salmon. Mactaquac broodstock collections numbered 322 M-SW fish.

Spawning Escapement, 1983

Collation of the total returns (Table 1), total removals (Table 6) and numbers of fish required to meet an egg deposition of 2.4 eggs/m^2 indicates that only 29 percent and 40 percent of the required M-SW spawners for 'above' and 'below' Mactaquac, respectively, were attained (Table 7). For 1-SW fish, 117 percent of requirements were met 'above' Mactaquac; 68 percent of requirements were met 'below' Mactaquac.

Stock Forecasts

a) Wild 1-SW salmon above Mactaquac

The 1984 forecast of wild 1-SW fish returning to Mactaquac in the absence of homewater removals was based on the regression of returns to homewaters of 1-SW fish which originated above Mactaquac on estimated Tobique River egg depositions adjusted for smolt age (Table 8). The log transformed equation provided an AM estimate for 1984 of 6,616 fish (95% C.L. 4,388-9,978).

The data used in the regression are the result of significant analytical and estimation procedures. Although basically the summation of Mactaquac counts, estimates of Kingsclear harvest and main stem sport fishery the estimates of 1-SW returns to Mactaquac required inclusion of the 1-SW fish destined for 'above' but which were removed in the commercial and by-catch fisheries. These fish were differentiated on the basis of estimated 'above':'below' productions which in turn required estimates of 1-SW (and later M-SW) production or returns to tributaries 'below' Mactaquac.

Estimation of returns to tributaries 'below' Mactaquac was founded on the evidence that egg depositions (determined in 1972-1973 from fence and Provincial angling data) of 120.2 and 303.5/100 m^2 and resultant fry densities of 22.0 and 33.86/100 m^2 were within the range of fry-on-egg data for the Tobique River (Fig. 2). Subsequently the Tobique data ($\log_e$ Y eggs = 0.9041 $\log_e$ fry + 2.4276 (n=12, r=0.93 $p < 0.001$) were used to predict Nashwaak River deposition to range from 4.5 x 10^6 eggs in 1971 to 15.7 x 10^6 eggs in 1978 (Table 9). Eggs, Provincial angling data, biological characteristics (Marshall and Penney, MS 1983) and fence data permitted derivation of total Nashwaak River returns. These ranged from 1,205 to 3,756 1-SW fish in 1972 and 1981, respectively, and 650 to 3,456 M-SW fish in 1979 and 1973, respectively (Table 10). Angler exploitation rates ranged from 0.20 in 1974 to 0.52 in 1982 and averaged 0.35 over the 12 years. Wild salmon returns to the Kennebecasis and Hammond rivers were estimated to have ranged from 15 to 1,446 1-SW fish in 1972 and 1976, respectively, and 57 to 2,177 M-SW fish in 1972 and 1977, respectively (Table 11). Expansion of the returns for Nashwaak, Hammond and Kennebecasis rivers to include all tributaries below Mactaquac provided estimates which range from 1,420 to 6,456 1-SW and 1,060 to 6,217 M-SW fish between the years 1970 and 1983.

Summation of all wild returns into either 'above' or 'below' Mactaquac categories permitted the final proportioning of by-catch and 1970-1971 commercial landings (Table 12). Total wild river returns, 1970-1983, averaged 8,510 1-SW and 9,923 M-SW fish. Over the same years 53 percent and 58 percent of the total 1-SW and M-SW production respectively are attributable to origins above Mactaquac. The remaining 47 percent and 42 percent of 1-SW and M-SW were produced below Mactaquac.

The adjusted egg depositions used in the 1984 forecast of 1-SW salmon were based on freshwater age of 1-SW fish sampled at Mactaquac, 1972 to 1983, and their expansion to total counts and estimated returns (Table 13). Assignment of the estimated returns to their respective year-classes indicated that the proportion of returning 1-SW fish which smoltified at age 2 ranged from 0.114 for the 1975 year-class to 0.619 for the 1973 year-class (Table 14). Proportions relevant to the 1984 forecasts were estimated by the 10-year average proportion of 0.347 age 2 and 0.653 age 3^+ smolts (Table 15). Calculated adjusted egg deposition ranged from 0.24 eggs/m^2 in 1968-1969 to 3.72 eggs/m^2 in 1974-1975.

b) Wild M-SW fish 'above' Mactaquac

Based on the regression $\log_e Y = 1.5741 + 0.08217 \log_e X$ (n=8, r=0.80, p=0.017) the 4,308 1-SW returns in 1983 (X) provide a forecast of 4,896 M-SW fish (95% C.L. 3,586-6,687) originating above Mactaquac which will return to homewaters in 1984 (Table 8).

c) Wild 1-SW fish 'below' Mactaquac

Regression of the estimated returns of 1-SW fish 'below' Mactaquac on the number of 1-SW returns 'above' Mactaquac, 1970-1983, (data from Table 12)

resulted in the equation Y = 2199.61 + 0.4103 X; r=0.68; p=.01. Solving 'Y' for an 'X' value of 6,616 1-SW fish to Mactaquac in 1984, yielded an estimate of 4,914 1-SW fish (95% C.L. 4,016-5,812) destined for tributaries 'below' Mactaquac.

d) Wild M-SW fish 'below' Mactaquac

Based on an average 42 percent of total Saint John River M-SW production originating below Mactaquac (Table 12) and the 1984 forecast of 4,896 M-SW fish to Mactaquac, the number of wild M-SW fish originating 'below' Mactaquac was estimated at 3,545 (4,896 (0.42)/0.58).

e) Hatchery returns

The average percentage returns to homewaters of smolts released at Mactaquac 1974-1982 and 1974-1981 as 1-SW and M-SW fish respectively were estimated at 2.149 percent and 0.779 percent (Table 16). Application of these return rates to smolts released at/ 'above' and 'below' Mactaquac provided forecasts of 3,106 and 1,047 1-SW fish to Mactaquac and 'below' Mactaquac respectively and 1,342 and 627 M-SW fish to Mactaquac and 'below' Mactaquac respectively (Table 16).

Forecast Summary

The forecast of total homewater returns (Table 17) to the Saint John River in 1984 is 15,683 1-SW (11,530 of wild and 4,153 of hatchery origin) and 10,410 M-SW fish (8,441 of wild and 1,969 of hatchery origin). For the total Saint John River the forecast returns minus the spawning requirements results in a surplus of 8,083 1-SW and 10 M-SW salmon. However, separation to 'above' and 'below' Mactaquac origins indicates a surplus over target escapements of 6,522 1-SW and 1,538 M-SW salmon for the former compared to a surplus of 1,561 1-SW fish and a deficit of 1,528 M-SW in the latter.

Discussion

Total estimated river returns in 1983 of 8,655 wild 1-SW and 8,326 wild M-SW fish were 2 percent above and 16 percent below the respective 14-year averages. The previous lows in 1978 and 1979, respectively, (43 percent and 60 percent below the average) were the result of the 1977 smolt-class (Table 12). Return rates for 1-SW and M-SW fish of hatchery origins were both only 39 percent of the respective 9- and 8-year averages (Table 16). These values for hatchery returns continued a 3-year downward trend and were the lowest for smolt-classes from Mactaquac since 1974.

Estimated removals by sport fishing in 1983 were also below the 1969-1982 average and the lowest since returns from the 1977 smolt-class (Table 18).

The commercial fishery, as in 1981 and 1982, operated under both reduced seasons and yearly quotas, i.e.,

1983 - Quota 3,700 salmon; 6,450 grilse
Season: July 4-29
with 1-week extension in Saint John Harbour
1982 - Quota 3,700 salmon; 6,450 grilse
Season: July 5-30.
1981 - Quota 6,000 salmon; 8,000 grilse
Season: River - June 7-July 31
Harbour and Bay - June 7-19, July 6-31

Removals reported by Smith (MS 1969) and in the Redbooks and proportioned into numbers of 1-SW (illegal) and M-SW fish (1949-1971) using 1-SW catch proportions of 1.6 percent in drift nets and 12.1 percent in trap nets (Wykes, MS 1972) and average weights of 2.4 kg/1-SW, 6.1 kg/2-SW and 10.2 kg/3+-SW are summarized in Table 19. Landings of 19 t are similar to the 1969-1971 levels which prompted the ban on commercial fishing. Low total returns in 1983 appear to be real - i.e., they are not the result of under/non-reporting in the various fisheries. The causes are, however, singularly unclear but implicate both the potential for the low smolt production from low returns of M-SW fish in 1979 and low sea-survival suggested by hatchery smolts.

The 1984 forecast return of 10,410 M-SW salmon (the key component of egg deposition) exceeds requirements by only 10 fish. Removals in 1984, equivalent to those of 1983 (61 percent of returns) would result in a spawning escapement only 39 percent of that required. Clearly, approaching spawning requirements in 1984 will be dependent on a significant reduction in the removals of M-SW fish.

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Table 1. Estimated total returns of wild and hatchery 1-SW and 2-SW and older (M-SW) salmon originating 'above' and 'below' Mactaquac Dam to the Saint John River, N.B., 1983.

Sea-age	Components	Number of fish								
		Origin above Mactaquac			Origin below Mactaquac			Total		
		Wild	Hatch.	Total	Wild	Hatch.	Total	Wild	Hatch.	Total
1-SW										
	Mactaquac counts	3,623	1,231	4,854	-	-	-	3,623	1,231	4,854
	Kingsclear catch	164	39	203	-	-	-	164	39	203
	Angled MS below Mactaquac	207	69	276	-	-	-	207	69	276
	Commercial fishery	283	95	378	808	45	853	1,091	140	1,231
	By-catch	31	11	42	32	5	37	63	16	79
	Returns to tribs. below Mactaquac	-	-	-	3,507	628	4,135	3,507	628	4,135
	Totals	4,308	1,445	5,753	4,347	678	5,025	8,655	2,123	10,778
M-SW										
	Mactaquac counts	1,712	299	2,011	-	-	-	1,712	299	2,011
	Kingsclear catch	512	76	588	-	-	-	512	76	588
	Angled MS below Mactaquac	98	17	115	-	-	-	98	17	115
	Commercial fishery	986	166	1,152	1,665	58	1,723	2,651	224	2,875
	By-catch	125	21	146	178	8	186	303	29	332
	Returns to tribs. below Mactaquac	-	-	-	3,050	139	3,189	3,050	139	3,189
	Totals	3,433	579	4,012	4,893	205	5,098	8,326	784	9,110

Table 2. Tag recoveries from 1-SW and M-SW salmon of hatchery origin taken at Mactaquac Dam and Kingsclear, 1976-1982.

	1-SW			M-SW		
	No. tag returns		Exploit.	No. tag returns		Exploit.
Year	Mact. Dam	Kingscl.	rate	Mact. Dam	Kingscl.	rate
1976	271	0	0.0	74	0	0.0
1977	252	2	0.0079	109	13	0.1066
1978	109	3	0.0268	94	20	0.1754
1979	300	11	0.0354	71	20	0.2198
1980	838	42	0.0477	197	50	0.2024
1981	185	9	0.0464	126	33	0.2076
1982	92	4	0.0417	54	39	0.4194
1978-1982	1524	69	0.0433	542	162	0.2301

Table 3. Derivation of the proportions of hatchery fish in the Saint John River commercial fishery, 1981-1985, which originated at/'above' and 'below' Mactaquac.

Year i	Smolt releases				Hatchery fish in commercial fishery				Source of hatchery fish			
					Obs. % marked[a]		Est. % marked[b]		% at/above Mact.		% below Mact.	
	At/above Mact.	Below Mact.		%	Year	Year	Year	Year	Year	Year	Year	Year
	Marked	Marked	Unmarked	Marked	i+ 1	i+ 2	i+1	i+2	i+ 1	i+ 2	i+ 1	i+ 2
1979	244,012	-	-	100.0	-	16.7	-	16.7	-	100	-	0
1980	232,258	-	-	100.0	34.5	4.3	34.5	4.3	100	100	0	0
1981	189,090	24,518	41,600	83.7	13.0	6.5	15.5	7.8	74.1	74.1	25.9	25.9
1982	172,231	35,519	45,016	82.2	9.3	-	11.3	-	68.1	68.1	31.9	31.9
1983	144,549	48,706	-	100.0	-	-	-	-	74.8	74.8	25.2	25.2

[a] sampling in commercial fishery.

[b] % marked in commercial fishery/% of smolts marked.

Table 4. Estimated numbers of 1-SW and M-SW fish of wild and hatchery origins harvested in the Saint John River commercial fishery, 1981-1983.

	Commercial landings						No. hatchery fish by origin			
	Total[a]		% Hatchery[b]		No. hatchery/wild		At/above Mactaquac[c]		Below[c]	
Year	1-SW	M-SW	1-SW	M-SW	1-SW	M-SW	1-SW	M-SW	1-SW	M-SW
1981	1,115	5,982	34.5	16.7	385/ 730	999/4,983	385	999	-	-
1982	1,754	2,550	15.5	4.3	272/1,482	110/2,440	202	110	70	-
1983	1,231	2,875	11.3	7.8	140/1,091	224/2,651	95	166	45	58

[a]Redbook values.

[b]Estimate based on sampling program for Adipose clips and known proportion of hatchery smolts which were marked (see Table 3).

[c]Product of the number of hatchery fish in the commercial fishery (this table) and the proportion of smolt releases contributing to that age-class which was released either at or 'below' Mactaquac (see Table 3).

Table. 5. Derivation of the numbers of 1-SW and M-SW wild fish originating 'above' and 'below' Mactaquac on the Saint John River, 1981-1983.

Sea-age	Year	No. fish at Mact., Kingscl., Angled MS (Total) Wild				Hatchery				Ratio W:H	No. hatchery fish design. 'Above'[a]	No. wild fish Above[b]	No. wild fish Below[c]
1-SW													
	1981	4,571	222	428	(5,221)	3,782	139	350	(4,271)	1.222:1.0	385	470	260
	1982	3,932	171	466	(4,569)	2,292	64	267	(2,623)	1.742:1.0	202	352	1,130
	1983	3,623	164	207	(3,994)	1,231	39	69	(1,339)	2.983:1.0	95	283	808
M-SW													
	1981	2,441	639	282	(3,362)	1,089	252	125	(1,466)	2.293:1.0	999	2,291	2,692
	1982	2,262	1,626	592	(4,480)	728	462	181	(1,371)	3.268:1.0	110	359	2,081
	1983	1,712	512	98	(2,322)	299	76	16	(391)	5.939:1.0	166	986	1,665

[a]Table 4.

[b]ratio x hatchery designated 'above'.

[c]Total wild fish (Table 1) minus no. wild fish 'above'.

Table 6. Estimated homewater removals of 1-SW and M-SW salmon originating 'above' and 'below' Mactaquac Dam on the Saint John River, N.B., 1983.

Sea-age	Components	Number of fish								
		Origin above Mactaquac			Origin below Mactaquac			Total		
		Wild	Hatch.	Total	Wild	Hatch.	Total	Wild	Hatch.	Total
1-SW										
	Kingsclear Indians	164	39	203	-	-	-	164	39	203
	Oromocto Indians	0	75	75	-	-	-	0	75	75
	Commercial fishery	283	95	378	808	45	853	1,091	140	1,231
	Angled									
	Tobique River	417	105	522	-	-	-	417	105	522
	Mainstem above Mact.	344	123	467	-	-	-	344	123	467
	Mainstem below Mact.	207	69	276	-	-	-	207	69	276
	Nashwaak River	-	-	-	835	49	884	835	49	884
	Hammond River	-	-	-	84	33	117	84	33	117
	Kennebecasis River	-	-	-	89	34	123	89	34	123
	Trucked to Aroostook R.	0	34	34	-	-	-	0	34	34
	Mortalities, etc.	13	6	19	-	-	-	13	6	19
	By-catch	31	11	42	32	5	37	63	16	79
	Totals	1,459	557	2,016	1,848	166	2,014	3,307	723	4,030
M-SW										
	Kingsclear Indians	512	76	588	-	-	-	512	76	588
	Commercial fishery	986	166	1,152	1,665	58	1,723	2,651	224	2,875
	Angled									
	Tobique River	220	17	237	-	-	-	220	17	237
	Mainstem above Mact.	148	14	162	-	-	-	148	14	162
	Mainstem below Mact.	98	17	115	-	-	-	98	17	115
	Nashwaak River	-	-	-	665	15	680	665	15	680
	Hammond River	-	-	-	128	11	139	128	11	139
	Kennebecasis River	-	-	-	70	6	76	70	6	76
	Hatchery broodfish	155	167	322	0	0	0	155	167	322
	Mortalities, etc.	5	1	6				5	1	6
	By-catch	125	21	146	178	8	186	303	29	332
	Totals	2,249	479	2,728	2,706	98	2,804	4,955	577	5,532

Table 7. Estimated homewater returns, removals and spawning escapement of 1-SW and M-SW salmon originating 'above' and 'below' Mactaquac Dam, Saint John River, 1983.

Sea-age	Category	Numbers of fish: Origin above Mactaquac Wild	Origin above Mactaquac Hatch.	Origin below Mactaquac Wild	Origin below Mactaquac Hatch.	Total Wild	Total Hatch.	Total Both
1-SW								
	Homewater returns	4,308	1,445	4,347	678	8,655	2,123	10,778
	Homewater removals	1,459	557	1,848	166	3,307	723	4,030
	Spawners	2,849	888	2,499	512	5,348	1,400	6,748
	Target spawners	3,200		4,400				7,600
	Percentage of target spawners	117		68				89
M-SW								
	Homewater returns	3,433	579	4,893	205	8,326	784	9,110
	Homewater removals	2,249	479	2,706	98	4,955	577	5,532
	Spawners	1,184	100	2,187	107	3,371	207	3,578
	Target spawners	4,400[a]		5,700				10,100[a]
	Percentage of target spawners	29		40				35

[a]Excludes the 300 broodfish required at Mactaquac FCS.

Table 8. Adjusted Tobique River egg depositions[a]/100 m^2 in year i and year i+1 recruiting to total wild 1-SW and M-SW salmon to Mactaquac in year i+5 and i+6 respectively, resultant M-SW:1-SW salmon ratios, and forecast numbers of 1-SW and M-SW fish to Mactaquac in 1984.

Year i-i+1 (1)	Eggs/100 m^2 (2)	Total 1-SW i+5 (3)	Total M-SW i+6 (4)	M-SW/ 1-SW (5)
1967-68		908	2,518	2.77
1968-69	23.95	2,070	5,811	2.81
1969-70	40.58	3,656	7,441	2.04
1970-71	74.35	6,858	8,177	1.19
1971-72	122.34	8,147	9,712	1.19
1972-73	85.39	3,977	4,021	1.01
1973-74	81.66	1,902	2,754	1.45
1974-75	371.61	6,828	10,924	1.60
1975-76	330.50	8,482	5,991	0.71
1976-77	245.10	5,782	5,001	0.86
1977-78		4,958	3,433	0.70
1978-79		4,308	4,896[c]	
1979-80	199.03	6,616[b]		

[a]See Table 15 for weighting procedure.

[b]Based on regression of 1-SW returns to Mactaquac, 1973-1981, (col. 3) on adjusted egg deposition in Tobique River, 1968-1969 to 1976-1977, (col. 2):

$$\log_e Y = 6.4418 + 0.4298 \log_e X;\ n=9,\ r=0.71,\ p=0.033$$

$$\hat{Y}_{1984} = 6{,}616(AM);\ 95\%\ C.L. = 4{,}388 \text{ to } 9{,}978$$

[c]Based on regression of MSW returns to Mactaquac 1976-1983, (col. 4) on 1-SW returns to Mactaquac 1975-1982, (col. 3):

$$\log_e Y = 1.5741 + 0.08217 \log_e X;\ n=8,\ r=0.80,\ p=0.017$$

$$\hat{Y}_{1984} = 4{,}896(AM);\ 95\%\ C.L. = 3{,}586 \text{ to } 6{,}687$$

Table 9. Mean fry densities, and calculated egg depositions for the Nashwaak River, 1970-1982.

Year (i)	Fry/100 m^2 year i+1	Calculated egg deposition[a]/ 100 m^2	Total eggs[c]
1970	24.39	210.5	10,394,490
1971	9.63	90.8	4,483,704
1972	22.00	120.2[b]	9,956,789
1973	33.86	303.5[b]	15,189,872
1974	34.39	287.1	14,176,998
1975	21.71	189.4	9,352,572
1976	19.30	170.4	8,414,352
1977	23.19	201.1	9,930,318
1978	38.62	318.9	15,747,282
1979[d]	9.43	89.1	4,399,758
1980	25.91	222.5	10,987,050
1981	23.05	200.1	9,880,938
1982	12.60	115.9	5,723,142

[a] $\log_e Y_{(eggs)} = 0.9041 \log_e X_{(fry)} + 2.4276$; $n = 12$, $r = 0.93$ $p < 0.001$ for Tobique River.

[b] based on estimated escapements from fence data.

[c] production area estimate is 4,938,000 m^2.

[d] estimated from provincial angling statistics, mean exploitation rate, and fry-on-egg relationship for Tobique River (Table 3 and Fig. 1).

Table 10. Parameters and derivation of total returns of salmon and angling exploitation rates for the Nashwaak River, 1970-1983.

Year	Sea-age	Eggs/♀[a]	Prop. ♀	Prop. pop'n[b]	Eggs/fish[c]	Egg prop's	Total eggs[d] (1,000's)	No. ♀'s[e]	No. ♂ + ♀'s[f]	No. angled	Total returns	Exploit. rate
1970	1-SW	3,592	.23	.487	402	.118	1,226.6	341	1,484	811	2,295	.35
	M-SW	6,828	.86	.513	3,012	.882	9,167.9	1,343	1,561	854	2,415	.35
1971	1-SW	3,389	.23	.781	609	.323	1,448.2	427	1,858	733	2,591	.28
	M-SW	6,778	.86	.219	1,277	.677	3,035.7	448	521	205	726	.28
1972[g]	1-SW		.32							581	1,205	.48
	M-SW		.83							926	1,890	.49
1973[g]	1-SW		.20							408	1,447	.28
	M-SW		.86							923	3,456	.27
1974	1-SW	3,238	.16	.533	276	.074	1,049.1	324	2,025	495	2,520	.20
	M-SW	8,182	.90	.467	3,439	.926	13,127.9	1,604	1,783	433	2,216	.20
1975	1-SW	3,238	.23[h]	.587	437	.138	1,290.7	399	1,733	663	2,396	.28
	M-SW	7,677	.86[h]	.413	2,727	.862	8,061.9	1,050	1,221	467	1,688	.28
1976	1-SW	3,692	.23	.650	552	.198	1,666.0	451	1,962	1,746	3,708	.47
	M-SW	7,441	.86	.350	2,240	.802	6,748.3	907	1,055	941	1,996	.47
1977	1-SW	3,492	.23	.479	385	.102	1,012.9	290	1,261	1,096	2,357	.46
	M-SW	7,551	.86	.521	3,383	.898	8,917.4	1,181	1,373	1,190	2,563	.46
1978	1-SW	3,676	.23	.469	397	.100	1,574.7	428	1,862	451	2,313	.20
	M-SW	7,775	.86	.531	3,551	.900	14,172.6	1,823	2,120	511	2,631	.19
1979	1-SW	3,368	.23	.813	630	.328	1,443.1			960	2,823	.35[i]
	M-SW	8,018	.86	.187	1,289	.672	2,956.6			221	650	.35[i]
1980	1-SW	3,891	.23	.483	432	.114	1,252.5	322	1,400	1,107	2,507	.44
	M-SW	7,548	.86	.517	3,356	.886	9,734.5	1,290	1,500	1,183	2,683	.44
1981	1-SW	3,233	.23	.685	509	.201	1,986.1	614	2,671	1,085	3,756	.29
	M-SW	7,455	.86	.315	2,020	.799	7,894.8	1,059	1,231	498	1,729	.29
1982	1-SW	4,084	.23	.617	580	.192	1,098.8	269	1,170	1,278	2,448 (2,164)[k]	.52
	M-SW	7,390	.86	.383	2,434	.808	4,624.3	626	728	792	1,520	.52
1983	1-SW									884[j]	2,526 (2,386)[k]	.35[i]
	M-SW									680[j]	1,943 (1,900)[k]	.35[i]

[a]Values for wild fish at Mactaquac.
[b]From Prov. angling.
[c]Product of first 3 columns.
[d]Egg prop.'s x eggs (Table 9).
[e]Eggs/eggs per ♀.
[f]No. ♀'s/prop.♀.
[g]Derived from fence data.
[h]Mean of fence and Westfield data.
[i]12-year mean of arcsin transformed data.
[j]13-year mean.
[k]Wild fish only (Hatchery fish were calculated by applying rates for the 1981 and 1982 smolt classes returning to Mactaquac + Kingsclear + MS sport fishery (from Table 16) of 0.0139 for 1-SW in 1982 and 0.0021 for M-SW in 1983 and 0.0078 for 1-SW in 1983 to respective releases of 20,400 and 18,000 smlolts to the Nashwaak River in 1981 and 1982.

Table 11. Estimated returns of 1-SW and M-SW salmon to tributaries[a] below Mactaquac Dam, Saint John River, 1970-1983.

Sea-age	Year	No. of wild salmon				
		Nashwaak	Nashwaak x 0.16	Kennebecasis and Hammond	Kennebecasis and Hammond x 0.49	Total
1-SW	1970	2,295	368	46	23	2,732
	1971	2,591	415	126	62	3,194
	1972	1,205	193	15	7	1,420
	1973	1,447	232	477	234	2,390
	1974	2,520	403	1,060	519	4,502
	1975	2,396	383	394	193	3,366
	1976	3,708	593	1,446	709	6,456
	1977	2,357	377	628	308	3,670
	1978	2,313	370	154	75	2,912
	1979	2,823	452	1,212	594	5,081
	1980	2,507	401	592	290	3,790
	1981	3,756	601	1,251	613	6,221
	1982	2,164	346	1,227[b]	601	4,338
	1983[c]	2,386	382	496[b]	243	3,507
M-SW	1970	2,451	392	62	30	2,935
	1971	726	116	146	72	1,060
	1972	1,890	302	57	28	2,277
	1973	3,456	553	229	112	4,350
	1974	2,216	355	674	330	3,575
	1975	1,688	270	537	263	2,758
	1976	1,996	319	814	399	3,528
	1977	2,563	410	2,177	1,067	6,217
	1978	2,631	421	340	167	3,559
	1979	650	104	326	160	1,240
	1980	2,683	429	1,292	633	5,037
	1981	1,729	277	571	280	2,857
	1982	1,520	243	823	403	2,989
	1983[c]	1,900	304	568[b]	278	3,050

[a]where Nashwaak represents 31.0 percent and Hammond + Kennebecasis equals 42.9 percent of production area below Mactaquac Dam.

[b]wild fish only (hatchery fish removed as per footnote i, Table 3, where hatchery releases to Kennebecasis + Hammond were 24,518 in 1981 and 24,714 in 1982).

[c]based on 13-year mean Provincial annual angling record.

Table 12. Estimated total returns of wild 1-SW and M-SW salmon originating 'above' and 'below' Mactaquac Dam, Saint John River, 1970-1983.

Sea-age	Year	(1) Mact. count	(2) Kings-clear	(3) Angled MS	(4) Trib. Returns BL. Mact.[a]	(5) Comm. fishery Total	(6) Comm. fishery Above	(7) Comm. fishery Below	(8) By-catch Total	(9) By-catch Above[d]	(10) By-catch Below[e]	Total returns (proportions) Above	Below	Total
1-SW														
	1970	2,874		78	2,732	200	105[b]	98[b]	3			3,057	2,830	5,887
	71	1,592		60	3,194	166	57	109	0			1,709	3,303	5,012
	72	784		83	1,420				107	41	66	908	1,486	2,394
	73	1,854		179	2,390				81	37	44	2,070	2,434	4,504
	74	3,389	27	214	4,502				59	26	33	3,656	4,535	8,191
	75	5,725	45	1,052	3,366				54	36	18	6,858	3,384	10,242
	76	6,797	307	1,014	6,456				52	29	23	8,147	6,479	14,626
	77	3,507	28	403	3,670				76	39	37	3,977	3,707	7,684
	78	1,584	43	231	2,912				113	44	69	1,902	2,981	4,883
	79	6,234	228	331	5,081				62	35	27	6,828	5,108	11,936
	80	7,555	378	503	3,790				67	46	21	8,482	3,811	12,293
	81	4,571	222	428	6,221	730[c]	470	260	194	91	103	5,782	6,584	12,366
	82	3,932	171	466	4,338	1,482[c]	352	1,130	79	37	42	4,958	5,510	10,468
	83	3,623	164	207[f]	3,507	1,091[c]	283	808	63	31	32	4,308	4,347	8,655
Mean												4,474 (.53)	4,036 (.47)	8,510 (1.00)
M-SW	1970	2,449		59	2,935	6,934	3,204[b]	3,749[b]	19			5,712	6,684	12,396
	71	2,235		89	1,060	3,473	2,391	1,082	0			4,733	2,142	6,875
	72	4,831		62	2,277				9	6	3	4,899	2,280	7,179
	73	2,367		91	4,350				165	60	105	2,518	4,455	6,973
	74	4,775	569	459	3,575				13	8	5	5,811	3,580	9,391
	75	6,200	739	446	2,758				77	56	21	7,441	2,779	10,220
	76	5,511	1,646	950	3,528				101	70	31	8,177	3,559	11,736
	77	7,247	864	1,489	6,217				184	112	72	9,712	6,289	16,001
	78	3,034	645	263	3,559				151	79	72	4,021	3,630	7,651
	79	1,993	561	152	1,240				70	48	22	2,754	1,262	4,016
	80	8,157	2,069	533	5,037				244	165	79	10,924	5,116	16,040
	81	2,441	639	282	2,857	4,983[c]	2,291	2,692	669	338	331	5,991	5,880	11,871
	82	2,262	1,626	592	2,989	2,440[c]	359	2,081	332	162	170	5,001	5,240	10,241
	83	1,712	512	98[f]	3,050	2,651[c]	986	1,665	303	125	178	3,433	4,893	8,326
Mean												5,795 (.58)	4,128 (.42)	9,923 (1.00)

[a]Reference Table 11.
[b]Values include by-catch.
[c]Reference Table 5 for proportioning to 'Above' and 'Below'.
[d]Columns (1+2+3+6)/columns (1+2+3+6+4+7) x Col. 8, where the 1970 and 1971 commercial and by-catch are combined and treated as by-catch without commercial landings.
[e]Below = (Total-Above).
[f]Based on unofficial Provincial estimate.
[g]Based on Table 2.

Table 13. Freshwater age and numbers of 1-SW fish (A) counted at Mactaquac fish passage facilities, Saint John River, 1972-1983, and (B) that would have returned to Mactaquac had they not been exploited within the river, 1972-1983 (see Table 12 for total of B).

Freshwater-age	Numbers of 1-SW fish											
	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
A												
2	110	1,413	1,593	1,941	3,962	922	391	3,166	2,214	1,280	794	2,348
3	596	404	1,762	3,727	2,658	2,545	1,160	2,974	4,986	2,861	2,902	1,275
4	78	37	34	57	177	39	33	94	355	430	236	0
Total	784	1,854	3,389	5,725	6,797	3,506	1,584	6,234	7,555	4,571	3,932	3,623
B												
2	127	1,578	1,718	2,325	4,749	1,046	469	3,468	2,486	1,619	1,001	2,792
3	690	451	1,901	4,465	3,186	2,887	1,393	3,257	5,598	3,619	3,659	1,516
4	91	41	37	68	212	44	40	103	398	544	298	0
Total	908	2,070	3,656	6,858	8,147	3,977	1,902	6,828	8,482	5,782	4,958	4,308

Table 14. Numbers of wild 1-SW salmon and proportion of age 2:1's of the total that would have returned to Mactaquac for the year-classes 1968-1978 (numbers of 1-SW fish from Table 13B).

Year class (i)	Numbers at age of 1-SW returns to Mactaquac				Prop. 2:1's of total
	2:1 (i+3)	3:1 (i+4)	4:1 (i+5)	Total	
1968		690	41		
1969	127	451	37	615	.207
1970	1,578	1,901	68	3,547	.445
1971	1,718	4,465	212	6,395	.269
1972	2,325	3,186	44	5,555	.419
1973	4,749	2,887	40	7,676	.619
1974	1,046	1,393	103	2,542	.411*
1975	469	3,257	398	4,124	.114*
1976	3,468	5,598	544	9,610	.361
1977	2,486	3,619	298	6,403	.388
1978	1,619	3,659	0	5,278	.307
1979	1,001	1,516			
1980	2,792				

*influenced by 1977 smolt-class with its reduced survival.

Table 15. Numbers of eggs/100 m^2 deposited in the Tobique River, 1968-1983, and derivation of weighted numbers of eggs contributing to annual returns of wild 1-SW fish at Mactaquac, 1973-1981 and 1984.

Tobique egg deposition		Proportion of age at smoltification		Eggs/100 m^2 contributing to 1-SW fish		Total wt'd egg contrib/100 m^2 to 1-SW fish @ Mact. (yr)
Year	Eggs/100 m^2	Age 2	Age 3^+	Yr i	Yr i+1	
1968	5.7	.207				
			.793		4.55	
1969	43.6	.445		19.40		23.95 (1973)
			.555		24.20	
1970	60.9	.269		16.38		40.58 (1974)
			.731		44.52	
1971	71.2	.419		29.83		74.35 (1975)
			.581		41.37	
1972	130.8	.619		80.96		122.33 (1976)
			.381		49.84	
1973	86.5	.411		35.55		85.39 (1977)
			.589		50.95	
1974	269.4	.114		30.71		81.66 (1978)
			.886		238.69	
1975	368.2	.361		132.92		371.61 (1979)
			.639		235.28	
1976	245.4	.388		95.22		330.50 (1980)
			.612		150.18	
1977	309.2	.307		94.92		245.10 (1981)
			.693		214.28	
1978	193.2					
1979	112.3					
			.653[a]		73.38	
1980	362.1	.347[a]		125.65		199.03 (1984)

[a]mean (n=10) calculated with angular transformation.

Table 16. Estimated total returns to the Saint John River from hatchery-reared smolts released at Mactaquac, 1974-1983, and forecast returns 'to' and 'below' Mactaquac for 1984.

Year of Release (i)	Number of smolts	Year of Return	Number of returns: Mactaquac MC	Mactaquac Dam	Kingscl.	Angled MS	By-catch	Commercial	Total	% Return
		i+1								
1974	337,281		1,771	3,564	28	977	34		6,374	1.890
75	324,186		2,863	4,831	219	1,129	32		9,074	2.799
76	297,350		1,645	4,533	36	708	70		6,992	2.351
77	293,132		777	1,779	49	369	70		3,044	1.038
78	196,196		799	2,722	100	186	20		3,827	1.951
79	244,012		3,072	6,687	335	640	59		10,793	4.423
80	232,258		921	2,861	139	350	74	385	4,730	2.037
81	189,090		828	1,464	64	267	21	202	2,846	1.505
82	172,231		374	857	39	69	11	95	1,445	0.839
83	144,549									
1974-1982	2,285,736								49,125	2.149[a]
		i+2								
1974	337,281		310	1,313	392	267	20		2,302	0.683
75	324,186		341	1,727	206	417	34		2,725	0.841
76	297,350		223	1,728	368	165	50		2,534	0.852
77	293,132		145	747	210	65	21		1,188	0.405
78	196,196		302	1,992	506	146	46		2,992	1.525
79	244,012		126	963	252	125	147	999	2,612	1.070
80	232,258		88	640	462	181	50	110	1,531	0.659
81	189,090		44	255	76	16	21	166	578	0.306
82	172,231									
83	144,549									
1974-1981	2,113,505								16,462	0.779[a]

Forecast for 1984:

	1-SW Smolts	1-SW Returns @ .02149	M-SW Smolts	M-SW Returns @ .00779
To Mactaquac	144,549	3,106	172,231	1,342
Below Mactaquac	48,706	1,047	80,535	627

[a]unweighted.

Table 17. Summary of the 1984 forecast for the Saint John River, New Brunswick (95% C.L. are shown in parentheses).

Requirement	1-SW			M-SW		
	Wild	Hatch.	Total	Wild	Hatch.	Total
Above Mactaquac	6,616 (4,388-9,978)	3,106	9,722	4,896 (3,586-6,687)	1,342	6,238
Target escpm.			3,200			4,400 + 300[1]
Surplus/deficit			+6,522/			+1,538/
Below Mactaquac	4,914 (4,016-5,812)	1,047	5,961	3,545	627	4,172
Target escpm.			4,400			5,700
Surplus/deficit			+1,561/			/-1,528
Total	11,530	4,153	15,683	8,441	1,969	10,410
Target escpm.			7,600			10,100 + 300[1]
Surplus/deficit			+8,083/			+10/

[1]Broodfish for Mactaquac Fish Culture Station.

Table 18. Angling catch (bright fish) for Saint John River, 1969-1982, reported by New Brunswick Dept. Natural Resources.

Year	Numbers of salmon			Rod-days of effort
	1-SW	M-SW	Total	
1969	1,512	624	2,136	7,082
1970	1,271	1,287	2,558	11,053
1971	1,171	695	1,867	8,498
1972	854	1,635	2,489	10,556
1973	1,330	1,546	2,876	15,863
1974	2,038	2,515	4,553	19,462
1975	2,498	1,678	4,176	23,956
1976	4,653	2,785	7,439	27,822
1977	4,333	4,415	8,748	36,828
1978	1,740	2,174	3,914	36,132
1979	3,306	777	4,083	27,965
1980	4,703	5,409	10,112	50,193
1981	4,109	1,961	6,070	46,466
1982	3,366	1,971	5,337	45,000
1983[1]	2,389	1,570	3,959	-
Avg. (1969-1982)	2,635	2,105	4,740	26,205

[1]1983 angling catches are estimated.

Table 19. Saint John River commercial salmon landings (kg), and estimated numbers of 1-SW and M-SW salmon, 1949-1983.

	Landings (kg)	Estimated numbers of salmon		
		1-SW	M-SW	Total
1949	107,285	1,486	16,086	17,572
1950	82,814	1,057	12,445	13,502
1951	119,022	1,552	17,864	19,416
1952	80,966	1,117	12,141	13,258
1953	99,608	1,613	14,861	16,474
1954	63,185	929	9,456	10,385
1955	37,421	799	5,520	6,319
1956	32,976	593	4,902	5,495
1957	46,357	753	6,915	7,668
1958	91,807	1,184	13,793	14,977
1959	95,431	2,077	14,304	16,381
1960	70,715	989	10,599	11,588
1961	63,484	820	9,537	10,357
1962	36,877	488	5,537	6,025
1963	28,531	641	4,200	4,841
1964	62,702	919	9,385	10,304
1965	118,308	1,525	17,774	19,299
1966	125,203	1,467	18,857	20,324
1967	62,239	665	9,394	10,059
1968	49,038	695	7,348	8,043
1969	17,092	312	2,539	2,851
1970	35,655	405	5,373	5,778
1971	17,531	342	2,596	2,938
	No commercial fishery 1972-1980			
1981	40,710	1,104	6,054	7,158
1982	18,565	1,711	2,487	4,198
1983	19,167	1,231	2,857	4,088

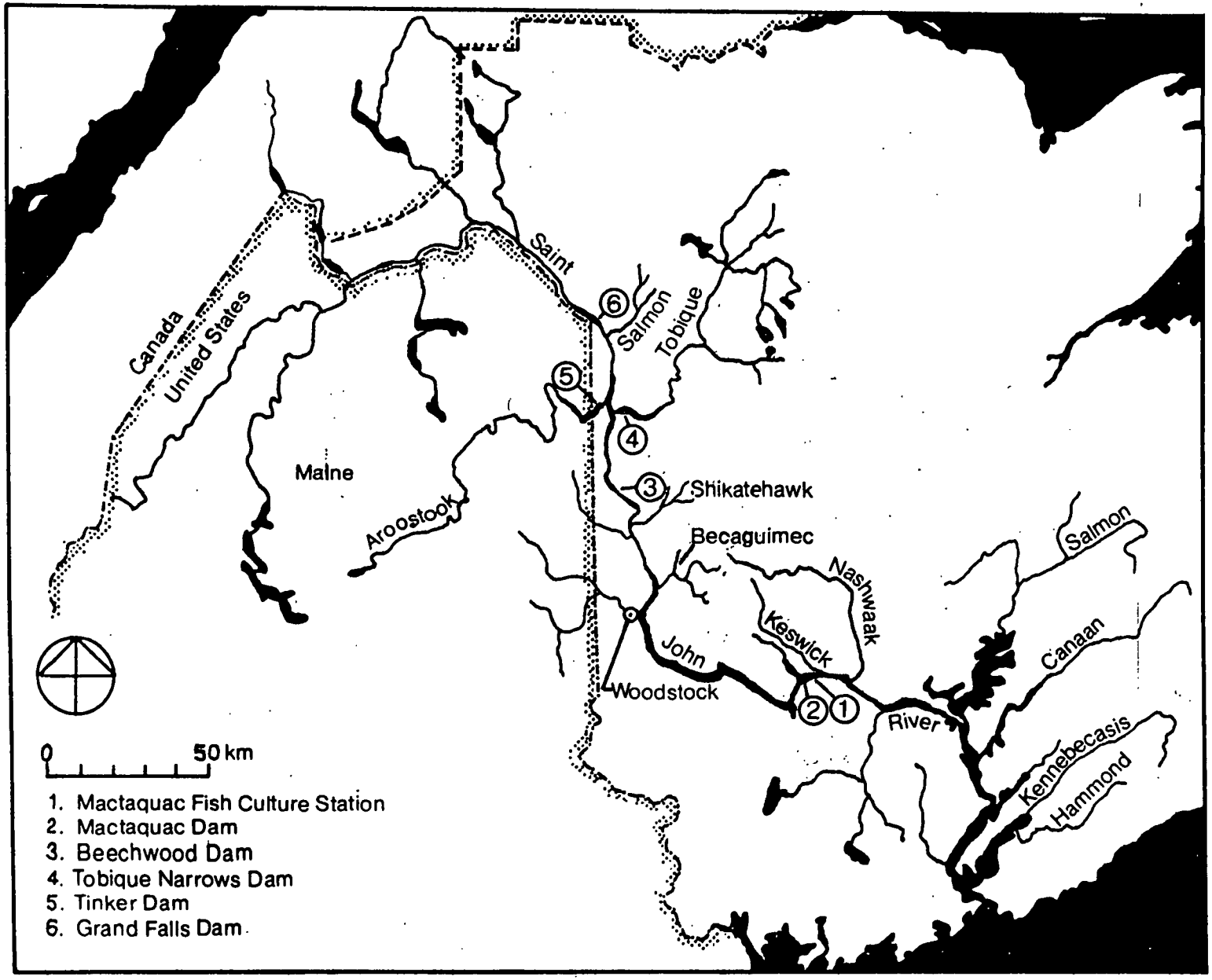

Figure 1. Map of Saint John River Drainage Basin.

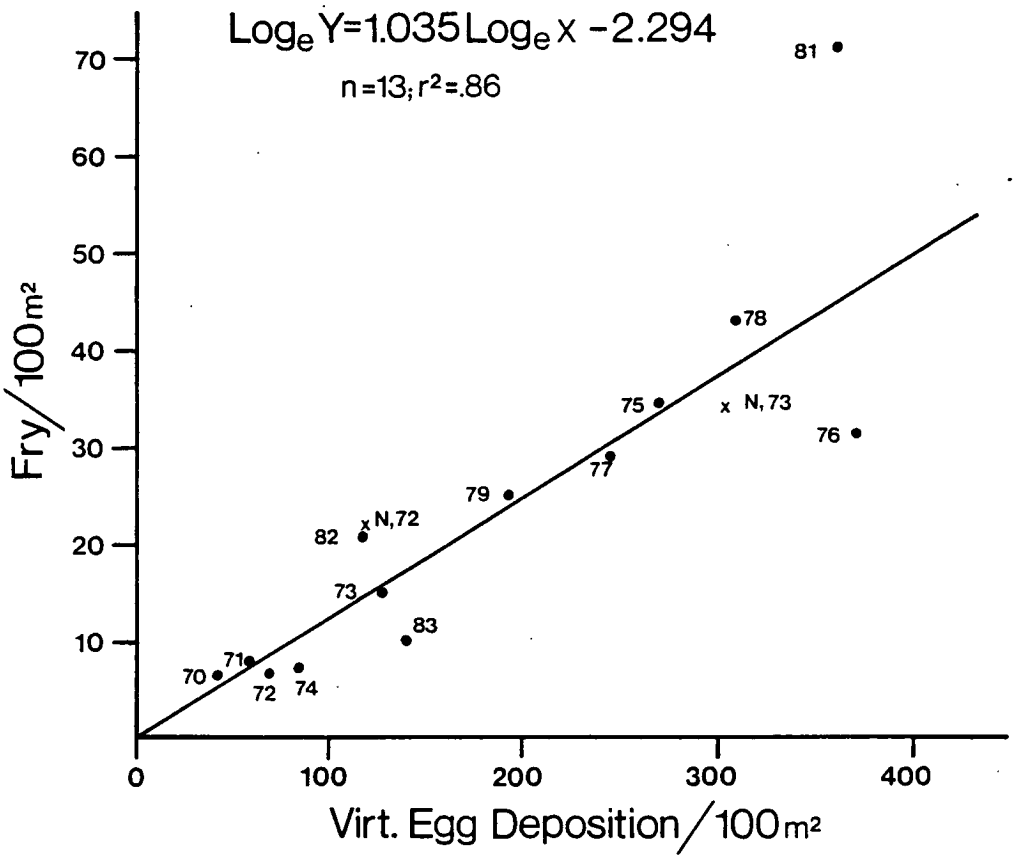

Figure 2. Relationship between estimates of egg deposition and resultant fry densities on the Tobique River 1970-1983, excl. of 1980, and proximity of two data pairs (N,72, N,73) from the Nashwaak River.