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Assessment of Atlantic Salmon of the Saint John River, N.B., above Mactaquac, 1989

by

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ABSTRACT

Estimated river returns destined for Mactaquac, Saint John River, 1989, were 10,861 1SW and 4,541 MSW salmon. Homewater removals/losses of about 3,600 1SW and 1,400 MSW fish led to an estimated spawning escapement above Mactaquac of 72 percent of the target number of MSW spawners. Wild and hatchery 1SW returns were within 6% of the forecast but for the third year in succession, MSW returns were significantly less (36%) than forecast.

The forecast of 1990 homewater returns destined for Mactaguac is about 10,100 1SW fish (6,900 more than the target escapement) and 7,075 MSW salmon (2,675 fish more than the target escapement). However, allocation of the MSW forecast surplus in 1990, (and later) would be imprudent given both the shortfall of egg depositions since 1986 and recent over-predicting of the returns.

RÉSUMÉ

Les estimations de remontées de saumons allant à Mactaquac, fleuve Saint-Jean, en 1989 étaient de 10 861 unibermarins et de 4 541 redibermarins. Compte tenu de retraits/pertes dans les eaux d'origine d'environ 3 600 unibermarins et 1 400 redibermarins, l'échappée estimée de reproducteurs en amont de Mactaque était d'environ 72 % du nombre-cible de géniteurs redibermarins. Les remontées d'unibermarins sauvages et d'écloserie étaient conformes à la prévision, à 6 % près, mais pour la troisième année de suite, les remontées de redibermarins étaient bien inférieures (36 %) à la prévision.

On prévoit que les remontées dans les eaux d'origine pour Mactaquac en 1990 s'établiront approximativement à 10 100 unibermarins (6 900 de plus que l'échappée-cible) et de 7 075 redibermarins (2 675 de plus que l'échappéecible). Toutefois, il serait imprudent d'attribuer le surplus prévu de redibermarins en 1990 (et dans les années subséquentes) en raison, d'une part, du déficit constaté dans le dépôt d'oeufs depuis 1986 et, d'autre part, de la surestimation récente des remontées.

INTRODUCTION

This document is background to the management of Atlantic salmon stocks of the Saint John River above Mactaquac, New Brunswick, and, as such, documents data and analyses available to early November 1989 relevant to stock status in 1989 and forecasts for 1990.

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 (MS 1989).

Forecasts made in 1988 suggested that 1989 homewater returns to both above and below Mactaguac portions of the river would number approximately 19,000 1SW and 12,100 MSW salmon. CAFSAC advised managers (CAFSAC Advisory Document 88/26) that for 1989 there would in total be 11,400 1SW and 2,000 MSW salmon surplus to spawning requirements, including a surplus of 2,700 MSW salmon originating at/above Mactaguac.

The Management Plan for 1989 was identical to that of 1988 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 and the Oromocto Band did not fish. In contrast, the Tobique Indian Band conducted an unsanctioned fishery between early-July and mid-September which, by various reports netted about 800 salmon. Summer discharges were sporadic with extensive flooding occurring in Victoria County on two occasions in August.

Unlike the 1988 assessment, the 1989 assessment is of returns, removals and a forecast for <u>only</u> those fish originating <u>at/above Mactaquac Dam</u>. Assessment of stocks below Mactaquac Dam had, since 1986 been based on the premise that wild returns to tributaries below Mactaquac were equal to the average proportion that wild downriver stocks were of the total river returns 1970-1983. This was necessary because catch statistics for lower river tributaries, which were used prior to 1986 to estimate returns independent of count data from Mactaquac Dam, became increasingly difficult to obtain by early November and to interpret. CAFSAC expressed concern over the constant proportion method as it allowed for neither a greater contribution by hatchery returns to recruitment of "wild" stocks above Mactaquac Dam, nor differential distant exploitation on the earlier-run stock components from above Mactaquac and later-run stock components from tributaries below Mactaquac. Thus, stock status and forecasts for tributaries below Mactaquac were discontinued.

METHODS

Returns destined for Mactaguac

Total returns of 1SW and MSW salmon of both wild and hatchery origin from and above Mactaquac Dam consist of the summation of Mactaquac counts, estimated angling catches in the mainstem area immediately below the Mactaquac Dam (including Kingsclear) and estimated by-catch in downriver shad, gaspereau and "other" species 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. Because the facility was closed on Oct. 20 rather than at the end of October a 1984-1988 average of the proportion of the total run in the last 10-12 days of the run was used to adjust the 'count' to that of a full season. The identification of 1SW and MSW returns from 1-year smolts released at Mactaquac and juveniles released above Mactaquac were dependent on fin erosion (principally dorsal fin). By-catch was estimated to be 2% of the 1SW and 5% of the MSW river returns - values which approximate the mean estimates for the years 1981-1984. Both the by-catch and sport catch were assumed to consist of fish of hatchery and wild origins in the same proportion as those counted at Mactaquac.

Removals of fish originating at/above Mactaguac

Removals include estimates of fish taken by the Tobique Indian Band, preliminary provincial, federal and native estimates of sport catch on the mainstem below Mactaquac, mainstem above Mactaquac (incl. Salmon River, Victoria Co.,) the Tobique River and a by-catch in the estuary. An estimate of the catch at Tobique Indian Reserve was obtained by a synthesis of information given on site and during negotiations for a Food Fishery Agreement. Additional removals include some fish; captured in the Mactaquac collection facilities and transferred to the Aroostook River, monitored through the newly operational fish-lift at Tinker Dam on the Aroostook River, retained at Mactaquac for broodstock, mortalities encountered during collection-handling operations and sacrificed for analysis. Losses of MSW fish to hook-and-release mortality were estimated at 2% of the run placed above Mactaquac, i.e., similar to a previously used 10% loss on estimated MSW sport catch. Losses to poaching and disease ascribed in the 1988 assessments were used in 1989, i.e., 4% of 1SW and 10% of MSW fish placed above Mactaquac (exclusive of those estimated to have been taken by the Tobique Indians). For the most part, losses were apportioned to hatchery/wild components on the basis of estimated stock composition.

Required Spawners

An accessible salmon-producing substrate of 12,261,000 m² above Mactaquac, an assumed requirement of 2.4 egg/m², 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 MS 1983). Because 1SW fish normally contribute so few eggs (usually fewer than 5% females) a management philosophy limits 1SW requirements to that number which provides males for MSW females unaccompanied by MSW males, i.e., 3,200 fish (Marshall and Penney op. cit.).

Stock Forecasts

1SW Wild

The 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, 1973-1987, on adjusted (method in Penney and Marshall MS 1984, with data updates, App. 1, 2 and 3 this paper) egg depositions in the Tobique River, 1968-1969 to 1982-1983.

Egg depositions for the period 1982-1983 were adjusted in the same manner as Penney and Marshall (MS 1984) using freshwater age composition from 475 wild 1SW fish sampled at Mactaquac in 1989 (one-third of scales was unread at time of assessment). Adjustment of the 1985 and 1986 egg depositions, principal contributors to 1SW returns in 1990, was done with the use of angular-transformed mean proportions for age 2:1 and age 3:1 1SW fish in the 1969 to 1983 year-classes.

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 s² (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).

<u>MSW Wild</u>

A forecast of MSW returns to homewaters in 1990 which originated above Mactaquac was again examined through the regression of the estimated MSW returns destined for Mactaquac, 1971-1989, on the estimated numbers of 1SW fish originating above Mactaquac and returning to Saint John River in the previous year. Analysis included the use of natural logarithms and conversion of the GM to AM. Because the prediction from the regression had been very different from returns, 1987-88, the forecast for 1989, and again for 1990 is estimated as the product of wild 1SW returns destined for Mactaquac 1989, and the mean of 7 MSW/1SW ratios < 1.0 since 1980.

<u>1SW Hatchery</u>

The release since 1985, of 1-year smolts, as opposed to principally 2year smolts 1967-1984, prevented the forecasting of 1SW or MSW hatchery returns by either the product of the long-term return rates and the number of smolts released or by regression technique. Instead, the return rate for age 1.1 fish returning to Mactaquac in 1990 was assumed to be the same as the mean (arcsine) of the 1986-1989 'adjusted' return rates (App.4). Age 1.1 returns were adjusted by removal of the estimated returns to Mactaquac from smolts released in tributaries below Mactaquac. Tag returns at Mactaquac were used to derive a mean (arcsine) proportion of adults that would return to Mactaquac from smolts released in tributaries below (App.5). Additional 1SW returns of age 3:1 and age 2:1 are expected at Mactaquac in 1990 from fall fingerlings (age 0⁺) culled from the 1-year smolt program and released in tributaries above Mactaquac in 1986 and 1987. Returns were calculated as the product of return rates to Mactaquac of releases of fall fingerlings above Mactaquac in 1985 and 1986 and the numbers released (App. 6). Release of unfed fry were accorded one-tenth the return rate of fall fingerlings.

MSW Hatchery

Returns as MSW fish from 1-year smolts released at Mactaquac in 1988 were estimated as the product of their number and adjusted mean (arcsine) return rate for 1-year smolts released from Mactaquac 1985-1987 (App.4). As with 1SW hatchery returns, MSW fish destined for Mactaquac from releases below were proportioned on the basis of tag returns 1985-1989 (App. 5).

As well, MSW returns of age 3:2 and age 2:2 were expected from fall fingerlings released above Mactaquac in 1985 and 1986. Returns of age 2:2 salmon were calculated as the product of their numbers and a return rate to Mactaquac of the 1984 and 1985 releases above Mactaquac (App. 6).

Maiden hatchery fish in 1988 and 1989 are also expected to contribute to repeat spawning MSW fish in 1990. This return was approximated by applying return rates of 0.05 (1SW) and 0.146 (MSW), for combined consecutive and alternate-year spawners (Marshall and MacPhail MS 1987) to 1989 adults of hatchery origin which were estimated to have spawned. This assumes that appropriate numbers of alternates would originate from the 1988 escapement.

RESULTS

Returns destined for Mactaquac

Estimated homewater returns in 1989 totalled 10,861 1SW and 4,541 MSW fish (Table 1). The removal by anglers in the mainstem immediately below Mactaquac is provisionally estimated at 1,005 1SW fish. Hatchery returns comprised 12% and 10% of the total 1SW and MSW returns, respectively.

Removals

Provisional sport 1SW removals additional to those in the main stem consist of 1,299 fish above Mactaquac (Table 2). The Tobique Indian Band harvested an estimated 800 salmon. Fishing was conducted below the Dam (2-3 nets) and in the Headpond (6-8 nets) with gill nets of 38 m length and a mesh size of 102 mm. The catch was assumed to consist of hatchery and wild 1SW and MSW fish in proportions similar to those placed in the Tobique Headpond and passed through the Tobique fishway.

MSW losses above Mactaquac to poaching and disease combined were set at 10% (exclusive of those taken by the Tobique Indians). 1SW losses to poaching and disease were set at 4%. Included in these losses are the dozen or so mostly MSW mortalities noted, heard-of or observed by provincial/federal officials working on the Tobique River and the 30 or so fish lost due to handling fish in the Tobique fishway. Fish sampled mostly from within the Half-Mile barrier pool by NBDNRE personnel and submitted to analyses for viral and bacterial pathogens again revealed furunculosis. Losses were, however, few compared to 1988.

Removals by all factions were estimated at 3,618 1SW fish of which 165 made their way over Tinker Dam on the Aroostook River and 1,371 MSW salmon of which 55 were transferred over the Tinker Dam and 425 retained as broodfish at Mactaguac.

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/m² indicate that 72% of the required MSW spawners were attained above Mactaquac, (Table 3). For 1SW fish, 225% of requirements were met above Mactaquac. An estimated 8% of wild and 2% of hatchery 1SW fish were female and had the potential to deposit about 1.8 million eggs, $(0.15/m^2)$ or the equivalent of about 240 MSW females.

Stock Forecasts

1SW Wild

The 1990 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 1990 is 7.393 1SW fish (95% C.L. 5,601-9,757) (Table 4). The method forecast 8,197 (5,846-11,493) 1SW fish for 1989; 9,522 fish were estimated to have returned.

MSW Wild

A forecast of wild MSW fish destined for Mactaquac in 1990 was provided by the product of the mean ratio (0.664) MSW/1SW 1980-1981 through 1988-1989, exclusive of the high ratios, 1983-1984, 1984-1985, and 9,522 1SW returns in 1989. The method suggests that MSW returns to Mactaquac in 1990 should be 6,325 fish. The same approach in 1989 suggested that 6,232 MSW would return in 1989 - 4,072 (65%) were actually accounted for. However, low sea-surface temperatures in the Labrador Sea in the winter of 1988-89 and unusual drift ice in W. Greenland in Aug-Sept of 1989 may foretell of at least an average to above average MSW:1SW ratio for 1990. Low sea temperatures of 1983-1984 coincided with high MSW:1SW ratios for 1984 and 1985. The regression loge Y = $5.721 + 0.341 \log_{\bullet} X (n=19; r^2=0.22; p < 0.05; Table 4)$ which has, since 1986, forecast MSW returns of double the actual and the 9,522 1SW returns to Mactaquac in 1989 provided an AM estimate of 7,530 MSW fish.

1SW Hatchery

The forecast of hatchery 1SW fish destined for Mactaquac in 1990 was in part calculated as the product of an estimated 238,204 1- and 2-year smolts released at Mactaquac and an adjusted 0.00940 return rate (Table 5), i.e., 2,239 fish. Another 235 and 89 would return from smolts placed above and below Mactaquac, respectively. In addition, it was estimated that fall fingerlings released above Mactaquac in 1986 and 1987 would contribute another 147 1SW fish (Table 5). The total forecast of hatchery 1SW returns to Mactaquac is <u>2,710 1SW</u> fish. The 1989 forecast, by these methods exceeded returns by about 35%. A lower average return rate for this forecast and the release in 1989 of more larger smolts would likely suggest that the forecast for 1990 is conservative.

MSW Hatchery

MSW returns destined for Mactaquac in 1990 were calculated as the sum of the product of an estimated return rate of 0.0038 and 142,195 smolts released at Mactaquac (540 fish) and 0.26 of returns from 71,812 smolts released below Mactaquac in 1988 (71 fish). Additional returns are expected from fall fingerlings released in 1985 and 1986 and a 0.0001 survival/return rate (Table 5). The forecast of total hatchery MSW returns to Mactaquac, including repeat spawners is <u>750 MSW</u> fish (Table 5).

Forecast Summary

The forecast of total homewater returns to Mactaquac, Saint John River in 1990 is 10,103 1SW (7,393 of wild and 2,710 hatchery origin) and 7,075 MSW fish (6,325 of wild and 750 of hatchery origin). Forecast returns minus the spawning requirements of 3,200 1SW and 4,400 MSW salmon result in potential surpluses of 6,903 1SW and 2,675 MSW salmon.

DISCUSSION

Estimated returns in 1989 of 10,861 wild and hatchery 1SW and 4,541 wild and hatchery MSW salmon were 106% and 64% of predicted returns. Comparisons of predicted and actual (estimated) returns for each of wild and hatchery fish since 1984 are as follows:

Sea-age	Returns	1984	1985	1986	1987	1988	1989	
Wild								
lSW	Predicted Returned Ret/Pred	6,616 8,311 1.26	7,063 6,526 0.92	5,075 7,904 1.56	4,989 5,909 1.18	6,054 8,930 1.48	8,197 9,522 1.16	
MSW	Predicted Returned Ret/Pred	4,896 9,779 2.00	8,413 10,436 1.24	7,702 6,128 0.80	8,327 4,352 0.52	6,983 2,625 0.38	6,232 4,072 0.65	

Sea-age	Returns	1984	1985	1986	1987	1988	1989	
Hatchery								
lsW	Predicted Returned Ret/Pred	3,106 1,451 0.47	4,292 2,018 0.47	117 862 7.37ª	2,319 3,328 1.44	2,165 1,250 0.58	2,080 1,339 0.64	
MSW	Predicted Returned Ret/Pred	1,342 1,115 0.83	873 875 1.00	1,134 797 0.70	2,654 480 0.18ª	1,023 912 0.89	882 469 0.53	

First returns from 1-year smolts.

MSW returns, including fish of hatchery origin are the fourth lowest of a 15-year data set (Table 6). Returns of wild 1SW fish above Mactaquac were 116% of predicted; wild MSW fish above were 65% of predicted values. Hatchery 1SW and MSW returns were 64% and 53% of forecasts. Despite the, lowest harvest of MSW fish in two decades (Table 7), and equally low losses (Table 2), spawning escapement of MSW fish was only 72% of requirement. Deficits in spawning escapement, 1986-1988 (82, 64, and 35% of requirements, respectively), together with that of 1989 should deter managers from allocating predicted MSW surpluses during the next several years.

For the third year in a row, wild MSW returns have been low relative to both the period of record and those predicted. In contrast, wild 1SW returns over the last few years have been high both with respect to the period of record and those predicted. Potential reasons for the resultant low MSW/1SW ratios (Table 4) including early (1SW) maturation of salmon which might otherwise have matured after two winters at sea and higher than normal natural mortality of those fish at sea during the second winter were discussed by Marshall (MS 1989). Early maturation/crossover to 1SW fish is unlikely to be evident in sex ratio data for 1SW fish (Marshall, op. cit.). However, the results have stimulated examination of other potential indices of marine survival/growth useful in a new/revised MSW forecast model. Until revised, predicted MSW values must be viewed with caution.

Predicted returns of hatchery-origin fish have had little reliability in most of the last six years. However, their predicted contributions to the run of hatchery and wild fish have in general been low (20% of 1SW and 12% of MSW in 1989), just as have been the estimated returns (12% of 1SW and 10% of MSW for 1989). Predictive capabilities for hatchery-origin fish are not only potentially impeded by the same operands affecting returns of wild fish but as well by the limited data set for returns from 1-year smolts (1986-1989), fish that have not been hi-graded to support the building of the aquaculture industry (1989) and on-going efforts to improve smolt quality. Hence, improvements in predicting hatchery returns may benefit from investigations that would allow normalization of the survivability of all smolts released from Mactaguac over the last two decades.

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00u				
age	Components	Wild	Hatch.	<u>Total</u>
lsw				
	Mactaguac counts	8,417	1,170	9,587
	Adi. to Nov. close ^a	8,451	1,188	9,639
	Angled MS below Mact	881	124	1,005
	By-catch ^b	190	27	217
	Totals	9,522	1,339	10,861
MSW				
	Mactaguac counts	3.854	437	4,291
	Adi. to Nov. close ^a	3,868	446	4,314
	By-catch ^b	204	23	227
	Totals	4,072	469	4,541

Table 1. Estimated total <u>returns</u> of wild and hatchery 1SW and MSW salmon <u>destined</u> for Mactaquac Dam on the Saint John River, N.B., 1989.

 Fishway closed Oct. 20, 10-12 days earlier than usual; 1984-88 proportions of run 0.004, 0.0155, 0.0035, 0.0201 used for 1SW, wild, hatch & MSW wild and hatch., respectively.

Proportions of 2% total 1SW returns and 5% total MSW returns.

		1 SW			MSW	
Components	Wild	Hatch	Total	Wild	Hatch	Total
Vincelory Indians	0	0	0	0	0	0
Tobique Indians ^b	491	69	560	219	21	240
Angled						
Tobique River	806	113	919	-	-	-
Mainstem above Mact.	333	47	380	-	-	-
Mainstem below Mact.	881	124	1,005	-	-	-
Harnsten berow Haber	0	0	0	64	6	70
moughed (passed to Aroost	145	20	165	52	5	55
Truckeu/passed to moose.	32	_	32	348	77	425
Hatchery broodrish	-	-	-	7	1	8
mortalities, etc.	202	42	340	313	31	344
Poaching/disease	2 90		217	204	23	227
By-catch	2 170		2 619	$\frac{201}{1207}$	164	1.371
Totals	3,176	442	3,010	1,207	104	1,011

Table 2. Estimated homewater <u>removals</u>^a of 1SW and MSW salmon destined for Mactaguac Dam on the Saint John River, N.B., 1989.

- Previous to significant federal and provincial input; wild:hatchery composition per estimated returns.
- Estimated at 800 fish, (approx. 10% exploit); ISW:MSW ratio similar to that of available fish, i.e., 0.70: 0.30.
- c Estimated at 2% of MSW of salmon released above Mactaguac (exclusive of those to Tobigue Indians).
- d Estimated at 4% of all 1SW and 10% of all MSW fish placed above Mactaquac (exclusive of those to Tobique Indians).

Sea-					
age	Components	Wild	Hatch.	Total	
1SW					
MSW	Homewater returns Homewater removalsª Retained below Mact. Spawners Target spawners ^b % of target spawners	9,522 3,176 34 6,312	1,339 442 18 879	10,861 3,618 52 7,191 3,200 225	
	Homewater returns Homewater removals ^a Retained below Mact. Spawners Target spawners ^b % of target spawners	4,072 1,207 14 2,851	469 164 9 296	4,541 1,371 23 3,147 4,400 72	

Table 3. Estimated homewater <u>returns</u>, <u>removals</u> and <u>spawning escapement</u> of 1SW and MSW salmon destined for and above Mactaquac Dam, Saint John River, 1989.

Includes broodfish for Mactaquac FCS (Table 2).
Excludes broodfish for Mactaquac FCS (Table 2).

				Recruits		
Eggs/10	0 m ²		1SW		MSW	MCH /
Years (1)	Number (2)	Year	Number (3)	Year	Number (4)	1SW (5)
1965-66		1970	3,057	1971	4,715	1.54
1966-67		71	1,709	72	4,899	2.87
1967-68		72	908	73	2,518	2.77
1968-69	23.95	73	2,070	74	5,811	2.81
1969-70	40.58	74	3,656	75	7,441	2.04
1970-71	74.35	75	6,858	76	8,177	1.19
1971-72	122.34	76	8.147	77	9,712	1.19
1972-73	85.39	77	3,977	78	4,021	1.01
1973-74	81.66	78	1.902	79	2,754	1.45
1974-75	371.61	79	6.828	1980	10,924	1.60
1975-76	330.50	1980	8,482	81	5,991	0.71
1976-77	244.80	81	5.782	82	5,001	0.86
1977-78	288.96	82	4.958	83	3,447	0.69
1978-79	167 00	83	4.309	84	9.779	2.27
1979-80	239 74	84	8.311	85	10.436	1.26
1980-81	219 60	85	6.526	86	6,128	0.94
1091-92	167 64	86	7 904	87	4.352	0.55
1002-02	22 Q7	87	5 909	88	2,625	0.44
1003-01	00.37	88	8 930	89	4.072	0.46
1001_05 170J-04		80	9,500	1990	7 5300	6.325d
1985-86	270.65	1990	7,3935	1990	<u></u> /	<u> </u>

Table 4. Adjusted Tobique River egg deposition*/100 m² (yr i & i+1) recruiting to total wild ISW and MSW salmon which would have returned to Mactaquac in the absence of homewater removals in yr i+5 and i+6, resultant MSW:ISW salmon ratios, and <u>forecast</u> numbers of ISW and MSW fish to Mactaquac in the absence of homewater removals in 1990.

- See App. 1, 2 and 3 for derivation.
- Based on regression of 1SW returns to Mactaquac, 1973-1987, (col. 3) on adjusted egg deposition in Tobique River, 1968-1969 to 1982-1983, (col. 2):

 $log_{e} Y = 6.596 + 0.402 log_{e} X; n=15, r^{2}=0.45, p=0.008$ Y₁₉₉₀ = 7,393 (AM); 95% C.L. = 5,601 to 9,757.

Based on regression of MSW returns to Mactaquac, 1971-1989, (col. 4) on 1SW returns to Mactaquac 1970-1988 (col. 3):

 $\log_{e} Y = 5.7209 + 0.3409 \log_{e} X$; n=19, r²=0.22 (p <0.05) Y₁₉₉₀ = 7,530 (AM).

^d Product of mean ratio (0.664) MSW/1SW, 1980-1981 to 1988-1989, excl. of 1983-1984 and 1984-1985 and 9,522 returns in 1989.

Release	<u>}</u>			Returns in 1990							
Year	Loc.	Stage	Number	Rate	Age	l SW	MSW				
1989 1989 1989 1987 1987 1986	At Bl Abv Abv Abv Abv	l-,2-yr smolt l-,2-yr smolt l-,2-yr smolt Fall fing. Unfed fry Fall fing.	238,204 47,389 50,000 145,428 266,257 220,176	0.00940ª 0.00940ª @0.2b 0.00940ª x 0.5 0.00050° 0.00050° x 0.1 0.00028°	1-,2.1 1-,2.1 1-,2.1 2.1 2.1 3.1	2,239 89 235 73 13 61					
1988 1988 1986 1985 Totals	At Bl Abv Abv	l-yr smolt l-yr smolt Fall fing. Fall fing. Adults 1989₫	142,195 71,812 220,176 289,000	0.0038ª 0.0038ª @ 0.26♭ 0.00010° 0.00010° 0.05 (1SW) 0.14	1.2 1.2 2.2 3.2 6 (MSW) various	2,710	540 71 22 29 <u>88</u> 750				

Table 5. Forecasts of hatchery 1SW and MSW returns to Mactaquac Saint John River, 1990, as estimated from numbers of various juveniles released at (At) or above (Abv) Mactaquac and estimated return rates.

Arcsine mean 1986-1989 adjusted return rate; proportions above and below (App. 4).

^b App. 5.

° App. 6.

^d Rates (Marshall and MacPhail MS 1987) applied to est. hatchery <u>spawners</u> (1989) i.e., 879 1SW and 296 MSW fish above Mactaquac.

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

Table 6. Estimated river returns of Saint John wild and hatchery ISW and MSW salmon destined for Mactaquac Dam, 1970-1989.

Preliminary

	Natin		Spo	ortb	Comme	cial	By-	catch ^c	Tc	<u>otal</u>
Year	1SW	MSW	1SW	MSW	1SW	MSW	1SW	MSW	1SW	MSW
1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988	27 73 526 64 92 328 713 361 235 203 353 471 600 280 300	569 739 2038 1070 1013 771 2575 891 2088 588 2135 2526 2400 1120 1200	392 319 311 704 2034 3490 3580 2540 1151 2456 3260 2425 1880 1453 1824 3060 1692 1650 1755	333 357 770 420 2080 1474 2134 3125 899 589 2409 1085 921 637	105 57 855 554 378	3204 2391 1228 469 1152	41 37 26 70 61 109 114 55 105 165 58 43 338 412 175 185 204	6 60 8 56 90 156 129 69 211 485 212 162 896 1771 346 242 177	497 376 352 741 2087 3633 4167 2713 1357 2839 4078 3835 2727 2077 2515 3943 2467 2115 2259	3537 2748 776 480 2657 2269 4262 4351 2041 1429 5195 3689 3690 2539 3031 4297 2746 1362 1377
1989	560	240	2304				217	221	3001	-107

Table 7. Estimated <u>landings</u> (numbers) of Native, sport, commercial and by-catch of 1SW and MSW salmon originating at or above Mactaquac on the Saint John River, 1970–1989.

Kingsclear, 1974-88, Tobique 1988-89.

DNRE and DFO sources, + calculated estimates (exploitation rates on known releases) for mainstem above Mactaquac.

Guesstimates from various sources or assumed proportions of the run.

Egg deposition		Proportion age at smoltification		Eggs/l contri to 1SW	00 m ² buting fish	Total wt'd egg contrib/100 m ²
Year	Number	Age 2	Age 3	Yr 1	Yr i+l	to 1SW fish @ Mact. (yr)
1968	5.7	0.207	0 702		4 66	
1969	43.6	0.445	0.755	19.40	7.55	23.95 (1973)
1970	60.9	0.269	0.333	16.38	44 52	40.58 (1974)
1971	71.2	0.419	0.581	29.83	41 37	74.35 (1975)
1972	130.8	0.619	0.381	80.96	49.84	122.33 (1976)
1973	86.5	0.411	0.589	35.55	50.95	85.39 (1977)
1974	269.4	0.114	0.886	30.71	238.69	81.66 (1978)
1975	368.2	0.361	0.639	132.92	235.28	371.61 (1979)
1976	245.4	0.388	0.612	95.22	150.18	330.50 (1980)
1977	309.2	0.306	0.694	94.62	214.58	244.80 (1981)
1978	193.2	0.385	0.615	74.38	118.82	288.96 (1982)
1979	112.3	0.429	0.571	48.18	64.12	167.00 (1983)
1980	362.1	0.485	0.515	175.62	186.48	239.74 (1984)
1981	118.7	0.279	0.721	33.12	85.58	219.60 (1985)
1982	139.8	0.587	0.413	82.06	57.74	167.64 (1986)
1983	69.4	0.450	0.550	31.23	38.17	88.97 (1987)
1984	385.5					
1985	301.7		<u>0.620</u> b	•• ••	187.05	
1986	220.0	<u>0.380</u> Þ		83.60		270.65 (1990)

App. 1. Number of eggs/100 m² deposited in the Tobique River, 1968-1986, and derivation of weighted number of eggs contributing to annual returns of wild 1SW fish at Mactaquac, 1973-1987 and 1990 (explanation in Penney and Marshall MS 1984).

a Derived from App. 2 and 3.

b Mean (n=16) calculated with angular transformation.

Year-	Numbe	<u>r at age of 1SW r</u>	<u>eturns to Mact</u>	aquac	Prop. 2:1's
<u>class (1)</u>	2:1(1+3)	3:1 (1+4)	<u>4:1 (i+5)</u>	<u> </u>	of_total
1968		690	41		
1969	127	451	37	615	0 207
1970	1 578	1 901	69	3 547	0.207
1071	1 710	4 465	212	5,547	0.445
1070	1,710	4,400		0,393	0.209
1072	2,323	3,100	44	5,555	0.419
19/3	4,/49	2,887	40	7,676	0.619
1974	1,046	1,393	103	2,542	0.411
1975	469	3,257	398	4,124	0.114
1976	3,468	5,598	544	9,610	0.361
1977	2,486	3,619	298	6,403	0.388
1978	1,619	3,659	13+6	5,296	0.306
1979	1,001	1,503	91+6	2,601	0.385
1980	2.793	3,540	176	6.509	0 429
1981	4,679	4,790	187	9 656	0.425
1982	1 548	3 737	270	5,050	0.405
1983	3 980	2,727	270	5,555	0.2/3
1084	2 015	2 745	202	0,111 C 402	0.30/
1005	Z, JID	3,243	323	0,403	0.450
1000	J, D12	4,990			
1980	4,209				

App. 2. Number of wild 1SW salmon and proportion of age 2:1's of the total that would have returned to Mactaguac for the 1969-1984 year-classes.

Fresh-	Number of 1SW fish													
age	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989=
A														
2	3,962	922	391	3,166	2,214	1,280	794	2,348	4,140	1,264	3,196	2,513	5,066	3,720
3	2,658	2,545	1,160	2,974	4,986	2,861	2,902	1,264	3,132	3,913	3,001	2,349	2,930	4,411
4	177	39	33	94	355	430	236	11	81	144	150	233	66	286
5										5				
6										5				
Total	6,797	3,506	1,584	6,234	7,555	4,571	3,932	3,623	7,353	5,331	6,347	5,095	8,062	8,417
B														
2	4,749	1,046	469	3,468	2,486	1,619	1,001	2,793	4,679	1,548	3,980	2,915	5,612	4,209
3	3,186	2,887	1,393	3,257	5,598	3,619	3,659	1,503	3,540	4,790	3,737	2,724	3,245	4,990
4	212	44	40	103	398	544	298	13	91	176	187	270	73	323
5										6				
6										6				
Total	8,147	3,977	1,902	6,828	8,482	5,782	4,958	4,309	8,311	6,526	7,904	5,909	8,930	9,522

App. 3. Freshwater age and number of wild 1SW fish (A) counted at Mactaquac fish passage facilities, Saint John River, 1976–1989, and (B) that would have returned to Mactaquac had they not been exploited/within the river, 1976–1989.

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App. 4. Estimated total number of 1SW and MSW returns to the Saint John River from hatchery-reared smolts released at Mactaguac, 1974-1989.

Releases			Returns (1SW/MSW)									
		Prop		Mactad	Juac	Kings-	Angled	By-	Commer-	·	<u>% return</u>	
Year	Smolts	<u>l-yr</u>	Year	Mig ch	Dam	clear	main SJ	catch	cial	Totalª	Unadj	Adj
1974	337,281	0.00	1975	1.771	3.564	28	977	34		6.374	1.890	
75	324,186	0.06	76	2,863	4.831	219	1.129	32		9.074	2.799	
76	297.350	0.14	77	1,645	4,533	36	708	70		6,992	2.351	
77	293,132	0.26	78	777	1.779	49	369	70		3,044	1.038	
78	196,196	0.16	79	799	2.722	100	186	20		3,827	1.951	
79	244.012	0.09	80	3.072	6,687	335	640	59		10,793	4.423	
80	232,258	0.12	81	921	2,861	139	350	74	385	4,730	2.037	
81	189,090	0.08	82	828	1,464	64	267	21	202	2,846	1.505	1.445
82	172.231	0.06	83	374	857	39	69	11	95	1,445	0.839	0.776
83	144,549	0.22	84	476	828	36	63	48		1,451	1.004	0.976
84	206,462	0.28	85	454	1,288	82	128	66		2,018	0.977	0.920
74-84	2.636.747				•					52,594	1.995	
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	(7)	17)	15	46	16		794	0.700	0.672
88	142,195	1.00	8др	(1	,018)	0	107	23		1,148	0.807	0.763
89	238,204	0.98		•								- -
1974	337.281		1976	310	1.313	392	267	20		2.302	0.683	<
75	324,186		77	341	1,727	206	417	34		2,725	0.841	
76	297.350		78	223	1.728	368	165	50		2,534	0.852	
77	293,132		79	145	747	210	65	21		1,188	0.405	
78	196,196		80	302	1,992	506	146	46		2,992	1.525	
79	244,012		81	126	963	252	125	147	999	2,612	1.070	
80	232,258		82	88	640	462	181	50	110	1,531	0.659	
81	189,090		83	44	255	76	17	23	166	581	0.307	0.285
82	172,231		84	84	722	201	5	103		1,115	0.647	0.559
83	144,549		85	73	492	189	5	116		875	0.605	0.553
84	206,462		86	16	471	266	4	40		<u> </u>	<u>0.386</u>	0.346
74-84	2,636,747									19,252	0.730	
85	89,051		87	4	338	110	4	24		480	0.539	0.453
86	191,495		88	(5)	11)	150	0	35		696	0.364	0.354
87	113,439		8 3 p	(3)	79)	0	0	20		399	0.352	0.330
88	142,195			•	-							
89	238,204											

 Includes returns from downriver stocking of smolts, 1981-1988; adjusted return rate removes downriver returns to Mactaquac (see App. 5).

ISW <u>hatchery</u> fish at Mactaguac were estimated at 0.857, 0.082 and 0.061 age 1.1, 2.1 and 3.1. MSW hatchery fish at Mactaguac were estimated at 0.850, 0.064, 0.026 and 0.06 age 1.2, 2.2, 3.2 and 'repeats', respectively. All estimates are preliminary.

App. 5. Smolt release information background to the calculation of 'adjusted' return rates for smolts released at Mactaquac and adjustment of hatchery (1982-1989) and wild (1982-1989) returns below Mactaquac. A:-Number of tag returns, return rates and proportionate contribution to Mactaquac from smolts released at and below Mactaquac 1983-1988; B:-Total smolts released below Mactaquac which originated from Mactaquac F.C.S. (also numbers released at Mactaquac) and C: Calculation of adjusted return rate for 1988 smolts returning as 1SW fish in 1989.

	À	lactaquac t	ags	1	<u>Below' tag</u>	<u>s</u>	
Return	Ret'n	Smolts	Ret'n	Ret'n Mact	Smolts	Ret'n rate (b	Ratio) a:b
year	Mact.	released	rate (a)	<u>Macc.</u>	12 000	0 00054	1.0 0844
1984	64	10,000	0.00640		15,000	0.00034	1.0 2860
1985	114	19,988	0.00570	26	15,996	0.00103	1.0.1707
1986	97	15,900	0.00610	13	11,952	0.00109	1:0.1/0/
1987	113	15,901	0.00711	20	4,975	0.00402	1:0.5654
1000	50	11 550	0.00511	8	13,277	0.00060	1:0.11/4
1900	55	7 761	0 00657	6	7,938	0.00076	<u>1:0.1157</u>
<u>1983</u> (21	7,701	0.00615	-	•	0.00125	1:0.2032
arcsine)			0.00010				
1985 1986 1987 1988 <u>1989</u> (arcsine)	30 24 41 26 14	10,000 19,988 15,900 15,901 11,550	0.00300 0.00120 0.00258 0.00164 <u>0.00121</u> 0.00186	11 10 9 1 3	13,000 15,996 11,952 4,975 13,277	0.00085 0.00063 0.00075 0.00020 <u>0.00023</u> 0.00049	1:0.28333 1:0.52500 1:0.29070 1:0.12195 <u>1:0.19008</u> 1:0.26344
	Return year 1984 1985 1986 1987 1988 1989 arcsine) 1985 1986 1987 1988 1989 arcsine)	Return Ret'n 1984 64 1985 114 1986 97 1987 113 1988 59 1989 51 arcsine) 30 1985 30 1986 24 1987 41 1988 26 1989 14 arcsine) 14	Mactaquac tReturnRet'nSmoltsyearMact.released19846410,000198511419,98819869715,900198711315,90119885911,5501989517,761arcsine)10,00019862419,98819874115,90019882615,90119891411,550arcsine)1411,550	$\begin{array}{c c c c c c c c c c c c c c c c c c c $	$\begin{array}{c c c c c c c c c c c c c c c c c c c $	$\begin{array}{c c c c c c c c c c c c c c c c c c c $	$\begin{array}{c c c c c c c c c c c c c c c c c c c $

B.		No. smolt	s released	
2.	Vear	Above	At	Below
	1981		189,090	44,918ª
	1002		172.231	80,535
	1003		144.549	48,706
	1001		206,462	46,126
	1904		89 051	56,992
	1982		101 495	38,387
	1986		112 420	39 445
	1987		113,433	71 010
	1988		142,195	/1,012
	1989	50,000b	238,204 ^b	<u>47,389</u>
	a not	incl' 21,200	from Minto	
	<pre>b incl.</pre>	2-yr smolts	from Saint	John Hatchery

C. Calculation of adjusted return rates for smolts released at Mactaguac

- In 1989, 1,148 1SW fish return to Mactaguac from 142,195 smolts released at Mactaguac and some of 71,812 released below Mactaguac (App.4).
- 2. From A(above) smolts contributing to Mactguac were (142,195 x 1) + (71,812 x .1157) = 150,504.
- 3. Adjusted return rate = 1,148/150,504 or 0.00763 (App. 4).

App. 6 Estimates of hatchery 1SW and MSW returns to the Saint John River, 1989, based on various numbers of juveniles released at (At) or above (Abv) Mactaguac and returns to Mactaguac.

Release				Returns in 1			
<u>Year</u>	Loc	c. Stage	Number	Rate	Age	1SW	MSW
1988	At	1-vr smolt	142,195	0.00763ª	1.1	1,085	
1988	B	l-vr smolt	71,812	0.00763@0.116b	1.1	63	
1986	Ahv	Fall fing.	220.176	0.082° x 1339/220,176	2.1	110	
1985	Abv	Fall fing.	289,000	0.061° x 1139/289,000	3.1	81	
1987	At	l-vr smolt	113,439	0.00330ª	1.2		374
1987	Bl	l-vr smolt	39,445	0.00330 @ 0.19 ^b	1.2		25
1985	Aby	Fall fing.	289,000	0.064° x 469/289,000	2.2		30
1984	Aby	Fall fing.	123,600	0.026° x 469/123,600	3.2		12
1 704		Repeat spaw	mers.	0.013 (28/2127 in 1988)			28
Total	<u> </u>	Nepeut opun		, , , , , , , , , , , , , , , , , , , ,		1,339	469

- a See App. 4
- b See App. 5
- c Footnote App. 4.