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**New estimates of commercial harvest and by-catch of Saint John River  
Atlantic salmon, 1981-1983.**

by

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**ABSTRACT**

Harvest statistics, based on log books from a commercial and by-catch fishery, 1981-1983, were questioned when analyses of forecast and stock-and-recruit models, which utilize returns of Saint John River Atlantic salmon from the last 20 years, revealed inexplicable deviations of patterns in the commercial fishery years from the non-commercial fishery years before 1981 and after 1983. New estimates of harvest, 1981-1983, were derived using 148 tags returned from hatchery-origin salmon in the fishery, 617 tagged fish which returned to Mactaquac Dam and a derived reporting rate of 0.44 (assumes a 15% stray rate) for tagged hatchery multi-sea-winter (MSW) salmon destined for Mactaquac Dam.

New estimates of the total numbers of MSW salmon harvested in the fisheries increased between 11% and 291%; the harvest of one-sea-winter (1SW) salmon increased between 103% and 184%. New harvest estimates for the hatchery and wild components originating at/above Mactaquac and used in forecast and stock-and-recruit modelling changed the estimates of total 1SW recruits to Mactaquac between +4% (1982) and +19% (1981) and of total MSW recruits between -4% (1981) and +90% (1983).

**RÉSUMÉ**

Les statistiques de récolte, fondées sur les journaux de pêche commerciale et de pêche accidentelle, pour 1981-1983 ont été remises en question lorsque les analyses des modèles de prévision et de stock-recrutement, qui font appel aux montaisons de saumon de l'Atlantique dans le Saint-Jean au cours des 20 dernières années, ont révélé d'inexplicables écarts entre les tendances de la pêche commerciale et celles de la pêche non commerciale avant 1981 et après 1983. De nouvelles estimations de la récolte de 1981 à 1983 ont été établies à partir de 148 étiquettes retournées qui provenaient de saumons d'élevage capturés par des pêcheurs, de 617 poissons étiquetés qui sont retournés au barrage de Mactaquac et d'un coefficient de déclaration de 0,44 (supposant un taux d'égarement de 15 %) pour le saumon pluribermarin d'élevage étiqueté destiné à retourner au barrage de Mactaquac.

Les nouvelles estimations du nombre total de saumons pluribermarins capturés ont augmenté de 11 % à 291 % et la récolte de saumons unibermarins de 103 % à 184 %. Les nouvelles estimations de récolte du saumon d'élevage et du saumon sauvage provenant de Mactaquac ou de l'amont de Mactaquac - qui sont utilisées dans les modèles de prévisions et de stock-recrutement - ont eu pour effet de modifier les estimations du nombre total de recrues d'unibermarins à Mactaquac de + 4 % (1982) à + 19 % (1981) et le nombre total de recrues de pluribermarins de - 4 % (1981) à + 90 % (1983).

## INTRODUCTION

Between 1972 and 1992, the commercial fishery for Atlantic salmon in tidal waters of the Saint John River and in the Bay of Fundy was open only in the years 1981-1983. Compensation had been paid to licensed salmon fisherman, 1972-1980, and was continued again 1984. Unlike the pre-1971 fisheries, licensed fishermen in the open period were restricted to individual quotas within abbreviated seasons and were required to tag and record all fish and to submit their catch and effort data in logbooks to the Department. Commercial fisherman not licensed for salmon were allowed nominal by-catch except in 1983 when the retention of salmon caught in non-salmon gear became prohibited. Catch statistics from logbooks and estimates of by-catch, 1981-1983 (Redbooks<sup>a</sup>), are a significant component of estimated returns of Atlantic salmon to the Saint John River (Marshall 1988; Penney and Marshall 1984) and, therefore, these records impact on potential stock-recruit relationships which incorporate these data.

Concern has existed during the last decade about the completeness of the 1981-1983 recorded commercial catch statistics due to recent and past allegations by some commercial fisherman that many fish went unreported and that the self-locking tamper-proof plastic tags that were used in that period were in fact re-useable; one fisherman, however, recently suggested that logbooks would have accounted for 90% of the harvest by licensed salmon fishermen. Analyses by Ritter et al. (1990) and a retrospective view of Mactaquac counts of hatchery and wild salmon and estimated returns to the Saint John River for the years 1981-1983 suggest strikingly similar and biologically inexplicable deviations from patterns prior to and after that fishing period.

This paper utilizes tag return (\$8 reward) data from the 1981-1983 commercial and by-catch fisheries and a derived tag reporting rate to estimate independently the numbers of hatchery and wild 1SW and MSW salmon destined for Mactaquac and for the entire Saint John River that were intercepted by the commercial and by-catch fisheries in and proximate to the river in each of those years.

## BACKGROUND

Licensed commercial salmon fishing units (fishermen), quotas and open seasons for fishing in the Saint John and adjacent Bay of Fundy are summarized as follows:

Year	No. of units <sup>b</sup>	Quotas	Open seasons (5-day fishing weeks)
1981	9 TN	6,000 MSW	June 8 - Jul 31; closure of FSDs
	52 DN	8,000 1SW	48,49, (Harbour and Bay)
	12 GN		June 19 (noon) - Jul 6 (9am)
1982	9 TN	3,700 MSW	Jul 5 - Jul 31
	51 DN	6,450 1SW	
	10 GN		

<sup>a</sup> Atlantic Salmon Commercial Catch Statistics, Maritime Provinces, annual series beginning 1970 and terminating in 1983. Published by DFO and its precursors.

1983	9 TN 49 DN 10 GN	3,700 MSW 6,450 1SW	Jul 5 - Jul 31; Harbour (below Reversing Falls) extended by variation July 31 - Aug 6
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<sup>b</sup> salmon trap nets, drift nets, gill nets.

The by-catch fishery consisted of unknown numbers of weirs, other drift nets and other surface gill nets fished mostly for shad and gaspereau in the Harbour area and herring in the adjacent Bay of Fundy.

Prior to 1970 the normal commercial season for salmon had been 15 May to 15 August. Penney (1983), noted that drift net catches of MSW salmon in the Bay of Fundy fisheries generally peaked between mid-June and mid-July, while 1SW fish were most evident during the month of July.

Estimated numbers of commercial and by-catch salmon landed, 1981-1983, used in previous assessments of Saint John River salmon originating above and below Mactaquac, Marshall (1988), are:

Year	Commercial		By-catch		Total	
	1SW	MSW	1SW	MSW	1SW	MSW
1981	1,115	5,982	268	816	1,383	6,798
1982	1,684	2,550	100	382	1,784	2,932
1983	1,186	2,817	79	332	1,265	3,149

## METHODS

Tags returned by commercial fisherman/buyers/port samplers and tags recorded at the Mactaquac sorting facilities during the study period were 1SW and MSW returns of Mactaquac hatchery-origin fish tagged as smolts (mostly age-2), 1979-1982.

### Harvest of salmon destined for Mactaquac

Harvests of hatchery salmon by the commercial and by-catch fisheries were estimated as the product of the number of tags returned from the fisheries, adjusted by a reporting rate, and total hatchery salmon counted at Mactaquac and the reciprocal of the total hatchery tag returns at Mactaquac Dam, i.e.,

$$\text{Harvest}_{\text{hch}} = \frac{\text{Count}_{\text{Mact}} * (\text{Tags}_{\text{comm}} * 1/\text{Rep rate})}{\text{Tags}_{\text{Mact}}}$$

Harvests of wild 1SW and MSW wild salmon taken in the commercial fisheries were essentially estimated as the product of the wild count at Mactaquac and the reciprocal of the estimated proportion ( $p_{\text{hch}}$ ) that hatchery fish taken in the fishery were of those in the commercial catch and

counted at Mactaquac (adjusted for stray rate), minus the wild count at Mactaquac, i.e.,

$\text{Harvest}_{\text{wild}} = [\text{Count}_{\text{Mact wild}} * 1/(1 - p_{\text{htch}})] - \text{Count}_{\text{Mact wild}}$ , where

$$p_{\text{htch}} = \frac{\text{Harvest}_{\text{htch}}}{\text{Harvest}_{\text{htch}} + [\text{Count}_{\text{Mact htch}} * 1/(1 - \text{stray rate})]}$$

The tag reporting rate used in this analysis was that rate which provided a tag return estimate of the total MSW Saint John River commercial harvest in one of the three years which equalled the product of the original harvest estimate, based on logbooks, and the reciprocal of a 0.9 completeness rate. (Logbooks were presumed to maximally account for 90% of MSW fish in any one year.) A differential reporting rate of 0.05 was assumed between MSW and 1SW fish because proportionately more of the latter were personally retained by fishermen, thereby reducing the likelihood of tags being recovered by secondary sources such as buyers and port samplers. (Some fisherman have since said that they returned only a few of the tags that came into their possession but point out that fish buyers would have had less compunction to withhold tags that came to their attention.) Reporting rate was assumed to be constant between years.

Stray rate of Mactaquac-origin hatchery fish between the lower estuary/Harbour and Bay of Fundy within the influence of the outflow of the Saint John River is unknown but is assumed to be 0.15. Only 70% of hatchery-origin 1SW and 60% of hatchery-origin MSW salmon captured and Carlin-tagged at Westfield, 1972-1974, were recovered at Mactaquac or in fisheries between. However, losses could not be apportioned between potential tag loss, tagging/handling mortality and straying. The contribution to Mactaquac of returns of untagged 1SW and MSW fish from about 45,000 and 81,000 hatchery smolts stocked in tributaries below Mactaquac in 1981 and 1982 is unknown.

#### Harvest of salmon destined for above and below Mactaquac, Saint John River

Estimates of all Saint John River salmon harvested in local fisheries were based on the estimates of hatchery fish taken in the fisheries, the proportion of hatchery fish originating from Mactaquac and the proportion of hatchery fish in port sampling of the commercial fishery (Penney and Marshall 1984), i.e.,

$$\text{Harvest}_{\text{total}} = \text{Harvest}_{\text{htch}} * 1/[p_{\text{Mact origin}} * p_{\text{htch comm sample}}]$$

One major assumption is that net selectivity for hatchery-origin fish was similar to that for wild fish.

## RESULTS

One hundred and forty-eight tags (44 1SW and 104 MSW salmon) were returned from commercial sources and 617 tagged fish (404 1SW and 213 MSW) returned to Mactaquac Dam over the three years (Table 1). Annual counts of wild 1SW salmon at Mactaquac ranged from 3,613 to 4,571; counts of wild MSW ranged from 1,711 to 2,441.

A tag reporting rate of 0.4412 (with stray rate set at 15%) provided an estimate of 1,262 hatchery MSW fish of Mactaquac-origin harvested in the commercial and by-catch fisheries in 1981 (Table 2). The 1,262 hatchery MSW salmon provided a total estimated harvest (hatchery + wild, above and below Mactaquac origins) of 7,554 MSW fish) or about 110% of the landings derived from log books (Table 3), i.e., the two estimates meet the conditions of the suggestion that, in at least one year, reported landings could have accounted for 90% of the harvest. The adjusted commercial harvests of MSW salmon in 1982 and 1983 were 216% and 291% greater than the respective original estimates. The reporting rate for 1SW fish was arbitrarily reduced by 0.05 and commercial harvests as estimated by tag returns increased by 103% to 184% from the original estimates (Table 3).

Old and new estimates of commercial and by-catch harvest of wild and hatchery 1SW and MSW salmon destined for and above Mactaquac, 1981-1983, are provided in Table 2.

## DISCUSSION

Under reporting of landings by commercial fisherman, particularly in 1982 and 1983, were not unexpected by the casual observer. A quota of less than 200 fish per fisherman, 43% of which was to be 1SW fish which required smaller mesh nets than were possessed by some fishermen, suggested that adherence to regulations would make total cost recovery difficult. Tag reporting rates by commercial fishermen in this fishery appear to have been maximally, 0.44 (with a stray rate of 15%; 0.52 if stray rate was assumed to be 0%) for MSW salmon; lower than the 0.7 value used for fishermen of insular Newfoundland (Marshall 1990) and the 0.5-0.6 range accorded fishermen of West Greenland in the late 1970's and early 1980's (Anon 1987).

Revisions in the commercial landings of 1981-1983 impact the estimate of recruits to the Saint John River and, in particular, preseason forecast models for 1SW and MSW returns and stock-and-recruitment investigations for salmon originating at and above Mactaquac Dam. Changes in estimates of total returns and percentage change destined for Mactaquac (Marshall 1992, 1993) can be summarized as follows:

	Year	Hatchery		Wild	
		1SW	MSW	1SW	MSW
Previous	1981	4,730	2,612	5,782	5,991
	1982	2,846	1,531	4,958	5,001
	1983	1,445	581	4,309	3,447
Revised	1981	5,627 (+19)	2,728 (+4)	6,614 (+14)	5,766 (-4)
	1982	3,038 (+7)	1,769 (+16)	5,174 (+4)	5,528 (+10)
	1983	1,564 (+8)	1,104 (+90)	4,555 (+6)	5,783 (+68)

Revised estimates of commercial and by-catch harvest among salmon destined for Mactaquac suggest exploitation rates of 0.12 to 0.21 for 1SW fish and 0.19 to 0.64 for MSW salmon. Previous data suggested exploitation rates of 0.07 to 0.10 and 0.10 to 0.44 for 1SW and MSW salmon, respectively.

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Table 1. Numbers of tags from the commercial fisheries (inc. by-catch) and Mactaquac, and counts of hatchery and wild salmon at Mactaquac, 1981-83.

Year	Sea-age	Tag returns		Mactaquac counts[a]	
		Comm.	Mact	Hatchery	Wild
1981	1SW	31	221	3,782	4,571
	MSW[b]	69	135	1,089	2,441
1982	1SW	9	127	2,292	3,931
	MSW[b]	14	58	728	2,254
1983	1SW	4	56	1,230	3,613
	MSW[b]	21	20	299	1,711

a - Ingram 1985; Ingram and Ensor 1990.

b - 2SW fish for tags.



Table 2. Estimates of the numbers of salmon harvested in the commercial fishery and by-catch which were destined for Mactaquac, 1981-1983. See footnotes and text for method of derivation of tag reporting rates and p-values.

Year	Previous estimates of harvest[a]				New estimates of harvest[b,c,d]			
	Hatchery		Wild		Hatchery		Wild	
	1SW	MSW	1SW	MSW	1SW	MSW	1SW	MSW
1981	459	1,146	561	2,629	1,356	1,262	1,393	2,404
1982	223	160	389	521	415	398	605	1,048
1983	106	189	315	1,125	225	712	561	3,461

a - Extracted from Marshall 1988.

b - Stray rates for hatchery 1SW and MSW salmon destined for Mactaquac assumed to be 0.15.

c - Tag reporting rates of 0.3912 (1SW) and 0.4412 (MSW) selected with insight gained from "percentage increase" of MSW salmon in 1981 (see Table 3).

d - p-values for hatchery fish (see text) used to derive estimates of wild harvest were as follows:

Year	1SW	MSW
1981	0.234	0.496
1982	0.133	0.317
1983	0.134	0.669

Table 3. Estimates of the numbers of Atlantic salmon caught in the commercial and by-catch fisheries of the Saint John River and approaches, 1981-1983, which originated above and below Mactaquac.

Year	Former harvests[a]		Adjusted harvests[b]		Percentage increase	
	1SW	MSW	1SW	MSW	1SW	MSW
1981	1,383	6,798	3,931	7,554	184	11
1982	1,784	2,932	3,620	9,262	103	216
1983	1,265	3,149	2,918	12,312	131	291

a - Extracted from Marshall 1988.

b - Utilizes new estimates for harvest of hatchery fish originating above Mactaquac (Table 2 and reporting rates of 0.3912 for 1SW fish and 0.4412 for MSW salmon) and proportions from Table 3, Penney and Marshall 1984 (see text for formula).