STATUS OF ATLANTIC SALMON IN THE MIRAMICHI RIVER IN 1991

by

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ABSTRACT

In 1991, total returns of large salmon (MSW virgin salmon+previous spawners) were similar to returns in 1990 and 25% greater than average returns over the last five years. Returns of small salmon (1SW virgin salmon) were 37% less than average returns during the last five years. Estimated returns from Millbank trap efficiency (29,949 large and 60,869 small) were close to mark-recapture (tagging at Millbank and recapture at traps and fences upstream) estimates (33,830 large and 61,964 small salmon). Target egg deposition requirements were exceeded in 1991 (158%). Large salmon contributed 90% of the egg production in 1991. Target egg deposition levels have been achieved or nearly achieved in each of the past 7 years in the Miramichi River. Previous spawners continued to increase as a proportion of the large salmon (39%) and total adult salmon (14.4%) returns. Angling catches, native harvests, and headwater barrier counts of large and small salmon were less in 1991 than average.

RESUME

Le nombre de gros saumons venant frayer (pluribermarins vierges et ceux ayant frayé auparavant) était semblable à celui enregistré en 1990, et surpassait de 25 pour cent la moyenne quinquennale. Le nombre de petits saumons revenus (unibermarins vierges) était inférieur à la moyenne quinquennale de 37 pour cent. Les retours estimés par la trappe de Millbank (se portant à 29,949 gros et 60,849 petits saumons) se rapprochaient des estimations basées sur la reprise des individus marqués à Millbank et captés par les trappes et clôtures en amont (qui, elles, se chiffraient à 33,830 gros et 61,964 petits saumons). Le nombre d'oeufs déposés en 1991 excédait les objectifs de 158 pour cent. Les gros saumons ont contribué à 90 pour cent de la production d'oeufs de 1991. Les objectifs de déposition d'oeufs pour la rivière Miramichi ont été atteints, ou presque, lors de chacune des 7 dernières années. Les pluribermarins ayant déjà frayé représentent une proportion des gros saumons (39,5 pour cent) et de tous les adultes (14,4 pour cent) toujours grandissante. Les prises des pêcheurs sportifs, des autochtones, et des barrières d'énumération en amont de la rivière ont toutes chuté en 1991.

INTRODUCTION

The objective of this document is to evaluate the status of Atlantic salmon in the Miramichi River in 1991. This paper is the 12th annual assessment of salmon stocks in the Miramichi River. Harvests from the angling and native fisheries are summarized and spawning escapement in 1991 is estimated using Millbank trap data and mark-and-recapture data.

A five year conservation program was implemented for Atlantic salmon in 1984 to increase spawning levels in rivers of the Maritime Provinces. Under this program commercial fishing for Atlantic salmon in the Maritime Provinces has been prohibited as has the possession or sale of salmon caught in non-salmon gear (by-catch). Anglers have been allowed to keep only small [one-sea-winter (1SW)] salmon (<63 cm in fork length), with season, possession, and daily bag limits of 10, 6, and 2 fish, respectively. Angling season for various sections of the Miramichi River System are summarized in Appendix 1. Native food fisheries at Burnt Church on Miramichi Bay and the Eel Ground and Red Bank Reserves on tidal waters of the Northwest Miramichi have not been regulated by season or quota.

This document uses the following terminology for different life stages of salmon. Kelts are spent salmon which are also referred to as black salmon or slinks. Bright salmon are ripe adult salmon in the river or estuary prior to spawning. Small salmon are adults less than 63 cm in fork length also referred to as 1SW salmon. Large salmon are adults greater than or equal to 63 cm in fork length. Large salmon contain components of previous spawners and virgin 2SW fish whereas small salmon are comprised of 1SW virgin salmon only.

METHODS

Landings

a. Sport

The Department of Fisheries and Oceans (DFO) provides monthly estimates of angling catches and effort. DFO conservation and protection officers make these estimates based on angling camp log records, Crown Reserve records, and from personal observations and interviews of anglers fishing in public waters. Estimates of catch and effort from public waters (Crown open waters) are less accurate than estimates from private camps and Crown Reserve waters. Angling data for the Southwest Miramichi River above Boiestown (York and Carleton Counties) were not available. Angling catches for these two counties were estimated from the average proportion of the total angling catch from these two counties from 1969 to 1983. Angling seasons in 1991 were similar to those in 1990 for most Miramichi tributaries (Appendix I).

The New Brunswick Department of Natural Resources and Energy (DNRE) estimates angling catches and total effort in the Miramichi each year. DNRE estimates were based on a licence stub reporting system, whereby a random sample of anglers was selected and asked to return records of their angling catch and the number of days spent fishing. Total angling catches were then estimated from the returns submitted. For the Miramichi River System, DNRE estimates are judged to be more accurate than DFO estimates (Randall and Chadwick 1983).

Angling for kelts in the Miramichi River occurred from 15 April to 15 May (Appendix I). The angling season for bright salmon was from June 8 to October 7 with variations for many tributaries and river sections (Appendix I).

The numbers of large salmon caught and released by anglers were not used as an index of abundance in this assessment; they were used to estimate the numbers of salmon lost to catch and release mortality only.

b. Native

A new interpretation of aboriginal fishing rights resulted in unrestricted fishing during 1991. Approximately 4000 net days of effort were observed in the river predominantly during the early run. There are no reliable estimates of the catches from this portion of the native fishery.

Numbers of salmon landed in the Indian food fishery at Burnt Church, Red Bank, and Eel Ground in 1991 were recorded by native fishery guardians on a daily basis and Band Councils reported these catches to the DFO Industrial and Native Fisheries Branch weekly. Independent estimates of salmon landings at Burnt Church were provided by DFO officers.

c. Other

Other removals of salmon include research samples, broodstock, and trap mortalities at DFO traps.

2. Abundance 1991

a. Counts

Adult salmon entering the Miramichi River during 1991 were monitored at the Millbank trap site from May 15 to October 25. Adult salmon returns to the Miramichi have been monitored at the Millbank trap since 1954. The trap was operated 5 days per week whereas in previous years the trap was checked every day.

Adult salmon were enumerated at five counting fences within the Miramichi watershed during 1991: Bartholomew River, Catamaran

Brook, and at headwaters of three tributaries, Dungarvon River, North Branch of the Main Southwest Miramichi, and the Northwest Miramichi (Figure 1). Counts of salmon have been available for the Dungarvon and Southwest (SW) Miramichi barriers since 1981, and at the Bartholomew River since 1977 (Bartholomew has been a major enhancement project on the Miramichi since 1977; Chadwick et al. 1985). Counts of salmon at the Northwest (NW) Miramichi barrier have been made since 1988, and salmon have been counted at Catamaran Brook in 1990 and 1991.

b. Sampling

All large and approximately 1 in 5 small salmon captured at the Millbank trap were sampled and scales were removed for aging. Fork length of all salmon was measured to the nearest millimetre. One in ten small salmon was sacrificed for internal sexing and weight determination (nearest 0.1 kg). In addition, sex of salmon tagged after 1 September were identified on the basis of external characteristics. External sexing has been has been verified and found to be accurate 97% of the time (n=37) after 1 September (Moore et al. 1991). Prior to September external sexing has not been reliable. All salmon released at the Millbank trap were tagged with Carlin tags using stainless steel wire.

c. Salmon traps at the Enclosure and Red Bank

Adult salmon were enumerated, tagged, measured (FL), and scale sampled at two traps situated at the Enclosure Provincial Park (Figure 1) during September and October 1991. The objective of this project was to evaluate the feasibility of estimating salmon returns to the Northwest and Southwest Miramichi Rivers separately. The Southwest Miramichi trap was operated by DFO in cooperation with the New Brunswick Salmon Council and the Northwest Miramichi trap was operated as a co-management initiative between DFO and the Eel Ground Indian Band. The Enclosure traps were operated in 1985-87 and recaptures of Millbank tags caught and released during these years were examined to aid in describing movements of fish captured in these traps.

Adult salmon were enumerated at two traps on the Northwest Miramichi River at Red Bank from 27 August to 5 November as a co-management initiative between DFO and the Red Bank Indian Band. The objectives of these traps were to train members of the Red Bank Indian Band in the operation of trap nets and provide DFO and the Band with data on salmon returns to the Northwest Miramichi River.

d. Electrofishing Surveys

Electrofishing surveys were conducted at 3 of the 15 standard headwater sites within the Miramichi watershed in July 1991. Densities of juvenile Atlantic salmon in the Miramichi have been determined by the removal method (Zippin 1956) at these sites since

1970.

3. Spawning Escapement

For both Methods 1 and 2, spawning escapement was estimated as returns to Millbank minus known removals of salmon at and above Millbank (harvests by native fishermen, broodstock removals, trap mortalities, and sampling mortalities).

Estimates of salmon mortalities from poaching and disease (PAD) (previously assumed to be 1,000 large and 4,000 small salmon annually) were not subtracted from returns in the calculation of spawning escapement. The CAFSAC subcommittee has agreed that the 2.4 eggs per square meter target includes an allowance for PAD. The mortality rate attributed to the stress of catch and release of large salmon by anglers was assumed to be 0.03 (Currie 1985).

a. Method 1. Millbank trap efficiency.

For 1991, a trap efficiency of 0.015 (95% confidence limits 0.012-0.020) was used. This trap catch efficiency was determined by mark-recapture data from small salmon for the period 1985 to 1987 (Randall et al. 1989). The trap count for Millbank includes mortalities. In 1991, the Millbank trap was operated during weekdays only and counts for 7 day per week operation were estimated by multiplying weekday catches by 1.3, the ratio of 7 day per week catches to weekday catches during 1986-90 (Appendix II). Returns to Millbank were estimated as the 7 day per week trap counts divided by the trap efficiency.

b. Method 2. Measurement of tagged to untagged ratios upstream.

Counts of tagged and untagged small and large salmon were recorded at four counting fences and four salmon traps during 1991 (Figure 1). The proportion of the population tagged was calculated by dividing the total tagged fish recaptured by total catch at the eight sites for small and large salmon, respectively. Returns of small and large salmon to Millbank were calculated by the Adjusted Petersen Method (Ricker 1975).

$$N = (M+1)(C+1)/(R+1)$$

where: M= number of fish tagged
C= sample examined for tags upstream
R= recaptures
N= returns to Millbank

Confidence limits for the estimate were calculated by treating the number of recaptures (R) as Poisson variable, obtaining 95% confidence limits for it from a table of the Poisson distribution, and substituting these upper and lower limits for R in the equation above (Ricker 1975). Tag loss was assumed to be negligible based on

tag retention experiments conducted during 1991 (Appendix III).

Catches of tagged and untagged small and large salmon were also collected from twelve angling camps in 1991. The proportions of the small and large salmon populations tagged were determined from these data using the method described above for fence and trap data. Returns to Millbank were not calculated from these data. We regard the fence and trap data as more reliable because the reporting rate is 100% and the location of the fences and traps provides data for all tributaries of the Miramichi River System while camp data provides coverage of only a limited part of the system.

c. Egg deposition levels

Total egg deposition requirements for the Miramichi River are 132 million eggs (Randall 1985). Based on the average reproductive potential of Miramichi salmon (number of eggs/fish), 23,600 large are required to produce these egg requirements. An additional 22,600 small salmon are needed to ensure a 1:1 sex ratio at spawning. For 1991, the reproductive potential was estimated from a length-fecundity relationship for Miramichi salmon (Randall 1989) and the average fork lengths and sex ratios as determined from samples collected at Millbank. Total egg deposition in 1991 was calculated as the product of reproductive potential (eggs per spawner) and the estimated numbers of small and large spawners. Egg deposition rates (eggs per square meter) were calculated as the egg deposition divided by the rearing area of the Miramichi River (55 million square meters).

4. Forecast

Returns of large salmon to the Miramichi in 1992 were forecasted using a probability distribution model. A detailed description of the model and analysis have been presented in a separate document (Claytor et al. 1992).

RESULTS

1. Landings

a. Sport
Small Salmon

During the 1991 kelt season the catch of small salmon was 38% lower than average catches from 1986-90 (Table 1). Effort was decreased from 1990 but 26% higher than the mean effort from 1986-90 (Table 1).

Angling effort during the bright salmon season was 34% greater than the 1986-90 mean. However, catch and CPUE for small bright salmon were decreased by 54 to 67% from the 1986 to 1990 mean values

(Table 1). Both early (prior to 1 September) and late (after 30 August) catches were decreased by similar amounts (53 to 55% - Table 1). Small salmon catches as estimated by DNRE and DFO were similar for the first time since 1986 (Table 2).

Large Salmon

The number of large salmon caught and released during the 1991 "bright" season are estimated by DNRE (Table 2). The total catch decreased by 47% from the average 1986-90 catch.

b. Native harvests of salmon in 1991

Harvests in native food fisheries totalled 1,111 small and 544 large salmon in 1991 (Table 3), as reported by the Band Councils for Red Bank, Eel Ground, and Burnt Church Indian Bands. Estimates of the harvest from native nets in Miramichi Bay off Burnt Church from monitoring by DFO Conservation and Protection staff are provided (Table 3).

Native harvests of small and large salmon, as reported by Band Councils, are 27% and 17% lower, respectively, than average harvests during the past five years.

During 1991, all of the native food fisheries harvested 91 to 100% of their total catch prior to 1 September (Table 4).

c. Other removals

In addition to the recorded harvests of salmon (Table 5), known salmon mortalities subtracted from the total returns are shown in Table 3.

2. Abundance 1991

a. Counts

Millbank Trap Counts

The estimated trap counts for the Millbank trap in 1991 were 913 small and 448 large salmon (Table 6). Counts of salmon at the Millbank salmon trap from 1970 to 1991 are shown in Figure 2. The efficiency of the Millbank trap (=the trap efficiency) has changed since 1954 (Randall et al. 1990). Comparison of 1991 counts with previous Millbank counts has been limited to the previous five years. Counts of early run small salmon were 43% lower than average counts from 1986 to 1990, while counts of large salmon were unchanged (Table 6). Counts of late run small salmon decreased 20% while late run large salmon counts increased by 81% compared to 1986 to 1990 averages (Table 6).

Bimonthly catches of small salmon for 1991 indicate that both early and late runs arrived at Millbank later than the 1986-90 average

and the peak bimonthly catch during the early run was much lower than average (Figure 3).

Mean Julian dates of arrival for small and large salmon at Millbank calculated from the bimonthly catches indicated that, in 1991, small salmon arrived 16 days later than average (average= 1986-90) and large salmon arrived 15.5 days later than average.

Headwater Barrier Counts

In general counts at barrier pools showed that runs were late and counts of small salmon were below average. Counts of large and small salmon at the barrier on the North Branch of the Southwest Miramichi River at Juniper (Figure 1) were 53% and 66% below average counts from 1986 to 1990, (Table 7). However the Juniper barrier washed out and high water prevented operation of the counting trap for seven days (Sept 25-Oct 2) during peak returns (35 to 203 salmon per day). Therefore Juniper counts for 1991 are not comparable to counts from other years.

Counts of large and small salmon at the Dungarvon River headwater barrier were 21% and 54%, respectively, below average counts from 1986 to 1990 (Table 7). The Dungarvon barrier was breached by the same storm that removed the SW barrier, however salmon movements before and after the washout were low and few fish would have migrated past the counting trap during the washout. Most (95% n=37) salmon recaptured at this barrier had been tagged during the early run at Millbank.

Counts of large and small salmon at the Northwest Miramichi River headwater barrier were 16% and 40%, respectively, below average counts from 1988 to 1990 (Table 7). The NW barrier washed out for one day during the storm that removed the other barriers but few fish were counted through the trap before or after the washout and counts are comparable to other years. All recaptures of salmon (n=46 from 1988-91) at this barrier were fish tagged during June and July at Millbank (early run).

Decreases in counts of small salmon at the Dungarvon (-54%) and Northwest Miramichi barriers(-40%) were similar to the decrease in early run counts at the Millbank trap in 1991 (-43%). Barrier counts of large salmon decreased more (-21% and -16% respectively) at these barriers than early run large counts at Millbank (-4%) (Table 7).

b. Sampling

During 1991, a total of 463 salmon (128 small salmon and 335 large salmon) were sampled for age composition and fork lengths, and subsamples of these were sexed (Table 8). The sex composition of large salmon was 84.1% female and 14.4% of small salmon were female. Based on the length-fecundity relationship for Miramichi

salmon (Randall 1989), the average fork lengths, and sex ratios of salmon in 1990, reproductive potential (average eggs per spawner) was estimated to be 6,394 eggs for large salmon and 461 eggs for small salmon (Table 8).

Smolt ages for 1SW, 2SW, and PS (previous spawner) salmon are given in Table 8. The proportion of previous spawners increased to 39% of all large salmon (>63 cm FL) scale sampled in 1991. Previous spawners have made up higher proportions of total Millbank salmon counts in 1990 (10%) and 1991 (14%) than in any other years since collection of age data began in 1966 (Figure 4).

c. Salmon traps at the Enclosure and Red Bank

The salmon trap on the Southwest (SW) Miramichi at the Enclosure operated weekdays from 22 August to 27 September when it washed out during a severe fall storm. During this time 193 small and 84 large salmon were captured (Table 9). Tags were applied to 178 small and 77 large salmon. Thirteen small salmon tags were recaptured, seven by anglers in the SW Miramichi, three in the trap where they were released, one in the Northwest (NW) Miramichi trap at the Enclosure, one in the Red Bank traps, and one in the Red Bank native food fishery. One large salmon tag was recaptured by an angler in the SW Miramichi.

The NW Miramichi salmon trap at the Enclosure operated from 27 August to 29 October for seven days each week. During this time 220 small and 83 large salmon were captured (Table 9). Tags were applied to 113 small and 62 large salmon. Eight small salmon tags were recaptured, five by anglers in the SW Miramichi, two by anglers in the NW Miramichi, and one by DFO staff in the Northwest Miramichi at Stewart Brook. Three large salmon with NW tags were recaptured, two by anglers in the SW Miramichi and one was recaptured at Millbank.

The observation that a high proportion of salmon tagged at the NW Enclosure trap were subsequently caught by anglers in the SW Miramichi prompted a review of records from the traps placed in the SW and NW Miramichi at the Enclosure in 1985, 1986, and 1987. Several salmon tagged at Millbank and recaptured at these traps were subsequently recaptured a second time by anglers upstream. In total three small and one large salmon recaptured at the NW Enclosure trap were subsequently recaptured by anglers, all in the SW Miramichi. Two small salmon recaptured at the SW Enclosure trap were subsequently recaptured by anglers, both in the SW Miramichi.

The salmon traps on the Northwest Miramichi at Red Bank operated from 26 August to 4 November. During this time 217 small and 182 large salmon were captured (Table 9). Two small and one large salmon with Millbank tags were recaptured at the Red Bank traps (Table 9).

d. Electrofishing

Mean densities of age 0+ fry averaged 0.45 fish per square meter and 1+ parr averaged 0.14 fish per square meter. Juvenile densities were correlated with egg deposition rates and indices of spawning escapement.

3. Spawning escapement in 1991

Both methods were in close agreement.

a. Method 1. Millbank trap efficiency

Adjusted counts at the Millbank trap of 913 small and 448 large salmon in 1991 resulted in estimates of 60,867 small and 29,867 large salmon returns to the Miramichi River at Millbank. Spawning escapement was estimated at 48,259 small and 29,089 large salmon (Table 10).

b. Method 2. Tag-Recapture estimate

During 1991, a total of 559 small and 317 large salmon were tagged at Millbank during 5 days per week operations.

The proportion of the small and large salmon populations marked with carlin tags at Millbank as measured at the counting fences and recapture traps are summarized in Table 9. Estimated returns of 61,962 small and 33,748 large salmon were calculated using the Adjusted Petersen Method (Table 10).

The proportion of the small and large salmon populations marked as estimated from data collected from 12 angling camps were 22% and 24% lower than proportions tagged at traps and fences (Table 9).

Numbers of spawners as estimated by Methods 1 and 2 were similar (Table 10). Total returns were estimated to be 29,949 to 33,830 large and 60,869 to 61,964 small salmon. Spawning escapements were estimated at 29,089 or 32,970 large and 48,259 or 49,354 small salmon. Assuming a reproductive potential of 6394 eggs per large spawner and 471 eggs per small spawner (Table 8), the above spawning escapements indicate total egg depositions of 158% (Method 1) or 177% (Method 2) of the target egg deposition for the Miramichi River.

c. Egg deposition levels, 1970 to 1991

Returns and spawning escapements of small and large salmon in the Miramichi River System from 1970 to 1991, as estimated from Millbank trap data (Method 1), are summarized in Table 11.

The egg deposition rate for 1991 was estimated to be 3.8 eggs per

square meter; large salmon contributed 89% of the total eggs (Fig. 5). Linear correlations between the egg deposition rates and indices of spawning escapement in the Miramichi River, including angling catches of large salmon (bright fish), angling catches of large salmon kelts, mean 0+ fry densities, and mean 1+ parr densities in the from 1969 to 1991 were all positive and significant (Table 12).

Correlations of egg deposition per square meter and mean juvenile densities (0+ fry and 1+ parr) using a log-log model were significant (r squared=0.52 p=0.0005 n=19 for 1+ parr; r squared=0.50 p=0.0005 n=20 for 0+ fry)(Fig. 6).

4. Forecast

The forecast model estimated that the probability of the returns being less than the spawning requirements for large salmon was 26% (Fig. 7). The probability of returns exceeding spawning requirements by 0 to 10,000 large salmon was 44% and the probability of returns exceeding the spawning requirements by more than 10,000 large salmon was 30%.

DISCUSSION

Returns of large salmon were above average yet harvests and counts at barrier pools were below average. The total harvest of bright small salmon in 1991 (11,250 fish) was 58% less than the average harvest over the previous 5 years (26,460 fish). An angling exploitation rate of 0.19 was estimated by dividing DNRE angling harvests by the number of salmon available to be harvested by anglers (small salmon spawning escapement + small salmon angling catch). Previous estimates (1966-88) from tag-recapture ranged between 0.17 and 0.46, and averaged 0.28 (Randall et al. 1990). Angling effort, although lower than the 1990 level, was 20% greater than the mean effort over the last five years. A 16 day delay in the arrival of salmon at Millbank would have contributed to a low angling exploitation and harvest in 1991.

Heavy rain in the fall resulted in washouts at all barrier pools. These washouts could explain the lower counts in 1991.

Counts of salmon at the Millbank trap and mark-recapture data from counting fences and traps indicated that total returns of large salmon were greater in 1991 than in 1990. Total returns of small salmon were lower than in 1990. Total returns in 1991 were estimated as 29,949 large salmon and 60,869 small salmon (Method 1), compared to 28,574 large salmon and 83,448 small salmon in 1990.

Estimates of total returns as calculated from Millbank trap data and from mark-recapture data were similar in 1991. As in previous

assessments, mark-recapture data were useful in providing an estimate of returns which was independent of the Millbank trap counts.

Management measures restricting the harvest of large salmon succeeded in allowing a high percentage (97%) of total large returns to survive and spawn. Repeat spawners increased to 39% of large returns and 14% of total adult salmon returns to Millbank. Repeat spawners have not comprised such a large proportion of returns in any year since 1966. Samples collected in 1931 indicated that at that time 12.8% of large salmon (>63 cm F.L.) in the Miramichi were previous spawners (Blair 1935). Returns of large numbers of previous spawners will decrease the annual variability in the number of large salmon returning to spawn by making the population less dependent on the at-sea-survival of one or two smolt classes of 2SW salmon (Chadwick 1988).

Egg deposition requirements were exceeded in 1991 (152% Method 1; Fig. 5) and nearly all (90%) of the total egg deposition came from large salmon. Repeat spawners accounted for a significant part of egg deposition by large salmon (40%) in 1991. Target egg deposition rates have been achieved or nearly achieved in the last seven years in the Miramichi River (Fig. 5).

Tag-recapture data from the NW Enclosure trap indicate that the movements of fish caught in this trap are primarily into the SW Miramichi (7 of 10 tags recovered upstream of Enclosure Park). Movements of fish from the SW Enclosure trap were predominantly into the SW Miramichi (8 of 10 tags recovered upstream of Enclosure Park).

In order to assess numbers of salmon returning to the NW Miramichi River we recommend that the monitoring trap be placed upstream of the Enclosure on the NW Miramichi in waters adjacent to the Eel Ground Indian Reserve. It is also recommended that DFO continue to operate the Millbank salmon trap until data sufficient for assessment of returns to the NW and SW Miramichi River Systems can be gathered at other locations.

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Summary Sheet

Stock: Miramichi River, SFA 16
Life Stage: juveniles (0+,1+,2+), small and large salmon
Target: 132 million eggs (23,600 large, 22,600 small salmon)

	1986	1987	1988	1989	1990	1991	86-90	91/86-90	MIN[1]	MAX[1]
River harvest[2]										
Large	1051	1344	687	1593	879	744	1111	-33%	449	12060
Small	28135	22023	31589	26815	23609	11248	26434	-57%	8700	31589
Estuary harvest[3]										
Large	18	21	78	78	107	82	60	+37%	1	18268
Small	16	16	52	31	15	2	26	-92%	0	5512
Spawning Escapement										
Large (X 1000)	30	18	21	16	28	29	22	+27%	4	33
Small (X 1000)	89	63	90	48	60	48	70	-31%	13	89
Total Returns										
Large (X 1000)	31	19	22	17	29	30	24	+25%	9	52
Small (X 1000)	118	85	122	75	83	61	96	-36%	24	122
% egg target met	178	142	150	97	151	158	144	+10%	23	192
Juvenile Densities[4]										
0+	23.9	74.5	95.1	72.2	94.6	44.6	72.1	-38%	9.4	95.1
1+	12.2	13.1	13.9	18.4	12.4	14.3	14.0	+2%	3.0	18.4
2+	3.9	2.5	1.8	2.6	2.9	10.4	2.7	+285%	0.8	10.4

[1] MIN MAX over the period 1971 to present unless stated otherwise.
[2] River harvest includes mortalities associated with catch and release, broodstock removals, Millbank trap mortalities, and samples.
[3] Estuary harvest is native catch from 1986-91.
[4] Number per square meter, from electrofishing surveys at 15 standard sites (3 in 1991).

Recreational catches: Have ranged from 2240 - 14266 large and 8390 - 30620 small salmon during the past 10 years. Effort (rod-days) has increased over recent years while catches were highest from 1985-90. 1991 catches of large and small salmon were the lowest since 1984 and 1983, respectively.

Data and assessment: An index trap has been operated on the Miramichi River since 1954. The trap efficiency, estimated in 1972-73, changed in the early 1980s when the river channel was altered and the trap was recalibrated in 1985-87. Estimated returns from the trap efficiency and mark-recapture are have been similar in recent years.

State of the Stock: Target egg deposition rates have been almost met or exceeded in each of the last seven years. Previous spawners have increased in number and proportion of the total adult catch in recent years.

Forecast for 1992: Forecasts for large salmon returns in 1992 estimated that the probability of the returns being less than the spawning requirements for large salmon was 26% (Fig. 12). The probability of returns exceeding spawning requirements by 0 to 10,000 large salmon was 44% and the probability of returns exceeding the spawning requirements by more than 10,000 large salmon was 30%.

Recommendations: DFO should continue to operate the Millbank salmon trap until data sufficient for assessments of returns to the NW and SW Miramichi Rivers can be collected at upstream sites. The NW Miramichi trap situated at the Enclosure should be moved upriver to a site adjacent to the Eel Ground Indian Reserve.

Table 1. Angling catch and effort data for kelt and bright 1SW salmon in the Miramichi River as estimated by DNRE, 1969 to 1991.

	Kelts			Bright Salmon				
Year	Catch	Rod Days	CPUE	Early Catch	Late Catch	Total Catch	Rod Days	CPUE
1969	2547	21646	0.12	17823	6461	24284	48525	0.50
1970	3719	5746	0.65	13880	5730	19610	56994	0.34
1971	2380	6447	0.37	11276	2451	13727	43074	0.32
1972	1500	3808	0.39	16053	3048	19101	50604	0.38
1973	1538	7997	0.19	12038	1819	13857	59620	0.23
1974	1512	7013	0.22	15542	2690	18232	59843	0.30
1975	1760	7616	0.23	13314	2284	15598	59746	0.26
1976	2316	6197	0.37	23384	3798	27182	66157	0.41
1977	2380	8082	0.29	12546	1044	13590	65266	0.21
1978	1401	7083	0.20	7357	908	8265	68635	0.12
1979	1476	6244	0.24	12654	1854	14508	67599	0.21
1980	2242	7064	0.32	9674	2323	11997	58074	0.21
1981	1732	6373	0.27	19205	3511	22716	72868	0.31
1982	2691	8910	0.30	19233	2169	21402	76041	0.28
1983	2060	6690	0.31	7310	1080	8390	87620	0.10
1984[1]	862	1403	0.61	8472	1925	10397	-	-
1985	2385	4196	0.57	17111	1328	18439	61693	0.30
1986	2473	6394	0.39	20611	5552	26163	67801	0.39
1987	2748	11180	0.25	14824	5941	20765	64453	0.32
1988	4216	4455	0.95	17971	12649	30620	82103	0.37
1989	5361	6124	0.88	17321	7105	24426	72892	0.34
1990	4134	15454	0.27	15256	6116	21372	122470	0.17
1991	2356	11028	0.21	7769	3531	11300	109597	0.10
Mean (86-90)	3786	8721	0.43	17197	7472	24669	81944	0.30
Change(91-mean)/mean	-38%	+26%	-51%	-55%	-53%	-54%	+34%	-67%

Footnote: [1] 1984 Catches are from DFO

Table 2. Angling statistics for bright large and small salmon in the Miramichi as reported by N.B. DNRE and DFO.

Year	Large Salmon		Small Salmon	
	DNRE	DFO	DNRE	DFO
1969	3,804	2,827	24,284	26,715
1970	3,268	2,057	19,610	19,662
1971	1,792	1,247	13,727	8,464
1972	8,933	5,456	19,101	15,472
1973	5,977	4,881	13,857	9,033
1974	7,184	5,895	18,232	17,957
1975	6,288	3,756	15,598	9,730
1976	7,374	5,319	27,182	14,749
1977	11,617	14,344	13,590	8,244
1978	4,893	4,196	8,265	5,353
1979	2,656	2,422	14,508	7,625
1980	6,546	5,422	11,997	7,533
1981	3,238	1,602	22,716	7,031
1982	4,608	2,642	21,406	9,217
1983	2,240	1,646	8,390	3,897
1984	4,692	-	10,397	9,892
1985	9,622	-	18,439	11,926
1986	14,266	-	26,163	28,299
1987	11,932	-	20,765	11,363
1988	10,095	-	30,620	13,732
1989	11,933	-	24,426	12,665
1990	9,258	-	21,372	11,584
1991	6,147	-	11,300	9,826
Mean 1986-90	11,497	-	24,669	15,529
Change (90-Mean)/Mean	-47%	-	-54%	-37%

Note: 1984-91 Multi-sea - winter salmon statistics represent numbers of fish hooked and released.
1984 DNRE catches are from DFO

Table 3. Preliminary salmon harvest in the Miramichi River above Millbank (HR) and estuary below Millbank (HE1), 1991. Harvests in 1990 are given for comparison.

	1990		1991	
	Small	Large	Small	Large
1. Miramichi River above Millbank				
Native				
Red Bank	900	300	899	350
Eel Ground	1195	202	210	112
Angling	21372	278	11300	184
Total	23467	780	12409	646
2. Miramichi estuary below Millbank				
Native				
Burnt Church reported	15	107	2	82
estimated by DFO	315	1307	70	130
Angling	-	-	-	-
Total	15	107	2	82
3. Other Removals (Millbank and above)				
Brood stock	0	85	97	99
Trap mortalities	37	14	29	32
Samples	105	0	63	0
Total	142	99	189	131
4. Total Removals	23924	2186	12600	859

Note: Large salmon angling kills are calculated assuming a catch-and-release mortality rate of 0.03.
Food fishery harvests are estimates from DFO C&P and native bands.

Table 4. Catch and effort for native food fisheries on the Miramichi in 1991 for early and late runs by week, as reported by band councils.

Week	Burnt Church			Eel Ground			Red Bank		
	Nets	Small	Large	Nets	Small	Large	Nets	Small	Large
Early run									
21	4	0	0	-	-	-	-	-	-
22	5	0	2	-	-	-	-	-	-
23	7	0	18	-	-	-	-	0	20
24	15	0	15	14	6	22	-	6	25
25	15	0	20	15	8	20	-	98	47
26	15	0	2	12	13	8	-	108	40
27	10	0	1	15	27	13	-	120	60
28	6	0	7	12	60	23	-	140	56
29	14	2	2	12	32	3	-	160	30
30	n.a.	0	2	8	29	6	-	120	20
31	0	0	0	6	11	5	-	90	20
32	2	0	0	6	9	4	-	28	16
33	1	0	1	1	0	0	-	15	8
34	0	0	0	0	0	0	-	8	3
35	-	-	-	1	0	0	-	4	3
Subtotal	100	2	70	102	195	104	n.a.	897	348
Late run									
36	-	-	-	2	0	0	-	2	2
37	2	0	0	2	0	0	0	0	0
38	2	0	0	2	8	6	2	0	0
39	3	0	3	3	3	2	0	0	0
40	3	0	9	1	3	0	-	-	-
41	-	-	-	1	1	-	-	-	-
Subtotal	10	0	12	11	15	12	2	2	2
Total Season	110	2	82	113	210	112	n.a.	899	350
Proportion early run	91%	100%	85%	90%	93%	93%	n.a.	100%	99%

Table 5. Recorded catches of salmon in all fisheries, Miramichi River and Bay, 1951-91 (includes commercial, by-catch, recreational, and native). Kelts angled in year i are added to landings in year i-1. 1991 data are preliminary. All data are numbers X 1000.

Year	Commercial Fishery			Angling Fisheries							Native Fishery			All Fisheries
				Kelts (yr i+1)			Brights (yr i)							
	Small	Large	Total	Small	Large	Total	Small	Large	Total	All	Small	Large	Total	
1951		27.6	27.6			12.0			9.6	21.6				49.2
1952		27.3	27.3			11.3			15.9	27.2				54.5
1953		24.4	24.4			10.1			18.2	28.3				52.7
1954		50.6	50.6			11.2			23.5	34.7				85.3
1955		15.3	15.3			8.9			14.7	23.6				38.9
1956		24.7	24.7			9.3			28.9	38.2				62.9
1957		29.9	29.9			8.4			19.5	27.9				57.8
1958		25.2	25.2			10.2			36.7	46.9				72.1
1959		37.3	37.3			9.5			10.3	19.8				57.1
1960		30.8	30.8			5.6			4.5	10.1				40.9
1961		30.0	30.0			9.5			11.0	20.5				50.5
1962		41.6	41.6			7.3			10.3	17.6				59.2
1963		40.7	40.7			5.2			50.9	56.1				96.8
1964		69.8	69.8			9.0			35.1	44.1				113.9
1965		69.5	69.5			16.0	38.7	3.9	42.6	58.6				128.1
1966		72.9	72.9			20.0	51.7	5.9	57.6	77.6				150.5
1967		102.2	102.2			14.1	41.8	4.1	45.9	60.0				162.2
1968		48.5	48.5			6.9	7.0	1.5	8.5	15.4				63.9
1969		41.3	41.3	3.7	1.6	5.3	24.3	3.8	28.1	33.4				74.7
1970		39.7	39.7	2.4	1.4	3.8	19.6	3.3	22.9	26.7				66.4
1971		18.3	18.3	1.5	0.5	2.0	13.7	1.8	15.5	17.5				35.8
1972		2.5	2.5	1.5	3.0	4.5	19.1	8.9	28.0	32.5				35.0
1973		0.9	0.9	1.5	3.0	4.5	13.9	6.0	19.9	24.4				25.3
1974		1.0	1.0	1.8	3.1	4.9	18.2	7.2	25.4	30.3				31.3
1975	0.4	0.7	1.1	2.3	1.4	3.7	15.6	6.3	21.9	25.6	0.4	0.2	0.6	27.3
1976	1.8	0.9	2.7	2.4	2.2	4.6	27.2	7.4	34.6	39.2	0.2	0.2	0.4	42.3
1977	0.4	6.9	7.3	1.4	2.1	3.5	13.6	11.6	25.2	28.7	0.5	0.4	0.9	36.9
1978	1.2	8.4	9.6	1.5	1.7	3.2	8.3	4.9	13.2	16.4	0.4	0.4	0.8	26.8
1979	5.5	1.7	7.2	2.2	1.5	3.7	14.5	2.7	17.2	20.9	0.1	0.2	0.3	28.4
1980	2.7	10.9	13.6	1.7	2.1	3.8	12.0	6.5	18.5	22.3				35.9
1981	1.6	7.8	9.4	2.7	1.4	4.1	22.7	3.2	25.9	30.0	1.0	0.5	1.5	40.9
1982	2.3	12.5	14.8	2.1	1.0	3.1	21.4	4.6	26.0	29.1	0.7	0.4	1.1	45.0
1983	1.6	17.1	18.7	0.9	0.7	1.6	8.4	2.2	10.6	12.2	0.4	0.2	0.6	32.5
1984	0.0	0.0	0.0	2.4	0.0	2.4	10.4	0.0	10.4	12.8	0.4	0.3	0.7	13.5
1985	0.0	0.0	0.0	2.5	0.0	2.5	18.4	0.0	18.4	20.9	0.5	0.3	0.8	21.7
1986	0.0	0.0	0.0	2.7	0.0	2.7	26.2	0.0	26.2	28.9	2.0	0.6	2.6	31.5
1987	0.0	0.0	0.0	4.2	0.0	4.2	20.8	0.0	20.8	25.0	1.3	0.9	2.2	27.2
1988	0.0	0.0	0.0	5.4	0.0	5.4	30.6	0.0	30.6	36.0	0.9	0.3	1.2	37.2
1989	0.0	0.0	0.0	3.9	0.0	3.9	24.4	0.0	24.4	28.3	1.1	0.5	1.6	29.9
1990	0.0	0.0	0.0	2.4	0.0	2.4	21.7	0.0	21.7	24.1	2.1	0.6	2.7	26.8
1991	0.0	0.0	0.0	-	0.0	-	11.3	0.0	11.3	11.3	1.1	0.5	1.6	12.9
1986-90 Mean											1.5	0.6	2.1	-
change = (91-mean)/mean											-27%	-17%	-24%	

Note: Angling catches from 1951-68 are from DFO
Angling catches from 1969-91 are from DNRE FISHSYS

Table 6. Counts of small and large salmon at Millbank, 1954 to 1991. Counts are divided into early (May to August 31) and late periods.

YEAR	TIME Early Small	Early Large	Late Small	Late Large	Total Small	Total Large	Proportion early small	Proportion early large
1954	904	347	925	1783	1829	2130	0.49	0.16
1955	646	99	1161	2747	1807	2846	0.36	0.03
1956	1145	216	2289	3142	3434	3358	0.33	0.06
1957	1322	516	2696	3410	4018	3926	0.33	0.13
1958	2152	549	6250	3823	8402	4372	0.26	0.13
1959	760	209	1400	4094	2160	4303	0.35	0.05
1960	1079	216	3424	4458	4503	4674	0.24	0.05
1961	2213	358	4639	2634	6852	2992	0.32	0.12
1962	1576	254	1387	1661	2963	1915	0.53	0.13
1963	2765	184	11343	1455	14108	1639	0.20	0.11
1964	4674	210	4269	798	8943	1008	0.52	0.21
1965	5023	399	10762	1418	15785	1817	0.32	0.22
1966	4564	310	5426	1323	9989	1632	0.46	0.19
1967	1480	73	6216	924	7723	997	0.19	0.07
1968	2492	292	726	1127	3239	1414	0.77	0.21
1969	3224	333	1116	328	4350	667	0.74	0.50
1970	1826	125	658	120	2484	245	0.74	0.51
1971	1849	370	113	24	1962	394	0.94	0.94
1972	2378	948	164	219	2542	1167	0.94	0.81
1973	1490	478	960	655	2450	1133	0.61	0.42
1974	2948	864	1090	927	4038	1791	0.73	0.48
1975	2954	629	594	580	3548	1209	0.83	0.52
1976	4072	641	867	302	4939	943	0.82	0.68
1977	1249	1189	256	745	1505	1934	0.83	0.61
1978	1150	535	115	58	1265	593	0.91	0.90
1979	2157	257	343	61	2500	318	0.86	0.81
1980	1802	837	337	256	2139	1093	0.84	0.77
1981	2020	173	154	26	2174	199	0.93	0.87
1982	2593	392	72	16	2665	408	0.97	0.96
1983	770	226	40	19	810	245	0.95	0.92
1984	966	294	44	39	1010	333	0.96	0.88
1985	901	287	11	24	912	311	0.99	0.92
1986	1324	345	439	124	1763	469	0.75	0.74
1987	1146	223	126	68	1272	291	0.90	0.77
1988	884	173	944	152	1828	325	0.48	0.53
1989	1062	211	66	46	1128	257	0.94	0.82
1990	858	189	389	238	1247	427	0.69	0.44
1991	597	220	316	228	913	448	0.65	0.49
86-90 avg	1055	228	393	126	1448	354	0.75	0.64
Change (91-avg)/avg	-43%	-4%	-20%	+81%	-37%	+27%	-13%	-23%

Table 7. Numbers of large and small salmon counted at barriers in three tributaries of the Miramichi River, 1981 to 1991.

Tributary	Year	Large	Small	Total	Dates Operated	No. of Days
North Branch of SW Miramichi River	1981	54	671	725	Jul. 5-Oct. 4	92
	1982	282	621	903	Jun. 30-Oct. 8	101
	1983	219	290	509	Jul. 4-Oct. 10	99
	1984	297	230	527	Jul. 10-Oct. 16	99
	1985	604	492	1096	Jul. 1-Oct. 20	112
	1986	1138	2072	3210	Jun. 30-Oct. 19	110
	1987	1266	1175	2441	Jul. 2-Oct. 19	110
	1988	929	1092	2021	Jun. 30-Oct. 24	117
	1989	731	969	1700	Jul. 1-Oct. 24	116
	1990	994	1646	2334	Jun. 29-Oct. 14	108
	1991	476	495	971	Jun. 30-Oct. 21	107
1986-90	Mean	1012	1391	2341		
Change (91-avg)/avg		-53%	-66%	-59%		
Dungarvon River	1981	112	550	662	Jun. 24-Oct. 8	107
	1982	122	483	605	Jun. 28-Oct. 15	110
	1983	126	330	456	Jun. 28-Oct. 14	109
	1984	93	315	408	Jul. 5-Oct. 12	100
	1985	162	536	698	Jun. 25-Oct. 10	108
	1986	174	501	675	Jun. 25-Oct. 21	119
	1987	202	744	946	Jun. 25-Oct. 14	112
	1988	277	851	1128	Jun. 2-Oct. 25	151
	1989	315	579	894	Jun. 1-Oct. 10	132
	1990	318	562	880	Jun. 1-Oct. 11	133
	1991	204	296	500	Jun. 4-Oct. 14	133
1986-90	Mean	257	647	905		
Change (91-avg)/avg		-21%	-54%	-45%		
Northwest Miramichi River	1988	234	1614	1848	Jun. 27-Oct. 26	122
	1989	234	901	1135	May 30-Oct. 12	136
	1990	331	1318	1649	May 29-Oct. 18	143
	1991	224	765	989	Jun. 4-Oct. 18	137
	Mean	266	1278	1544		
Change (91-avg)/avg		-16%	-40%	-36%		

Table 8. Biological characteristics of adult salmon sampled at the Millbank trap, 1971-91.

1. Fork length, sex ratio, and reproductive potential.

Sea age	n	FL	SD	n	% female	eggs/spawner
MSW	335	79.3	9.18	182	84.1	6394
1SW	128	53.7	3.25	90	14.4	461

2. Smolt ages

		% at age				% at age		
	n	2	3	4	n	2	3	4
	1SW Salmon				2SW Salmon			
1991	124	47.6	50.8	1.6	200	61.0	39.0	0.0
1990	252	46.8	50.0	3.2	239	52.3	46.9	0.8
1989	284	32.4	64.1	3.5	134	57.5	42.5	0.0
1988	252	58.7	39.3	2.0	197	62.9	36.6	0.5
1987	199	40.2	58.8	1.0	43	48.8	51.2	0.0
1986	243	55.1	44.0	0.8	133	42.9	57.1	0.0
1985	141	31.9	68.1	0.0	87	57.5	42.5	0.0
1984	148	43.9	56.1	0.0	51	66.7	33.3	0.0
1983	136	41.9	58.1	0.0	33	60.6	39.4	0.0
1982	316	35.4	60.8	3.8	37	27.0	73.0	0.0
1981	418	35.7	62.0	2.4	26	34.6	65.4	0.0
1980	361	45.2	54.0	0.8	204	39.2	60.8	0.0
1979	519	35.5	63.0	1.5	40	30.0	70.0	0.0
1978	260	26.2	69.6	4.2	127	28.3	70.9	0.8
1977	296	31.1	66.5	2.4	355	74.1	25.6	0.3
1976	549	54.8	44.3	0.9	82	36.6	63.4	0.0
1975	733	28.9	68.4	2.7	227	43.6	56.4	0.0
1974	1124	31.9	67.8	0.4	419	56.6	41.8	1.4
1973	605	44.6	43.5	11.9	590	18.8	75.6	5.6
1972	504	8.7	88.1	3.2	414	16.4	81.6	1.9
1971	204	11.3	81.7	6.9	291	10.6	87.3	2.1
	Previous Spawners							
1991	127	64.3	34.1	1.6				
1990	149	68.5	31.5	0.0				
1989	71	53.5	46.5	0.0				
1988	45	57.8	42.2	0.0				
1987	11	63.6	36.4	0.0				
1986	23	34.8	65.2	0.0				
1985	13	53.8	46.2	0.0				
1984	3	33.3	66.7	0.0				
1983	8	50.0	50.0	0.0				
1982	9	0.0	100.0	0.0				
1981	13	15.4	84.6	0.0				
1980	11	18.2	72.7	9.1				
1979	19	52.6	42.1	5.3				
1978	21	57.1	42.9	0.0				
1977	20	35.0	60.0	5.0				
1976	14	57.1	42.9	0.0				
1975	35	42.9	57.1	0.0				
1974	43	39.5	58.1	2.3				
1973	26	15.4	76.9	7.7				
1972	15	6.7	86.6	6.7				
1971	26	15.4	76.9	7.7				

Note: Eggs/spawner are calculated for 1SW and MSW salmon as follows (Randall 1989):

$$\text{Eggs/spawner (1SW)} = \%\ \text{Female} \times e^{[3.1718 \times \text{Ln(FL)} - 4.5636]}$$

$$\text{Eggs/spawner (MSW)} = \%\ \text{Female} \times e^{[1.4132 \times \text{Ln(FL)} + 2.7560]}$$

Table 9. Estimated tagged to untagged ratios, and tag return rates for 1991.

Location	Small Salmon Count	Small Salmon Recaptures	Small Salmon Proportion	Large Salmon Count	Large Salmon Recaptures	Large Salmon Proportion
A. Counting Fences						
1. Bartholomew Fence	113	1	0.0088	20	1	0.0500
2. Dungarvon Barrier	296	1	0.0034	204	3	0.1470
3. SW Enclosure Trap	193	2	0.0104	84	0	0.0000
4. NW Enclosure Trap	220	2	0.0091	83	0	0.0000
5. Red Bank Traps	217	2	0.0092	182	1	0.0055
6. Catamaran Fence	76	2	0.0263	51	1	0.0196
7. NW Miramichi Barrier	765	6	0.0078	224	1	0.0045
Total	1880	16	0.0085	848	7	0.0083
1990	2399	28	0.0117	739	3	0.0041
1989	2260	23	0.0102	683	7	0.0103
B. Index Angling Camps						
1. Rocky Brook	224	0	0.0000	130	0	0.0000
2. Miramichi Salmon Club	114	1	0.0088	26	1	0.0385
3. Wades	144	3	0.0208	70	0	0.0000
4. Halfway Bar						
5. Black Brook	157	2	0.0127	106	1	0.0094
6. Salmon Brook	133	1	0.0075	72	0	0.0000
7. Deadman	56	0	0.0000	13	0	0.0000
8. Rocky Bend	29	1	0.0345	32	0	0.0000
9. Burnt Hill	96	0	0.0000	56	1	0.0179
10. Sevogle Salmon Club	61	0	0.0000	15	1	0.0667
11. Miramichi Inn	135	1	0.0074	71	1	0.0141
12. Miramichi Fish & Game	208	0	0.0000	208	0	0.0000
Total	1357	9	0.0066	799	5	0.0063
1990	2397	14	0.0058	699	4	0.0057

Table 10. Spawning escapement as estimated by Methods 1 (Millbank trap efficiency) and 2 (tag-recapture). 95% confidence limits for estimates of returns to Millbank, spawning escapement, % of required spawners, and % required egg deposition are shown in brackets.

	Method 1		Method 2	
Large salmon				
1. Total returns	29949		33830	
2. Harvest below Millbank	82		82	
3. Returns to Millbank	29867	(22400-37333)	33748	(17531-71048)
4. Harvest above Millbank	646		646	
5. Broodstock/trap mortalities	132		132	
6. Spawners	29089	(21622-36555)	32970	(16753-70270)
7. Required spawners	23600		23600	
% achieved	123%	(92-155%)	140%	(71-298%)
Small salmon				
1. Total returns	60869		61964	
2. Harvest below Millbank	2		2	
3. Returns to Millbank	60867	(45650-76083)	61962	(39013-103271)
4. Harvest above Millbank	12409		12409	
5. Broodstock/trap mortalities	189		189	
6. Spawners	48259	(33042-63475)	49354	(26385-90663)
7. Required spawners	22600		22600	
% achieved	214%	(146-281%)	224%	(117-401%)
% egg deposition	158%	(116-199%)	177%	(90-372%)

Table 11. Estimates of spawning escapement (S) and total returns (R) of large and small salmon (from Method 1) in the Miramichi River, 1971 to 1991.

Year	HE1	HE2	HR	MIL	E1	MILR	S	R	S/R
Large Salmon									
1971	15,128	3,140	1,792	399	0.043	9,279	4,347	24,407	0.18
1972	2,282	163	8,933	1,151	0.043	26,767	17,671	29,049	0.61
1973	866	0	5,977	1,13	0.043	26,326	20,349	27,192	0.75
1974	941	22	7,184	1,791	0.043	41,651	34,445	42,592	0.81
1975	724	19	6,626	1,208	0.043	28,093	21,448	28,817	0.74
1976	871	7	7,591	943	0.043	21,930	14,332	22,801	0.63
1977	6,865	0	12,060	1,934	0.043	44,977	32,917	51,842	0.63
1978	8,377	0	5,287	693	0.043	16,116	10,829	24,493	0.44
1979	1,659	0	2,854	318	0.043	7,395	4,541	9,054	0.50
1980	10,899	0	6,546	1,093	0.043	25,419	18,873	36,318	0.52
1981	7,137	699	3,738	199	0.022	9,045	4,608	16,182	0.28
1982	12,213	298	4,989	408	0.022	18,545	13,258	30,758	0.43
1983	16,788	269	2,409	245	0.022	11,136	8,458	27,924	0.30
1984	1	0	449	333	0.022	15,136	14,687	15,137	0.97
1985	5	0	611	311	0.015	20,733	20,122	20,738	0.97
1986	18	0	1,051	469	0.015	31,267	30,216	31,285	0.97
1987	21	0	1,344	291	0.015	19,400	18,056	19,421	0.93
1988	78	0	687	325	0.015	21,667	20,980	21,745	0.96
1989	78	0	1,593	257	0.015	17,133	15,540	17,211	0.90
1990	107	0	879	427	0.015	28,467	27,588	28,574	0.97
1991	82	0	778	448	0.015	29,867	29,089	29,949	0.97
Mean 1986-90			1,111			23,587	22,476	23,887	
Change=(90-mean)/mean			-30%			+27%	+29%	+25%	
Small Salmon									
1971	0	0	13,727	1,962	0.055	35,673	21,946	35,673	0.62
1972	39	0	19,101	2,543	0.055	46,236	27,135	46,275	0.59
1973	0	0	13,857	2,540	0.055	44,545	30,688	44,545	0.69
1974	0	0	18,232	4,038	0.055	73,418	55,186	73,418	0.75
1975	393	0	16,040	3,548	0.055	64,509	48,469	64,902	0.75
1976	1,780	39	27,381	4,939	0.055	89,800	62,380	91,580	0.68
1977	379	28	14,089	1,505	0.055	27,364	13,247	27,743	0.48
1978	1,232	2	8,700	1,268	0.055	23,055	14,353	24,287	0.59
1979	5,510	2	14,605	2,500	0.055	45,455	30,848	50,965	0.61
1980	2,697	0	11,997	2,139	0.055	38,891	26,894	41,588	0.65
1981	1,332	296	23,716	2,174	0.034	63,941	39,929	65,273	0.61
1982	1,997	314	22,068	2,665	0.034	78,382	56,000	80,379	0.70
1983	1,360	229	8,746	810	0.034	23,824	14,849	25,184	0.59
1984	1	0	10,777	1,010	0.034	29,706	18,929	29,707	0.64
1985	0	0	18,985	912	0.015	60,800	41,815	60,800	0.69
1986	16	0	28,135	1,763	0.015	117,533	89,398	117,549	0.76
1987	16	0	22,023	1,272	0.015	84,800	62,777	84,816	0.74
1988	52	0	31,589	1,828	0.015	121,867	90,278	121,919	0.74
1989	31	0	26,815	1,128	0.015	75,200	48,385	73,231	0.66
1990	15	0	23,609	1,247	0.015	83,133	59,724	83,448	0.72
1991	2	0	12,409	913	0.015	60,867	48,259	60,869	0.79
1986-90 Mean			26,434			96,507	70,112	96,593	0.69
Change=(90-Mean)/Mean			-53%			-37%	-31%	-37%	

HE1 = Harvest in estuary below Millbank
HE2 = Harvest in estuary above Millbank
HR = Harvest in river (includes angling, native fishery above Millbank, broodstock, millbank trap mortalities, and samples)
MIL = Millbank trap count
E1 = Millbank catch efficiencies
MILR = Returns to Millbank
S = Spawners
R = Total returns

Table 12. Indices of spawning escapement in the Miramichi River, 1970 to 1990.

Year (i) 1	Angled Large Kelt (i) 2	Angled Large Bright (i-1) 3	0+ fry (i) 4	1+ parr (i+1) 5	Eggs/sq meter (i-1) 6
1969	1,828	1,512	-	6.1	-
1970	1,647	3,804	35.3	7.9	-
1971	1,352	3,268	20.1	8.3	-
1972	547	1,792	9.8	3.0	0.56
1973	2,970	8,933	24.9	11.0	1.85
1974	3,037	5,977	34.2	12.8	2.39
1975	3,111	7,184	40.0	11.7	4.61
1976	1,446	6,288	25.1	8.4	3.06
1977	2,156	7,374	51.8	10.7	2.38
1978	2,126	11,617	36.4	9.0	3.88
1979	1,668	4,893	19.7	8.3	1.45
1980	1,504	2,656	34.5	7.0	0.95
1981	2,118	6,546	53.6	9.8	2.44
1982	1,368	3,238	15.0	6.7	0.86
1983	960	4,608	44.5	6.5	2.16
1984	666	2,240	19.1	8.9	1.03
1985	3,771	4,692	56.4	12.2	1.81
1986	6,856	9,622	55.4	13.1	2.49
1987	5,099	14,266	74.5	13.9	4.27
1988	5,700	11,932	95.1	18.4	3.40
1989	7,382	10,095	72.2	12.4	3.61
1990	5,641	11,933	94.6	14.3	2.33
1991	2,997	9,258	44.6	-	3.63
1992	-	6,147	-	-	3.79

Correlations:

	n	r	p
2 with 3	23	0.76	0.0001
2 with 4	22	0.83	0.0001
2 with 5	22	0.84	0.0001
2 with 6	20	0.52	0.0201
3 with 4	22	0.76	0.0001
3 with 5	22	0.79	0.0001
3 with 6	21	0.73	0.0002
4 with 5	21	0.82	0.0001
4 with 6	20	0.52	0.0177
5 with 6	19	0.60	0.0072

Notes: a. Eggs per sq meter are estimated from Method 1.
b. Angling catches are DNRE Fishsys values.

Legend

1. Millbank Trap
2. Southwest Enclosure Trap
3. Northwest Enclosure Trap
4. Red Bank Indian Reserve
5. Northwest Miramichi headwater barrier
6. Southwest Miramichi headwater barrier
7. Bartholomew River counting fence
8. Dungarvon headwater barrier
9. Catamaran Brook counting fence
10. Burnt Church Indian Reserve
11. Eel Ground Indian Reserve

■ Native Food Fishery

● Salmon counting facility

▲ Index angling camp

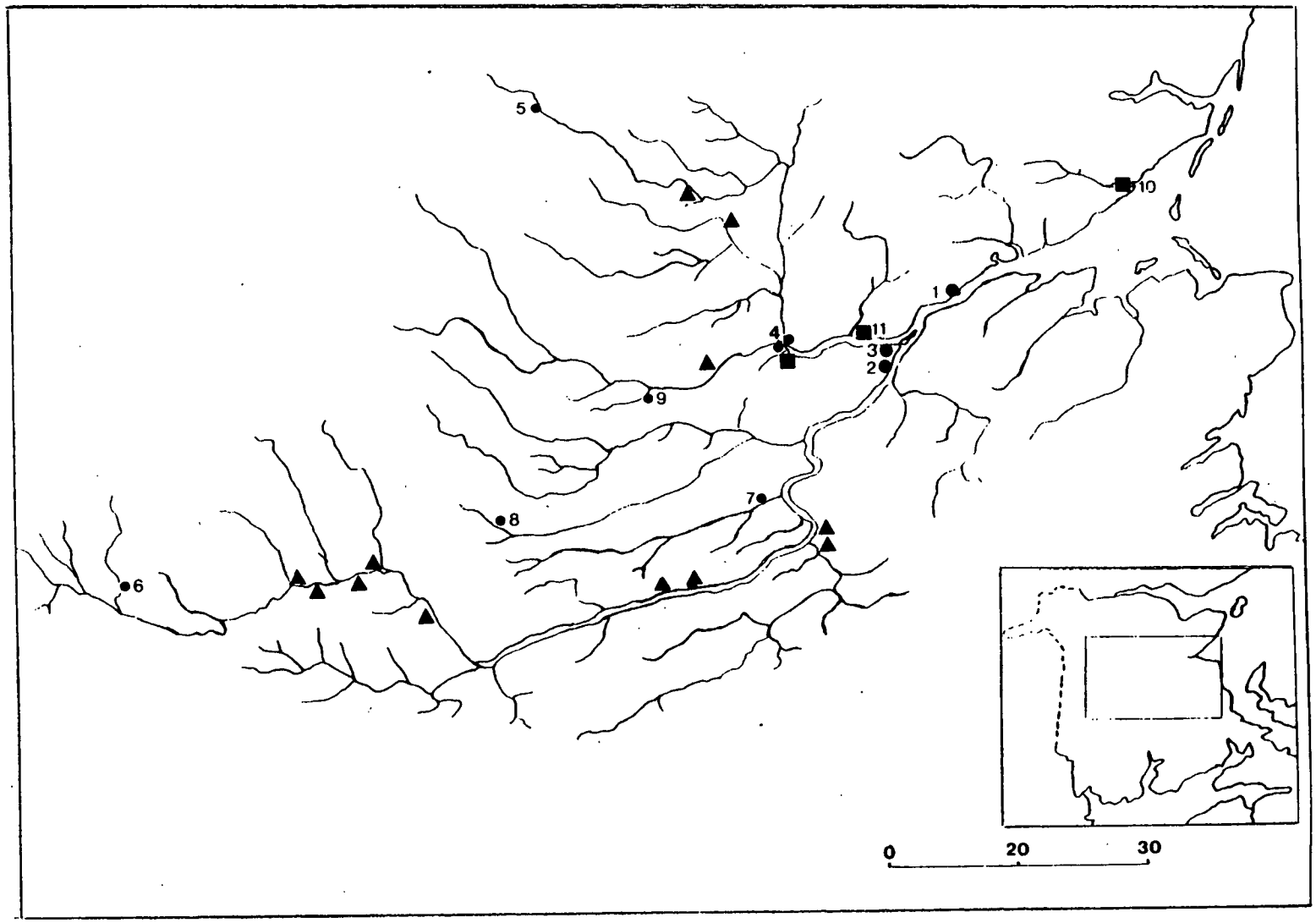

Figure 1 The Miramichi River system and locations referred to in the text.

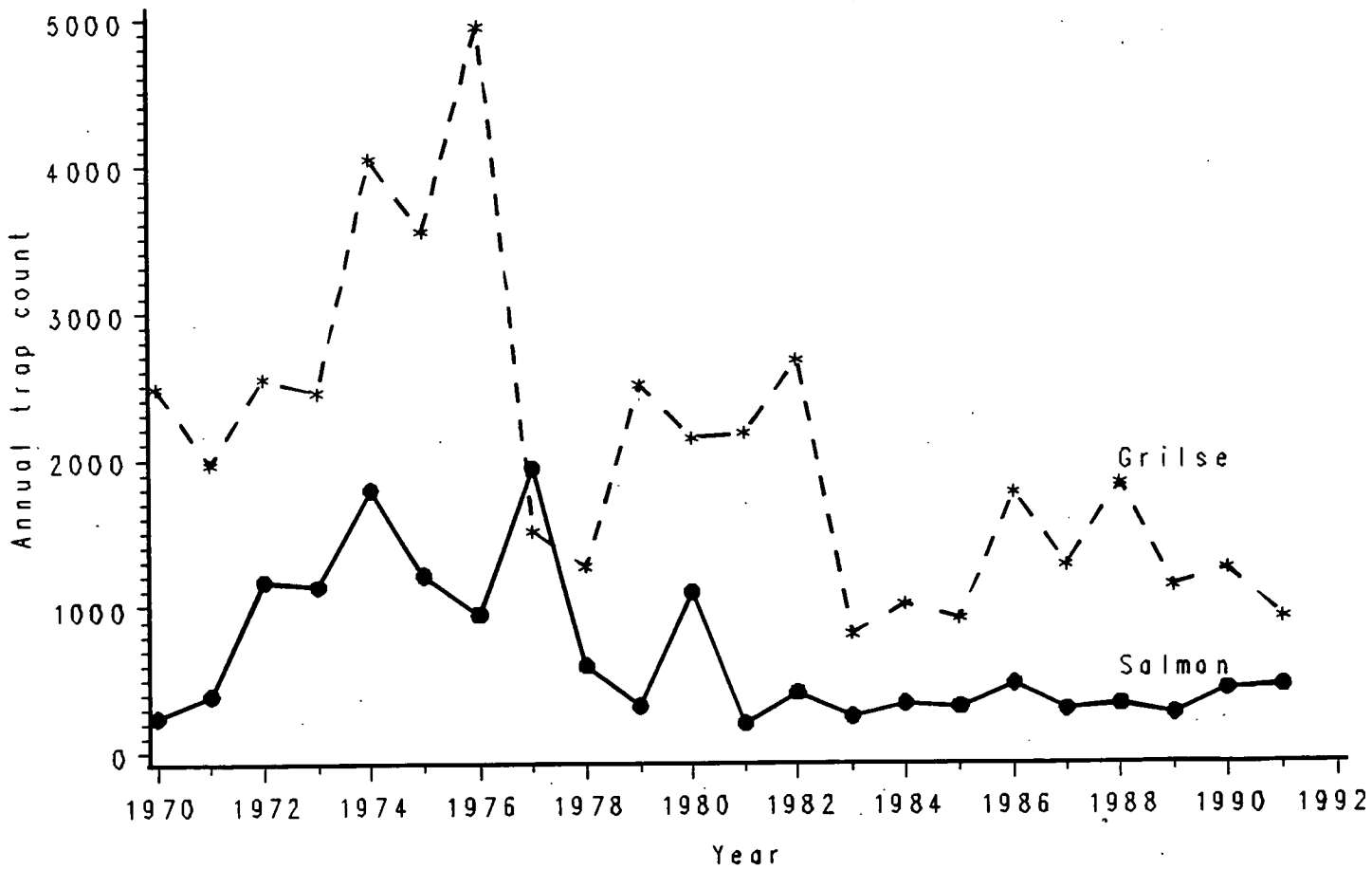

Figure 2. Annual counts of MSW (solid line) and 1SW (dashed line) at Millbank from 1970 to 1991.

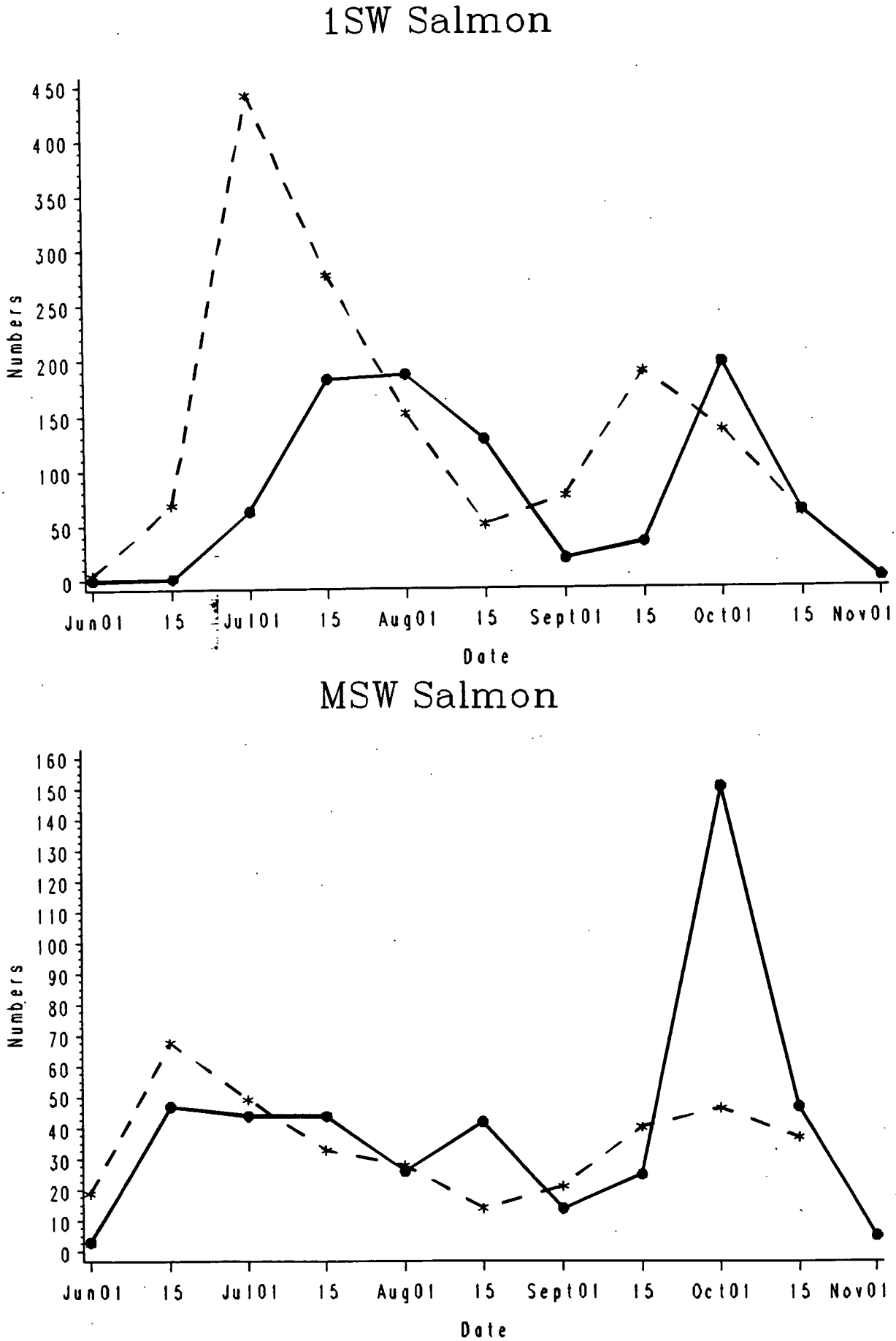

Figure 3. Bimonthly counts of 1SW (upper) and MSW (lower) salmon at Millbank. Counts in 1991 (solid lines) are shown relative to mean counts from 1986-90 (dashed lines).

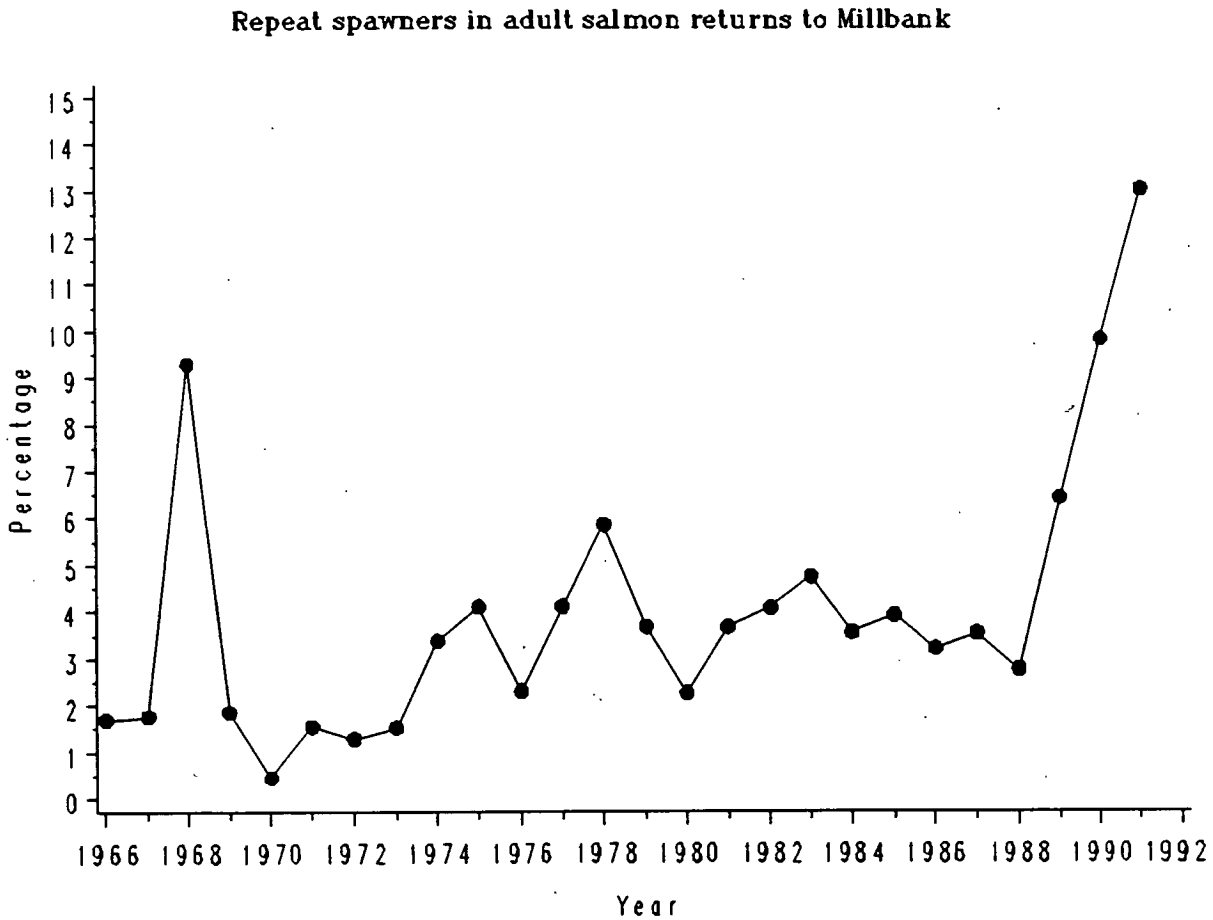

Figure 4. Percentages of previous spawners in adult (MSW+1SW) salmon at Millbank from 1966-91.

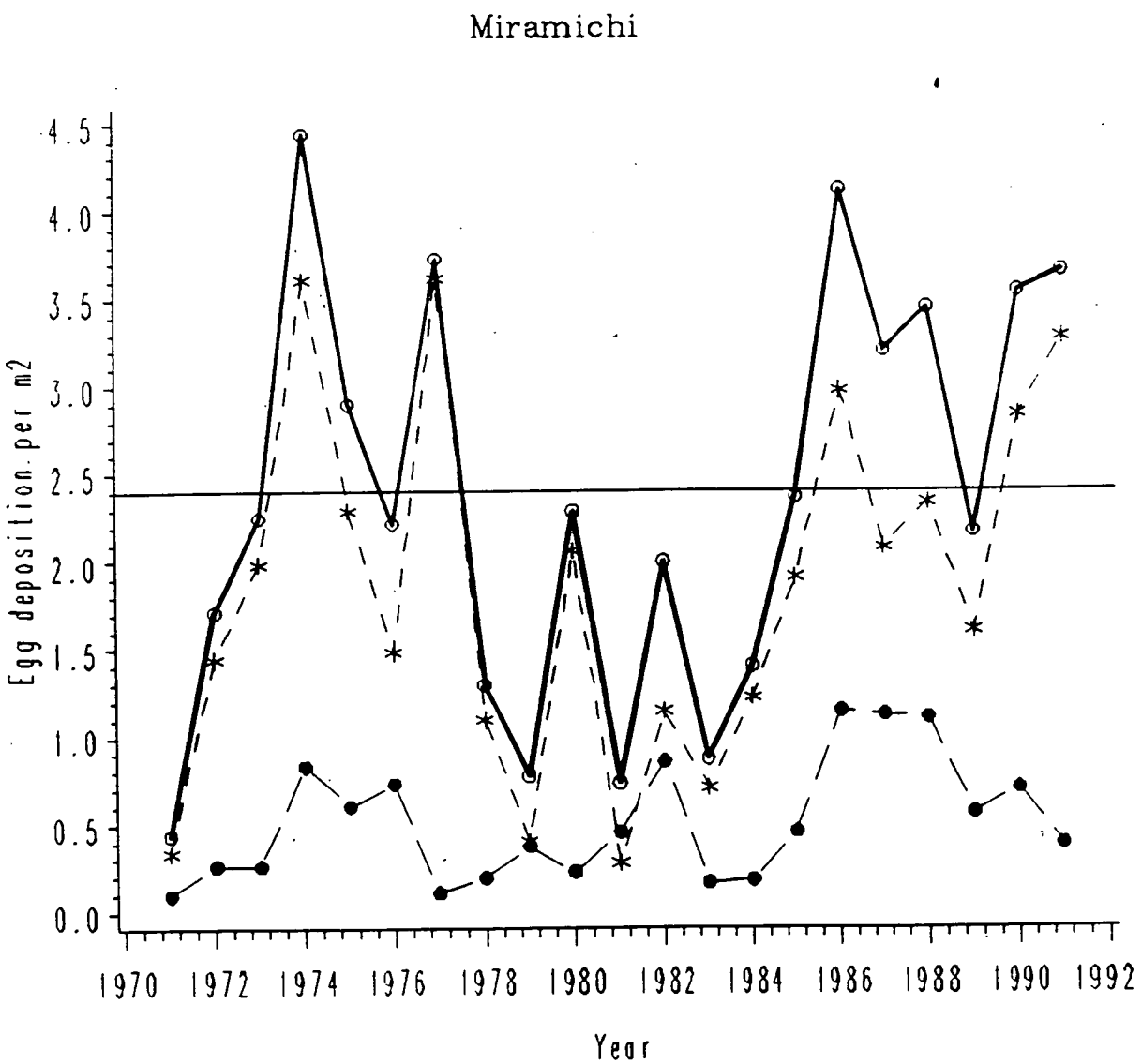

Figure 5. Estimated egg deposition rates (number of eggs per square meter) in the Miramichi River, 1971 to 1991. Egg depositions from 1SW salmon (dots), MSW salmon (stars), and total egg deposition (circles) are shown separately in relation to the target of 2.4 eggs per square meter.

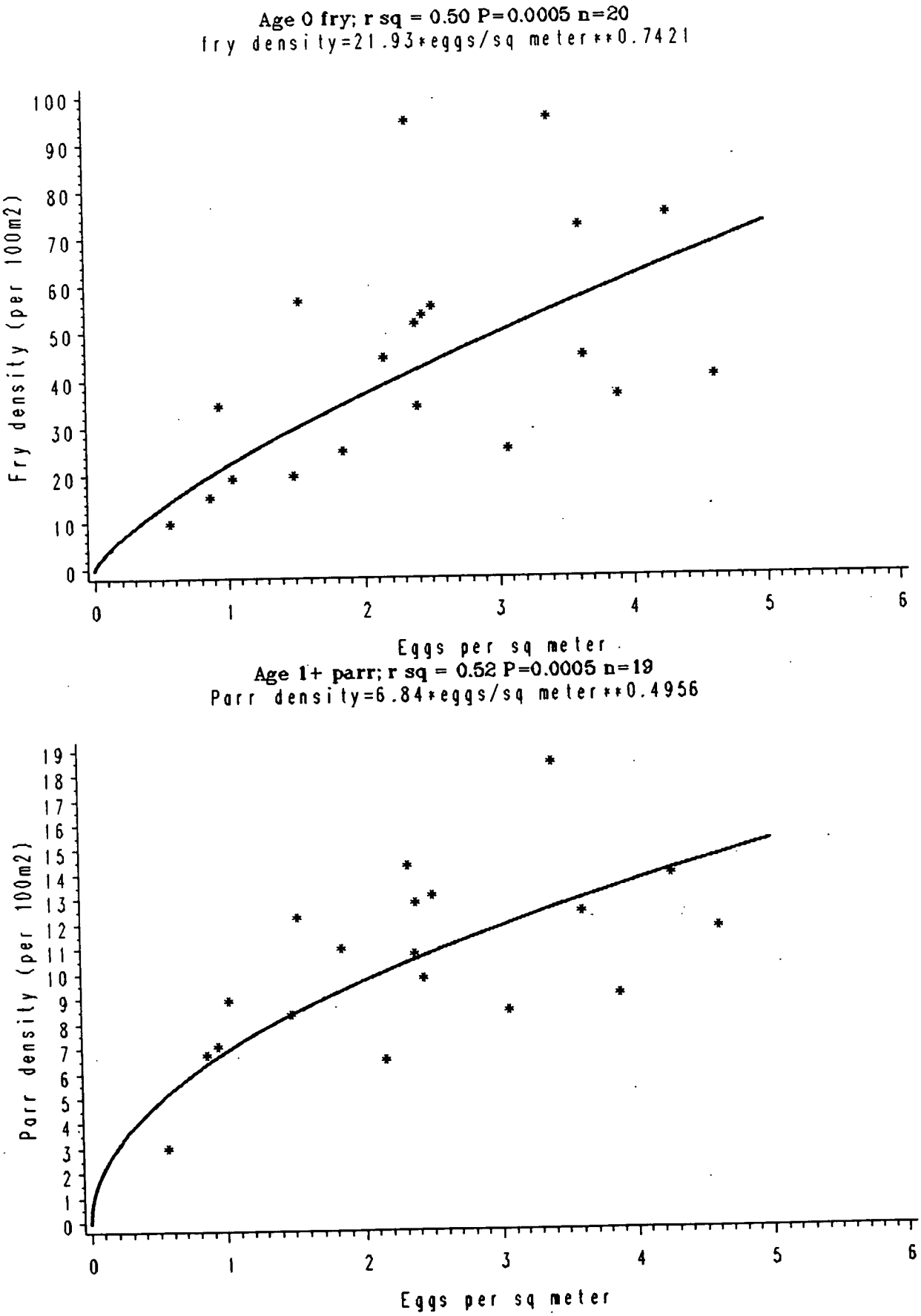

Figure 6. Relationships between egg deposition rates and resulting age 0+ (upper) and age 1+ (lower) parr densities in the Miramichi River from 1970 to 1991.

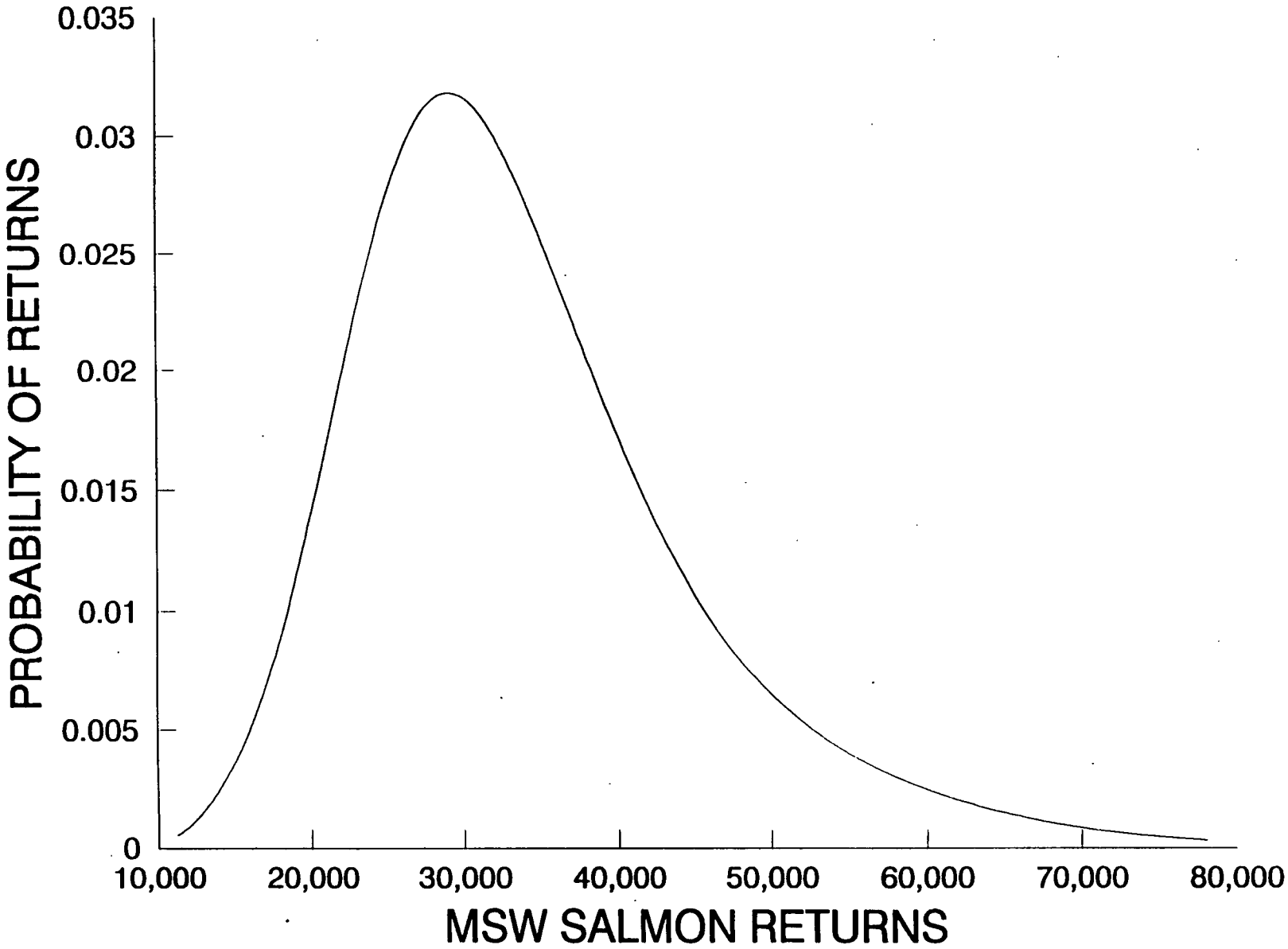

Figure 7. The probability distribution of forecasted large salmon (MSW salmon + previous spawners) in 1992 (from Claytor et al 1992).

APPENDIX I Angling seasons on Miramichi tributaries, 1990 and 1991.

Tributary	Season 1990	1991
General	June 8 to October 15	June 8-October 7
Exceptions		
Bartholomew		
-above Ledbetters Bk	closed	closed
-below Ledbetters Bk	June 8 to September 25- Saturdays only September 28 to October 14- All week	June 8 to Sept 28-Saturdays only Sept 29 to Oct 15 All week
Bartibog	June 1 to October 29	June 1 to October 29
Cains	June 8 to October 15	June 8 to October 15
Dungarvon		
-above Underwood Bk	June 8 to September 15	June 8 to September 15
Little Southwest		
-above Catamaran Bk	June 8 to September 15	June 8 to September 15
Main Southwest		
-above McKeil Bk	June 8 to September 15	N.A.
-MacKeil Bk to Burntland Bk	June 8 to October 7	N.A.
-North and South Branches	N.A.	June 8 to September 15
-above Burntland Bk to fork of North and South Branch	N.A.	June 8 to September 30
-head of tide to Cains R.	N.A.	June 8 to October 15
Northwest		
-above Little River	June 8 to August 31	June 8 to August 31
Renous		
-above Forks	June 8 to September 15	June 8 to September 15
Rocky Brook	June 1 to August 31	June 1 to August 31
Sevogle		
-above Square Forks	June 8 to September 15	June 8 to September 15
Other tributaries of the Main Southwest Miramichi		
-above Cains except Rocky Bk	June 8 to September 15	June 8 to September 15

Appendix II Millbank counts fishing 5 days vs. 7 days per week

INTRODUCTION

In order to operate salmon traps at Millbank and on the NW and SW Miramichi at the Enclosure in 1991 it was necessary to operate the Millbank trap 5 days per week rather than 7 days per week as in the past.

Two methods have been used to estimate returns to the Miramichi River at Millbank. Method 1, dividing the Millbank trap counts by the trap efficiency, would need a conversion factor to estimate returns from weekday catches only. Method 2, dividing the number of fish tagged at Millbank by the proportion tagged as measured by recapture facilities upstream, would not need to be adjusted for weekday tagging only.

METHODS

The Millbank trap efficiency, calculated from tag-recapture data collected in 1985 to 1987, has not changed from 1985 to the present. During these years the Millbank trap has been fished at each slack water between 0800 hrs. and 1600 hrs on weekdays and once per day, at slack water between the hours of 0800 and 1600 on weekends. Counts of small and large salmon for 1985 to 1990 were compared to counts from weekdays only during those years. Conversion factors for calculating returns to Millbank from weekday counts were calculated first as the ratios of total counts to the weekday counts from 1985 to 1990 for small and large salmon, respectively. Secondly, conversion factors were calculated as the mean ratios of total counts to weekday counts from 1985 to 1990 for large and small salmon, respectively. Standard deviations and coefficients of variation were calculated for conversion factors calculated by this second method.

RESULTS

	Large salmon			Small salmon		
Year	Total(A)	Wkdays(B)	A/B	Total(C)	Wkdays(D)	C/D
1985	311	237	1.31	912	735	1.24
1986	469	381	1.23	1763	1333	1.32
1987	291	223	1.30	1272	848	1.50
1988	325	238	1.37	1828	1301	1.41
1989	257	189	1.36	1128	924	1.22
1990	427	364	1.17	1247	1016	1.23
Total	2080	1632	1.27	8150	6157	1.32
Mean			1.29			1.32
sd			0.08			0.11
Coeff Var			6%			8%

Mean conversion factors for large (A/B) and small salmon (C/D) were similar and both had low coefficient of variation values (6% and 8%).

A factor of 1.3 was selected to estimate 1991 total counts from weekday operations.

APPENDIX III. RETENTION OF CARLIN TAGS, T-BAR TAGS, AND OPERCULAR TAGS BY GRILSE

INTRODUCTION

One of the assumptions made in the mark-recapture program used to estimate the number of grilse and MSW salmon in the Miramichi River, is that fish tagged at Millbank with Carlin tags do not shed these tags. It is important to test this assumption, because to the extent that it is untrue, the reported population size is an overestimate.

There is reason to believe that tag loss is a problem. Chaput and Jones (1991) used a Carlin tag mark-recapture program to estimate MSW returns to the Margaree River in 1990, and performed an experiment on retention of tags. Five of 18 MSW fish held in broodstock tanks, shed their Carlin tags within 21 days. On this basis, Chaput and Jones (1991) applied a tag loss rate of 0.013 tags per day.

In addition to examining retention of Carlin tags, we were interested in the retention of other types of tags that could in future be used in our mark-recapture program. The two tags of interest -plastic T-bar tags and aluminum opercular tags - have the advantage over Carlin tags of being easier and faster to apply.

The following experiment was conducted to examine the retention of all three types of tag. This work was conducted by William Villet, an undergraduate student from Plymouth Polytechnic Institute (Plymouth England,) as a B.Sc. thesis project under the supervision of Simon Courtenay and Kevin Davidson (DFO), and with the assistance of the staffs of the Millbank station, and Miramichi hatchery. A full description of the experiment will be published as a technical report.

METHODS AND MATERIALS

Between July 4 and July 15, 1991, 60 grilse, caught in the Millbank trap, were transported to the Miramichi hatchery, where they were held in an indoor Swede pond measuring 7.6 X 7.6 m. On July 16, the fish were tagged as follows.

Fish were anaesthetized with MS222, weighed, measured (fork-length), examined for kype, and tagged. Carlin tags were those used in the Miramichi mark-recapture program: a blue plastic disc measuring 8 X 4.5mm suspended on a stainless steel wire. One end of the wire is passed through a hypodermic needle placed through the dorsal musculature of the fish, just anterior to the dorsal fin. The other end of the wire is passed over the back of the fish, anterior to the dorsal fin, and the two ends of the wire are intertwined and folded back against the fish. T-bar tags, manufactured by Floy Tag and Manufacturing Inc., Seattle Washington, were 100mm long, with a 10mm bar, and a 76mm long

fluorescent orange sleeve. A tagging gun with a long needle was used to insert tags into the dorsal musculature on the left side of the fish, beneath the middle of the dorsal fin. Opercular tags were 50 X 5mm strips of aluminum, bent double, with one end sharpened to fit through a slot in the other end. These tags were manufactured by Ketchum MFG. Co. Ltd., Ottawa, Ontario for the marking of day-old chickens. They were applied to the left operculum of fish with pliers, with the insertion in the middle of the operculum and the bent edge bordering the posterior edge of the operculum. The first half of the fish tagged were tagged with labelled side of the tag on the outside of the operculum, and the second half of the fish were tagged with the labelled side inside the operculum. The differential application was done in order to determine which method resulted in less damage to the fish and better retention. Carlin tags were applied by Michel Biron, a regular DFO technician at the Millbank trap. T-bar tags were applied by Perry Swan (DFO), and opercular tags were applied by Kevin Davidson (DFO).

After recovery from the anaesthetic, fish were held for 1 hour in a 4% salt bath to discourage bacterial growth around tagging wounds. Every second fish tagged was released into a penned section of Stewart Brook which runs through the hatchery grounds. Remaining fish were placed back into the indoor Swede pond. Dividing the fish between the natural and artificial settings was done in order to compare tag retention in the natural setting with the more commonly reported retention in artificial conditions.

On September 17 and 18, the experiment was ended. The interval between tagging and recovery was set at 63 days because 95% of tags put on at the Millbank trap are recovered within this period (1986-1990 data, mean=20, SD=19, range:0-92 d). Fish in Stewart Brook were recovered on September 17 by electrofishing, and were anaesthetized, weighed, measured, examined for kype,photographed, and had tags removed. Fish in the indoor Swede pond were similarly handled on September 18. Following the experiment, all fish were released into Stewart Brook, downstream of the penned section.

Temperatures in both Stewart Brook and the Swede Pond were monitored daily and never differed by more than 3 degrees C, being usually within 2 degrees (temperature range: 11 - 20 degrees C). The waters were otherwise similar, as the Swede pond received water from Stewart Brook, upstream of the penned section.

RESULTS

In the two week period following tagging (July 17-30), 9 fish died: 7 in Stewart Brook and 2 in the Swede pond. Four mortalities were sent to the Fish Health Service Unit (DFO Halifax lab) for examination. J. W. Cornick returned a diagnosis of "No bacterial or viral pathogens or parasites. Some secondary fungus infection. Probable cause of death due to excessive handling." No mortalities occurred after this initial period.

On August 11, 6 fish escaped from the penned section of Stewart Brook during a period of high water. One fish bearing all three tags was recovered in the Eel Ground Native fishery on August 16. A second fish bearing the opercular tag and Carlin tag was recovered by an angler on September 2.

Retention of tags by the remaining 17 fish in Stewart Brook and 28 fish in the Swede pond was as follows:

	CARLIN	T-BAR	OPERCULAR
BROOK	17	13	6
(%)	(100)	(76)	(35)
POND	28	26	9
(%)	(100)	(93)	(32)
TOTAL	45	39	15
(%)	(100)	(87)	(33)

Carlin tags were retained by all fish, and in all cases we observed very little damage around the insertion of the stainless steel wire. None of the tags was loose or appeared in danger of being shed.

T-bar tags were less well retained than Carlin tags. The rate of tag loss was greater for the fish held in Stewart Brook, than for the fish held in the Swede pond. Wounds around the insertion were variable in size - ranging between 2 and 6mm, and in several cases were surrounded by an area of lifted scales. Three of the tags on fish in the Swede pond, and 1 of the tags on fish in the Brook were loose and appeared in danger of being shed.

Opercular tags were least well retained of the tag types examined, and were retained at a similar rate in the Brook and Pond. Typically, the insertion of these tags had eroded a large hole through the operculum, leaving the tag hanging loosely from the hole. Tags were shed when the erosion opened the hole to the posterior edge of the operculum, leaving a V-shaped indentation in the operculum which in some cases exposed the gills. Of the 6 tags retained by fish in the Brook, 4 had eroded holes in the operculum and were loose. Of the 9 tags retained by fish in the Pond, 7 had eroded holes in the operculum and were loose.

Length, weight, and sex (based on presence or absence of kype) characteristics of the fish that completed the experiment were as

follows:

		LENGTH (CM)		WEIGHT (KG)		SEX		
		JULY	SEPT	JULY	SEPT	M	F	?
BROOK	MEAN	53.1	53.4	1.52	1.42	8	6	3
	SD	3.0	4.2	0.24	0.24			
	N	17	17	17	17			
POND	MEAN	51.7	53.1	1.42	1.32	14	8	6
	SD	2.1	2.3	0.19	0.19			
	N	28	28	28	28			

DISCUSSION

The retention of Carlin tags by grilse, as they are installed for the mark-recapture program for the Miramichi salmon assessment, appears to be 100% over the typical period between tagging and recovery. The poorer retention of T-bar tags and opercular tags is doubtless to some degree a function of the relative unfamiliarity of the taggers with these tags. Nevertheless, it seems unlikely that even experienced taggers could entirely prevent tag loss. Furthermore, the expected advantage of opercular and T-bar tags over Carlin tags - ease of application and removal - was not realized. Opercular tags proved very difficult to apply and remove. T-bar tags were easy to remove, but difficult to apply in a consistent fashion. Therefore, the conclusion of this study is clear: our present tagging program is serving us well and is superior to at least some alternatives.

The difference in tag retention observed in this experiment and in that reported by Chaput and Jones (1991) may be a function of application, or of the size of fish tagged. It remains to be determined whether MSW fish tagged on the Miramichi retain Carlin tags as well as grilse appear to. It is hoped that this question can be addressed in a study similar to the present study. The mortality that reduced sample sizes in the present study can probably be reduced by reducing handling stress on the fish. Stress associated with transportation to the hatchery can be reduced by obtaining fish from the nearby Enclosure traps rather than the Millbank trap. Tagging stress can be reduced by applying only Carlin and T-bar tags.

LITERATURE CITED

Chaput, G. and R. Jones. 1991. Assessment of Atlantic salmon (Salmo salar) in the Margaree River, Nova Scotia 1990. CAFSAC Research Document 91/3: 31pp.