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Status of Atlantic salmon in the Miramichi River, 1986

by

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ABSTRACT

Mark-recapture data indicated 30,300 MSW salmon returned to the Miramichi River in 1986; total returns were 7% greater than predicted in the 1985 assessment (28,400 MSW salmon). Returns of 1SW salmon in 1986, however, greatly exceeded average returns: 110,700 1SW salmon returned, compared to a historic average of 44,900 fish. Increased returns in 1986 may have resulted from good marine survival. Mean weight of 1SW salmon in 1986 was greater than average, indicating favourable growth conditions at sea. The 1986 management plan which restricted homewater harvests of salmon resulted in 93% of MSW salmon and 70% of 1SW salmon potentially surviving to spawn. As a result, spawning requirements were apparently met in 1986. About 54,200 MSW salmon and 37,900 1SW salmon are predicted to return in 1987, indicating potential surpluses of 30,600 MSW salmon and 15,300 1SW salmon.

RESUME

Les données de marquage-recapture indiquent que 30 300 saumons PHM sont retournés dans la rivière Miramichi en 1986; les retours totaux étaient supérieurs de 7 % aux prévisions faites en 1985 (28 400 saumons PHM). Les retours de saumons 1HM en 1986 ont dépassé de beaucoup les valeurs moyennes : 110 700 saumons 1HM sont retournés, comparativement à une moyenne historique de 44 900 poissons. Les retours accrus en 1986 peuvent résulter d'une bonne survie en mer. Le poids moyen des saumons 1HM en 1986 a été supérieur à la moyenne, ce qui indique des conditions de croissance favorables en mer. Le plan de gestion de 1986, qui limitait les prises de saumons dans les eaux territoriales a eu pour effet que 93 % de saumons PHM et 70 % de saumons 1HM ont pu survivre pour frayer. Ainsi, les besoins en matière de frai ont été satisfaits en 1986. On prévoit que 54 200 saumons PHM et 37 900 saumons 1HM seront de retour en 1987, ce qui indiquerait des surplus potentiels de 30 600 saumons PHM et de 15 300 saumons 1HM.

INTRODUCTION

The management plan for Atlantic salmon in the Miramichi River in 1986 was a continuation of a five-year plan to conserve stocks which was initiated in 1984. There was no commercial fishery in Miramichi Bay or estuary. Anglers were allowed to keep only 1SW salmon (< 63 cm); all MSW salmon were released. Season, possession and daily bag limits for anglers remained at 10, 6 and 2 fish, respectively. Daily and seasonal bag limits did not include hooked-and-released salmon, but anglers were obliged to stop fishing after retaining the daily limit or after releasing a maximum number of fish equal to twice the daily limit. Catch-and-release regulations also applied to the kelt fishery (15 April to 15 May).

Native food fisheries at Burnt Church, Eel Ground and Red Bank were not restricted by quota as in previous years. Possession or sale of Atlantic salmon caught in non-salmon gear (by-catch) was illegal in all areas of New Brunswick.

The objective of this assessment was to summarize landings of Atlantic salmon in 1986 and to evaluate the impact of the 1986 management plan on salmon stocks in the Miramichi River.

METHODS

1. Landings and trap counts

Angling catches of 1SW salmon in the Miramichi River were provided monthly by DFO fishery officers. Angling data from the upper Southwest Miramichi River (York and Carleton counties) were not available; landings from this area were estimated from the average proportion of catches from these two counties from 1974 to 1983. As in previous assessments, DFO landings were adjusted by correlation with historic landings (1969 to 1985) as estimated by Department of Natural Resources and Energy (DNRE), which are considered more accurate (Randall and Chadwick 1983). Numbers of MSW salmon caught and released by anglers were estimated by correlation between Millbank trap catch and angling catch, 1969 to 1983 (Table 1). Angling effort was recorded in rod-days, where one rod-day was one angler fishing for any portion of one day.

Landings of MSW and 1SW salmon from Native fisheries at Burnt Church, Red Bank and Eel Ground were reported from Band Council offices periodically during the season.

Returns of MSW and 1SW salmon entering the Miramichi River in 1986 were monitored daily at the Millbank trap (operated since 1954), at two recapture traps just above the confluence of the Northwest and Southwest Miramichi tributaries (operated since 1985) and at two headwater fish barriers on the Dungarvon and SW Miramichi tributaries (operated since 1981 by DNRE). Biological characteristics of salmon were determined from samples collected at Millbank and at the Northwest and Southwest recapture traps. About 700 salmon were examined and the following information was recorded: fork length to nearest cm; weight to nearest 0.1 kg; sex; and scales for aging.

2. Recruitment

During July and August of 1986, 32 sites in headwater tributaries of the Miramichi River were surveyed by electrofishing to determine densities of juvenile salmon. Densities of age 0+ and 1+ salmon were estimated by the removal method (Zippin 1956; Randall and Chadwick 1986). Mean densities of age 1+ parr have been used as an index of recruitment for the Miramichi River (Chadwick and Randall 1986).

3. Spawning escapement in 1986

As in the 1985 assessment (Randall et al. 1986), two methods were used to estimate spawning escapement in 1986:

Method 1: Numbers of MSW and 1SW salmon returning to Millbank were estimated by a mark-recapture experiment in 1986. About 96% of MSW and 91% of 1SW salmon captured at Millbank were marked (Carline tags and/or adipose clipped). Recapture traps in the Northwest and Southwest tributaries (Fig. 1) were monitored continuously throughout the salmon run, and all tagged/fin clipped salmon were carefully enumerated. Returns of salmon to Millbank were estimated by the adjusted Petersen method (Ricker 1975), where:

$$N = \frac{(M + 1)\ (C + 1)}{R + 1}$$

where M = number of salmon marked
C = catch at recapture traps
R = recaptures
N = population estimate at time of marking (Millbank)

Confidence intervals (95%) were calculated assuming R approximated a binomial distribution (Ricker 1975). Tagging mortality was assumed to be 0.20, as in the 1985 assessment (Randall et al. 1986). Spawning escapement was estimated as salmon returns to Millbank minus known removals in the river.

Method 2: Ratios of spawner per MSW and 1SW salmon counted at Millbank were calculated for the period 1971 to 1984. Spawners were back-calculated from densities of age 1+ parr by assuming 10% survival from eggs to 1+ parr (Elson 1957; 1974; Chadwick 1982) and a total rearing area of $55 \times 10^6\ m^2$ (Amiro 1983). Mean number of eggs per spawner in the Miramichi River was calculated by Randall (1985). The average ratio of spawner to salmon counted at Millbank was 10.96 (Table 2). Spawning escapement was calculated as the product of this ratio and counts of MSW and 1SW salmon at Millbank in 1986.

For both Methods 1 and 2, salmon mortalities from disease and poaching were assumed to be 1,000 MSW salmon and 4,000 1SW salmon. Mortality caused by the stress of catch and release of MSW salmon by anglers was estimated to be 3% (Currie 1985; Randall et al. 1986).

Total egg deposition requirements for the Miramichi River was estimated to be 132 x 10^6 eggs (Randall 1985). Based on average fecundities of Miramichi salmon, Randall (1985) estimated 23,600 MSW salmon and 22,600 1SW salmon are required to produce the required egg deposition.

4. Predicting salmon returns in 1987

Returns of MSW salmon to the Miramichi River in 1987 were predicted from a significant multiple regression between the number and proportion female 1SW salmon returns (year i) and MSW salmon returns in year (i+1). For both 1SW and MSW salmon, total returns from 1971 to 1986 were estimated as returns to Millbank plus commercial landings in Miramichi Bay and estuary for years when a commercial fishery operated. Returns to Millbank were estimated assuming a constant trap efficiency of 0.043 for MSW salmon and 0.055 for 1SW salmon for the period 1971 to 1984 (Turner 1983; assuming a tag loss rate of 0.20). These efficiencies are higher than those used in the 1985 assessment (Randall et al. 1986) because a tag loss rate was not applied in that year. Returns to Millbank in 1985 and 1986 were estimated by mark-recapture data.

Returns of 1SW salmon in 1987 were predicted from historic averages, 1982 to 1986.

RESULTS

1. Landings in 1986

Angling catches of 1SW kelts in 1986 decreased by 59% from 1985 (1,447 fish versus 3,531 in 1985) despite similar angling effort in both years (Table 3; Appendix I). This decrease is difficult to explain because angling catches of bright 1SW salmon from the same spawning runs (1984 and 1985) were about equal (Table 1).

Catches of bright 1SW salmon in 1986, however, increased substantially (by 137%) from 1985 with a total reported catch of 28,299 fish (Table 3). Part of this increase was probably due to increased effort, since rod-days increased from 33,159 in 1985 to 53,178 in 1986 (an increase of 60%). Angling catch and effort in September in particular were substantially higher in 1986 than in 1985 (Table 3). Reported landings of 1SW salmon in

1985 were 2.5 times the 1969 to 1985 average (Table 1). Reported catches of 1SW salmon by DFO officers were adjusted slightly by correlation with DNRE data (1969 to 1985) which gave an adjusted catch of 27,051 1SW salmon (Table 1).

Native fishermen at Burnt Church, Eel Ground and Red Bank also reported increased catches of 1SW salmon in 1986. Reported landings in 1986 were 1,988 1SW salmon, compared to 546 in 1985 and 381 in 1984 (Table 4). Landings of MSW salmon were also up in 1986: total catch was 640 MSW salmon which was about twice the catches in 1984 and 1985 (Table 4). Effort in the Native fisheries was approximately the same in all three years.

Total reported landings of 1SW and MSW salmon in 1986 are compared to 1984 and 1985 landings in Table 5. Landings in 1986 were the highest recorded for the three-year period, particularly for 1SW salmon. Long-term landings for the Miramichi River (1951 to 1986) are given in Table 6.

Counts of both 1SW and MSW salmon at the Millbank trap in 1986 increased from 1985. Catches of 1SW salmon increased by 93% (from 912 in 1985 to 1,763 in 1986) while catches of MSW salmon increased by 51% (from 311 in 1985 to 469 in 1986). Both counts are still below long-term averages; counts of 1SW salmon in 1986 were 73% of the 1969 to 1985 average and MSW salmon counts in 1986 were 61% of the long-term average (Table 1). However, recent counts at Millbank trap may not be comparable to historic counts because of an apparent change in catch-efficiency (see below). Data from two headwater barriers generally also showed increases in catches in 1986. Counts of both 1SW and MSW salmon at the headwaters of the SW Miramichi were substantially above the 1981 to 1985 mean (counts in 1986 were 3.9 times greater for MSW salmon and 4.6 times greater for 1SW salmon; Table 7). Counts of both 1SW and MSW salmon at the Dungarvon barrier were also above average, but the difference was not as large as for the SW barrier (Table 7).

Age 1SW salmon returned earlier to the Miramichi in 1986 than in the previous year, as indicated by counts at the Millbank trap (Fig. 2). Also, the late run (August and September) of both 1SW and MSW salmon was larger in 1986 than in 1985 (Fig. 2). Mean weight (kg) of 1SW salmon at Millbank was greater than average in 1986 (Fig. 3b),but 2SW salmon were average. Larger than average sizes for 1SW salmon was also evident in angling data provided by DFO fishery officers (Table 3). Aging data indicated 1SW salmon were from the 1982 (49%) and 1983 (51%) year-classes, while 2SW salmon were from the 1981 (64%) and 1982 (36%) year-classes. Detailed information on biological characteristics of salmon sampled in 1986 is given in Table 8.

2. Recruitment

Average densities of age 0+ and 1+ salmon at 32 sites in 1986 were 54.4 and 14.5 fish.100 m^{-2}, respectively (Table 9). Densities of both age groups were above average (about twice the 1970 to 1985 mean), suggesting relatively high spawning levels in 1984 and 1985. Chadwick and Randall (1986) noted age 1+ parr (year i+1) were significantly correlated to angled kelts (year i) for the period 1969 to 1982 (R^2 = 0.68, P < 0.001). Recent parr densities (1983 to 1986) and kelt data indicate this correlation still exists, but it is much weaker (Fig. 4; R^2 = 0.47, P < 0.01). Nevertheless, average age 1+ parr densities appear to be an indication of recruitment in the Miramichi River.

3. Spawning escapement in 1986

Mark-recapture information for 1SW and MSW salmon marked at Millbank and recaptured in upstream traps in 1986 is summarized in Table 10. Results of the Petersen estimate of salmon returns to Millbank (assuming a tag loss rate of 0.20) are given below:

	N	95% confidence interval
1SW	110,718	(76,651-166,077)
MSW	30,317	(16,241- 62,011)

Catch efficiency of the Millbank trap did not change significantly from 1985, but it was again significantly lower than the efficiency estimated in 1973 (Table 11). Catch efficiencies in 1973 were 2.69 times higher for MSW salmon and 3.44 times higher for 1SW salmon than efficiencies in 1986.

Numbers of MSW salmon released by anglers were estimated to be 7,253 fish (Table 1). Assuming a catch-and-release mortality rate of 0.03 (Randall et al. 1986), total angling mortalities were estimated to be 218 MSW salmon.

As in the 1985 assessment (Randall et al. 1986), two adjustments were made before the ratio of spawner to Millbank count (Method 2) was used to estimate spawning escapement in 1986. First, to account for the change in the Millbank trap efficiency since 1973, adjusted counts of MSW salmon (1,262) and 1SW salmon (6,065) were used. Second, estimated angling catches of MSW salmon (minus catch-and-release mortalities) were added to the estimated spawners. The latter adjustment was necessary because MSW salmon were released in 1986, while in other years when the spawner/Millbank count ratio was calculated, MSW salmon were landed.

Numbers of MSW and 1SW spawners in 1986, as estimated by Methods 1 and 2, are given below:

	Method 1	Method 2
MSW salmon		
1. Total returns	30,317	
2. Harvest	858	
3. Poaching and disease	1,000	
4. Broodstock	54	
5. Trap mortalities	117	
6. Estimated spawners	28,288	20,867
7. Required spawners	23,600	23,600
% of target achieved	120%	88%
1SW salmon		
1. Total returns	110,718	
2. Harvest	29,039	
3. Poaching and disease	4,000	
4. Spawning escapement	77,679	66,472
5. Target spawners	22,600	22,600
% of target achieved	344%	294%

In 1986, average fecundity for 1SW and MSW salmon using length-fecundity relationship given by Randall 1985 was 721 and 5,474 eggs per fish, respectively. Thus, Method 1 above indicates an egg deposition of 210.9 x 10^6 eggs (160% of requirements), while Method 2 indicates a deposition of 162.2 x 10^6 eggs (123% of requirements).

4. Prediction of 1987 returns

Total returns of 1SW and MSW salmon to Miramichi River from 1971 to 1986 are given in Table 12. As mentioned previously, the catch-efficiency of Millbank trap has decreased significantly in recent years (1985 and 1986) compared to 1973 (Table 11). This decrease may have resulted from dredging activities in Miramichi estuary which were initiated in 1981. For this reason, returns of 1SW and MSW salmon from 1981 to 1984 were estimated two ways: using unadjusted catch efficiencies (i.e. assuming constant catch efficiencies from 1971 to 1984 of 0.055 for 1SW and 0.043 for MSW salmon), and using adjusted lower catch efficiencies as calculated from correlations between Millbank catches and angling catches (calculations in Appendix III). Adjusted catch efficiencies indicated significantly higher returns of both 1SW and MSW salmon in these years (Table 12).

MSW salmon returns in 1987 were predicted using both sets of data (Table 13) below:

	R^2	F	P < F	Prediction
Unadjusted	0.62	9.69	0.0031	54,170
Adjusted	0.50	6.08	0.0150	48,591

Because the unadjusted data gave the best regression, these data were used to predict returns in 1987. The equation was:

$$y = 41{,}314.00 + 0.40x_1 - 1{,}127.41 \arcsin \sqrt{x_2}$$

where y = returns of MSW salmon (year i+1)
x_1 = returns of 1SW salmon (year i)
x_2 = proportion female 1SW salmon (year i)

MSW salmon returns in 1987 were predicted to be 54,170 (31,019 - 77,320).

Returns of 1SW salmon in 1987 were predicted from the previous five-year average returns (1982-1986) (Table 12). Because 1986 returns were significantly higher than in other years, a geometric mean was used. 1SW salmon returns were predicted to be about 37,900 fish.

DISCUSSION

Returns of MSW salmon spawners to the Miramichi River in 1986 were estimated to be 30,300 fish, which was slightly greater (7%) than predicted in the 1985 assessment (28,400; Randall et al. 1986). Total returns of 1SW salmon, however, were significantly above average: 1986 returns were 110,700 fish, compared to a long-term (1971 to 1985) average of 44,900 1SW salmon (Table 12). The abundance of 1SW salmon in the river was reflected in the angling and Native fisheries, both of which reported good catches in 1986.

Reasons for the increased abundance of 1SW salmon in 1986 are difficult to identify. Increased returns may have resulted from high marine survival rates. Samples at Millbank indicated 1SW salmon were significantly larger than average (Fig. 3), suggesting growing conditions at sea were favourable, and this may have affected survival as well.

The 1986 management plan for Atlantic salmon resulted in a high proportion of total returns that potentially survived to spawn, as was the case in 1984 and 1985 as well (Randall et al. 1985 and 1986). About 93% of MSW salmon that returned to the Miramichi River in 1986 potentially survived to spawn because there were no homewater fisheries. Both methods used in this assessment for estimating spawners indicated that egg deposition requirements were exceeded in 1986.

Mark-recapture information on adult salmon in Miramichi estuary in 1986 confirmed that the catch efficiency of Millbank trap has decreased significantly in recent years. Catch efficiencies of both 1SW and MSW salmon were not significantly different between 1985 and 1986, but both were significantly lower than in 1973 (Table 11). Changes in catch efficiency among years may have resulted either from random interannual variability or, more likely, from changes in the salmon migration route through the estuary because of dredging activities. Either possibility must be thoroughly investigated with annual mark-recapture experiments if Millbank trap counts are to be used to estimate total salmon returns in future.

Uncertainties about the Millbank trap efficiency do not affect estimates of spawning success in the Miramichi River in 1985 and 1986 because returns were calculated directly from mark-recapture data. However, estimates of returns in previous years, particularly during the period 1981 to 1984, may be erroneous if a constant trap efficiency (as calculated in 1973) is used. Returns of salmon from 1981 to 1984 as estimated with adjusted lower catch efficiencies (Table 12 and Appendix III) are significantly higher than returns as estimated using the 1973 efficiencies (Table 12). Historic data from Millbank are presently being investigated in detail to identify the most appropriate catch efficiencies to use for this period. For forecasting MSW salmon returns in 1987, unadjusted data were used because they produced the highest regression coefficient. Unadjusted data were used to forecast MSW salmon returns in 1985 and 1986, and forecasts for these years were reasonably close to actual returns as estimated from mark-recapture data (Table 14).

Regression analysis indicate returns of MSW salmon in 1987 could be relatively high, 54,200 fish, with a potential surplus to spawning requirements of 30,600 MSW salmon. Assuming average returns of 1SW salmon in 1987, total returns could be 37,900 fish, indicating a potential surplus of 15,300 1SW salmon.

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REFERENCES

Amiro, P.G. 1983. Aerial photographic measurement of Atlantic salmon habitat of the Miramichi River, New Brunswick. CAFSAC Res. Doc. 83/74.

Chadwick, E.M.P. 1982. Stock-recruitment relationship for Atlantic salmon (Salmo salar) in Newfoundland rivers. Can. J. Fish. Aquat. Sci. 39: 1496-1501.

Chadwick, E.M.P. and R.G. Randall. 1986. A stock-recruitment relationship for Atlantic salmon in the Miramichi River, New Brunswick. North American Journal of Fisheries Management 6: 200-203.

Currie, B. 1985. North Pole stream hook and release program. Proceedings of the 1985 Northeast Atlantic Salmon Workshop, Moncton, NB. 176 p.

Elson, P.F. 1957. Number of salmon needed to maintain stocks. Can. Fish. Cult. 21: 19-23.

Elson, P.F. 1974. Impact of recent economic growth and industrial development on the ecology of Northwest Miramichi Atlantic salmon (Salmo salar). J. Fish. Res. Board Canada 31: 521-544.

May, A.W. and W.H. Lear. 1971. Digest of Canadian Atlantic salmon catch statistics. Fish. Res. Board Can. Tech. Rept. 270, 106 p.

Randall, R.G. 1985. Spawning potential and spawning requirements of Atlantic salmon in the Miramichi River, New Brunswick. CAFSAC Res. Doc. 85/68.

Randall, R.G. and E.M.P. Chadwick. 1983. Assessment of the Miramichi River salmon stock in 1982. CAFSAC Res. Doc. 83/21.

Randall, R.G. and E.J. Schofield. 1983. Biological assessment of Atlantic salmon in the Miramichi River, NB, 1983. CAFSAC Res. Doc. 83/83.

Randall, R.G. and E.M.P. Chadwick. 1986. Density as a factor affecting the production of juvenile Atlantic salmon (Salmo salar) in the Miramichi and Restigouche rivers, New Brunswick. Polskie Archivum Hydrobiologii (In press).

Randall, R.G., E.M.P. Chadwick and E.J. Schofield. 1985. Status of Atlantic salmon in the Miramichi River, 1984. CAFSAC Res. Doc. 85/2.

Randall, R.G., E.M.P. Chadwick and E.J. Schofield. 1986. Status of Atlantic salmon in the Miramichi River, 1985. CAFSAC Res. Doc. 86/2.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board Can. No. 191. 382 p.

Smith, S.J. 1981. Atlantic salmon sport catch and effort data, Maritimes Region, 1951-1979. Can. Data Rept. Fish. Aquat. Sci. No. 258, 267 p.

Swetnam, D.A.B. and S.F. O'Neil. 1985. Collation of Atlantic salmon sport catch statistics, Maritime Provinces, 1960-69. Can. Data Rep. Fish. Aquat. Sci. No. 533, 289 p.

Turner, G.E. 1983. An efficiency estimate of the Millbank estuarial sampling trap, Miramichi River, New Brunswick, 1973. CAFSAC Res. Doc. 83/78.

Zippin, C. 1956. An evaluation of the removal method of estimating animal populations. Biometrics 12: 163-189.

Table 1. Angling statistics for MSW and 1SW salmon in the Miramichi River as estimated by DNRE and DFO, and salmon catches at Millbank 1969 to 1986.

	MSW salmon			1SW salmon		
Year	DFO	DNRE	Millbank	DFO	DNRE	Millbank
1969	2,827	3,804	667	26,715	24,284	4,350
1970	2,057	3,268	245	19,662	19,610	2,484
1971	1,247	1,792	399	8,464	13,727	1,962
1972	5,456	8,933	1,151	15,472	19,101	2,543
1973	4,881	5,977	1,132	9,033	13,857	2,450
1974	5,895	7,184	1,791	17,957	18,232	4,038
1975	3,756	6,288	1,208	9,730	15,598	3,548
1976	5,319	7,374	943	14,749	27,182	4,939
1977	14,344	11,617	1,934	8,244	13,590	1,505
1978	4,196	4,893	693	5,353	8,265	1,268
1979	2,422	2,656	318	7,625	14,508	2,500
1980	5,422	6,546	1,093	7,533	11,997	2,139
1981	1,602	3,238	199	7,031	22,716	2,174
1982	2,642	4,608	408	9,217	21,402	2,665
1983	1,646	2,240	245	3,897	8,390	810
1984	---	[7,690]	333	9,892	18,794	1,010
1985	---	[9,622]	311	11,926	18,439	912
Mean	4,247	5,749	769	11,324	17,041	2,429
1986		[7,253][1]	469	28,299	[27,051][2]	1,763

[ ] Catch and release of MSW salmon.

1 MSW angling catch and release in 1986 was estimated from a correlation between Millbank salmon (x) and DNRE salmon (y) from 1969 to 1983; $y = 1,746.56 + 4.36\,(x)$, $R^2 = 0.79$, $y\,(1986) = 7,253$. Catch of MSW salmon in 1986 was adjusted upwards (from 469 to 1,262) to account for the change in catch efficiency of Millbank trap (0.016 in 1986 versus 0.043 in 1973).

2 Angling catch of 1SW salmon in 1986 was estimated from a correlation between DFO salmon (x) and DNRE salmon (y) from 1969 to 1985; $y = 10,363.46 + 0.59\,(x)$; $R^2 = 0.43$; $y\,(1986) = 27,051$.

Table 2. Ratios of spawner to fish (1SW and MSW) counted at Millbank Trap, 1971 to 1984 (see text).

Year (i)	Parr/m^2 (i+2)	Eggs/ fish	Spawners MSW	Spawners 1SW		Ratio of spawner to Millbank count
1971	0.016	1,206	1,233	6,064		3.09
1972	0.097	1,911	8,710	19,207		7.57
1973	0.112	2,125	9,160	19,828		8.09
1974	0.099	2,444	6,840	15,439		3.82
1975	0.096	2,149	6,241	18,329		5.17
1976	0.100	1,541	5,711	29,980		6.06
1977	0.074	3,761	6,082	4,740		3.14
1978	0.063	2,846	4,298	7,877		6.20
1979	0.091	1,370	4,128	32,405		12.98
1980	0.094	2,492	7,012	13,734		6.42
1981	0.104	956	5,026	54,807		25.26
1982	0.068	1,450	3,430	22,363		8.41
1983	0.097	1,832	6,756	22,365		27.58
1984	0.145	2,006	9,859	29,897		29.61
					Mean	10.96
					SD	9.34

Table 3. Angling catch-and-effort data for 1SW salmon in the Miramichi River in 1986 as estimated by DFO fishery officers. Data for 1985 given for comparison.

	1986			1985		
	Kelts	Brights	Rod-days	Kelts	Brights	Rod-days
April	850		2,651	2,161		3,959
May	597		3,622	1,370		2,904
TOTAL	1,447		6,273	3,531		6,863
Mean weight (kg)	1.33			1.38		
June		1,388	4,909		597	4,398
July		7,950	11,231		4,691	10,428
August		5,301	11,522		3,458	7,317
September		13,260	23,416		3,053	10,208
October		400	2,100		127	808
TOTAL		28,299	53,178		11,926	33,159
Mean weight (kg)		1.78			1.58	

Table 4. Native fishery landings in Miramichi River and Bay, 1984 to 1986.

	1986		1985		1984	
	1SW	MSW	1SW	MSW	1SW	MSW
Red Bank	1,064	336	216	127	147	108
Eel Ground	908	287	330	195	233	200
Burnt Church	16	17	0	5	1	1
TOTAL	1,988	640	546	327	381	309

Table 5. Preliminary 1986 salmon landings in the Miramichi River and Bay. Landings for 1984 and 1985 are given for comparison.

	1986		1985		1984	
	1SW	MSW	1SW	MSW	1SW	MSW
Native	1,988	640	546	327	381	309
Angling[1]	27,051	(218)[2]	18,439	(289)[2]	18,794	(231)[2]
TOTAL	29,039	858	18,985	616	19,175	540

[1] Angling landings from DNRE (Table 1).

[2] Assuming a catch-and-release mortality rate of 0.03.

Table 6. Recorded catches of salmon in all fisheries, Miramichi River and Bay, 1951-86 (includes commercial, by-catch, recreational and Native). Kelts angled in year i are added to landings in year i-1. Data sources are given in Appendix II. 1986 data are preliminary. All data are numbers x 10^3.

				ANGLING										
	COMMERCIAL			Kelts (yr i+1)			Bright (yr i)				NATIVE			GRAND
Year	1SW	MSW	Total	1SW	MSW	Total	1SW	MSW	Total	Total	1SW	MSW	Total	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	1.6	0.7	2.3	8.4	2.2	10.6	12.9	0.4	0.2	0.6	32.2
1984	0.0	0.0	0.0	2.4	0.0	2.4	18.8	0.0	18.8	21.2	0.4	0.3	0.7	21.9
1985	0.0	0.0	0.0	-	0.0	-	18.4	0.0	18.4	18.4	0.5	0.3	0.8	19.2
1986	0.0	0.0	0.0	-	-	-	27.1	0.0	27.1	27.1	2.0	0.6	2.6	29.7

Table 7. Numbers of MSW and 1SW salmon counted at barriers in two tributaries of the Miramichi River, 1981 to 1986.

Tributary	Year	MSW	1SW	Total
North Branch of SW Miramichi	1981	54	645	699
	1982	288	615	903
	1983	223	284	507
	1984	297	228	525
	1985	604	492	1,096
	Mean	293	453	746
	1986	1,138	2,072	3,210
Dungarvon River	1981	112	570	682
	1982	113	450	563
	1983	126	325	451
	1984	93	315	408
	1985	162	536	698
	Mean	121	439	560
	1986	174	501	675

Table 8. Biological characteristics of adult salmon sampled at three estuarial traps in the Miramichi River in 1986. FL is mean fork length (cm) and W is mean weight (kg).

	n	FL (SD)	n	W (SD)	n	% male
Millbank trap						
1SW	150	54.1 (3.00)	150	1.70 (0.24)	150	78
2SW	39	72.6 (2.89)	39	4.52 (0.60)	39	13
PS	7	79.1 (6.20)	7	5.73 (0.88)	7	57
Southwest trap						
1SW	178	56.9 (3.65)	177	1.95 (0.48)	120	79
2SW	127	75.4 (3.72)	127	4.63 (0.95)	114	23
PS	19	87.1 (7.21)	20	8.10 (4.16)	15	40
Northwest trap						
1SW	111	55.5 (3.07)	111	1.87 (0.50)	64	80
2SW	61	74.6 (3.33)	61	4.51 (0.95)	50	14
PS	16	82.3 (8.44)	16	7.00 (4.91)	13	54
Total						
1SW	439	55.6 (3.50)	438	1.84 (0.43)	334	79
2SW	227	74.7 (3.61)	227	4.58 (0.90)	203	19
PS	42	83.9 (8.00)	43	7.31 (4.16)	35	49

Table 9. Juvenile Atlantic salmon densities (number .100 m^{-2}) in the Miramichi River, 1970 to 1986. (n = number of sites; 95% confidence limits in parenthesis.)

Year	n	Age 0+	Age 1+
1970	44	14.6 (9.4-22.5)	3.0 (2.4- 3.9)
1971	66	14.5 (10.8-19.4)	5.1 (3.9- 6.7)
1972	66	5.5 (4.2- 7.3)	5.1 (4.0- 6.4)
1973	73	17.5 (13.1-23.5)	1.6 (1.4- 1.9)
1974	90	24.4 (17.7-33.7)	9.7 (7.4-12.5)
1975	89	25.7 (18.7-35.4)	11.2 (8.6-14.5)
1976	80	18.8 (13.7-25.7)	9.9 (7.6-12.9)
1977	86	34.8 (25.4-47.7)	9.6 (7.5-12.4)
1978	87	22.7 (17.4-29.5)	10.0 (7.6-13.1)
1979	48	13.4 (9.6-18.7)	7.4 (5.4-10.3)
1980	45	21.5 (14.7-31.6)	6.3 (4.5- 8.9)
1981	47	41.3 (28.4-60.0)	9.1 (6.3-13.1)
1982	85	11.1 (8.5-14.4)	9.4 (7.3-12.1)
1983	85	27.9 (20.6-37.8)	10.4 (7.9-13.8)
1984	83	16.6 (12.2-22.5)	6.8 (5.4- 8.6)
1985	40	49.5 (27.4-89.3)	9.7 (6.7-14.2)
1970-85 mean		22.5	7.8
1986	32	54.4 (30.8-96.0)	14.5 (9.0-23.2)

Table 10. Summary of mark-recapture data in the Miramichi River, 1986. Data from 1985 are given for comparison.

	Millbank	Recapture traps		
		Southwest	Northwest	Total
1986				
MSW salmon				
Catch	469	585	264	849
Meshed	48	39	30	69
Broodstock	0	34	20	54
Marked	404 (4)[1]	0	0	0
Recaptures	2	3	5	8
1SW salmon				
Catch	1,763	1,519	832	2,351
Meshed	25	0	2	2
Marked	1,587	0	0	0
Recaptured	8	17	9	26
1985				
MSW salmon				
Catch	311	486	204	690
Meshed	27	41	13	54
Broodstock	40	61	0	61
Marked	222 (3)[1]	0	0	0
Recaptures	3	4	0	4
1SW salmon				
Catch	912	848	695	1,543
Meshed	0	0	0	0
Marked	600	0	0	0
Recaptured	1	10	5	15

[1] Considered inaccessible to recapture traps.

Table 11. Estimated catch efficiency (± 95% CL's) of Millbank trap in 1973, 1985 and 1986.

MSW salmon	
1973	0.043 (0.033-0.056)
1985	0.013 (0.005-0.029)
1986	0.016 (0.008-0.029)
1SW salmon	
1973	0.055 (0.044-0.069)
1985	0.020 (0.012-0.032)
1986	0.016 (0.011-0.023)

Table 12. Estimated returns to Millbank, commercial landings and total MSW and 1SW salmon returns to the Miramichi River, 1971 to 1986.

	Returns to Millbank		Commercial		Total returns	
Year 1	1SW 2	MSW 3	1SW 4	MSW 5	1SW 6	MSW 7
1971	35,673	9,279	0	18,268	35,673	27,547
1972	46,236	26,767	39	2,445	46,275	29,212
1973	44,545	26,326	0	866	44,545	27,192
1974	73,418	41,651	0	963	73,418	42,614
1975	64,509	28,093	393	743	64,902	28,836
1976	89,800	21,930	1,819	878	91,619	22,808
1977	27,364	44,977	407	6,865	27,771	51,842
1978	23,055	16,116	1,234	8,377	24,289	24,493
1979	45,455	7,395	5,512	1,659	50,967	9,054
1980	38,891	25,419	2,697	10,899	41,588	36,318
1981	39,527 (62,114)	4,628 (8,652)	1,628	7,836	41,155 (63,742)	12,464 (16,488)
1982	48,455 (76,143)	9,488 (17,739)	2,311	12,511	50,766 (78,454)	21,999 (30,250)
1983	14,727 (23,143)	5,698 (10,652)	1,588	17,055	16,315 (24,731)	22,753 (27,707)
1984	18,364 (56,111)	7,744 (22,200)	---	---	18,364 (56,111)	7,744 (22,200)
1985	46,417	24,323	---	---	46,417	24,323
1986	110,718	30,317	---	---	110,718	30,317

Data sources: Column 2: 1971 to 1984 calculated from Millbank catch/0.055; 1985 and 1986 returns from mark-recapture data. (Numbers in parentheses indicate returns estimated using lower catch efficiencies, 1981 to 1984, see text.)

3: 1971 to 1984 calculated from Millbank catch/0.043; see other notes above.

4 and 5: from Redbooks; 1982 and 1983 drift landings adjusted for underreporting (Randall and Schofield 1983).

6: Column 2 + Column 4.

7: Column 3 + Column 5.

Table 13. Total returns of MSW and 1SW salmon (calculations in Table 12) to the Miramichi River, 1971 to 1986. Proportion of 1SW salmon which were female is also given. Returns of MSW salmon forecasted for 1987 are given in parenthesis (regression equation in text).

Year	1SW returns (year i)	% females (year i)	MSW returns (year i+1)
1971	35,673	11.0	29,212
1972	46,275	22.0	27,192
1973	44,545	16.9	42,614
1974	73,418	30.2	28,836
1975	64,902	27.4	22,808
1976	91,619	24.1	51,842
1977	27,771	22.8	24,493
1978	24,289	37.4	9,054
1979	50,967	27.4	36,318
1980	41,588	19.3	12,464 (16,488)
1981	41,155 (63,742)[1]	25.1	21,999 (30,250)
1982	50,766 (78,454)	29.5	22,753 (27,707)
1983	16,315 (24,731)	29.2	7,744 (22,200)
1984	18,364 (56,111)	21.7	24,323
1985	46,417	22.8	30,317
1986	110,718	22.0	(54,170)

[1] Numbers in parentheses are returns as estimated using lower catch efficiencies (see text).

Table 14. Comparison of predicted and actual returns of salmon as estimated in annual assessments of the Miramichi salmon stock, 1984 to 1986 (Randall et al. 1985; 1986).

	1SW returns			MSW returns		
Year	Predicted	Actual	Spawner/ returns ratio	Predicted	Actual	Spawner/ returns ratio
1985	42,000	46,400	0.53	18,400	24,300	0.93
1986	40,700	110,700	0.70	28,400	30,300	0.93
1987	37,900			54,200		

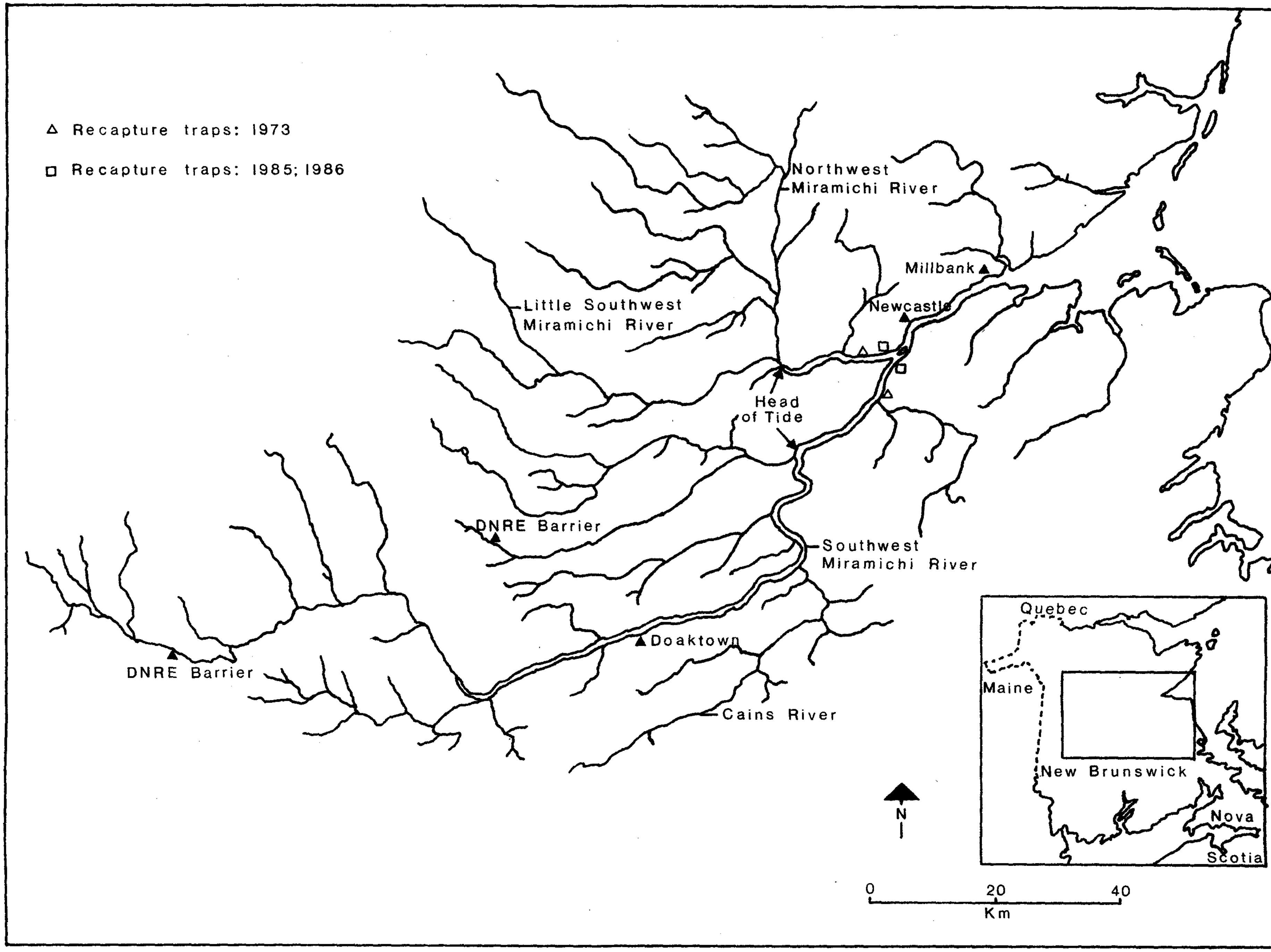
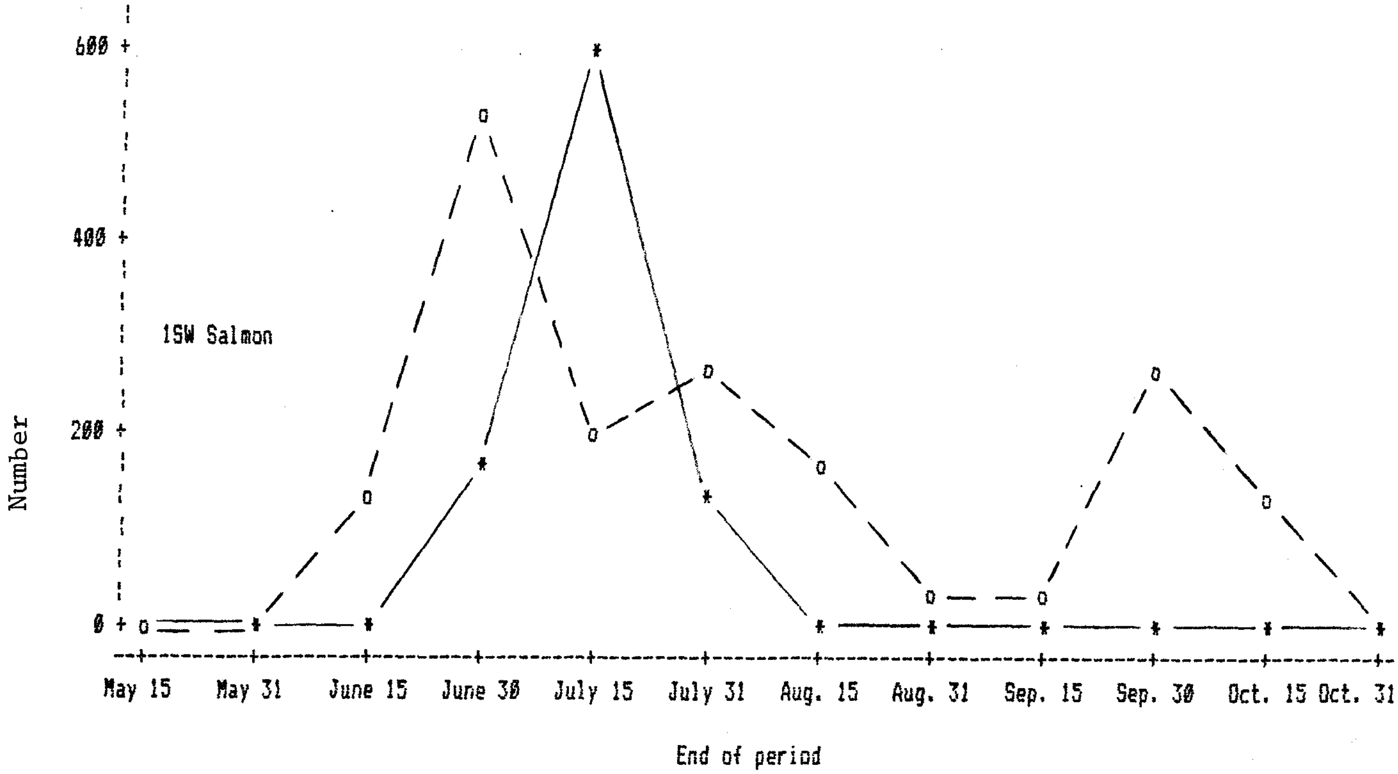


Fig. 1. General location of recapture traps in the Northwest and Southwest tributaries of the Miramichi River system.



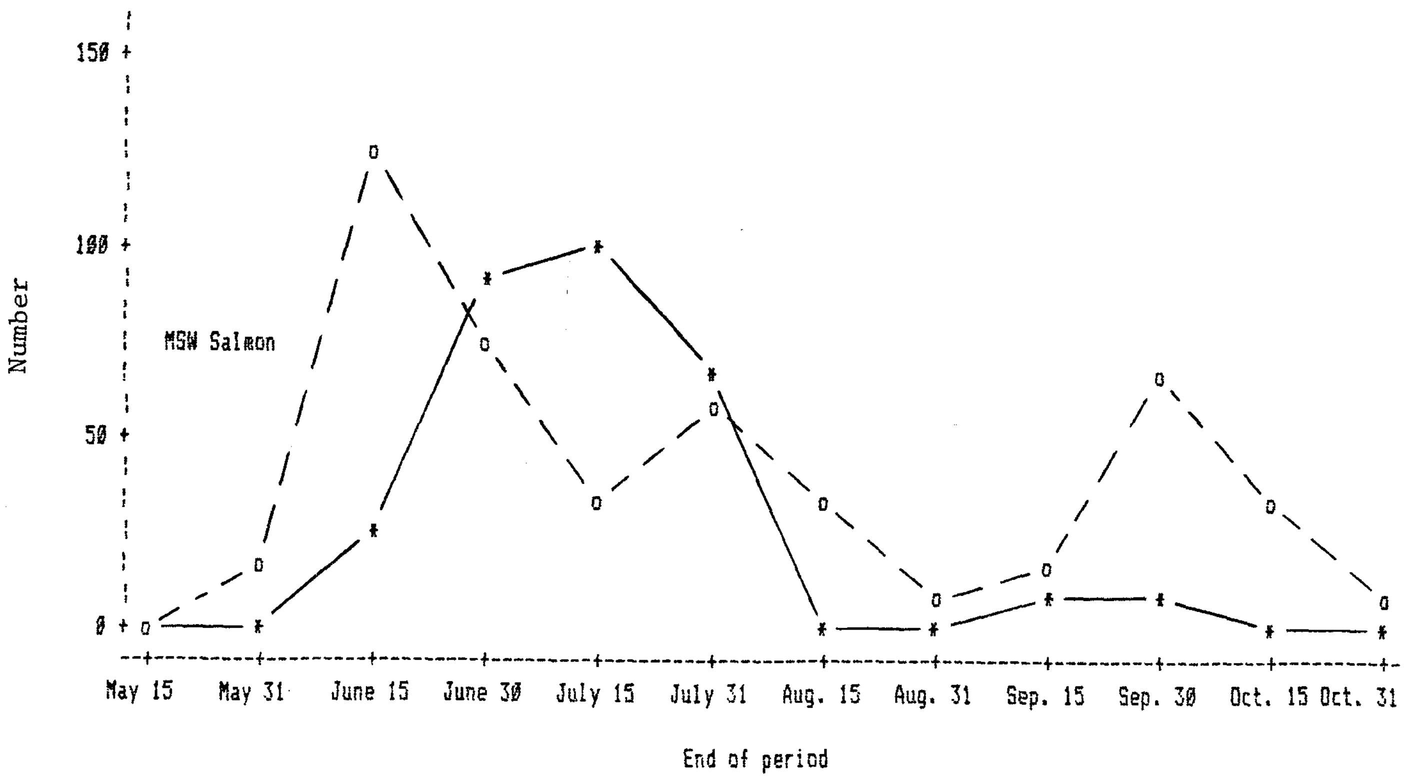


Fig. 2. Salmon caught in half-month periods at Millbank, 1985 (*) and 1986 (o)

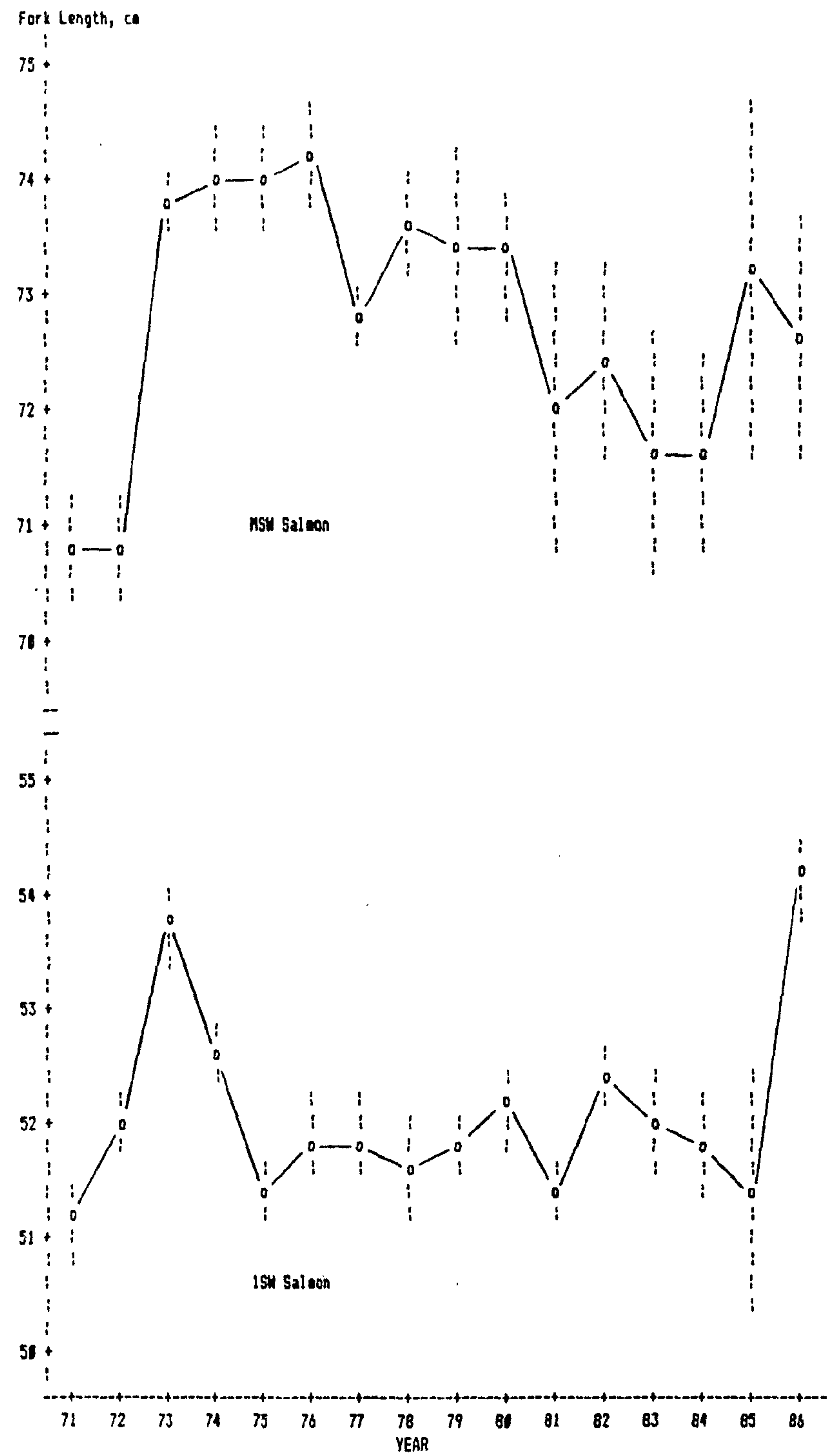


Fig. 3a. Mean fork length for 1SW and MSW salmon sampled at Millbank, 1971-1986. 95% confidence limits are indicated.

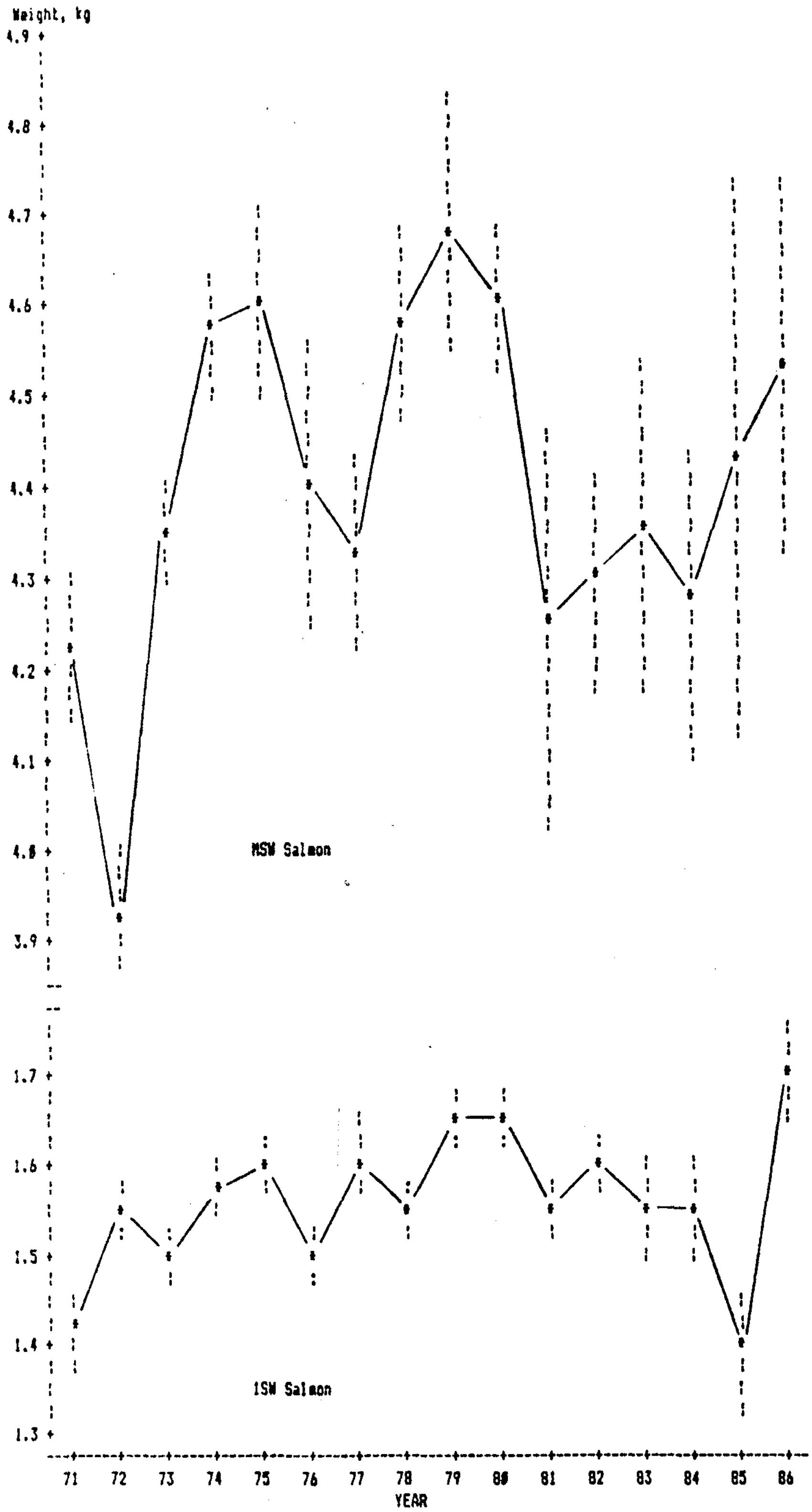


Fig. 3b. Mean weight for 1SW and MSW salmon sampled at Millbank, 1971-1986. 95% confidence intervals are indicated.

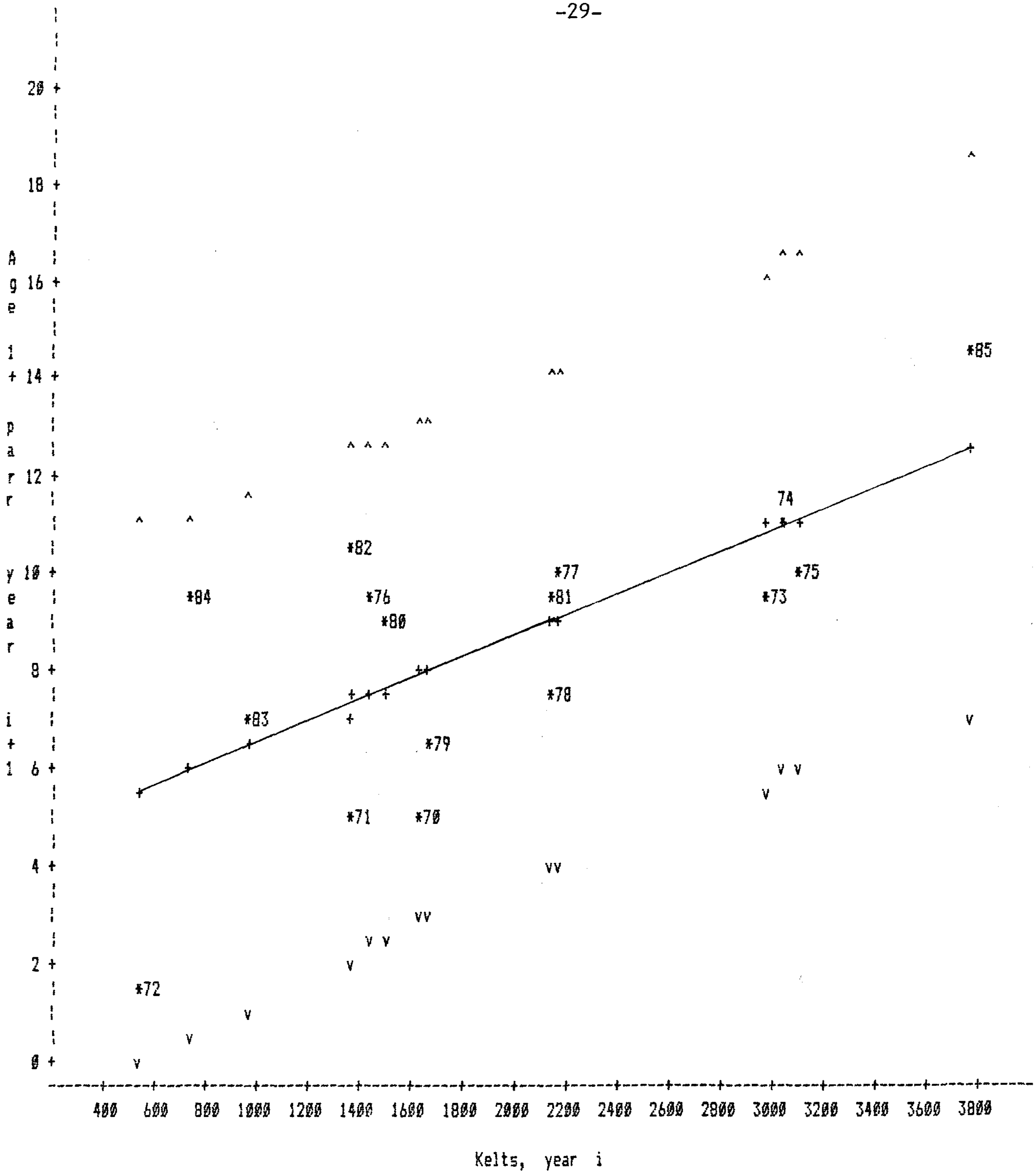


Fig. 4. Stock-recruitment relationship for Atlantic salmon in the Miramichi River. Angled MSW kelts, year i were used as an index of spawning stock, and small parr densities, year i+1 (number per 100 sq m) as an index of recruitment.

Legend: * observed values + calculated regression
^ upper, v lower bounds of 95% CI for predictions

APPENDIX I. Angling seasons on Miramichi tributaries, 1986 and 1985.

Tributary	Season 1986	Season 1985
General (bright salmon)	8 June - 30 September	8 June - 30 September
Exceptions		
Bartholomew	Closed	Closed
Bartibog	1 July - 15 October	1 July - 15 October
Cains	1 July - 15 October	1 July - 15 October
Dungarvon (above Underwood Brook)	8 June - 15 September	8 June - 15 September
Little Southwest (above Catamaran)	8 June - 15 September	8 June - 15 September
Southwest (above MacKeil Brook)	8 June - 15 September	8 June - 15 September
Northwest (above Little River)	8 June - 31 August	1 June - 31 August
Renous (above North Renous)	8 June - 15 September	8 June - 15 September
Rocky Brook	1 June - 31 August	1 June - 31 August
Sevogle (above Square Forks)	8 June - 15 September	8 June - 15 September
Other tributaries of Main Southwest Miramichi (above Cains River - except Rocky Brook)	8 June - 15 September	8 June - 15 September

APPENDIX II

Salmon landings for Miramichi Bay and River given in Table 6 are from the following sources:

1. Commercial data

   Commercial data for 1951 to 1969 are from May and Lear (1971) and assume salmon weigh 4.46 kg on average.

   Commercial data 1970 to 1983 are from Redbooks (compiled by Freshwater and Anadromous Division, Science Branch, Halifax). Redbook drift net landings are adjusted upwards by 1.5 (1982) and 2.48 (1983) as discussed by Randall and Schofield (1983).

2. Angling data

   Angling data for 1951 to 1959 from Smith (1981); 1960 to 1968 from Swetnam and O'Neil (1985); 1969 to 1985 from DNRE.

3. Native data

   Native fisheries landings are from DFO unpublished files.

4. All 1986 data are preliminary.

APPENDIX III

Adjusted catch efficiencies of Millbank trap for the period 1981 to 1983 were estimated using regressions between Millbank catches and angling catches, 1969 to 1980 (data in Table 1).

1SW salmon

Regression between Millbank catch (y) and DNRE angling catch (x) from 1969 to 1980:

$$y = -304.35 + 0.19\ (x)$$
$$R^2 = 0.74,\ \text{d.f.} = 10,\ P < 0.001$$

	y	$\hat{y}$	$(y/\hat{y})\ (0.055)$
1981	2,174	3,942	0.030
1982	2,665	3,696	0.040
1983	810	1,264	0.035
		Mean	0.035

MSW salmon

Regression between Millbank catch (y) and DNRE catch (x) from 1969 to 1980:

$$y = -26.43 + 0.17\ (x)$$
$$R^2 = 0.77,\ \text{d.f.} = 10,\ P < 0.001$$

	y	$\hat{y}$	$(y/\hat{y})\ (0.043)$
1981	199	521	0.016
1982	408	753	0.023
1983	245	352	0.030
		Mean	0.023

Catch efficiencies in 1984 were assumed to be averages of the 1985 and 1986 estimates, i.e. 0.018 for 1SW salmon and 0.015 for MSW salmon.