DFO Atlantic Fisheries
Research Document 96/127

MPO Pêches de l'Atlantique
Document de recherche 96/127

Stock Status of Atlantic Salmon on the Northumberland Strait, Nova Scotia area rivers in 1995

by

S.F. O'Neil, D.A . Longard, and C.J. Harvie
Science Branch
Maritimes Region
Department of Fisheries and Oceans
P.O. Box 550
Halifax, Nova Scotia B3J 2S7

Abstract

Fifteen separate rivers on the Northumberland Strait shore of Nova Scotia support Atlantic salmon stocks. Stock status information is provided for eight of those stocks based on estimated targets and escapements calculated from exploitation rates in the angling fishery. Additional information is included for the three principal rivers in the area, East River, Pictou; River Philip and West River, Antigonish. Anglers reported harvesting or releasing 349 small salmon (grilse) and 530 large salmon on the rivers within the area. First Peoples reported harvesting 54 small and 124 large salmon in the two estuarial traps (East River and River Philip) and angling fisheries. Two methods were examined to estimate escapements, one which required adjusting license stub reported catches and a range of exploitation rates and the other which did not adjust the angling data and used the 1995 Margaree River derived exploitation rates. Arguments are presented which favour the second method which provides escapement estimates which are the larger of the two methods. Juvenile salmon numbers were found to be high relative to the numbers found on many rivers in the Maritimes on several of the rivers examined, but particularly on West River, Antigonish where parr numbers were greater than 70 parr per 100 m^2. Trial counts of fish by snorkel divers confirmed that the conservation requirement was met for Sutherlands River and supported the exploitation rate evidence that River Philip had exceeded the conservation requirement in 1995. Forecasts were only possible using the 5-year estimates for returns. The forecast for 1996 is for surplus numbers of grilse (variable numbers) on the three principal rivers of the area and for the number of large salmon returns to exceed requirements by approximately 25% on those same rivers.

Résumé

Sur le littoral néo-écossais du détroit de Northumberland, quinze cours d'eau différents abritent des stocks de saumon atlantique. Nous présentons des données sur l'état de huit de ces stocks grâce à des estimations des cibles et des échappées calculées à partir des taux d'exploitation de la pêche à la ligne. Des renseignements complémentaires sont fournis pour les trois principaux cours d'eau de la région : rivière est de Pictou, rivière Philip et rivière ouest d'Antigonish. Les pêcheurs sportifs ont déclaré la capture ou la remise à l'eau de 349 petits saumons (grilses) et de 530 grands saumons dans les rivières de la région. Les Premières Nations ont déclaré la récolte de 54 petits et de 124 grands saumons dans les deux trappes estuariennes (rivière est et rivière Philip) et à la pêche à la ligne. Nous avons examiné deux méthodes permettant d'estimer les échappées, l'une qui nécessitait un ajustement des prises déclarées d'après les volets des permis et d'une gamme de taux d'exploitation, l'autre qui n'ajustait pas les prises de la pêche sportive et qui employait les taux d'exploitation tirés de la pêche sur la Margaree en 1995. Nous présentons des arguments en faveur de la deuxième méthode, qui donne des estimations des échappées plus élevées que dans l'autre. Les effectifs des jeunes saumons étaient élevés, par rapport à ceux observés dans de nombreuses rivières des Maritimes, dans plusieurs des cours d'eau examinés, et particulièrement sur la rivière ouest d'Antigonish, où on comptait plus de 70 tacons pour 100 m^2. Des dénombrements expérimentaux effectués par des plongeurs libres ont confirmé que l'exigence de conservation était respectée pour la rivière Sutherlands, et que, comme l'indiquaient les taux d'exploitation, le niveau nécessaire à la conservation était dépassé sur la rivière Philip en 1995. C'est seulement avec les estimations quinquennales des remontes qu'il a été possible de faire des prévisions. Pour 1996, on prévoit un surplus de grilses (en nombres variables) sur les trois principaux cours d'eau de la région, et une remonte de grands saumons qui dépassera les besoins d'environ 25 % sur ces rivières.

Table of Contents

STOCK: East River (Pictou Co.) (SFA 18)
TARGET: 1.8 million eggs (271 large, 57 small salmon)

Year	1990	1991	1992	1993	1994	1995	MIN[2]	MAX[2]	Mean[2]
Angling catch[1]									
Large	299	440	371	221	87	51	87	670	284
Small	109	121	111	56	23	39	23	129	84
First Peoples' harvest									
Large	-	-	-	139	141	28			-
Small	-	-	-	-	5	2			-
Total returns[3]									
Large	407	619	523	456	265	113	111	942	454
small	247	270	251	127	60	150	60	303	191
Spawning escapement[3]									
Large	403	614	519	313	123	111	111	933	394
Small	182	200	184	92	41	127	41	223	140
% of Egg target met (large)									
	148	227	192	115	45	41	45	344	145

[1] All angling catches are NS license stub estimates. Large salmon angling catch for 1986 to present is hook-and-release estimates.
[2] Min, Max are for 1986 to 1994. Mean for 1990 to 1994.
[3] Return estimates exclude First Nation harvests. Return estimates for 1990-94 based on resampling; Escapements calculated from returns; 5% mortality assumed for hook and release on small and large fish.

Description of fisheries and fishery data: Harvests occurred in recreational and First Peoples' fisheries. A food fishery agreement was signed with Pictou Landing First Nation. Harvests under this agreement occurred on East River Pictou, in an estuary trapnet. Reported harvest was 2 small and 28 large salmon. An additional 60 large fish were released. Sportcatch data are obtained from license stubs and angler diaries. Recreational catch on East River, Pictou was about 18% of the 1990-94 mean value for large salmon, and 46% of the 5-year mean for small salmon.

Research Data: Juvenile surveys by electrofishing indicated parr levels above 28 parr/100 m^2. A trial diver survey of spawners on November 6 and 7 on 14% of the river main stem counted 8% of the large salmon spawner requirement.

Estimation of stock parameters: Small salmon returns are calculated using fall fishery exploitation rates from the Margaree River (based on tag returns). Large salmon returns for 1995 were estimated using the 1995 Margaree River exploitation rates. The exploitation rate was derived from license stub reported catches and the population estimate for the Margaree River based on tag returns (through seining and a tributary fence) from those applied at an estuary trap.

Assessment results: Spawning escapement estimates were below target for large salmon (41% of requirement) and over 200% of target for small salmon.

Ecological considerations: Discharge was low in 1994 and 1995, relative to the 1989-93 mean discharge, through September and most of October (until October 23). The low water probably influenced the angling catch because fish were not available for angling until late in the season.

Future prospects: Average returns indicate that the requirement for large salmon spawners is likely to be exceeded by about 25% in 1996. Similarly, small salmon spawners are expected to exceed target by a margin of 50 fish or more.

Management considerations: Angler access to East River, Pictou fish has been restricted to late autumn. This has provided the fish a margin of safety from harvest and no doubt contributed to the forecast surplusses. Local client groups have expressed concern regarding poaching of salmon on all rivers in the Northumberland Strait Nova Scotia area. Estimates of those removals are notoriously difficult to estimate and have not been taken into account when estimating escapements or forecasts. Some caution should be exercised when allocating projected surplusses to account for the losses due to illegal harvest.

STOCK: River Philip (SFA 18)
TARGET: 2.3 million eggs (358 large, 75 small salmon)

Year	1990	1991	1992	1993	1994	1995	MIN[2]	MAX[2]	Mean[2]
Angling catch[1]									
Large[1]	191	421	322	338	176	234	184	421	289
Small	155	164	179	167	87	140	76	179	150
First Peoples' harvest									
Large	-	-	-	50	15	52			-
Small	-	-	-	0	9	30			-
Total returns[3]									
Large	279	578	461	474	281	520	279	578	415
small	362	360	398	373	198	538	169	538	338
Spawning escapement[3]									
Large	276	573	457	469	264	508	264	573	408
Small	268	262	292	276	137	430	124	430	247
% of Egg target met (large)									
	77	160	128	131	74	142	44	160	114

[1] All angling catches are NS license stub estimates. Large salmon angling catch for 1986 to present is hook-and-release estimates.
[2] Min, Max are for 1986 to 1994. Mean for 1990 to 1994.
[3] Return estimates exclude First Nation harvests. Return estimates for 1990-94 based on resampling; Escapements calculated from returns; 5% mortality assumed for hook and release on small and large fish.

Description of fisheries and fishery data: Harvests occurred in recreational and First Peoples' fisheries. A food fishery agreement was signed with Millbrook First Nation. Harvest under this agreement was 30 small salmon and 52 large salmon. The recreational catch of large salmon on River Philip was slightly below the 1990-94 mean and 58 fish above the 1994 value. A food fishery trapnet on River Philip operated from October 1 to October 28 and showed the greatest catches around October 16. The majority of the angling catch also occurred after a storm event on October 13.

Research Data: Several sites were electrofished in 1995 using a 5 minute spot-check technique and a complete density derived for one site using mark recapture. The density data indicates parr in excess of 50 per 100 m^2 and the spot-check sites, catches per 5-minutes similar to those noted in other years..

Estimation of stock parameters: Small salmon returns are calculated using fall fishery exploitation rates from the Margaree River (based on tag returns). Large salmon returns for 1995 were estimated using the 1995 Margaree River exploitation rate derived from license stub reported catches and the population estimate for the Margaree River which is based on tag returns through seining and a tributary fence from those applied at an estuary trap.

Assessment results: Spawning escapement estimates were 142% of the required number of large spawners and over 500% of the conservation requirement for small salmon.

Ecological considerations: Discharge was low in 1994 and 1995, relative to the 1989-93 mean discharge, through September and most of October (until October 23). The low water probably influenced the angling catch because fish were not available for angling until late in the season.

Future prospects: Average returns indicate that target large salmon spawners are likely to be exceeded by about 25% in 1996. Similarly, small salmon spawners are expected to exceed target by a considerable margin (possibly by more than 200 fish).

Management considerations: Angler access to River Philip fish has been restricted to late autumn. This has provided the fish a margin of safety from harvest and no doubt contributed to the forecast surplusses. Local client groups have expressed concern regarding poaching of salmon on all rivers in the Northumberland Strait Nova Scotia area. Estimates of those removals are notoriously difficult to estimate and have not been taken into account when estimating escapements or forecasts. Some caution should be exercised when allocating projected surplusses to account for the losses due to illegal harvest.

STOCK: West River (Antigonish Co.) (SFA 18)
TARGET: 1.15 million eggs (353 large, 1 small salmon)

Year	1990	1991	1992	1993	1994	1995	MIN[2]	MAX[2]	Mean[2]
Angling catch[1]									
Large	200	294	277	248	126	138	126	476	229
Small	152	65	136	66	44	82	44	152	92
First Peoples' harvest									
Large	-	-	-	-	-	-			-
Small	-	-	-	-	-	-			-
Total returns[3]									
Large	284	414	398	339	181	307	175	649	323
small	342	146	312	148	105	315	105	342	211
Spawning escapement[3]									
Large	281	410	395	335	180	300	173	645	320
Small	253	108	233	108	77	266	77	253	156
% of Egg target met (large)	80	116	112	95	51	85	51	116	91

[1] All angling catches are NS license stub estimates. Large salmon angling catch for 1986 to present is hook-and-release estimates.
[2] Min, Max are for 1986 to 1994. Mean for 1990 to 1994.
[3] Return estimates exclude First Nation harvests. Return estimates for 1990-94 based on resampling; Escapements calculated from returns; 5% mortality assumed for hook and release on small and large fish.

Description of fisheries and fishery data: Harvests occurred in recreational fisheries. Angling catch and effort data is obtained form license stubs and angler diaries. The recreational catch of large salmon on West River, Antigonish was 60% of the 1990-94 mean and similar to the 1994 value. The majority of the angling catch occurred after October 20.

Research Data: Two sites were electrofished in 1995. Fry and total parr densities exceeded 100 and 78 fish per 100 m2, respectively. These data are similar to densities found at the same sites in 1994.

Estimation of stock parameters: Small salmon returns are calculated using fall fishery exploitation rates from the Margaree River (based on tag returns). Large salmon returns for 1995 were estimated using the 1995 Margaree River exploitation rates derived from license stub reported catches and the population estimate for the Margaree River which is based on tag returns through seining and a tributary fence from those applied at an estuary trap.

Assessment results: Spawning escapement estimates were 85% of target for large salmon and 266 fish surplus to target for small salmon.

Ecological considerations: Discharge was low in 1994 and 1995, relative to the 1989-93 mean discharge, through September and most of October (until October 23). The low water probably influenced the angling catch because fish were not available for angling until late in the season.

Future prospects: Average returns combined with supplementary evidence indicates that the required number of large salmon spawners are likely to be exceeded by about 25% in 1996. Similarly, small salmon spawners are expected to exceed the conservation requirement by a considerable margin (possibly by more than 200 fish).

Management considerations: Angler access to West River fish has been restricted to late autumn. This has provided the fish a margin of safety from harvest and no doubt contributed to the forecast surplusses. Local client groups have expressed concern regarding poaching of salmon on all rivers in the Northumberland Strait Nova Scotia area. Estimates of those removals are notoriously difficult to estimate and have not been taken into account when estimating escapements or forecasts. Some caution should be exercised when allocating projected surplusses to account for the losses due to illegal harvest.

1. *Introduction*

The Northumberland Strait, Nova Scotia area encompasses the area from the New Brunswick/Nova Scotia border to the Canso Causeway (Fig. 1). Fifteen rivers within the area have been fished for Atlantic salmon within the past 6 years and 11 have been fished with some regularity (Fig. 1, Table 1).

This report focuses mainly on the three principal rivers in the area, River Philip; East River, Pictou (Fig. 2); and West River, Antigonish. It documents the information available on the habitat areas, egg requirements, juvenile density data and catch data. In addition, estimates of Atlantic salmon escapements relative to targets are examined.

2. *Description of Fisheries and Fishery Data*

Sport Fishery

Angling seasons on the Northumberland Strait NS rivers were from September 1 to October 31. Salmon typically enter the rivers in October. Some exceptions apply such as for River Philip where historically there was a small but regular run of salmon as early as July (see angling catch data, Swetnam and O'Neil 1985 and O'Neil and Swetnam 1991).

The Atlantic salmon sport catch on the rivers in Northumberland Strait NS, as reported on license stubs, was 234 grilse (1SW fish; salmon< 63 cm.) retained, 115 grilse released and 530 large salmon (MSW fish; salmon >=63 cm.) released (Table 1). The collective (retained and released) catch of 349 grilse was 158% of the 1994 figure of 221 fish and 78% of the previous (1990-94) 5-year mean of 450 grilse. The 530 large salmon reported released in 1995 was similar to the 553 large salmon angled in 1994 but well below the mean number angled over the previous 5 years (1990-94) of 1,100 fish (Table 1).

The sportcatch of large salmon on East River, Pictou in 1995 (51 fish) was lower than in 1994 and well below the 5-year (1990-94) mean of 284 fish. Grilse catch by anglers was improved in 1995 (39 fish) relative to 1994, when only 23 grilse were caught, but well below the 5-year average catch of 84 fish (Table 1; Fig. 3).

On River Philip, anglers caught 140 grilse, 107 of which were harvested. This figure is up from the 1994 level, but again, below the 5-year-mean-grilse catch of 150 fish (Fig. 3). A total of 234 large salmon were released on River Philip in 1995 as compared with 176 in 1994 and 289 on average over the period 1990-94.

The catch of grilse on West River, Antigonish (82 fish), was up somewhat from the 1994 figure (44 fish)and similar to the 5-year-mean catch of 92 grilse(Table 1). The 1990-94 average large salmon catch of 229 fish was well above the 138 fish released in 1995 (Fig. 3).

Angler diaries were mailed to 67 anglers: 22 for East River, Pictou, 25 for River Philip, and 20 for West River, Antigonish. The diaries were the pocket book format as opposed to the larger forms on individual sheets of paper that were used in past years. The individuals who were mailed diaries were selected on the basis of two criteria: 1) their previous track record with respect to diary completion; and 2) the success rate they reported on license stubs for 1994. Anglers who failed to return the diary were mailed a single reminder letter. The overall response rate was 83% which varied depending on the target river such that anglers from the Philip, East and West rivers returned 75%, 86% and 89% of the diaries mailed, respectively (Table 2a). Only 38 of the 54 fishers who returned diaries actually reported fishing in 1995. Diary anglers reported killing 31 grilse and releasing an additional 7 grilse and 72 large salmon (Table 2b). Collectively, diary holders fished 309 days and 1,364 hours thus fishing an average of 4.4 hours per "rod day".

The catch per unit effort (CPUE) as catch per rod day reported in diaries was 0.169 for the East River, Pictou (10 fishers), 0.378 for River Philip (15 fishers), and 0.462 for West River, Antigonish (13 fishers) (Table 2b). These figures are somewhat higher than CPUEs reported via license stubs on River Philip (0.254) and West River, Antigonish (0.412), but lower than that reported on East River, Pictou (0.194). The selection criteria for the diary holders limits distribution of diaries to the more successful anglers so the disparity in CPUEs on 2 of the rivers is not surprising. The higher CPUE reported on license stubs relative to diaries on East River is perhaps a reflection of the overall low number of fish taken by anglers. Diary holders commented that fish were generally not seen and that numbers appeared low.

Catches of large salmon are assumed to be indicators of stock status because estimation of escapement of fish to the Northumberland Strait Nova Scotia rivers is based on exploitation rates. The lower than average large salmon catches during the past two-years may have been due to factors other than abundance and are discussed below.

First Nations' Fishery

Five First Nation groups indicated an intent to harvest salmon from Northumberland Strait NS rivers, Indian Brook, Millbrook, Pictou Landing, Afton and the Native Council(Table 3a). Pictou Landing reported harvesting 28 male salmon and 2 grilse on East River, Pictou, at their estuarial trap (Fig. 2). They also reported releasing 60 large salmon during the period the trap was operating from (approximately) September 30 to November 15. A daily record of First Nation catches is not available for East River. Millbrook First Nation harvested 82 fish in an estuarial trap in River Philip, 52 large and 30 small salmon (< 63 cm; Table 3b).

Run timing

The timing of catch of salmon on East River, Pictou; River Philip and West River, Antigonish, can be used as an indicator of run timing to the area. Angler diaries and the First Nation's trap records on River Philip were used to plot catch-by-day data as a means of reviewing run timing (Figure 4). Fish entered River Philip the earliest of the 3 rivers with the first catch reported on September 12. On all 3 rivers, however, the angling catch occurred predominantly after the middle of October, for both salmon and grilse. The First Nation's trap on River Philip was in place for several days before reporting a catch on October 11. The trap washed out on October 28 but, nevertheless, the catch occurred largely after mid-October.

3. *Target*

Habitat area

The collective habitat area for the Northumberland Strait NS rivers is 5,076,601 m^2 (Table 4). Habitat area has not been measured for most rivers in the area. Edwards (1956) summarized the results of an on-site survey of River Philip that was conducted in 1956. The estimate of rearing area was made by measuring widths and lengths of the stream areas to arrive at a total for the entire river. Edwards (1956) documented a total rearing area of 987,600 m^2 for River Philip of which about 25,500 m^2 was inaccessible above a dam and which remains inaccessible today.

Estimates of habitat for the more northerly rivers of the area (those of Cumberland, Colchester, and Pictou counties) were based on the ratio between the habitat area and drainage basin area for the River Philip watershed, as follows:

For example, for East River, Pictou:

$$\frac{\text{River Philip "measured" habitat area } (m^2)}{\text{River Philip drainage basin size } (m^2)} = \text{Ratio A} \qquad \frac{987{,}596}{725{,}970{,}700} = 0.0013604$$

East River, Pictou habitat area = Ratio A x East River, Pictou drainage basin size

$= 0.0013604 \times 535{,}971{,}583\ m^2 = 729{,}125\ m^2$

This procedure has been used previously to estimate rearing areas for Northumberland Strait Nova Scotia rivers by Chaput and Jones (1994) and Claytor et. al. (1995).

Drainage basin areas are available from the Land Registration and Information Service (LRIS), Department of Municipal Affairs, Province of Nova Scotia. Measurement of areas was originally completed for New Brunswick and Nova Scotia watersheds by the now defunct Maritime Resource Management Service of Amherst, Nova Scotia, using a standardized procedure. The drainage basin areas used to estimate habitat areas were obtained from LRIS (unpublished) and are given in Table 4.

The habitat area of South River, Antigonish was estimated through an on-site survey to be 95,000 m^2 (*c.f.*, Chaput and Jones 1994). The habitat area:drainage basin area ratio for the South River was also used to arrive at habitat area estimates for the Afton, Pomquet, and Tracadie rivers (Table 4).

Chaput and Jones (1994) classified West River, Antigonish in the same group as the South River . A review of the physiography of the West River, Antigonish, based on an examination of 1:50,000 scale topographic maps, indicated that the river was more similar in drainage basin characteristics to River Philip than to South River. The Beaver and James River tributaries of West River, Antigonish are high gradient streams which originate in the Keppoch Mountain area similar to the streams of River Philip which originate in a more western portion of the Cobequid Mountain range. The South River has a much lower overall gradient. Thus, for this assessment the habitat area for West River, Antigonish was based on the ratio of habitat area to drainage basin size for River Philip. Adjustment of the habitat area of West River, Antigonish to the River Philip ratio results in a habitat area approximately 326,000 m^2 larger than the area used in the past (Chaput and Jones 1994, Claytor et. al. 1995). An on-site survey of West River, Antigonish is currently being completed and should be available for a more reliable habitat estimate within the next couple of years (C. MacInnes[1], pers. comm.).

Egg and adult requirements

The egg requirements for each river were calculated using the conservation 2.4 eggs per m^2 (Anon. 1991a and 1991b), the biological characteristics available for the nearest stock, and the habitat areas (Table 4). The calculation of the egg and adult requirements for East River, Pictou and South River are given as examples in Table 5.

Biological characteristic data were only available for two of the Northumberland Strait Nova Scotia stocks, East River, Pictou, and South River. The South River data were applied to rivers in Antigonish County (Afton, Pomquet, South, Tracadie and West, Antigonish) and the East River, Pictou, data to the other rivers in the area. The estimated egg requirements for the north N.S. rivers range from 45,000 on the Afton River to 2.3 million on River Philip (Table 4).

---

[1] Charles MacInnes, Habitat biologist, Fisheries and Oceans, Antigonish, N. S.

The egg requirement for the rivers in the area is expected to come from large salmon. Grilse are required to ensure a minimum number of males are available to provide a 1:1 ratio with the number of females required to meet minimum egg requirements.

The number of spawners required to meet the conservation requirement for the three principal rivers in the area is:

	Grilse	Large Salmon
East River, Pictou	57	271
River Philip	75	358
West River, Antigonish	1	353

The numbers of large salmon required on the remaining rivers range from 14 on the Afton River to 232 on the Wallace River (Table 4).

4. *Research data*

Electrofishing surveys of juvenile Atlantic salmon were conducted on East River, Pictou; River Philip; West River, Antigonish; River John; Wallace; Middle, Pictou; and Sutherlands rivers in 1995 (Tables 6 and 7). Comparison of recent densities with those obtained in 1978 indicate fry densities have increased markedly on East River, Pictou; French; and West, Antigonish, rivers. Parr densities on East River, Pictou, do not show the same increase over the 1978 values. On French and West, Antigonish, rivers, however, the parr densities in 1994 or 1995 are 1.5 to 5 times higher on the sites where comparisons are possible (Table 6). Standard multiple-sweep removal or mark-recapture density estimates were only made at a few of the many sites electrofished during the past number of years due to resource constraints. Instead, the majority of sites visited were fished in a standard fashion for 5 minutes (300 seconds on the electrofishing timer). Comparison of the results of the 5 minute surveys over the years' 1992-95, at several sites, indicates juvenile numbers (fry and parr) have remained similar (Table 7).

Estimates of adult salmon escapement for the Northumberland Strait Nova Scotia rivers has been done in the past by using an angling exploitation rate from the fall run of salmon on the Margaree River. In an attempt to find an alternate means to estimate escapement, diver float counts were conducted on portions of three of the area rivers, River Philip; East River, Pictou; and Sutherlands River (Table 8). The partial counts by snorkel divers were done as a trial to determine the feasibility for a broader application during some future year and to validate the estimate of returns.

A trap was installed in the Middle River, Pictou, fishway to trap returning adult salmon and evaluate the restoration program ongoing there. The trap was operated from late September until early November. The Pictou County Rivers Association operated the facility with the assistance of the Nova Scotia Department of the Environment.

5. *Estimation of stock parameters*

Atlantic salmon returns were estimated using an exploitation rate derived from data from the Margaree River, Nova Scotia. The Margaree River discharges into the Gulf of St. Lawrence in relative close proximity (the Margaree is geographically located 103 km from West River, Antigonish) to the Northumberland Strait Nova Scotia rivers. In addition, the Margaree River is believed to support a distinct fall run of fish which is arguably similar to the late run of salmon to the Northumberland Strait Nova Scotia rivers.

Estimation of returns was done by two methods.

Method A: The method described by Chaput and Jones (1994) was used to estimate returns by applying a range of exploitation rates (based on the fall Margaree River sport fishery and tag returns) and license stub catch adjusted downwards to account for their estimate of bias. The returns of grilse and large salmon were estimated separately but in the same manner. The range of exploitation rates used was 0.13 to 0.39 for small salmon and 0.09 to 0.27 for large salmon. The angling catch from license stubs was adjusted downwards by a factor which ranged from 1.3 to 2.3 for small salmon and 2.4 to 6.0 for large salmon. Calculation of returns and escapements was achieved as follows:

1. Randomly drawing a catch adjustment factor from a uniform distribution of those factors within the range given and dividing it into the catch to arrive at an "adjusted catch."

2. Randomly drawing an exploitation rate from a uniform distribution of those rates within the range given and applying it to the "adjusted catch" which produces an estimate of returns.

3. The first 2 procedures are repeated for each of the years 1985-95 using the same catch adjustment factor and exploitation rate and the catch value for that year to provide a series of return estimates.

4. The returns over the 1985-94 time period are averaged.

5. The procedure in steps 1 to 4 is repeated 1000 times (resampling) to create separate probability distributions for the average (1985-94) and the 1995 returns based on adjusted catches and the range of exploitation rates.

6. The 90% confidence intervals were determined as the 5th and 95th percentiles of the resampling distributions.

7. The probability that the 1995 return exceeded the average 1985-94 return (the point estimate was the median) was determined from the resampling distribution of the 1995 data.

8. Escapements were estimated in the same manner as the returns but the grilse harvest (adjusted with the same factor used to calculate the return estimate) and a 5% mortality for the catch and release of grilse and large salmon (5% of adjusted released catch) were subtracted from each return estimate in the appropriate resampling distribution.

The Method A return estimation procedure was applied to East River, Pictou; River Philip and West River, Antigonish. Application of this procedure was limited to the 3 larger rivers where it was previously employed by Chaput and Jones (1994) and because of uncertainty in the catch adjustment aspects of the procedure (see discussion below).

Method B Northumberland Strait Nova Scotia river returns in 1995 were estimated using exploitation rates derived from the 1995 Margaree River data. Separate procedures were used for grilse and large salmon. The exploitation rate for grilse was based exclusively on the fall run and calculated from tag returns from anglers for fish tagged at the estuarial (Levis) trap. The procedure incorporated a tag loss factor of 0.01 tags per day and a median number of days to recapture of 11.5 days. It also included a non-reporting rate of 30% for tags recovered by anglers. The 1995 exploitation rate for the fall run (after September 1) on the Margaree River for grilse was estimated to be 26% (Table 9; L. Marshall et. al. In prep.).

The large salmon catch rate was estimated to be a minimum of 15% based on tag returns (calculated similar to the procedure for grilse, see Table 9) or 45% based on the license stub reported catch and the population estimate (i.e., total return estimate) for the river. The population estimate for the Margaree River for 1995 was 2,365 large salmon (Marshall et. al., In prep.). Anglers reported catching and releasing 1,040 large salmon throughout the 1995 angling

season (summer and fall). These data indicate a catch rate of approximately 0.45 for large salmon on the Margaree River in 1995.

Estimation of returns/escapements using Method B was attempted for all rivers in the area where the angling data were sufficient.

6. *Assessment results and discussion*

Results

Method A:

Return estimates for large salmon for 1995 based on the median values of the probability distributions were 72 fish for East River, Pictou, 337 fish for River Philip and 192 fish for West River, Antigonish (Table 10). The probability that the 1995 estimates were greater than the 1985-94 average returns for the 3 rivers was 0 %, 31% and 12% for the East, Philip and West rivers, respectively. These estimates suggest that returns of large salmon in 1995 were low relative to the 1985-94 averages. The returns of grilse were estimated to be similar to the long term averages for River Philip and West River, Antigonish but had a low probability of exceeding the average for East River (Table 10).

The median probability for the large salmon escapements were 72 fish for East River, 322 fish for River Philip, and 195 fish for West River, Antigonish (Table 10). These estimates can be compared with the conservation requirements (Table 4) and for all three rivers, they would not have been met.

Method B:

In-river return estimates for large salmon in 1995 using a 45% exploitation rate and the license stub reported catch were 113 fish for East River, Pictou; 520 fish for River Philip; and 307 fish for West River, Antigonish. Grilse returns were estimated at 150 for East River, Pictou, 538 for River Philip, and 315 for West River, Antigonish using the 26% exploitation rate derived from tag returns (Table 11). The return of fish destined to the Northumberland Strait NS rivers would include salmon harvested in First Nation estuarial traps. Those large salmon estimates were 141 for East River, Pictou, and 572 for River Philip where traps were operated. Escapements for large salmon were similar to returns, except on East River and River Philip where First Nations harvested fish, because only a 5% mortality on hooked-and-released large salmon was applied to calculate escapements from returns (Table 11). The conservation requirement for number of spawners was exceeded only on River Philip among the Northumberland Strait Nova Scotia rivers where such a calculation was possible (Table 11). The escapement of large fish to East River, Pictou was 41% of the conservation requirement. Similarly, by the same method, only 23% of the required large fish escaped to the Wallace River.

The "minimum" exploitation rate estimate derived from tag returns of 15% for large salmon was not applied in this procedure (see Section 10 below).

If it is assumed that poaching removals (Table 12) occurred after the angling catches then deficits to targets would have exceeded those included in Table 11. The fishery officer estimates of illegal removals are rough estimates which would include removals that occurred before, during and after the angling catch occurred. Consequently, the data were not taken into account when calculating escapements. The First Nations removals took place before the angling fishery so the return estimates to the rivers excludes those catches.

Float counts

The number of fish required to meet spawning requirements was counted by snorkel divers on the Sutherlands River where the survey covered 100% of the accessible area (Fig. 5; Table 8). Although the visibility was not perfect, the stream was narrow (7-10 meters), thus allowing the survey team to have confidence that their count was close to 100% of the fish present in the stream at the time of the survey. The snorkel divers counted 17 grilse and 24 large salmon. The survey was conducted on November 6, 1995 at a time when redd construction was observed to be underway. Thus, it was unlikely that large numbers of additional spawners, if any, entered the system after the survey was conducted. Escapement to Sutherlands River approximately met the conservation requirement (Table 11).

A portable counting fence was installed on Sutherlands River by Pictou Landing First Nation and DFO in mid-September. No fish were observed at the fence prior to November 3. On November 3 the trap was washed out by high water so it was removed. All fish are believed to have entered the system during a 3 day period.

Snorkel divers surveyed 3 sections[2] of the main stem of River Philip which covered a total of 2.1 kms. The visibility was reasonably good but would not have allowed 100% enumeration of the fish present. Divers counted 117 large salmon and 17 grilse which represents approximately one-third of the requirement for large salmon of 358 fish. The total length surveyed represented 8% of the main stem below the Thompson Road bridge near the Cobequid Fish Culture Station. These data support the indication from the Method B escapement estimates that targets were exceeded.

The East River, Pictou diver survey consisted of a sampling exercise on the upper section of the river, and a float count on 2 other sections (Fig.2; Table 8). A total of 26 fish were encountered, 5 grilse and 21 large salmon. The number of large salmon represents 7.7% of the target of 271 fish with approximately 14% of the river main stem surveyed. The survey covered portions of river which exceeded 30 meters in width and visibility was only 5 to 7 meters. The divers conducting the float noted that fish were observed singly or in pairs and numerous false or partially constructed redds were seen. Fish were not located in the typical holding pools so the divers could easily have missed as many as they counted. Tributaries, such as McLellans Brook and the West Branch were not surveyed or included in the river distance measurement. Extrapolating the snorkel diver survey to estimate the total escapement of salmon would provide a useful reference based on a fixed number counted. Divers counted 21 large salmon in 14% of the main stem of the river which could arguably be expanded to 150 fish. This number is close to the 111 estimated escaped by Method B (Table 11), and well above the 72 salmon estimated by the Method A procedure.

In addition to the float survey, DFO staff and members of the Pictou County Rivers Association collected 11 large salmon from a single pool on McLellans Brook, a tributary of East River, only 5 days before the float count (for broodstock: 6 fish were returned to the brook and 5 were kept for spawning at the hatchery).

Middle River, Pictou

Restoration efforts for the salmon run on Middle River, Pictou have been underway for some time. Some success has been achieved with 53 salmon returns in 1991. Considerable difficulties remain with the management of the reservoir and fish passage on the river. The reservoir serves as the water source for the Kimberly Clark pulp plant (formerly Scott Worldwide) and Michelin (extraction's of up to 28 million gallons per day) so facilitation of smolt and returning adult migrations has been problematic. Broodstock have been collected from East River, Pictou to provide a source of salmon fry for the restoration program. The trap which was

[2] A forth section was surveyed near the town of Oxford, but the poor visibility made it impossible to see fish. This section is not included in the summary of the float count.

operated in 1995 caught only 2 large salmon. Fishway operation procedures in 1995 have been examined and modifications in 1996 should result in better access for adults. The electrofishing survey in 1995 failed to find any 0+ parr (Table 7) at the sites visited so adults probably didn't ascend the fishway in 1994. A review of the Middle River, Pictou program is underway.

Discussion

The estimates of escapement for the Northumberland Strait Nova Scotia rivers either indicate substantial shortfalls in escapements relative to the conservation requirements (Method A) or those which more closely approximate requirements (Method B).

River	MSW target	Large salmon escapement estimates Method A	Method B
East River, Pictou	271	72	111
River Philip	358	322	508
West River, Antigonish	353	195	300

License stub bias

Angler returned license stub data were observed to differ with respect to catch estimates and the ratio of large salmon to grilse from on-site trap catch and creel survey data in 1987 and 1988 on the Margaree River (Claytor and O'Neil 1990). The discrepancies led to the general conclusion that anglers were inflating the number of large salmon they released and that the stub system for the Margaree River was biased. In 1987 and 1988, the estimate of "bias" was obtained by comparing the creel survey and trap data with the license stub data. The ratio of large salmon to grilse from the index traps in the estuary were observed to have ratios of large salmon to grilse more similar to the creel data than to the stub data.

License stub data, by their nature, involve biases; recall, response and a third bias which can be termed avidity bias for the purposes of this discussion. A means to compensate for the response bias has been developed and applied to the Nova Scotia data (O'Neil *et al.* 1986; O'Neil and Harvie 1993). Recall bias can affect harvest estimates because the time lag between the angler catching the fish and recording the data on the license stub can be great; e.g., up to 7 months. The consequences and magnitude of recall bias have been well documented in surveys of this nature (Fisher et. al. 1990). The actual impact of recall bias on the Nova Scotia salmon license stub (SALMO-NS) system has not been quantified. However, recall bias is known to have more of an impact if response rates are low. Response rates in the SALMO-NS system are uncharacteristically high (>70% most years with a single reminder; >90% with 3 reminders). Given the high response rate and the phenomenon that recall bias is not necessarily a bias upwards or downwards, it was felt that the effect could be ignored for the SALMO-NS system.

Avidity bias and response bias are almost synonymous. Anglers who are more interested in a fishery or more successful typically respond in programs such as SALMO-NS at a higher rate. This is a form of avidity bias which is compensated for within the SALMO-NS system and which we describe as response bias (O'Neil *et al.* 1986; O'Neil and Harvie 1993). Another element or component to "avidity" bias is the enthusiasm the fisher carries with him or her from the river to the license stub to exaggerate the actual number of fish angled. This phenomenon was described and an attempt made to estimate it in 1987 and 1988 on the Margaree River (Claytor and O'Neil 1990). The actual phenomenon was associated with reports of the release of large salmon. The mandatory release of large salmon became law in the Nova Scotia sports fishery on August 8, 1984. Beginning in 1985, the number of large salmon released appeared to be biased upwards.

There are no sources of measure of the avidity bias during recent years. However, there are several means of examining whether a substantial bias remains or has largely disappeared as these authors believe.

Examination of the relationship between large salmon sport catch on the St. Mary's River and wild grilse returns to the LaHave or Liscomb rivers indicates the degree to which the 1985 and 1986 values for sportcatch exceed any other values (Fig. 6). These large increases in reported multi-sea-winter salmon catches are well above any increases noted through an actual count at the Morgan Falls (MF) fishway. These data suggest the bias phenomenon, with respect to the St. Mary's River sportcatch, was short-lived, only 2-4 years after the release of large salmon became mandatory.

Salmon which enter the LaHave River either take the main branch and ascend the Morgan Falls fishway, take the North Branch, or remain to spawn in the lower river. If one assumes that the LaHave River ratio of large salmon to grilse destined for Morgan Falls (grilse destined for Morgan Falls: where the grilse count at MF is added to the grilse harvest as reported by the angler and assumed to be unbiased) is a true indicator of proportionate returns by size category to the river, these data can be compared with license stub data (Table 13). If a trend in bias exists with a difference in ratios of MSW:1SW fish, over time, a plot of the difference between sportcatch ratios and MF trap count ratios should exhibit that trend. If, on the other hand, the bias is consistent, there should be no apparent trend and a plot of a difference in the ratios should be uniformly high over the time period. The data indicate the lack of evidence of bias in 1984 (before release of MSW fish became mandatory) and an apparent substantial increase in the difference in ratios in 1985 and 1986 (Fig. 7, Table 13). The large difference in the ratios in 1985 and 1986 relative to the similar "difference" in ratios during 1987-94 supports the evidence that a bias occurred but was short lived. The mean and standard deviation of the "difference" in ratios for the LaHave stub data was 0.0114 ± 0.023 for the years 1989-1993 (Table 13; The 1994 value was excluded because the angling fishery on the LaHave River in 1994 was closed July 5). The 1995 difference in ratios is 0.242 which is significantly different than the mean (1989-93) of 0.114 ($p<0.01$). The authors do not believe the large difference in 1995 is due to bias but do not have a definitive explanation. It is possible that the anecdotal evidence provided by anglers, that there was an exceptional run of large salmon on the North Branch of the LaHave River in 1995 relative to other years, influenced the angling catch but not the count at Morgan Falls (E. Jefferson[3], pers. comm.).

A similar exercise can be completed for the Margaree River where the ratio of large salmon to grilse for index trap data, as reported in angler diaries, and the numbers reported on license stubs can be compared graphically over a several year period (Fig. 8; Table 14). Examination of the plot shows the lack of any evidence that one ratio is uniformly high or low with respect to the other since 1987.

Collectively, these data fail to show evidence that an avidity bias has existed since at least 1989. They do not support the use of an adjustment factor of 2.4 to 6.0 for the large salmon reports on license stubs. Consequently, use of a license stub catch adjustment factor for current data cannot be supported.

Additional evidence to favour Method B over Method A can be found in the estimation of exploitation rates. If the Method A estimate of returns was correct, anglers would have caught 71% of the large salmon on East River, 69% of the fish on River Philip and 72 % of the fish on West River, Antigonish based on the reported catch on license stubs. These catch rates seem unlikely given the relatively short angling season; the first fish reported angled on East River by logbook anglers in 1995 was on October 23, 8 days before the season closed.

In a retrospective look at estimates of escapements to West River, Antigonish, using Method A, the technique would seem to greatly underestimate the number of spawners. The

---

[3] Eric Jefferson, Biological technician, Fisheries and Oceans, Halifax, N. S.

juvenile density data on West River, Antigonish suggests that escapements were high on West River during recent past years. The density of total parr on James and Beaver rivers (tributaries of the West) were 127 and 79 parr per 100 m^2, respectively (Table 6). These numbers far exceed those noted on many other systems, such as the St. Mary's River which has an adjacent headwater drainage area, and virtually all (one exception) sites on the Margaree River where spawners have exceeded targets since at least 1985 (Chaput et. al. 1994; L. Marshall, pers. comm.[4]). The fry (0+ parr) densities in 1995 at those same sites were 238 and 275 fry per 100 m^2, numbers approximately equal to or in excess of the number of eggs desired to meet the conservation requirement. The number of spawners estimated in 1993 and 1994 for West River by Method A were 95% and 51% of the conservation requirement, respectively (Table 15). It is unlikely that escapements that are one-half of the requirement could have resulted in fry densities which are roughly equal to the expected egg requirement.

Consequently, Method B is believed to provide a more realistic estimate of returns and escapement.

7. *Ecological considerations*

Returns to Northumberland Strait NS rivers in 1994 and 1995 were largely believed to be delayed because of low water conditions. The discharge data from Middle River, Pictou, support the premise that water was unusually low during the past two years until late in October (Fig. 9). Middle River, Pictou, is located at the mid-point in the Northumberland Strait NS area so should represent the general precipitation and discharge events exhibited by the other rivers within the area. A plot of the mean daily discharge from mid-September until mid-November for 1994, 1995 and the 1989-93 mean indicates the extent to which recent (94-95) discharges were lower than usual until well into October.

The first reported sport catches of salmon on East River, Pictou and West River, Antigonish, occurred after a storm event on October 16. Similarly, on River Philip, the first major catch of fish occurred after the storm event on October 13, which is clearly evident on the run timing (Fig. 4) and discharge graphs (Fig. 9).

8. *Forecast / prospects*

The only means of forecasting for the Northumberland Strait NS rivers is using average returns. A forecast is provided for East River, Pictou, River Philip and West, Antigonish in Table 15. The return estimates for 1991 to 1994 were obtained from Claytor et. al. (1995; revised for the redefined habitat areas) and were calculated as described in Method A. These data were used with the Method B calculation of returns for 1995 to calculate a 5-year average. The forecast of returns of large salmon in 1996 to the three rivers is 395 for East River, 463 for River Philip and 328 for West River, Antigonish. These figures exceed targets for large salmon by 45% and 29% on East River, Pictou and River Philip, respectively. The forecast, using the 5-year average, for West River, Antigonish indicates the conservation requirement would be approximated by returns in 1996 - 93% (Fig. 10; Table 15).

---

[4] Dr. Larry Marshall, Biologist, Fisheries and Oceans, Halifax, N.S

9. *General discussion*

Use of tag returns from MSW salmon

. If one applies the estimate of 195 fish, the Method A median 1995 escapement (Table 10) to the West River at an average of 3,263 eggs per fish (Table 5), the target eggs of 1.15 million would be short by almost 517 thousand or 45%. The estimated escapement in 1994 by the same method indicated 180 spawners would escape to the river (Table 15; Fig. 10). This number represents an even greater shortfall (50% of requirement) and the electrofishing evidence suggests escapements are at exceptionally high levels. Thus, forecasts based on the adjusted angling catches would appear to underestimate returns by a considerable margin. Using the current year exploitation rate from the fall Margaree River sportfishery based on tag returns may cause the estimate of escapements to be high relative to real values. Deriving exploitation rates on large salmon based on tag returns is difficult because large salmon must be released alive. Highly visible tags may allow anglers to see that the fish they have hooked is tagged and thus land it to record the tag number or remove the tag. However, even the most careful or experienced angler may have difficulty in removing or reading a tag on a large salmon, particularly if they are fishing alone. Anglers can harvest grilse and handle those they intend to release more easily than large salmon so tag recoveries from grilse should be more reliable. Thus, the large salmon exploitation rate on the Margaree River based on tag returns may be biased downwards unless non-reporting is accounted for. The figure applied to arrive at the 1995 MSW salmon exploitation rate for non-reporting was an educated guess at 30% (L. Marshall, pers. comm.) but similar to the 33% figure calculated by Claytor and O'Neil (1991). The potential for error in the non-reporting rate is also large. Consequently, estimation of returns to the Northumberland Strait NS rivers using the annually calculated exploitation rate based on tags has a certain risk associated with it. The tendency would be to overestimate returns.

Angling population components in license stub data

Application of Margaree River data to the Northumberland Strait NS rivers would be appropriate if the characteristics of various aspects of the systems are similar. The angling population on the Margaree River consists of 35% or more of non-residents (Fig. 11). The non-resident proportion on the 3 principal Northumberland Strait NS rivers has variably ranged from 0% to 17% over the period 1984-91. Direct application of exploitation rates from the Margaree to the Northumberland Strait NS rivers would be appropriate only if the angler performances were similar such as their relative catch-per-unit of effort. Yet, with such a disparity in proportion non-resident, distinct "performances" , in terms of fishing success, could be expected. However, that has not been true in the Margaree River example. The resident and non-resident CPUEs for the Margaree River anglers have varied similarly over the years examined (Fig. 11-top 2 panes). The CPUEs for the Northumberland Strait NS rivers have varied widely for both angling groups over the same time period. Nevertheless, the similarities in catch rates for the two groups on the Margaree shows that the high non-resident component of the fishing group there would not unduly influence the overall performance for the river relative to rivers with mostly resident fishing populations. Thus, use of the Margaree River angler data to estimate exploitation rates for the Northumberland Strait Nova Scotia rivers would not be compromised by the high non-resident component of the Margaree angling population.

10. Management recommendations

The trial diver count data supports the exploitation rate derived spawning escapements. A surplus of spawners occurred on River Philip but not on East River, Pictou where the escapement estimates were ambiguous, but short of conservation requirements. On West River, Antigonish, although spawners surplus to conservation requirements were not evident from the angling data using exploitation rates, additional evidence supports that conservation requirements were probably met or exceeded. Diver corroboration of a surplus was not available but the logbook CPUE was 0.462 fish per day which is the highest catch rate of the 3 rivers

where logbooks were used, by a substantial margin (Table 2b). Juvenile salmon densities on West River, Antigonish tend to suggest spawners have exceeded requirements during at least the last 3 years. Parr densities in 1994 and 1995 were above 70 parr per 100m^2 and fry densities during those same years were 190 fish per 100 m^2 or more.

Given the short angling season in 1994 and 1995 due to late entry of fish into the non-tidal portion of the Northumberland Strait Nova Scotia area rivers, exploitation may have been low compared to years previous. Nevertheless, the recent 5-year average returns based on a 45% MSW exploitation rate in 1995, and the previous estimation procedure 1991-94, returns are expected to exceed targets on East River, Pictou (145%), River Philip (129%), and approach target on West River, Antigonish (93%) (Table 15; Fig. 10).

The electrofishing evidence does not support the low number of spawners estimated for West River, Antigonish in 1994. Numbers surplus to requirements cannot be forecast with any certainty but could be expected to be in a range similar to that for River Philip of at least 25%.

Surplus grilse should return to each of the three rivers according to the 5-year averages. The forecast grilse surplus returns destined to the rivers would be approximately 110 for East River, Pictou; 300 for River Philip and 200 for West River, Antigonish (Table 15).

The estimated number of fish taken illegally within the Northumberland Strait Nova Scotia area have not been incorporated into the assessment other than to document the reports in a table for information. Conservation and Protection officers are convinced that the number of fish removed from some of the rivers in the area is substantial but acknowledge numbers are difficult to estimate. Hence our reluctance to incorporate the data into the assessment. However, managers should be aware of these removals and consider them when allocating surplusses.

Acknowledgements

Victor Crowell participated in the data collection on many of the Northumberland Strait Nova Scotia area rivers. Deborah Stewart summarized the angler license stub data and Jane Avery compiled the angler logbook information. Tom Gloade and Adrian Gloade from Millbrook First Nation collected data on River Philip trap catches and contributed to the data collection on several other rivers; Wayne Deny coordinated Pictou Landing First Nation input in the East River and Sutherlands River programs. Ross Jones provided invaluable input in the form of data collected previously through the Moncton Diadromous Fish Division office and advice on how to interpret the data. He also provided advice and directions in the field for the trap and electrofishing operations. Many constructive editorial comments were contributed by R. Picard and W. White who reviewed the manuscript.

References

Anonymous. 1991a. Definition of conservation for Atlantic salmon. CAFSAC Advisory Doc. 91/15. 4p.

Anonymous. 1991b. Quantification of conservation for Atlantic salmon. CAFSAC Advisory Doc. 91/16. 15p.

Cameron, J.D. and R. W. Gray. 1978. Estimated densities of juvenile Atlantic salmon and other freshwater fishes in selected Nova Scotia streams, 1978. Can. Data Rep. Fish. Aquat. Sci. No. 163. 43p.

Chaput, G. and R. Jones. 1994. Mainland Gulf Nova Scotia Atlantic salmon (*Salmo salar*) stock status. DFO Atlantic Fisheries Res. Doc. 94/8. 49p.

Chaput, G., R. Jones, L. Forsythe, and P. LeBlanc. 1994. Assessment of the Atlantic salmon (*Salmo salar*) stock of the Margaree River, Nova Scotia, 1993. DFO Atlantic Fisheries Res. Doc. 94/6. 64p.

Claytor, R.R., R. Jones, P. LeBlanc, and G. Chaput. 1995. Mainland Gulf Nova Scotia Atlantic salmon (*Salmo salar*) stock status, 1994. DFO Atlantic Fisheries Res. Doc. 95/15. 33p.

Claytor, R.R. and S.F. O'Neil. 1990. Interpreting Atlantic salmon (Salmo salar) angling statistics on the Margaree River, Nova Scotia. CAFSAC Res. Doc. 90/24. 33p.

Claytor, R.R. and S.F. O'Neil. 1991. Using small creel surveys and mark-recapture experiments to interpret angling statistics, p. 195-205. In Guthrie, D., J.M. Hoenig, M. Holliday, C.M. Jones, M.J. Mills, S.A. Moberly, K.H. Pollock, and D.R. Talhelm [ed.], Creel and Angler Surveys in Fisheries Management. American Fisheries Society Symposium 12.

Edwards, H.E. 1956. River Philip salmon survey. MS Rept. No. 60-10. 20p.

Fisher, W.L., A.E. Grambsch, D.L. Eisenhower and D.R. Morganstein. 1990. Length of recall period and accuracy of estimates from the National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. Department of Economics, Susquehanna Univ., Selinsgrove, Penn. Working Paper 89-10. 28p.

Marshall, T. L., R. Jones, P. Leblanc, and L. Forsythe. In prep. Status of Atlantic salmon stocks of the Margaree and other selected rivers of Cape Breton Island, 1995.

O'Neil, S.F., M. Bernard, and J. Singer. 1986. 1985 Atlantic salmon sport catch statistics, Maritime Provinces. Can. Data Rept. Fish. Aquat. Sci. No. 600. 71p.

O'Neil, S.F. and C.J. Harvie. 1993. Evaluation of the precision of catch data in the Nova Scotia Atlantic salmon catch-effort card system and feasibility of a New Brunswick application. CAFSAC Res. Doc. 93/31. 34p.

O'Neil, S.F. and D.A.B. Swetnam. 1991. Collation of Atlantic salmon sport catch statistics, Maritime Provinces, 1951-59. Can. Data Rept. Fish. Aquat. Sci. No. 860.

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

Appendix 1

Gulf Mainland Nova Scotia Client Services Meeting on Atlantic Salmon

December 13, 1995

Attendees

Warren Parsons	Dept. of Fisheries & Oceans, Fisheries & Habitat Mgmt. Br.
Leroy MacEachern	Dept. of Fisheries & Oceans, Fisheries & Habitat Mgmt. Br.
Shane O'Neil	Dept. of Fisheries & Oceans, Science
Denis Haché	Dept. of Fisheries & Oceans, Fisheries & Habitat Mgmt. Br
David Longard	Dept. of Fisheries & Oceans, Science
Jive Logan	
George Taylor	Outdoor Centre, City of Hfx
Bob Boudreau	
Clayton Mills	Pictou Co., River's Association
Don MacLean	Nova Scotia Dept. of Fisheries
Walter Devereaux	
Gary McGrait	Antigonish Rivers Association
Kim Robbins	Antigonish Rivers Association
Terry MacIntyre	Nova Scotia Salmon Association
Peter Gaye	Cumb. Co. River Enhancement
Graham MacKenzie	Pictou Co., River's Association
Delbert Smith	Pictou Co., River's Association
Samiel Lloyd	Pictou Co., River's Association
Bob Taylor	Pictou Co., River's Association
Allister Allard	Pictou Co., River's Association
Willie Deyoung	Pictou Co., River's Association
Richard Kellock	Pictou Co., River's Association
Bob Peek	Pictou Co., River's Association
Bob Ferguson	Pictou Co., River's Association
Parker Wong	Pictou Co., River's Association
Robert Christie	PHEPP
Bennie	Pictou Co., River's Association
Bill Cardiff	Pictou Co., River's Association
Dick Pavllen	Pictou Co., River's Association
David Longard	Dept. of Fisheries & Oceans, Science
John William	Student, NS School of Fisheries
Darren Tower	NS Dept. of Fisheries/CCREA
Pierre Sampson	ACAP, Cape Breton
Billy Corbett	Guysborough County Inshore Fisherman Association
Keith Allison	Medway Environmentally Concerned Citizens, Liverpool, N.S.
Wayne Samson	Musquodoboit River Association
Bernie Atkins	Shelburne County Marine Industry Comm.
Bob Roberts	Guysborough County Inshore Fisherman Association
Basil Baker	Musquodoboit River Association
Steven Theriault	Project Managers for Community Groups (CARP)
Myrna McQuaid	Avon Waterways Society
Norma Jean Prosper	Pictou Fishery School

Minutes

- A suggestion was made to place an advertisement in the newspaper or use some other means to advertise meeting to reach a broader group.

- There was a question of whether or not juvenile year classes were looked at. DFO uses a breakdown of year classes in the electrofishing sites as well as looking at juvenile ages when reading scales from adult salmon.

- It was suggested that DFO should err on the side of caution when making assessments and when setting seasons and bag limits.

- Denis Haché gave a short explanation of the fishway operation at Middle River, Pictou. He also made a few suggestions of fishway operations which will make a more efficient operation under fluctuating head pond levels.

- Bob Ferguson gave a brief description of the Bear Brook habitat restoration project. Their group worked on 14 miles of river placing 81 structures in the stream. They had 14 students, and 2 on the UI top-up program, employed on the project.

- Concern was expressed for fluctuating water flows in rivers and whether or not deforestation of the watershed had an adverse effect on river quality.

- It was suggested that the fishing season should be extended into November during years of low water and upstream migration of salmon is delayed. DFO personnel and anglers expressed concern for successful spawning of salmon after being angled just before or during spawning season.

- Anglers would like more information on the First Nations harvest of salmon and native rights pertaining to fishing.

- There has not been any discussion to date on 1996 First Nations fishing harvest.

- Anglers expressed a great deal of concern regarding poaching of Atlantic salmon. It was suggested that River Watch programs do help, especially with the reduction in resources of the Conservation and Protection Branch of DFO.

Table 1. Atlantic salmon sportcatch and effort for Northumberland Strait - Nova Scotia rivers, 1994, 1995, and means, 1990-94.

	1995 Preliminary				1994				1990 - 94 means							
	Grilse		Salmon		Grilse		Salmon		Grilse				Salmon		Effort	
River	retained	released	released	Effort	retained	released	released	Effort	retained	95% C.I.	released	95% C.I.	released	95% C.I.	roddays	95% C.I.
Northumberland Shore																
Barney's	1	0	0	5	0	0	4	52	4	5.0	1	2.2	5	4.5	44	42.6
East: Pictou Co.	22	17	51	465	14	9	87	619	54	36.1	30	20.7	284	169.9	1118	445.7
French: Pictou Co.	1	0	1	11	0	0	0	22	1	3.3	0	0.7	3	4.2	20	6.6
Middle: Pictou Co.									0	N/A	1	N/A	1	N/A	4	N/A
Pomquet									0	N/A	0	N/A	0	N/A	3	N/A
Pugwash										N/A		N/A		N/A		N/A
River John	5	3	18	105	12	1	37	183	23	20.5	7	5.5	61	25.7	218	67.7
River Phillip	107	33	234	1482	61	26	176	1191	113	45.6	37	24.1	289	129.0	1345	299.1
Shinimicas	0	0	0	1						N/A		N/A		N/A		N/A
South	1	3	0	51	4	5	10	78	4	3.2	3	3.7	7	2.4	47	30.3
Sutherlands									1	N/A	0	N/A	0	N/A	12	N/A
Tidnish									0	N/A		N/A		N/A		N/A
Tracadie									1	N/A	0	N/A	0	N/A	7	N/A
Wallace	16	12	25	577	11	11	57	480	17	8.4	11	4.9	74	38.9	485	281.2
Waugh	9	5	33	155	7	10	36	101	13	4.9	5	4.1	44	44.8	159	93.9
West: Antigonish Co.	48	34	138	534	29	15	126	760	54	32.5	38	26.9	229	83.6	773	111.0
West: Pictou Co.	24	8	30	455	4	2	20	246	25	15.1	7	4.3	100	83.3	434	237.2
Wright									0	N/A	0	N/A	0	N/A	1	N/A
Totals	234	115	530	3841	142	79	553	3732	307.4		139.6		1097		4655.4	

Table 2a. Number and response rates for angler diaries mailed to anglers on the three principal rivers of the Northumberland Strait, Nova Scotia area, in 1995.

River	Number mailed	No. returned wrong address	Effective number	Voluntary Response		Response to Letter		Total returned	Overall % response
				Number	%	Number	%		
River Philip	25	1	24	12	50	6	25	18	75
East Pictou	22	0	22	12	55	7	32	19	86
West Antigonish	20	1	19	15	79	2	11	17	89
Total	67	2	65	39		15		54	83

Table 2b. Number of effective diaries, catch,effort and catch per unit effort (CPUE) for diary holders on three Northumberland Strait, Nova Scotia area rivers in 1995.

River	Diary holders that fished	Catch				Effort		CPUE	
		Grilse		Salmon released	Total	Hours	Rod days	Per hour	Per rod day
		Retained	Released						
East River, Pictou	10	0	0	10	10	270.5	59	0.037	0.169
River Philip	15	23	1	46	70	839	185	0.083	0.378
West River, Antigonish	13	8	6	16	30	254	65	0.118	0.462
Total	38	31	7	72	110	1363.5	309		

Table 3a. First Nation Atlantic salmon harvest allocations and reported harvests in the North Nova Scotia area in 1995.

		Harvest plan or license allocation		Reported harvest	
First Nation	River/area	1SW	MSW	1SW	MSW
Afton	Afton & Pomquet	55	22		
	Barney's	9	26		
	French: Pictou Co.	9	26		
	South	5	19		
	West, Antigonish	61	68		
Indian Brook	River Philip (kelt)	10	40		
	Wallace (kelt)	5	20		
	Waugh (kelt)	5	20		
Millbrook	River Philip - spring	10	40		
	- fall	110	60	30	52
	Wallace - spring	5	20	2	6
	- fall	25	30		
	Waugh - spring	5	20	0	0
	- fall	10	15		
Pictou Landing	East, Pictou	35	140	2	28
	Merigomish Hbr.	10	30	12	30
	River John	10	24	3	5
	West, Pictou	8	16	0	3
Native Council	SFA 18	1820[a]		5	

a Tags available for issue but not necessarily issued.

Table 3b. Mean lengths, sex and size category of Atlantic salmon captured in the First Nation's trap at River Philip in 1995.

	Mean length (cm)	Number caught	Percent of catch
Fish < 63 cm.			
females	50.0	1	1.2
males	58.8	29	35.4
Sub-total	**54.6**	**30**	**36.6**
Fish >= 63 cm.			
females	78.4	33	40.2
males	79.1	19	23.2
Sub-total	**78.6**	**52**	**63.4**
All fish combined	**69.8**	**82**	**100**

Table 4. The drainage basin areas, habitat areas, egg requirements (and difference from those used previously) and spawner requirements for the north Nova Scotia rivers.

River	Drainage basin area ($m^2 \times 10^2$)	Reference river for area estimate	Habitat area [1] ($m^2 \times 10^2$)	Egg requirements @240 eggs/100 m^2 (in 1000s of eggs)	Change in egg requirements [2] (in 1000s of eggs)	Spawner requirements	
						Grilse	Salmon
Afton River	432526	South	189	45	-15	0	14
Barney's River	1564104	Philip	2128	511	41	17	79
East River, Pictou	5359716	Philip	7291	1750	-60	57	271
French River, Pictou	1278680	Philip	1740	417	27	14	65
Middle River, Pictou	2170644	Philip	2953	709		23	110
Pomquet River	1756531	South	769	185	15	1	57
Pugwash River	1815574	Philip	2470	593		19	92
River John	2920443	Philip	3973	954		31	148
River Philip	7259707	Philip	9621	2309	-1	75	358
South River	2170158	South	950	228	-2	0	70
Sutherlands River [3]			666	160	0	5	25
Tracadie (Monastery) River	1202519	South	526	126		1	39
Wallace River	4578838	Philip	6229	1495		49	232
Waugh River	2301964	Philip	3132	752		25	116
West River, Antigonish	3530382	Philip	4803	1153	783	1	353
West River, Pictou	2445182	Philip	3326	798		26	124
Totals			50766	12184		343	2151

[1] The habitat area:drainage basin area ratio used to calculate habitat areas where measurements were not available were: for River Philip: 0.0013604 and for South River: 0.00043776.

[2] Difference in egg requirement from those used by Chaput and Jones 1994.

[3] Area below falls, from Chaput and Jones 1994.

Table 5. Estimation of spawner requirements for East River (Pictou) and South River (adapted from Claytor et. al. 1995).

EAST RIVER PICTOU					
Habitat area (sq.m.)			729,125		
Optimal egg deposition (2.4 eggs/sq.m.)			2.4		
Total egg requirements			1,749,900		
Biological characteristics					
Fecundity			1,764	eggs/kg	
Small salmon	% female		5		
	mean wt. (kg)		1.7		
Large salmon	% female		60		
	mean wt. (kg)		6.1		
Eggs per small salmon spawner	=	eggs/kg * mean wt(kg) * % female			
	=	1764 * 1.7 * 5%			
	=	150			
Eggs per large salmon spawner	=	1764 * 6.1 * 60%			
	=	6,456			
Required number of large salmon	=	271	—>>	163	female
				108	male
Deficit males	=	54			
Small spawners to obtain deficit males	=	54 / 0.95			
	=	57			
Spawning requirements:	Large	271			
	Small	57			
SOUTH RIVER					
Habitat area (sq.m.)			95,000		
Optimal egg deposition (2.4 eggs/sq.m.)			2.4		
Total egg requirements			228,000		
Biological characteristics					
Fecundity			1,764	eggs/kg	
Small salmon	% female		3		
	mean wt. (kg)		1.3		
Large salmon	% female		50		
	mean wt. (kg)		3.7		
Eggs per small salmon spawner	=	eggs/kg * mean wt(kg) * % female			
	=	1764 * 1.3 * 3%			
	=	69			
Eggs per large salmon spawner	=	1764 * 3.7 * 50%			
	=	3,263			
Required number of large salmon	=	70	—>>	35	female
				35	male
Deficit males	=	0			
Spawning requirements:	Large	70			
	Small	0			

Table 6. Densities (multiple sweep removal or mark-recapture) of juvenile Atlantic salmon caught by electrofishing in Northumberland Strait Nova Scotia rivers during some years from 1978 to 1995. Data for 1978 from Cameron and Gray (1978) and for 1991 to 1994 from Chaput and Jones (1994) and Claytor et.al. (1995). The rivers are listed geographically from west to east.

		Fry per 100 m^2						Parr per 100 m^2					
River	Site	1978	1991	1992	1993	1994	1995	1978	1991	1992	1993	1994	1995
River Philip	1			0[a]			21.6[b]				36.0		53.5
Wallace	3[c]	56.9						7.9					
East R. Pictou	3	41.7		116.8		34.0	104.8	39.6		30.1		27.0	28.3
	4			342.5	64.0	169.0	123.6			84.0		34.0	40.6
	7												
French, Pictou	1	34.9						7.6					
	2	3.5						11.6					
	3	41.7		90.8		120.0		8.4		15.6		40.0	
Barneys	3			97.8		151.0				32.9		20.0	
West R. Antigonish	2	24.6		268.1		238.0	195.5	24.6		86.6		145.0	126.8
	4	71.8	226.4	244.8	165.0	275.0	237.2	52.5	67.7	78.2	51.0	71.0	78.6
Pomquet	6			3.2		0.0				20.5		13.0	

a Only 1 fry captured, no density estimate possible.
b density of fry estimated using parr capture efficiency; regression of 3 sweep removal for fry was not significant
c named site 6 in 1978

Table 7. Number of fry and parr caught within 5 minutes of electrofishing on several Northumberland Strait Nova Scotia rivers, 1992-1995. Data for 1992-1994 from Chaput and Jones (1994) and Claytor et.al. (1995).

River	Site	Fry caught (5 minutes)				Parr caught (5 minutes)			
		1992	1993	1994	1995	1992	1993	1994	1995
River Philip	1								
	2				7				1
	3				104				20
	4								
	5		4				3		
	6		90				33		
Wallace	1		14		26		10		12
	2		11		50		3		2
	3		37		26		31		17
	4		24		16		26		11
	5		25		16		14		6
River John	1		0		7		27		25
	2		11		0		34		48
	3		54		73		27		13
	4		35		16		10		21
	5		17		14		9		15
	6		9		21		11		9
Middle R. (Pictou)	95.1				0				3
	95.2				0				3
	95.3				0				0
	95.4				0				0
East R. (Pictou)	5	36	65	53	45	10	18	23	16
	6	16		22	0	0		0	13
	7	51		70	57	45		26	45
	8		57				41		
Sutherlands	1	37		51	32	28		42	24
	2[a]	0			0	0			0
	3	91		100	61	17		27	12
French, Pictou	1	56		28		45		23	
	2	29		69		3		8	
Barneys	1	46		94		42		66	
	2	44				11			
	4	13		30		2		8	
West (Antigonish)			87				33		
Pomquet	1	36		64		3		6	
	2	75		66		30		6	
	3	35		78		15		30	
	4	49		15		32		19	
	5	36		36		37		23	
Afton	1	0		0		0		0	
	2	20		78		16		28	
	3	43		64		3		21	

a Site located above Parks Falls which is believed to be impassable.

Table 8. Numbers of Atlantic salmon counted and the dates and areas covered on rivers surveyed by snorkelling in the Northumberland Strait Nova Scotia area in 1995.

River	Float date	Length of river surveyed	Percent of main stem of river surveyed[1]	Number of fish counted 1SW	Number of fish counted MSW	Survey team
East River, Pictou	Nov. 6, 7/95	4.3 km	14.30%	5	21	Longard, O'Neil, Goff, Crowell
River Philip	Nov. 2/95	2.13 km	8.10%	17	117	T. Gloade, A. Gloade, S. O'Neil
Sutherlands	Nov. 6/95	4.6 km	100%	17	24	Longard, O'Neil, Goff, Crowell

1 The length of river floated was measured on a 1:50000 topographic map and related to the total length of the main stem of the river. The main stem included that portion of the river from the head of tide to the uppermost reaches of the main river channel.

Table 9. Exploitation rates and the derivation procedure for estimation of returns for the Northumberland Strait Nova Scotia rivers.

Estimation of exploitation rates from the Margaree River, 1995[1].

Grilse :

Tags applied at the Levis trap = 83

Tag loss (tags applied * L * M) = 10
(where L is the tag loss rate of 0.01 tags lost per day; and M is the median number of days to recapture of 11.5)

Tag returns assuming a 70% response = 19
(13 tags returned plus an assumed 6 not returned)

Exploitation rate[2] = $\frac{\text{tags returned}}{\text{tags applied - tag loss}} = \frac{19}{73} =$ 26.03%

Large salmon :

Tag method

Tags applied at the Levis trap = 286

Tag loss (Tags applied * L * M) = 21
(where L = 0.01 and M = 7.5)

Tag returns assuming a 70% response = 39
(27 tags returned plus an assumed 12 not returned)

Exploitation rate[3] = $\frac{\text{tags returned}}{\text{tags applied - tag loss}} = \frac{39}{265} =$ 14.72% or approximately 15%.

License stub & population estimate method

Large salmon angled as per license stubs = 1040

Population estimate for large salmon for Margaree R.[1] = 2365

Exploitation rate = $\frac{\text{Salmon angled}}{\text{Population size}} = \frac{1040}{2365} =$ 43.97% or approximately 45%.

Exploitation rates for application to Northumberland Strait Nova Scotia rivers:

Grilse:		26%
Large salmon:	minimum	15%
	maximum	45%

1 The Margaree River population assessment data and tag data were obtained from Marshall et. al. In prep.
2 The exploitation rate for grilse is based on tags recovered from fish which in most cases were eligible for harvest.
3 The exploitation rate for large salmon based on tags returned is known to be biased low because all large salmon have to be released alive and tags or tag numbers are difficult to obtain.

Table 10. Estimates (median values) of returns and escapements in 1995, averages (1985-94) and confidence intervals (5th and 95th percentiles) from resampling probability distributions based on exploitation rates and catch adjustments, with the probabilities that the median 1995 estimates exceed the averages and targets, for 3 Northumberland Strait Nova Scotia area rivers.

		Median values		Confidence intervals (90%)			
				1SW		MSW	
	River	1SW	MSW	Lower	Upper	Lower	Upper
Returns							
1995	East (Pictou)	88	72	52	160	39	143
	Philip	309	337	189	563	177	669
	West (Antigonish)	180	192	107	331	104	402
Average 1985-94	East (Pictou)	191	521	114	348	278	1035
	Philip	273	421	167	497	221	837
	West (Antigonish)	189	318	113	348	172	666
Probability that 1995 > average	East (Pictou)	0.014	0.000				
	Philip	0.626	0.307				
	West (Antigonish)	0.450	0.123				
Difference: (1995-avg.)/avg.	East (Pictou)	-54%	-86%				
	Philip	13%	-20%				
	West (Antigonish)	-5%	-40%				
Escapements							
1995	East (Pictou)	73	72	41	148	39	138
	Philip	246	322	137	514	176	680
	West (Antigonish)	153	195	87	308	107	400
Average 1985-94	East (Pictou)	155	517	85	315	282	999
	Philip	215	402	120	451	220	850
	West (Antigonish)	159	323	90	323	178	662
Probability that 1995 > average	East (Pictou)	0.039	0.000				
	Philip	0.609	0.308				
	West (Antigonish)	0.457	0.125				
Difference: (1995-avg.)/avg.	East (Pictou)	-53%	-86%				
	Philip	14%	-20%				
	West (Antigonish)	-4%	-40%				

Exploitation rates and catch rate adjustments used to derive the resampling distributions

	Range	
	1SW	MSW
Exploitation rate	0.13 - 0.39	0.09 - 0.27
Catch rate adjustments	1.3 - 2.3	2.4 - 6.0

Table 11. Atlantic salmon returns, escapements and returns relative to targets (surplus or deficit) for Northumberland Strait Nova Scotia rivers in 1995[a].

River	Angling catch			River destined returns[b]		Escapement[c]		Spawner requirements		Surplus or deficit based on Margaree expl. rate	
	Total grilse	Salmon	Grilse retained	Grilse	Salmon	Grilse	Salmon	Grilse	Salmon	Grilse	Salmon
East River, Pictou	39	51	22	152	141	127	111	57	271	70	-160
River John	8	18	5	34	45	26	39	31	148	-5	-109
River Philip	140	234	107	568	572	430	508	72	358	358	150
Sutherlands						17[d]	24[d]	5	25	12	-1
Wallace River	28	25	16	108	56	91	54	49	232	42	-177
Waugh	14	33	9	54	73	45	72	25	116	20	-45
West River, Antigonish	82	138	48	315	307	266	300	1	353	265	-53
West River, Pictou	32	30	24	123	67	99	65	26	124	73	-58

a Little or no catch was reported so escapements could not be calculated for Afton; Barney's; French, Pictou; Middle, Pictou; Pomquet; Pugwash; South and Tracadie (Monastery) rivers.

b In-river returns based on angling catch and exploitation rates from the fall Margaree fishery in 1995 for 1SW (0.26) and for the entire season for MSW salmon (0.45) are added to First Nation reported harvests to arrive at river destined returns; refer to Table 9 to see the exploitation rate estimation procedure.

c River-destined returns minus First Nation harvest and the angler grilse harvest plus a 5% mortality on grilse releases; a 5% mortality on MSW releases by anglers was assumed.

d Escapement based on float count.

Table 12. Estimated numbers of large salmon illegally removed from rivers of the Northumberland Strait Nova Scotia area in 1995.

River	Number of MSW salmon[1]
Afton	5
Barney's	25
East, Pictou	75
French, Colchester	20
French, Pictou	25
Pomquet	20
Pugwash	50
River John	60
River Philip	100
Shinimicas	30
South	20
Sutherlands	10
Tracadie	20
Wallace	40
Waugh	40
West, Antigonish	20
West, Pictou	30

1 These numbers are rough estimates provided by DFO Fishery Officers.

Table 13. Atlantic salmon sportcatch reported on license stubs on the LaHave River, the ratio of large salmon to grilse (MSW:1SW) for those data, the ratio of large salmon to grilse counts at Morgan Falls and the difference between the 2 ratios for the years 1984-93 and 1995[1]. The grilse "destined" for Morgan Falls is the total of the count of grilse at the trap and the license stub estimated harvest of grilse.

	Angling catch (estimated)				Morgan Falls counts (full season)				
	1SW		MSW	Ratio	Morgan Falls	Destined		Ratio	Stub ratio -
Year	Retained	Total (ret&rel)	Total	MSW:1SW	1SW counts	MF 1SW counts	MF MSW counts	MSW:1SW	MF ratio
1984	1339	1482	290 [2]	0.196	2290	3629	548 [2]	0.151	0.045
1985	1683	1868	994	0.532	1453	3136	705	0.225	0.307
1986	1844	2115	951	0.450	1717	3561	667	0.187	0.262
1987	2562	2943	464	0.158	3055	5617	605	0.108	0.050
1988	1518	1652	310	0.188	3524	5042	450	0.089	0.098
1989	2445	2854	669	0.234	2495	4940	682	0.138	0.096
1990	2008	2381	581	0.244	2458	4466	492	0.110	0.134
1991	233	277	142	0.513	608	841	320	0.380	0.132
1992	1021	1123	181	0.161	2567	3588	277	0.077	0.084
1993	919	1120	241	0.215	1171	2090	193	0.092	0.123
1995	553	631	238	0.377	949	1502	203	0.135	0.242
							Mean 1989-93		0.011
							S.D. for 1989-93 mean		0.023

[1] The angling season was closed July 5 in 1994, so the data are excluded.

[2] Includes 123 MSW fish retained by anglers.

Table 14. Sportcatch from license stubs (observed values), catch from angler log books and trap counts for the Margaree River and the ratios of MSW fish to 1SW fish (MSW:ISW), 1987-1995.

	Observed catch			Log books (total season)			Trap catches [1]		
Year	Total grilse	Salmon	Ratio MSW:1SW	Grilse	Salmon	Ratio MSW:1SW	Grilse	Salmon	Ratio MSW:1SW
1987	925	1757	1.90			1.30 [4]	28 [2]	116 [2]	4.14 [2]
1988	749	1647	2.20			2.40 [4]	197 [3]	197 [3]	N/A [3]
1989	464	1298	2.80	46	115	2.50	84	356	N/A [3]
1990	514	1193	2.32	72	105	1.46	163	302	1.85
1991	586	1370	2.34	60	203	3.38	174	205	1.18
1992	539	1541	2.86	79	204	2.58	229	881	3.85
1993	696	987	1.42	63	79	1.25	249	374	1.50
1994	331	1118	3.38	24	130	5.42	112	464	4.14
1995	247	796	3.22	19	94	4.95	131	405	3.09

[1] Data from Chaput *et al*. (1994), Claytor et. al. 1995 and L. Marshall, pers. comm.; numbers captured at 2 traps were summed.
[2] Trap operated June 23 - Oct. 17 for approximately one week per month.
[3] Fall run only, data not used.
[4] From Claytor & O' Neil CAFSAC Res Doc. 90/24.

Table 15. Estimates of returns, escapements and percentage of conservation requirements achieved with 5-year (1991-95) means for East River, Pictou, River Philip, and West River, Antigonish. Estimates for 1991-1994 are revised from Claytor *et al*. (1995) to reflect changes in habitat areas; the 1995 figures are from Method B.

	Grilse			Large salmon		
		Escapement			Escapement	
Year	Returns	Number	% of requirement	Returns	Number	% of requirement
	East River, Pictou					
1991	270	200	351%	619	614	227%
1992	251	184	323%	523	519	192%
1993	127	92	161%	456	313	115%
1994	60	41	72%	265	123	45%
1995[a]	152	127	223%	141	111	41%
Mean 1991-1995	172	129	226%	401	336	124%
	River Philip					
1991	360	262	349%	578	573	160%
1992	398	292	389%	461	457	128%
1993	373	276	368%	474	469	131%
1994	198	137	183%	281	264	74%
1995[a]	568	430	573%	572	508	142%
Mean 1991-1995	379	279	372%	473	454	127%
	West River, Antigonish					
1991	146	108	-[b]	414	410	116%
1992	312	233	-[b]	398	395	112%
1993	148	108	-[b]	339	335	95%
1994	105	77	-[b]	181	180	51%
1995[a]	315	266	-[b]	307	300	85%
Mean 1991-1995	205	158	-[b]	328	324	92%

Conservation requirements:	Grilse	Large salmon
East River, Pictou	57	271
River Philip	75	358
West River, Antigonish	1	353

a The 1995 return estimate includes First Nation catches.
b The number required is only 1 grilse so percent surplus not applicable. Number surplus can be calculated by subtracting 1 from the number that escaped.

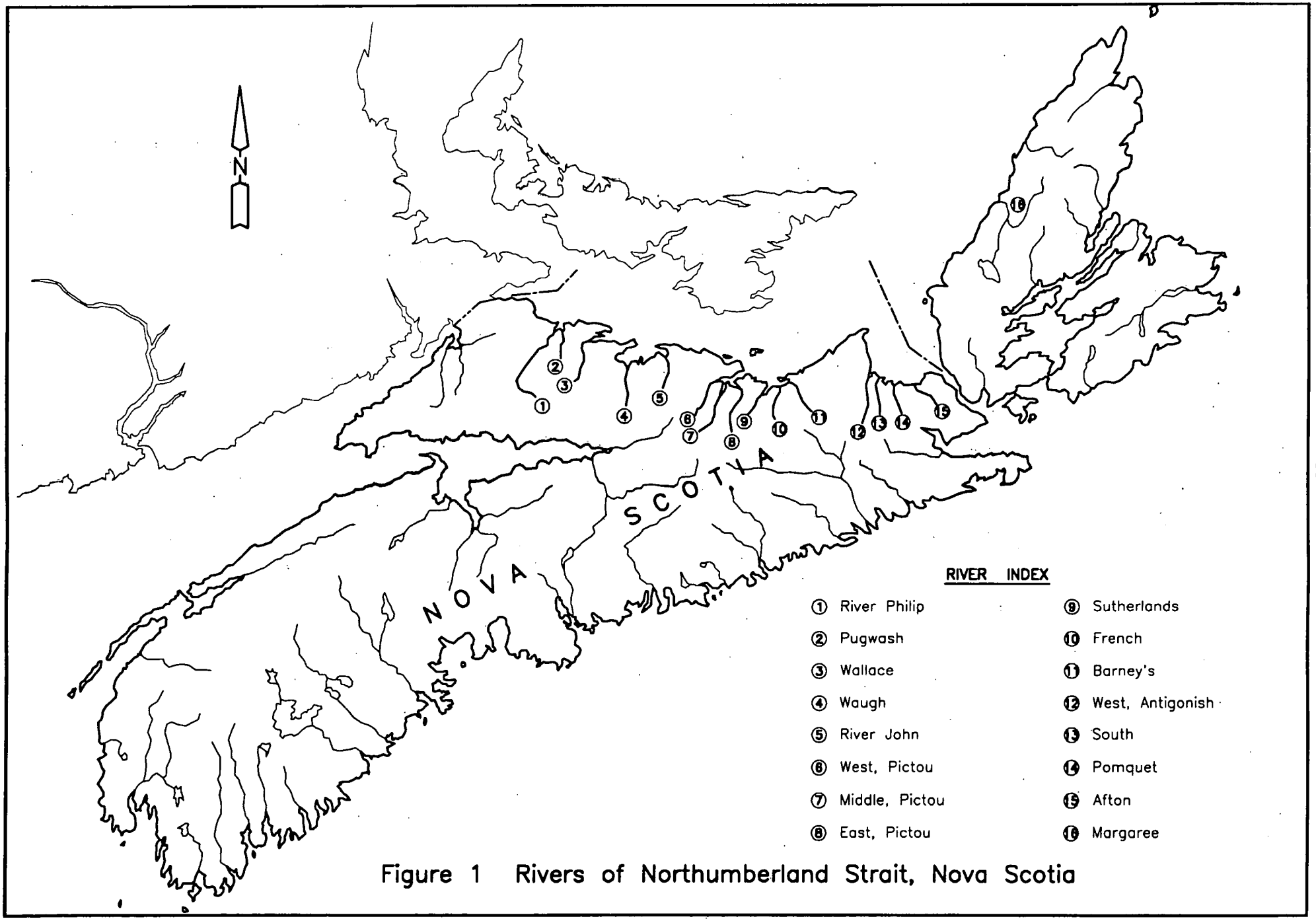

Figure 1 Rivers of Northumberland Strait, Nova Scotia

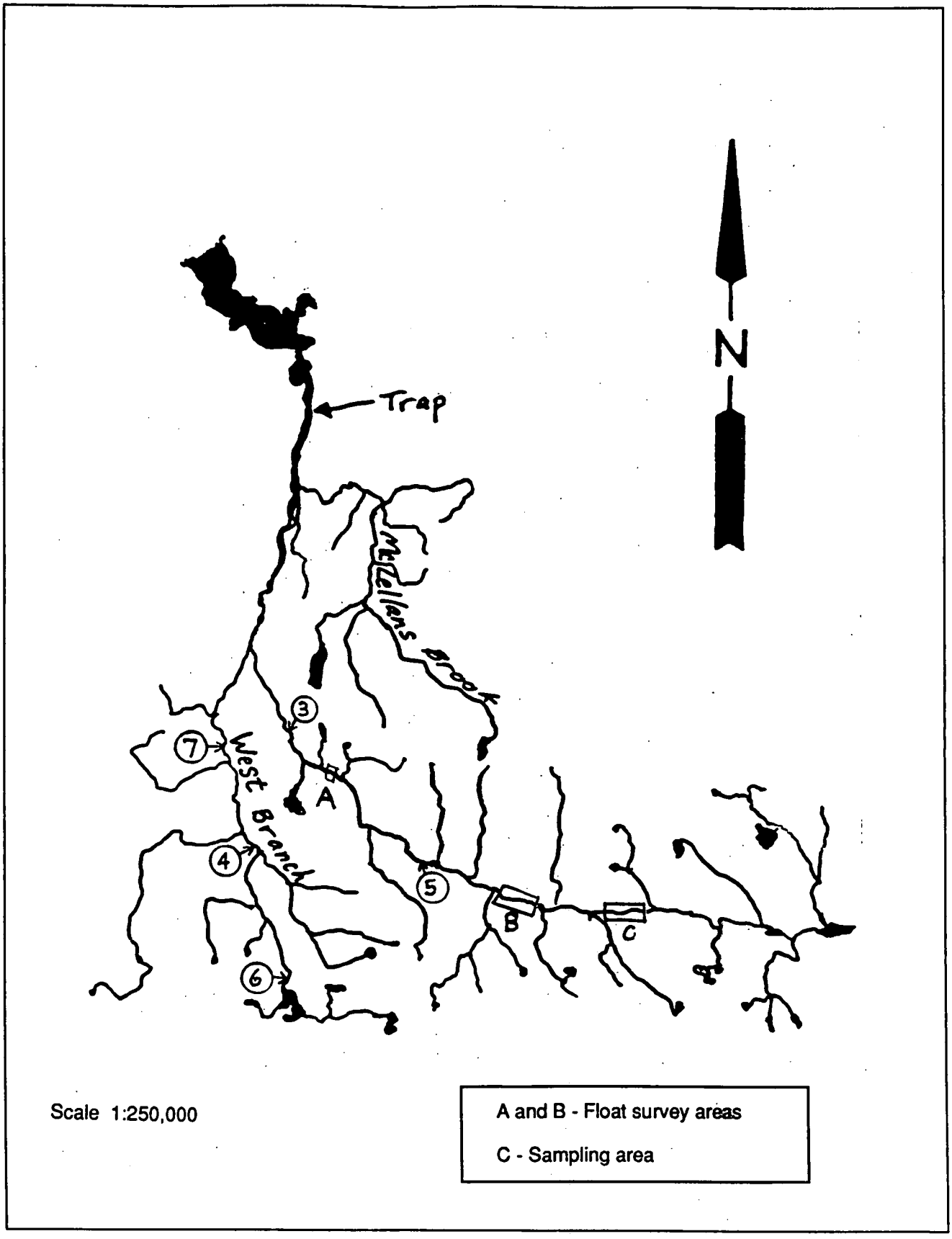

Figure 2. Electrofishing sites, float survey sites, adult sampling sites and First Nations' trap location on East River, Pictou.

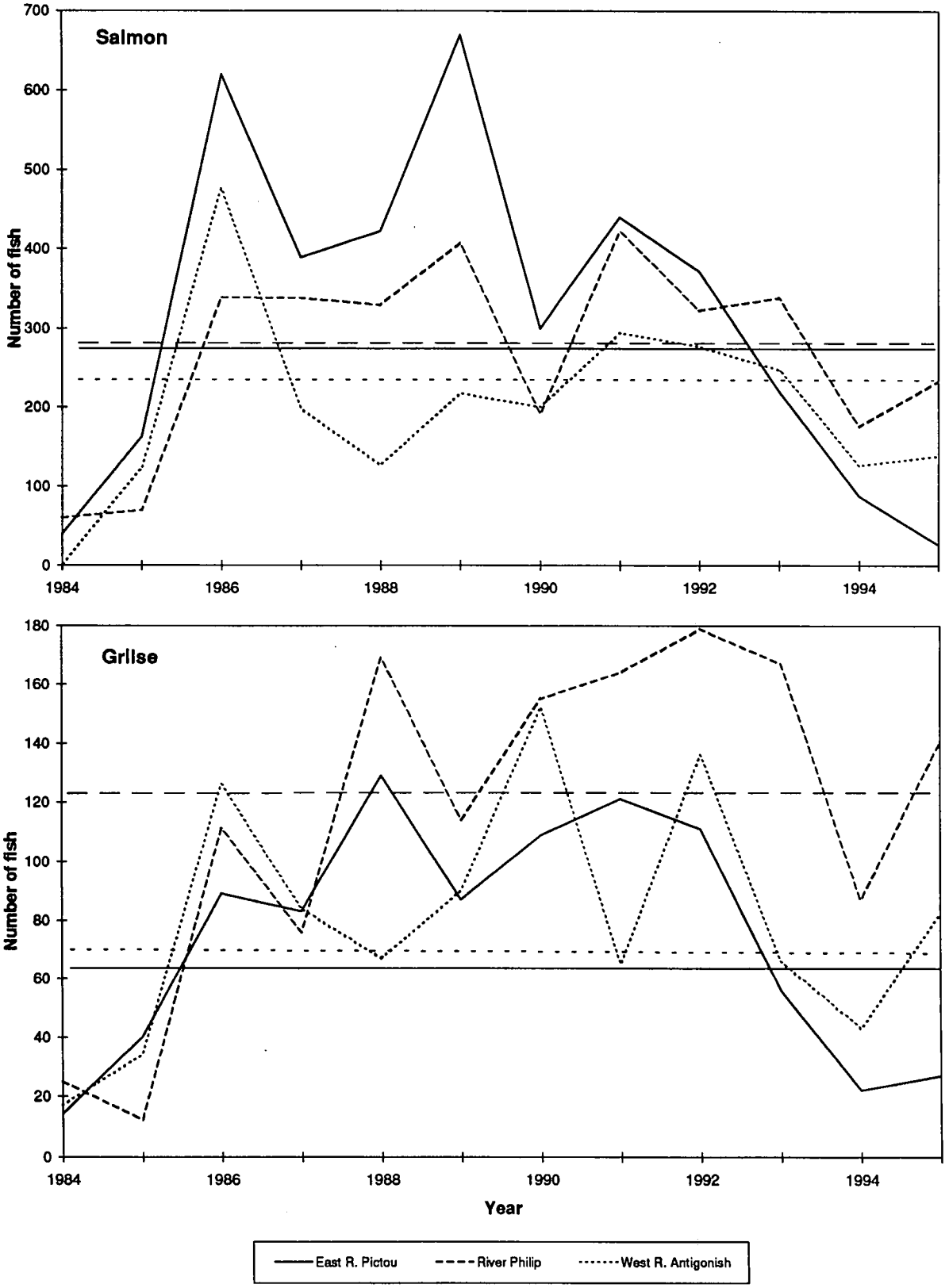

Figure 3. The number of salmon and grilse (retained plus released) angled on the 3 principal rivers of the Northumberland Strait-Nova Scotia area, 1984-95. Data are from license stub reports. The horizontal lines represent the 5 year mean catch (1990-94) for each river.

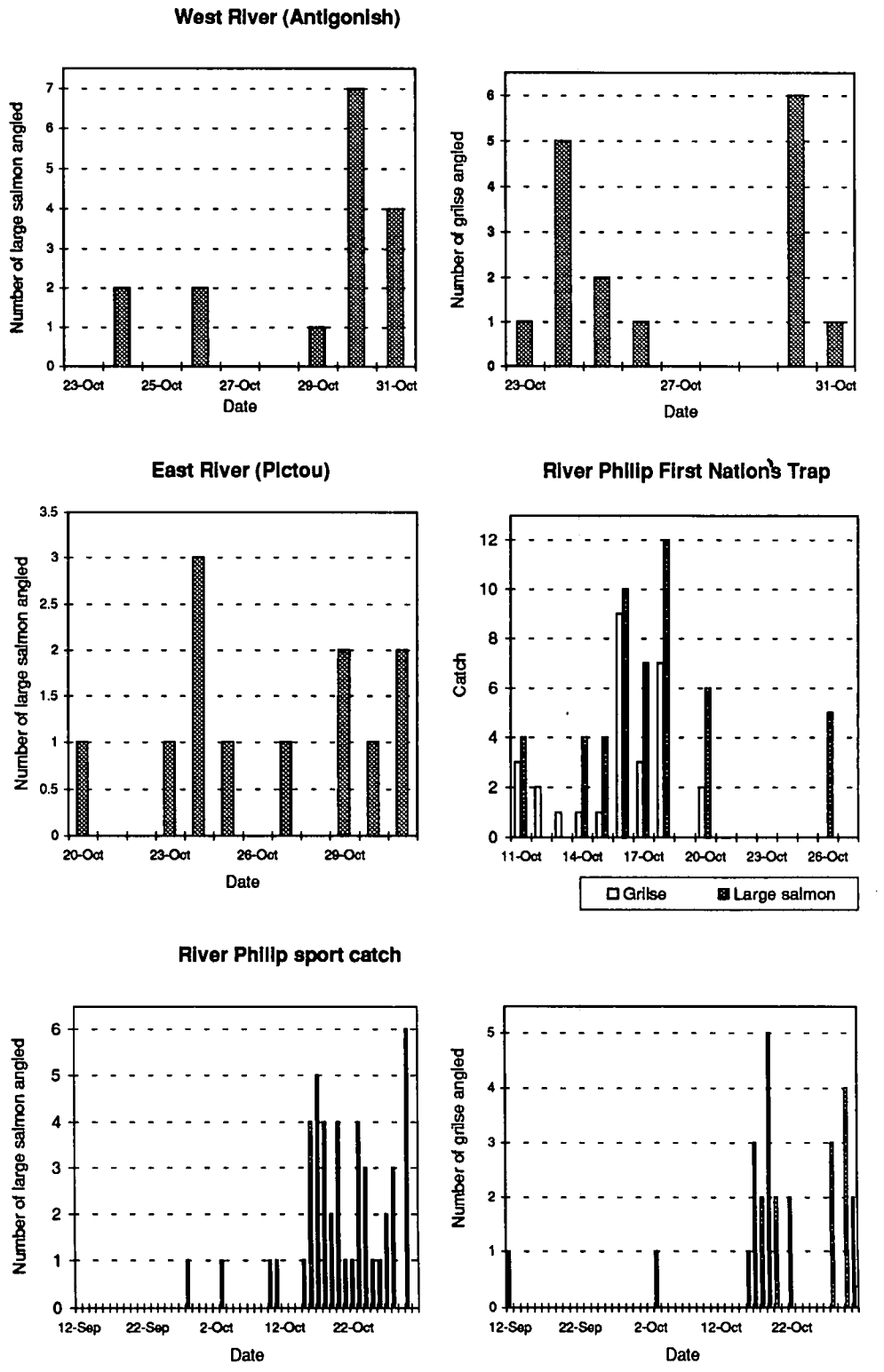

Figure 4. Run timing of large salmon and grilse based on catch reports by date from logbooks on West River, Antigonish; East River, Pictou and logbook and First Nation trap catches on. River Philip, 1995.

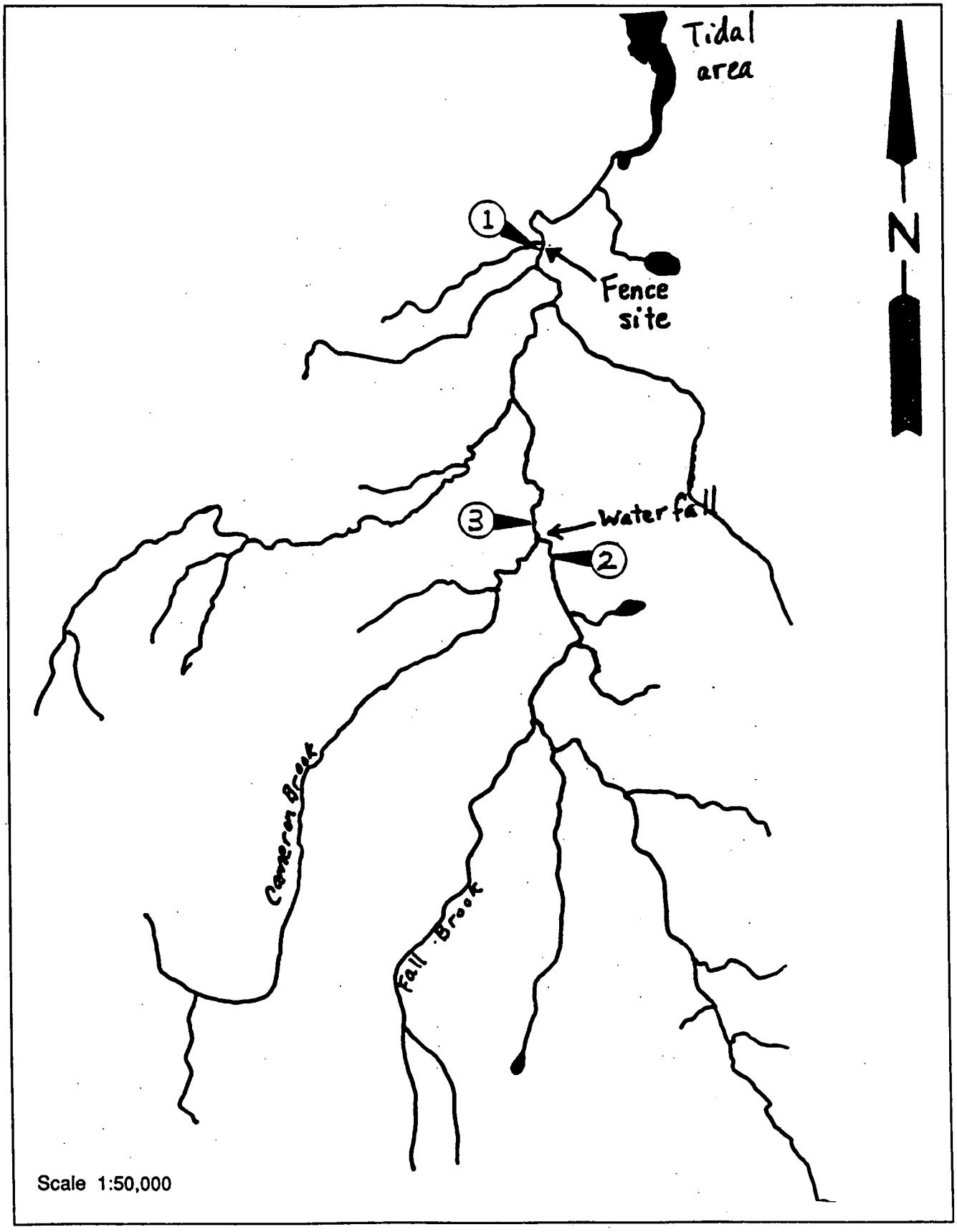

Figure 5. Electrofishing sites, First Nations fence location and the waterfall which is the upstream barrier for salmon migration on the Sutherlands River.

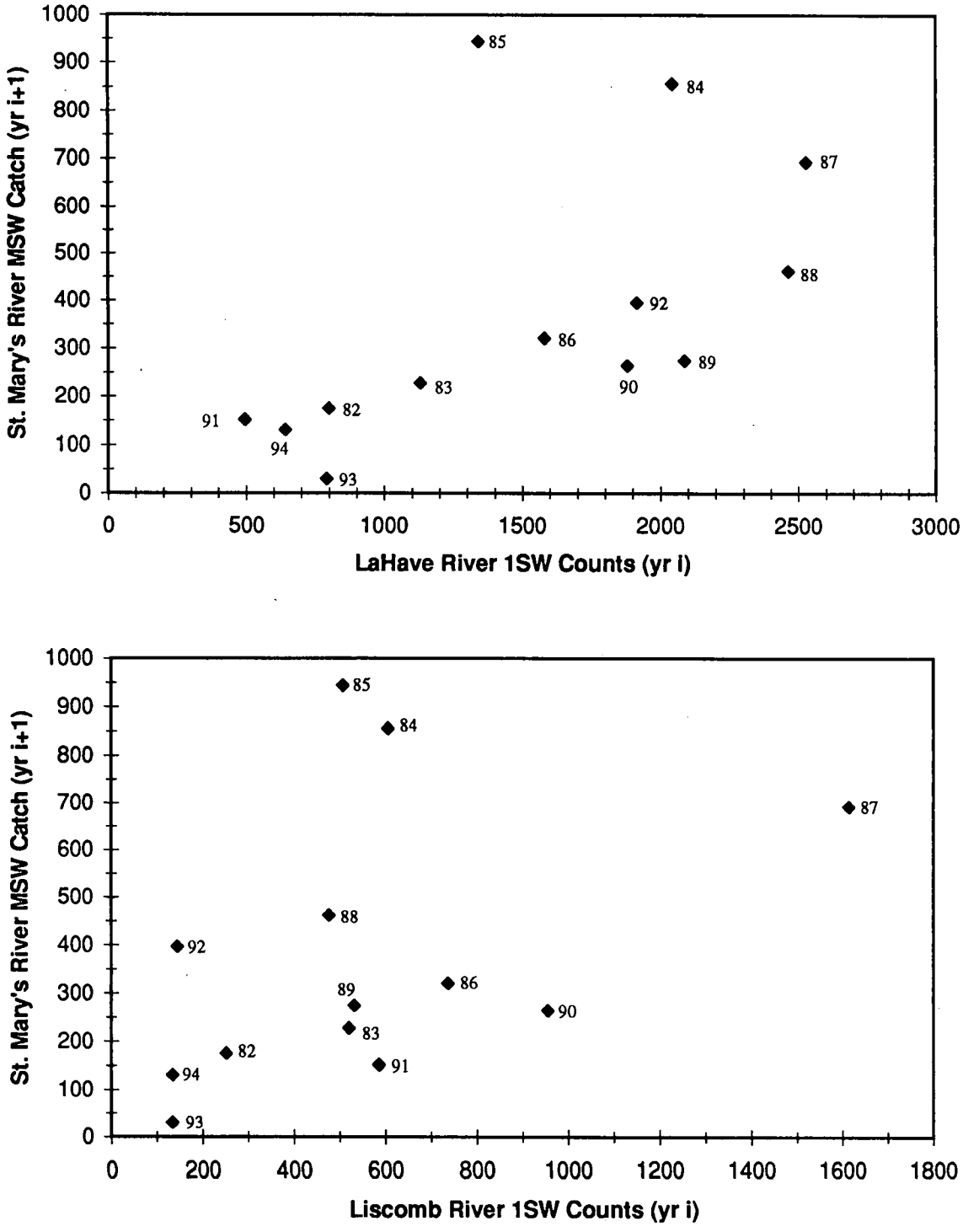

Figure 6. Scatter plots of the St. Mary's River large salmon sportcatch in year i+1 plotted against both the LaHave wild grilse returns in year i (upper graph) and the Liscomb River wild grilse counts in year i (lower graph), 1982-1994. Each grilse year (year i) is indicated on the plots.

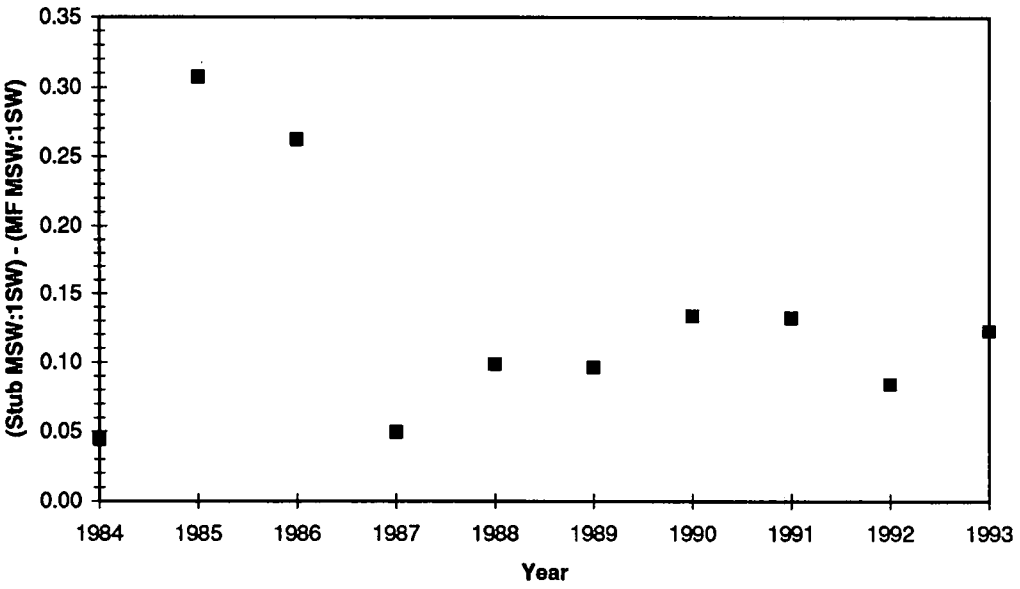

Figure 7. Scatter plot of the difference between the LaHave River sportcatch ratio of large salmon to grilse from license stubs and the ratio of large salmon to grilse destined to Morgan Falls, LaHave River, trap counts, 1984-93. The grilse destined for Morgan Falls are the total count of grilse added to the license stub estimated harvest of grilse.

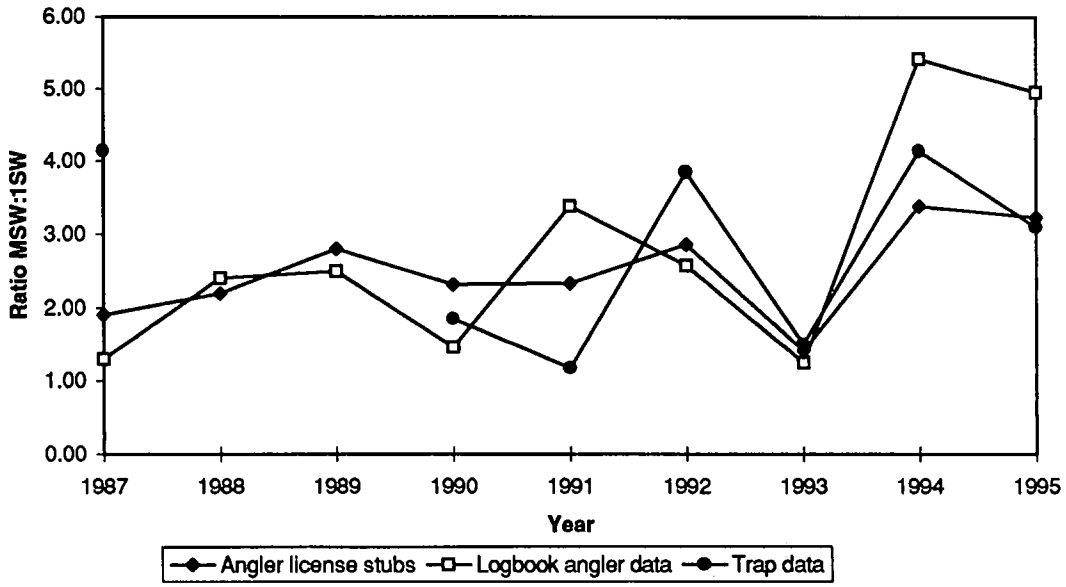

Figure 8. Ratios of large salmon to grilse for three catch data sources on the Margaree River, angler license stubs, angler logbooks and the estuary traps, 1987-1995 (1988 and 1989 trap data excluded because the trap only operated in the autumn).

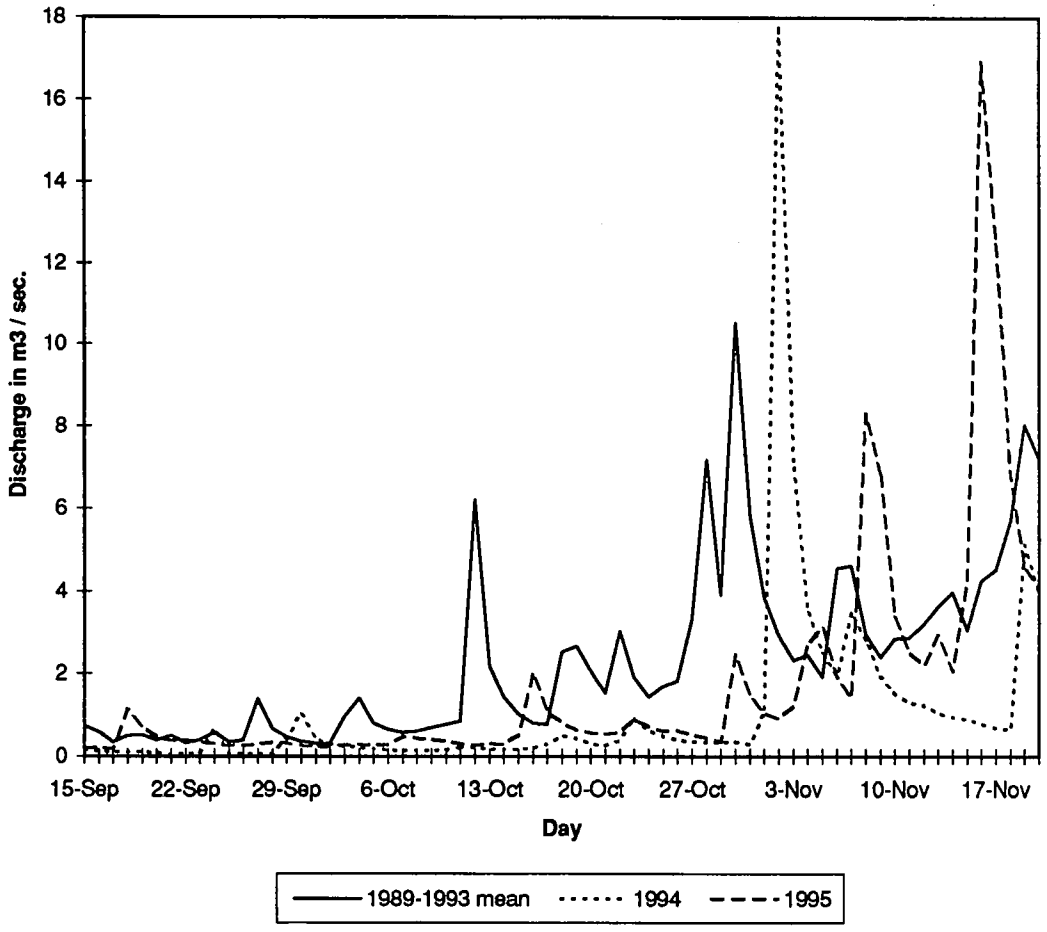

Figure 9. Mean daily discharge in cubic meters per second on Middle River, Pictou, in 1994, 1995 and as an average over the 5 year period 1989 - 1993.

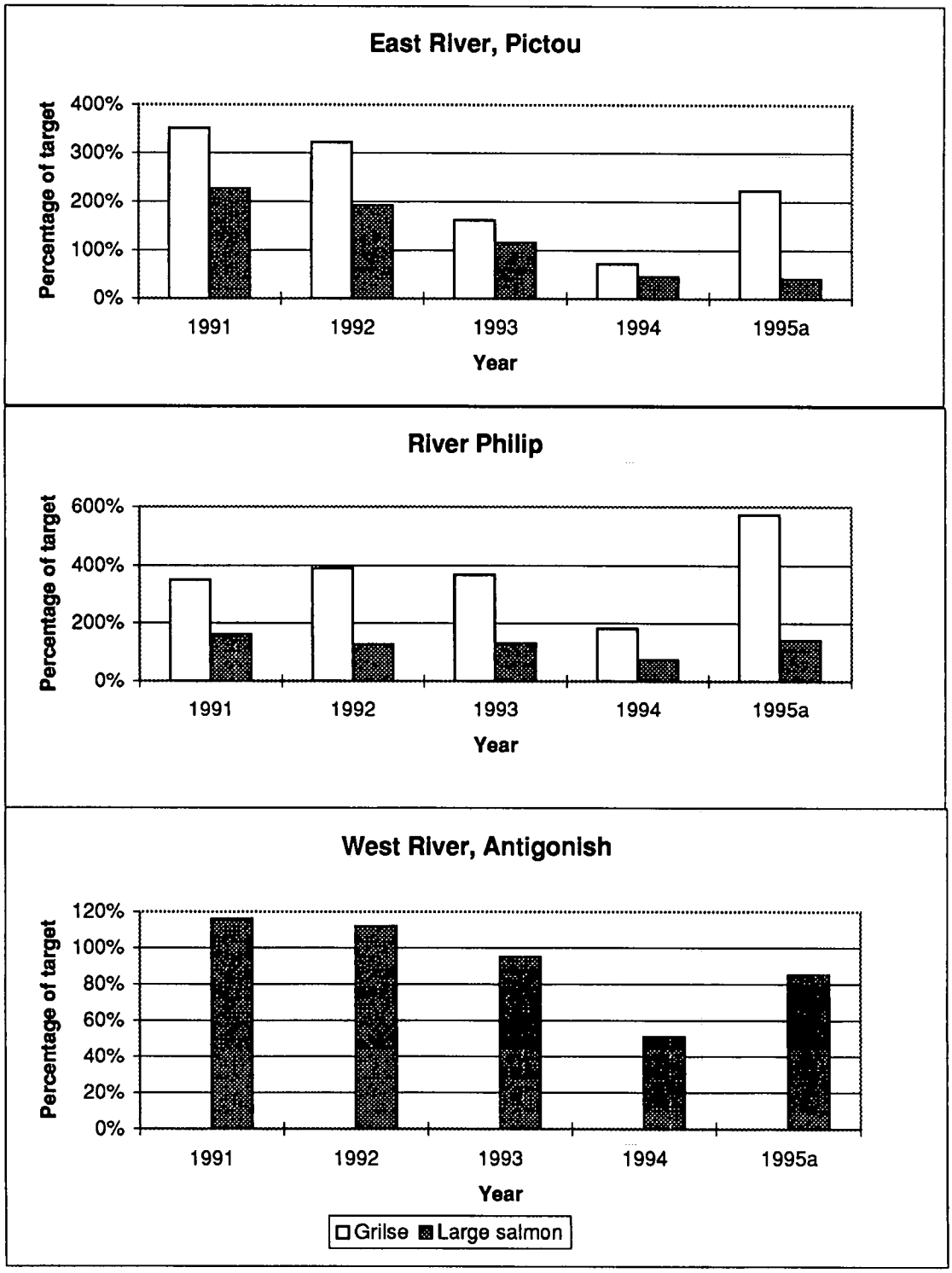

Figure 10. Percentage of conservation requirement achieved on three Northumberland Strait, Nova Scotia area rivers, 1991-1995. The escapements for the years 1991-94 were estimated with adjusted sportcatches and a range of exploitation rates; for 1995, the catch data was not adjusted and and the exploitation rate was calculated from the 1995 Margaree River data (refer to text and Table 15).

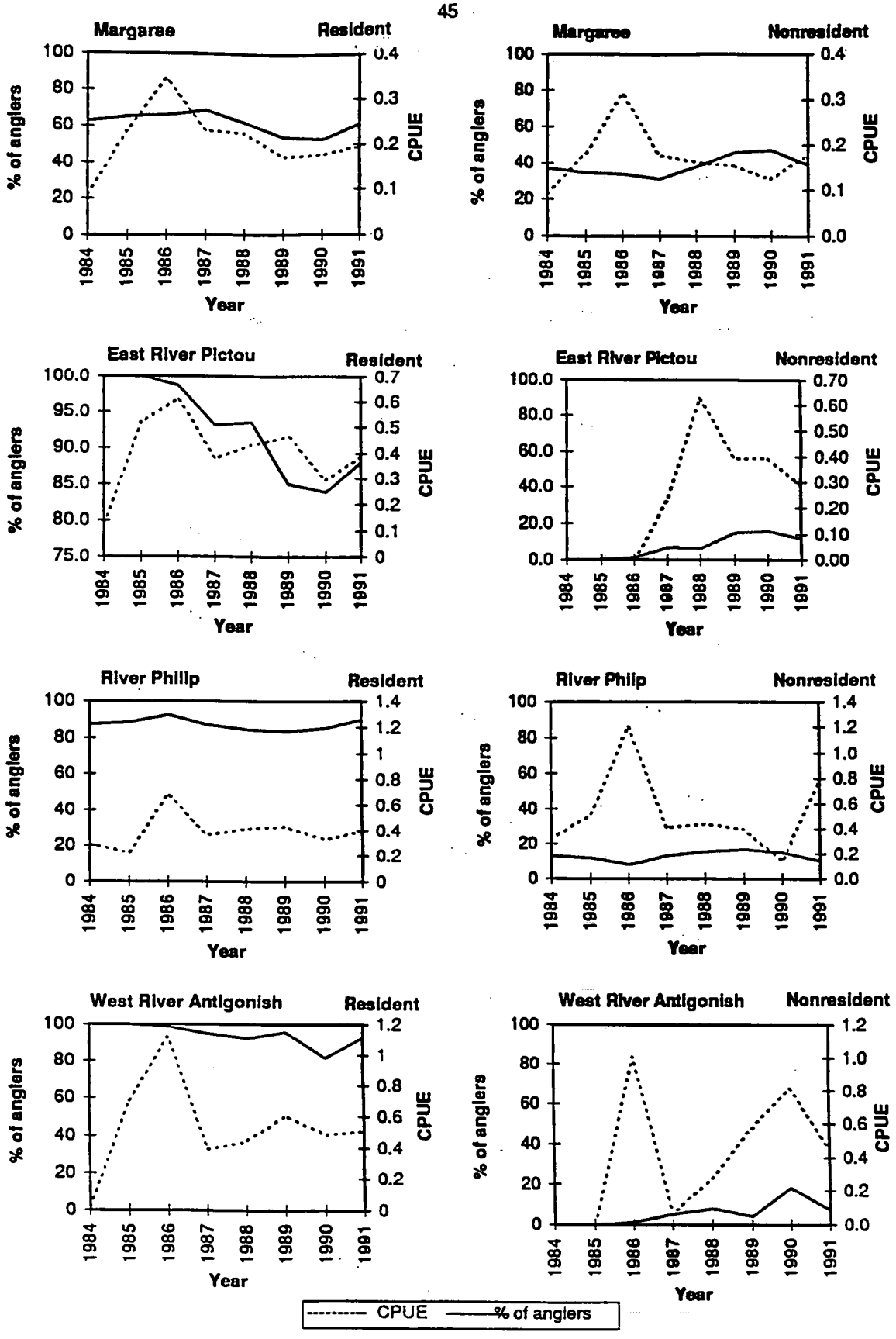

Figure 11. Percentage of resident and non-resident anglers and the catch per unit of effort for each group on the Margaree, East Pictou, Philip and West Antigonish rivers, 1984 to 1991.