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Atlantic salmon (*Salmo salar* L.) stock status on rivers in the Northumberland Strait, Nova Scotia area, in 1996

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Abstract

Fifteen separate rivers on the Northumberland Strait shore of Nova Scotia support Atlantic salmon stocks. Stock status information for 1996 is provided for nine of those stocks based on the conservation requirements and escapements calculated either from mark-and-recapture experiments (East River, Pictou and River Philip) or capture (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 823 small salmon (grilse) and 1,985 large salmon on the rivers within the area. First Peoples reported harvesting 13 small and 94 large salmon from an estuarial trap in East River, Pictou, and with seine nets in River Philip.

Juvenile salmon densities were found to be high compared with those found on many rivers in the Maritime Provinces. The mean densities of fry and parr on West River, Antigonish, in an electrofishing survey, expanded to five sites from two in 1995, were greater than 160 fry and 80 parr per 100 m².

Two population estimates were calculated from the mark-and-recapture experiment on East River, Pictou (minimum and maximum); both indicated escapements were surplus to requirements in 1996. The population estimate on River Philip, based on the mark-recapture method, also indicated spawners were surplus to the conservation requirement in 1996. On Sutherlands River, on Nov. 7, snorkel divers counted adult salmon which numbered more than twice the desired conservation number. On several other rivers in the area estimated spawner numbers exceeded requirements (River John; Waugh; West, Antigonish; and West, Pictou). The estimated escapements to South River and Wallace River were 56% and 63% of the conservation levels, respectively.

Forecasts were possible only by using the five-year estimates for returns and are provided for East River, Pictou; River Philip and West River, Antigonish. The forecast of returns for 1997, based on the five-year average returns, is for surplus numbers of grilse (variable numbers) and for the number of large salmon returns to exceed requirements by 17% to 60% on those same rivers.

Résumé

Quinze rivières de la côte du détroit de Northumberland de la Nouvelle-Écosse abritent des stocks de saumon atlantique. Des renseignements sur l'état des stocks en 1996 sont présentés pour neuf de ces stocks en fonction des besoins de conservation et des échappées calculées à partir des essais par marquage et recapture (rivières East, Pictou, et rivière Philip) ou des taux de capture (exploitation) de la pêche à la ligne. Des renseignements supplémentaires sont donnés pour les trois principales rivières de ce secteur (rivière East à Pictou, rivière Philip et rivière West, à Antigonish).

Les pêcheurs à la ligne ont signalé avoir récolté ou remis à l'eau 823 petits saumons (madeleineaux) et 1 985 gros saumons dans ces rivières. Les Premières nations ont signalé la récolte de 13 petits saumons et de 94 gros saumons dans un piège situé dans l'estuaire de la rivière East, à Pictou, et dans des sennes placées dans la rivière Philip.

Les densités de saumons juvéniles étaient élevées comparativement à celles de bon nombre d'autres rivières des Maritimes. Les densités moyennes d'alevins et de tacons déterminées par un

relevé par pêche électrique élargi de deux (1995) à cinq sites de la rivière West, Antigonish, étaient supérieures à 160 alevins et 80 tacons par 100 m².

Deux estimations de population ont été calculées à partir des résultats d'un essai par marquage-recapture sur la rivière East, Pictou (minimum et maximum). Les deux indiquaient des échappées excédentaires aux besoins pour 1996. L'estimation de la population dans la rivière Philip, faite à partir des données de marquage-recapture, indiquait aussi un excédent de géniteurs par rapport aux besoins de conservation. Des plongeurs avec tuba ont dénombré, le 7 novembre, les saumons adultes dans la rivière Sutherlands et la valeur obtenue dépassait de plus du double les besoins de conservation. Pour plusieurs autres rivières du secteur, le nombre de géniteurs estimé était supérieur aux exigences (rivière John; rivière Waugh; rivière West, Antigonish; rivière West, Pictou). Les échappées estimées des rivières South et Wallace correspondaient respectivement à 56 % et 63 % des exigences de conservation.

Des prévisions ne pouvaient être effectuées qu'à l'aide des estimations sur cinq ans des remontées. Elles sont présentées pour les rivières East, à Pictou, Philip et West, à Antigonish. Les prévisions des remontées pour 1997, reposant sur la moyenne des remontées sur cinq ans, donnent des excédents de saumoneaux (valeurs variables) et de gros saumons supérieurs de 17 % à 60 % aux besoins pour ces mêmes rivières.

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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 six years and 11 have been fished with some regularity (Fig. 1, Table 1).

This report provides information on several rivers but focuses mainly on the three principal rivers in the area, River Philip; East River, Pictou; 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 conservation requirements are examined.

Middle River, Pictou

A restoration program for the impounded Middle River, Pictou, has been ongoing since 1987. In 1996, a review of the program was begun which included a trial project to monitor smolt movements in the headpond. The trial identified several concerns regarding emigration of smolts from the headpond. Ten adult salmon were processed through the fishway in 1996; more may have returned during high water in September when the reservoir gates were opened.

Additional work is planned for 1997 to finalize the review of the potential of the system for salmon restoration. A detailed report of the review will be completed at that time.

Description of fisheries and fisheries data

Recreational fisheries and Native food fisheries occur in the Northumberland Strait, Nova Scotia, area (North NS).

The terminology used throughout this document describes Atlantic salmon as follows : grilse, one-sea-winter, 1SW, and small salmon are used synonymously to describe a salmon which is less than 63 cm. in length and is assumed to have spent only one winter at sea before returning to spawn; large salmon, multi-sea-winter salmon, and MSW describe a salmon which has spent at least 2 winters at sea before returning to spawn for the first time and are fish 63 cm. or more in length. Repeat-spawning salmon are fish which have spawned previously, either as a grilse or large salmon, and are usually greater than 63 cm. in length. Angled fish greater than 63 cm. in length are assumed to be large salmon for the purposes of this report.

Sportfishery

The angling season for all rivers in North NS in 1996 was the same as in 1995, from September 1 to October 31. The season and daily bag limits remained at eight and two grilse, respectively.

Preliminary indications are that approximately 3,600 salmon anglers purchased licenses in Nova Scotia in 1996. A total of 2,316 useable license stubs was returned (by the time of this writing) and these contributed to the sportcatch database, an estimated response rate of 64%. The procedure used to estimate the number of fish harvested and released from the various rivers in the province and the accuracy of the information has been described previously (O'Neil and Harvie 1993; O'Neil *et al.* 1986). Twelve rivers in the North NS area were visited by anglers in 1996, 908 of whom returned license stubs.

North NS angler effort increased in 1996 to 5,780 rod-days from 4,078 rod-days in 1995 (Table 1). That effort was also higher than the five-year (1991-95) average of 4,638 rod-days.

Collectively, the anglers who fished the North NS rivers in 1996 harvested 471 grilse, and released 352 grilse and 1,985 large salmon. Although these data are preliminary, the estimated catch in 1996 (2,808 total fish) was up from the 909 fish reported angled in 1995 and also well above the 1991-1995 average catch of 1,449 fish (Table 1).

The numbers of grilse and large salmon released on every river within the area increased in 1996 over 1995 and were higher than the five-year-averages (1991-95). The number of grilse harvested also increased over the previous year and the five-year average on all rivers but one; fewer grilse were retained on East River, Pictou, in 1996 (31 fish) than were harvested, on average, during the previous five years (42 fish; Table 1).

The catches of fish on the three principal rivers in the area were considerably higher than the 1995 catches (Fig. 2). The large salmon catches on East River, Pictou; River Philip; and West River, Antigonish, in 1993 were near their recent five-year means (1991-95), but then fell to well below the means for two years, 1994 and 1995 (Fig. 2). The 1996 catch of MSW fish increased to well above the mean and, in the case of River Philip and West River, Antigonish, to the highest level of the time series 1984-1996.

Grilse catches on East, Philip and West rivers are generally lower and have varied less widely than the large salmon catches (Fig. 2). The 1996 grilse catches on River Philip and West River, Antigonish, also represent the highest catches for the 1984-1996 time series. On East River, Pictou, the total grilse catch in 1996 of 69 fish was similar to the 1991-1995 mean catch of 70 fish, but well below the high of the 1984-96 period of 129 grilse which occurred in 1988.

The catch per unit effort (CPUE) from license stub data was high in 1996 relative to recent years for East River, River Philip and West River (Fig. 3). CPUEs were close to the highest of the 1984-96 period for all three rivers if you consider that the 1985 and 1986 estimates were biased upwards (O'Neil *et al.* 1996). The implication of the high CPUE data, a greater abundance of fish, can be better appreciated when considered concurrently with the effort data; effort was also the highest for the period for River Philip and West River, Antigonish (Fig. 3).

Native food fishery

Millbrook, Pictou Landing, Afton, and Indian Brook First Nations and Native Council had salmon food fishery fishing agreements or licenses for rivers within the North NS area in 1996 (Table 2).

Millbrook First Nation harvested two grilse and 45 large salmon on River Philip. High water rendered their trap inoperable so the fish were harvested by seining in late November after the fish had spawned. Pictou Landing First Nation harvested 63 fish: 11 grilse, 49 large salmon and three fish of unknown size (Table 2). Several additional fish captured were released. No harvest data were available for other First Nation groups prior to the preparation of this report.

Millbrook and Pictou Landing First Nations participated in data collection and related activities either in association with their food fisheries or as a training or research initiative.

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, license stubs and the First Nation's trap records on East River, Pictou were used to plot catch-by-day data as a means of reviewing run timing. The angler license stub data indicated that the earliest catch occurred on

West River, Antigonish, with the first catch reported on September 1, opening day. On all three rivers, however, the angling catch, according to the stub data, occurred predominantly in mid-October, for both salmon and grilse (Fig. 4). This event was also true for the anglers that recorded their catch and effort in diaries (Fig. 5). According to the diary and stub data, few fish were angled the last few days of October. At the First Nation's trap on East River, Pictou, the first fish was captured on September 2. The greater proportion of the fish captured in the trap was taken in late October (October 20-28); the last fish was captured at the trap on Nov. 2.

Thus, although fish were available earlier in 1996 than in 1995 or 1994, the increased catch-per-unit effort, when combined with the increase in effort, provides supporting evidence that the fish abundance was greater in 1996 than in either prior year.

Conservation requirements

Habitat area

The collective habitat area for the Northumberland Strait, Nova Scotia rivers is 5,357,000 m² (Table 3). Habitat area has not been measured for most rivers by either of the methods in common use, on-site measurement and aerial photo interpretation. A more comprehensive and perhaps more objective survey of habitat area through orthophoto/aerial photo interpretation may be done at some future date if resources become available. In the meantime, the habitat area has been estimated based on the ratio of habitat area to drainage basin size which has been calculated for two rivers in the area, River Philip and South River. The ratio obtained from River Philip, based on a survey by Edwards (1956) and the Land Registration and Information Service¹ drainage basin measurements, was used to estimate rearing area in those rivers in the western portion of North NS and West River, Antigonish (Table 3). The procedure for estimating rearing area was as follows:

For example, for East River, Pictou:

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

$$\begin{aligned} \text{East River, Pictou, habitat area} &= \text{Ratio A} \times \text{East River, Pictou, drainage basin size} \\ &= 0.0013604 \times 535,971,583 \text{ m}^2 = 729,125 \text{ m}^2 \end{aligned}$$

This procedure has been used previously to estimate rearing areas for Northumberland Strait, Nova Scotia, rivers by Chaput and Jones (1994), Claytor *et al.* (1995), and O'Neil *et al.* (1996).

The habitat area of South River, Antigonish was estimated through an on-site survey to be 95,000 m² (*cf.*, 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 3, Fig. 6).

¹ Land Registration and Information Service, Department of Municipal Affairs, 1660 Hollis St., Box 2254, Halifax, N.S. B3J 3C8

Egg and adult requirements

The egg requirements for each river were calculated using the conservation 2.4 eggs per m² (Anon. 1991a and 1991b), the biological characteristics available for the nearest stock, and the habitat areas (Table 3).

Biological characteristic data were only available for two of the Northumberland Strait, Nova Scotia, area 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 (Table 4). The estimated egg requirements for the North NS rivers range from 45,000 on the Afton River to 2.3 million on River Philip (Table 3).

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 conservation egg requirements (Tables 3 and 4).

The numbers of spawners required to meet the conservation requirement for the three principal rivers in the area are (Table 3, Fig. 6):

	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 3, Fig. 6).

Research data

Juvenile Atlantic salmon densities

Electrofishing surveys of juvenile Atlantic salmon were conducted on Sutherlands River, Wallace River and West River, Antigonish, in 1996 (Tables 5 and 6). Juvenile Atlantic salmon are often referred to as parr or fry depending on the age of the fish or the terminology in use by the author. In this report, fry are used synonymously with 0+ parr and refer to young-of-the-year Atlantic salmon. Parr is used collectively to refer to all juvenile salmon ages, young-of-the-year, one-year olds and two-year olds, unless the age is specifically mentioned, such as 1+ parr which refers to one-year-old salmon.

The survey on Sutherlands River was limited to five-minute spotchecks (300 seconds on the electrofishing timer) at two sites visited in previous years (Table 5). Anglers have expressed concern over the state of the salmon stock on Wallace River so six sites were electrofished on the Wallace in 1996, four using the five-minute survey and two as full mark-and-recapture density estimates.

Parr densities at two sites on West River, Antigonish have been high relative to parr densities on all other systems in the province (O'Neil *et al.* 1996). The 1996 program was directed at collecting data on additional sites within the system to obtain a broader perspective on parr densities. In keeping with the program objectives, five density estimates were obtained on West River, Antigonish, four with the mark-and-recapture technique (Amiro *et al.* 1989) and one site (site 5) with a three-sweep removal technique with no barriers. The latter site was fished with the three-sweep method because the crew did not have sufficient time to return a second day to conduct a recapture.

Estimation of stock parameters

Sutherlands River

Sutherlands River discharges into Merrigomish Harbour where a limited First Nation harvest occurs. The return of fish to Sutherlands River is used as an index of returns to the three Merrigomish Harbour rivers (Sutherlands; French, Pictou; and Barney's) because all three stocks may be vulnerable to the harvest there.

The number of adult salmon in Sutherlands River was counted during a snorkel-diver survey on November 7, 1996. The lower 5.6 kms of the river is accessible for salmon below an impassable natural barrier. The length of river below the falls was divided into two sections and one snorkel diver, accompanied by a second person on foot, floated a section and recorded the number of large salmon and grilse observed.

Mark-and-recapture population estimates

Adult salmon population estimates were produced for River Philip and East River, Pictou, using a mark-and-recapture technique. The terminology related to a mark-and-recapture experiment can often be confusing. For the purposes of clarification in this document, tags (marks) were applied to salmon captured in a seine net during the marking part of the experiment. The "recapture" refers to the snorkel-diver survey of the river when divers looked for marked and unmarked fish. Recapture is used here as a synonym with the more commonly used term "capture"; it was used to avoid confusion with the use of capture as it applies to the angling fishery.

The adult salmon surveys occurred between October 28 and November 6. The salmon in the two rivers typically spawn around the week of November 6 (S. Lloy², pers. comm.), and none of the female fish captured during tagging had completed spawning.

Mark (tag) application

Salmon were seined at various locations in the rivers (Figs. 7 and 8) and bright orange streamer tags were applied to each fish in the dorsal fin near the musculature of the back. The tags were applied with a heavy gauge sewing needle. Each needle had a streamer tag inserted through the eye so that once the needle was pushed through the fin, the tag could be held in place and the needle removed from the tag. The streamer tags were 10.2 cm in length and shaped with a narrow middle section so that once the tag was inserted the shape of the tag held it in place. The tags were visible from either side of the fish because approximately five cm of the tag extended from each side of the dorsal fin. Tag loss was considered negligible because recaptures occurred within one week of tag application and experiments regarding tag retention had zero tag loss until well after one week (Marshall *et al.* In prep.).

Tags were applied on October 28 and November 5 on East River, Pictou and River Philip, respectively. The angling season closed on October 31 on both rivers. It was assumed that no tags were lost to the angling fishery because of a storm which began on the afternoon of October 28 which limited angling until the season closed, and no grilse were reported angled during Oct. 27 to 31 on East River, Pictou, on license stubs, and the fact that only four grilse were tagged on East River.

On East River, Pictou, 24 tags were applied at the lower end of the portion of the main river covered in the recapture diver float survey (Fig. 7). Consequently, two population estimates were

² S. Lloy, Fisheries and Oceans, Cobequid Fish Culture Station, Collingwood Corner, N.S.

generated for the river depending on the number of marks included in the calculations (refer to assessment results below).

Recapture procedure

The recapture of the tags applied was by floating the two rivers, counting fish and making note of the marked and unmarked fish observed. Each river was divided into sections and two snorkel divers were assigned to float each section. Each diver in a team would float a short stretch of river or pool and confer with their partner to confirm the number seen. Divers recorded the number of grilse and large salmon seen in addition to the fish with tags.

East River, Pictou

East River was divided into four sections but only three were floated because of a shortage of divers (Table 7; Fig. 7). The main river from Sunnybrae to Springville was surveyed as was the West Branch from one-half kilometer above Iona Church to Eureka and two pools on McLellans Brook. The area from Springville to the head of tide was not surveyed (Fig. 7). The recapture took place on November 4, one week after the marks were applied.

River Philip

River Philip was divided into three sections which provided coverage of the river from near the hatchery (Thompson Road bridge) to Oxford Junction (Fig. 8). The area below Oxford Junction was not included in the survey because of poor visibility and a shortage of divers. The poor visibility was determined during a trial survey of the river in 1995 (O'Neil *et al.* 1996) and confirmed by surveying the area just below the Oxford Junction bridge in 1996. The recapture occurred on November 6, one day after the fish were tagged (Table 7).

The area floated for the recapture includes areas of the river above (2 kms) and below (7 kms) locations where fish were marked (Fig. 8).

Estimation procedure

The population estimates for East and Philip rivers were calculated using the adjusted Petersen (Ricker 1975) and Bayesian (*loc. cit.* Gazey and Staley 1986) techniques. The population figures derived were post-fishery estimates so the pre-fishery estimate (returns) was achieved by adding the appropriate Native and angling harvest and hook-and-release mortality (assumed at 5%) to the post-fishery estimates. The returns estimate was determined for total fish, and the numbers of large salmon and grilse were estimated by applying the proportion of the two age classes from the number of each size observed during the snorkel-diver surveys (i.e., the recapture sample).

Assessment results and discussion

Juvenile salmon surveys

Sutherlands River

The numbers of parr captured per five minutes of fishing on Sutherlands River in 1996, 28 and 19 parr, were similar to the numbers found in past years which have varied from a low of 12 to a high of 42 fish (Table 5). The range in number of fry found over the four different years of surveys (1992, 1994, 1995 and 1996) was 30 to 100 fish. The 1996 fry numbers (30 and 42 fry at two sites) were somewhat lower than those found in recent past years (Table 5).

Wallace River

Fry and parr numbers caught during five minutes of electrofishing were variably higher or lower, depending on the site and year, than the numbers found when the same sites were fished in 1993 and 1995 (Table 5). There was no apparent large deviation from the numbers noted in previous years.

Parr densities (1+ and 2+ combined) based on the mark-and-recapture estimates were 10.4 and 17.8 fish per 100 m² at the two sites fished in 1996 (Table 6, Fig. 6). Parr densities were not available for recent years for comparison, but densities reported in 1978 were 7.9 and 20.4 parr per 100 m² (Cameron and Gray 1979). Only one site is directly comparable from the 1978 and 1996 data sets, site 6 (Table 6). The fry and parr densities in 1978 at that site were 65.3 and 20.4, respectively. In 1996, the densities were 86.1 and 10.4 fry and parr, respectively. Comparison of the data from the two data sets can provide valuable insight into how juvenile numbers may have changed over time. However, the differences noted are ambiguous and not exceptional. Consideration of the differences in techniques used is necessary in order to make any comparison of density estimates over years. The electrofishing done by Cameron and Gray (1979) used barriers and three-sweep removals on fairly small sites. The 1978 electrofishing site area was 96 m² and probably confined to the riffle section of the stream. In 1996, the area fished was 235 m² and included riffle, pool and a portion of a flat. Nevertheless, juvenile numbers did not differ substantially.

Collectively, the juvenile densities on the Wallace River are lower than the numbers found on several other North NS streams, but higher or comparable to those observed elsewhere in Nova Scotia such as on the St. Mary's River (O'Neil and Harvie 1995) or Musquodoboit River (Amiro 1993). Production of parr at Elson's "norms" would be near 24 parr per 100 m² which is higher than the parr density at the two sites on the Wallace (Elson 1967). Additional electrofishing to estimate densities is required to determine if the standing population of parr is low for the system relative to the perceived conservation requirement (i.e., Elson's 24 parr per 100 m²).

West River, Antigonish

The fry and parr (1+ and 2+ combined) densities on West River at two sites (James River - site 2; Beaver River - site 4) have exceeded 160 fry per unit (one unit=100m²) and 70 parr per unit annually, the past three years (1994-1996; Table 6). Fry and parr densities were the highest of those estimates available for the Beaver River site in 1996 (Fig. 9). The Beaver River site is located in a remote location and has been free of habitat disruptions related to development so would be a useful indicator site for changes in density over time (Fig. 10). Densities of fry and parr have increased considerably from those found in 1978 and indicate a generally increasing trend (Fig. 9). The densities of the parr on James River have been subject to changes in habitat;

the streambank was reinforced in 1984 and a stream-bottom sill was placed above the site in 1990 (C. MacInnes³, pers. comm). Nevertheless, densities on James River exceed those on other rivers in the North NS area.

The mean parr density (1+ and 2+) for West River, Antigonish in 1996 was 87.2 fish per 100 m² (Fig. 6). The mean fry density was 165.0 fish per 100 m². These values are the averages of the densities found on the five sites in 1996. The sites chosen in 1996 were intended to provide a broader sample of the river than the two sites fished since 1991. Site 3 is in the lower portion of the Ohio River where the gradient is low relative to the gradient of the James and Beaver river sites (Fig. 10). The site originally fished in 1978 covered an area of 189 m² (Cameron and Gray 1979). In 1996, the crew attempted to locate the precise location fished in 1978 and found two areas within 400 meters of each other which fit the description provided by Cameron and Gray (1979). Those areas were both characterized by short riffle sections 30m in length between two flats, low gradient areas of uniform depth and velocity. It is unclear from the earlier work whether the electrofishing site was confined to the riffle section of the stream, but it was a common practice when selecting barrier sites. The area fished in 1996 (269 m²) included the riffle and an area of flat which constituted about 50% of the site fished. Consequently, we would expect our 1996 data to indicate densities lower than those found on the Ohio River in 1978 if they were confined to the riffle area and it was assumed that the number of adult spawners had remained similar. Instead, the fry density was higher by a factor of 2 and the parr density increased from 0.5 parr per unit in 1978 to 20.9 parr per unit in 1996. A similar difference in densities was also evident at site 1 on the main West River (Table 6).

Float counts and mark-and-recapture population estimates

East River

Two population estimates were generated from the data on East River. The minimum Bayesian post-fishery estimate was 457 fish (5th and 95th percentiles 317 and 1,003; Table 8a; Fig. 11) and the maximum post-fishery estimate, 723 fish (5th and 95th percentiles 499 and 1,570; Table 8b; Fig. 11).

Minimum estimate: Assumptions of mark-and-recapture

A total of 67 fish was marked on East River, Pictou, and 87 were counted during the recapture snorkel-diver survey (Table 7). During the marking exercise, 24 fish were tagged at a pool at Springville at the lowermost end of the portion of the main river that was floated (Fig. 7-marking site 2). Due to technical reasons, the area of the river below Springville was not surveyed as part of the recapture. Consequently, there was a good probability that some of the tags applied would not be available for the recapture because some tagged fish may have moved downstream after the marking was completed. There are no data regarding the proportion of fish that "fall back" or the length of time that it takes them to return to near or beyond the area in the river where they were tagged. The recapture on the East River, Pictou, was one week after the tags were applied, somewhat longer than is usually the case for these types of experiments on Nova Scotia rivers. Thus, it is possible that our survey would not have complied with the underlying assumption of mark-and-recapture experiments, that the marked fish would have mixed randomly with the unmarked fish (Ricker 1975). In order to accommodate that possibility, the number of fish marked at Springville and the one fish seen near Springville during the recapture were removed from the data prior to calculating the population estimate to provide a minimum estimate of

³ C. MacInnes, Fisheries and Oceans, Antigonish, N.S.

population size. The minimum post-fishery estimate (Bayesian) of the number of fish in the population using these data was 457 (Table 8a).

The numbers of salmon and grilse estimated to be in the river post-fishery were calculated from the proportions observed (i.e., proportions in snorkel-diver count). Returns were estimated by adding the number of fish harvested and those estimated lost through hook-and-release angling (assumed at 5%) to the post-fishery population estimate. The proportions of salmon (0.841) and grilse (0.159) in the return (pre-fishery) estimate were calculated from a combination of the proportion observed in the recapture and the number that would have been seen had they not been removed in the angling fishery (Table 9). The pre-angling fishery population of grilse and large salmon return estimates were 80 and 424 fish.

Maximum estimate

All fish tagged during the marking exercise were included in the mark-and-recapture estimation procedure to arrive at a maximum population estimate for East River, Pictou, for 1996 (Table 7 and 9). The post fishery Bayesian estimate of 723 fish was 58% larger than the minimum estimate (Table 8b).

The maximum estimate of returns (pre-angling fishery) to East River, Pictou, was calculated in the same manner as the minimum estimate to be 770 fish (Table 9). The pre-angling fishery population of grilse was 107 fish, and of large salmon, 663 fish (Table 9). Total return to the river was calculated by adding the First Nation harvest at the estuary trap to the pre-angling fishery returns estimates for total returns estimates of 118 grilse and 712 large salmon.

The removals of salmon by illegal means and estimated by Department of Fisheries and Oceans (DFO) fishery officers were not taken into account for calculating returns (Table 10). The estimated illegal removal of large salmon from East River, Pictou, was 125 fish.

Escapement relative to conservation requirements

Escapement is equivalent to the post-fishery population estimate calculated from the mark-and-recapture procedure. The minimum and maximum escapement estimates were 457 and 723 fish, respectively. The number of large salmon and grilse estimated from each figure were compared with the conservation requirement for East River, Pictou, of 271 large and 57 small salmon. A surplus number of large salmon spawners occurred with both the minimum and maximum estimates (Table 11; Fig. 6). A slight shortfall in grilse spawners would have been evident with the minimum estimate from this procedure, but sufficient large salmon spawners surplus to the requirement would have escaped fisheries to compensate for any shortage of grilse males. A mean escapement estimate was calculated as the average of the minimum and maximum values and also compared with the spawner requirement. If the mean escapement estimate best approximates the true population size, small and large spawner numbers would have exceeded the requirement (Table 11).

The mean number of large salmon spawners (mean of min. and max. estimates) in 1996 on East River, Pictou, was 529 fish which was 195% of the conservation requirement. A surplus of large salmon spawners of that magnitude precludes the requirement for any grilse.

River Philip

A total of 33 salmon was marked on River Philip and during the snorkel-diver survey the next day, 380 fish were counted, 12 with marks (Table 7). The post-fishery-population estimate was 1,084

large salmon and grilse (5th and 95th percentiles, 563 and 2,391; Table 12; Fig. 12). The fish were marked at locations throughout the survey area and the recapture covered portions of the river above and below the areas where tagging occurred so the assumptions related to mark-and-recapture were considered to have been met (Fig. 8; Table 7). The returns estimate (pre-fishery population; Bayesian estimator) was 1,345 fish; 1,076 large salmon and 269 grilse (Table 9 and 12).

DFO fishery officers estimated that 100 large salmon were removed from River Philip illegally in 1996 (Table 10). These fish were not taken into account when calculating returns to the river.

Escapement relative to conservation requirements

The post-fishery population or escapement estimates of 1,046 large salmon and 94 grilse were greater than the numbers of fish required to meet the conservation requirement (Table 11). The escapement estimate for large salmon in 1996 was 292% of the requirement and for grilse, 125% of the desired number of spawners (Table 13).

Sutherlands River

The stream area below the falls is mostly 10m in width or less so the divers conducting the survey were able to see fish without any difficulty. Most of the fish observed were in pools which were typically not more than 5-7 m in width. In addition, because the water level was relatively low at the time of the survey, fish would remain in the pool in which they were observed and could be watched for some time and approached to within a few meters, thus providing divers with ample opportunity to count fish and identify the size.

Divers counted 59 large salmon and 19 grilse (Table 11). These counts were 236% and 380% of the conservation requirements for large salmon (25 fish) and grilse (5 fish), respectively.

Escapements on the other Northumberland Strait, Nova Scotia, area rivers

Escapements of large salmon were surplus to conservation requirements on River John, Waugh River and West River, Pictou (Table 11). Escapement estimates were calculated from the 0.60 capture rate and the license stub reported angling catches (capture rates described below).

Escapement of salmon to rivers without a report of an angling catch were not possible with the exception of those which drain into Merrigomish Harbour; the French, Pictou; Sutherlands and Barney's. The returns of salmon to French and Barney's rivers were assumed to correspond to returns to Sutherlands River where the snorkel-diver survey counted large salmon spawners which were 236% of requirement.

Angling capture (exploitation) rates

Estimates of returns to rivers in the North NS area in past years were based on applying an exploitation rate to the reported (or adjusted reported) angling catch (O'Neil *et al.* 1996; Claytor *et al.* 1995). Catch of fish in a predominately hook-and-release fishery, such as the North NS rivers, could include multiple captures of the same fish. Thus, the rate of fish captured is not equivalent to an exploitation rate in a harvest fishery. The term capture rate is used in this document to refer to the rate of catch of fish in the angling fishery which would include some multiple captures. Capture rate and exploitation rate should be considered synonymous for comparison with

previous assessments for the Northumberland Strait, Nova Scotia, area rivers because previous documents used the term exploitation rate exclusively.

Two capture rates can be reported for East River, Pictou, for 1996: 0.69 based on the reported angling catch (harvest plus release) and the minimum pre-angling fishery population estimate; and 0.45 based on the same angling data and the maximum population estimate (Table 11). The two population estimates for East River resulted in catch rates of near 0.70 (max.) and 0.45 (min.) which could not be reconciled using information from the angling fishery. Consequently, the capture rate used for East River, Pictou, was the average of the two rates, 0.57.

The capture rate for River Philip in 1996 was calculated from the total angling catch of 837 fish and the pre-fishery population estimate of 1,345 fish to be 0.62 (Table 11).

A capture rate for the other North NS rivers was calculated as the mean of the East River (0.57) and River Philip (0.62) rates, at 0.595 or approximately, 0.60 (Table 11).

The capture rates for both East River, Pictou, and River Philip were higher than those typically assumed or estimated for the rivers on the Northumberland Strait coast of Nova Scotia. In 1995, the Margaree River exploitation rate for large salmon was 0.45 and for grilse, 0.26 (O'Neil *et al.* 1996). Assessments for the North NS area previous to 1995 used a range of exploitation rates derived from a number of years for the fall fishery on the Margaree River (Claytor *et al.* 1995; Chaput and Jones 1994). The range for large salmon was 0.09 to 0.27, and for grilse, 0.13 to 0.39. The 1996 estimated angling capture rate for the Margaree River for large salmon was 0.61, and for grilse, 0.56 (L. Marshall⁴, pers. comm.). The capture rate for large salmon was based on the population estimate for large fish (2,800) and the number reported angled on license stubs (1,710). The grilse capture rate on the Margaree was estimated from the population estimate for large fish, the proportion of the fish captured at the Levis trap as grilse (38%) and the license stub reported catch of grilse (964).

Although previous estimates of capture rates were low relative to the 0.60 value for the North NS area in 1996, the capture rates calculated for three separate Gulf Shore rivers, the East, Philip and Margaree, were consistent at near 0.60. In addition, a capture rate of 0.61 was noted on the Musquodoboit River on the eastern shore of Nova Scotia in 1996 (O'Neil *et al.* 1997). Separate capture rates for salmon and grilse could not be derived from the mark-recapture data.

If the capture rate is affected by the amount of effort, the capture rate on the rivers in the area with low effort estimates may have been lower. In the absence of data to confirm that possibility, the 0.60 capture rate was used to estimate returns (Table 11).

Forecast

The forecast of returns to rivers of North NS is confined to the three principal rivers in the area, East, Pictou; Philip and West, Antigonish. The forecast is based on the average of the most recent five-years of return estimates. In 1996, those estimates were based on the mark-and-recapture procedures used on East River, Pictou, and River Philip. Atlantic salmon returns to West River, Antigonish, were estimated from the capture rate of 0.60 derived from the East and Philip rivers and applied to the 1996 angling catch on the West River. In 1995 the return estimate was calculated using the Margaree River exploitation rates of 0.26 for grilse and 0.45 for large fish (O'Neil *et al.* 1996). The Atlantic salmon returns in 1993 and 1994 were estimated from the range of exploitation rates previously derived from the Margaree and a catch figure which was adjusted for a bias (Claytor *et al.* 1995; Chaput and Jones 1994). The procedure was described subsequently in O'Neil *et al.* (1996) and justification for discontinuing the angling catch bias adjustment was presented.

⁴ L. Marshall, Diadromous Fish Division, Science Branch, Fisheries and Oceans, Halifax, N.S.

The estimate of returns to the North NS rivers in the past has been based on exploitation rates from the Margaree River in the absence of data specific to the North NS rivers. The mark-and-recapture experiments were conducted in 1996 to provide information on these rivers.

The forecast return of large salmon to East River, Pictou, in 1997 is 146% of the conservation requirement; to River Philip, 160% of the requirement, and to West River, Antigonish, 117% of the desired conservation level (Table 13; Fig. 13). The forecast of grilse returns in 1997 for the same three rivers is well above the requirement. The East River, Pictou, grilse forecast is for over 240% of the 57 grilse required; for River Philip, grilse returns are forecast to exceed the requirement of 75 fish by over 400%. Only one grilse is required for West River, Antigonish to balance the male to female ratio and the forecast return for large salmon in 1997 is 17% more than the requirement so all grilse would be available for harvest. The five-year average return of grilse was estimated at 277 fish.

Management considerations

Returns of salmon to most of the Northumberland Strait, Nova Scotia, area rivers in 1996 were surplus to the conservation requirement. The two exceptions were the South and Wallace rivers where spawners fell short of requirements by a substantial margin (i.e., by at least 35% of the conservation requirement; Table 11). The sportfisheries on all rivers in the area are autumn, cool-water fisheries and are limited to a grilse harvest so do not present a threat to the stocks. The stocks of those two rivers could not sustain a directed harvest which would remove large salmon from the potential spawners.

Illegal removals of salmon are known to occur on most rivers in the area and fishery officers are becoming less able to estimate or control that removal. The estimate of removals in 1996 was over 700 fish (Table 10). Managers should exercise caution when allocating surplus fish because of the uncertainty about, but potential impact of, the illegal harvest.

The current management strategy in place for the Northumberland Strait, Nova Scotia, area rivers is restrictive in view of the forecast for the three principal stocks of the area for 1997.

Ecological considerations

Water levels on the Northumberland Strait Nova Scotia area rivers in 1996 were much higher through the angling season than in 1994 or 1995 (Fig. 14). Relatively heavy storms in September resulted in discharge levels on streams in the area which were higher than the recent mean discharge. Comparison of the 1996 discharge with the mean discharge over the period 1989-93, which excludes the low water levels noted in 1994 and 1995, provides insight into the magnitude of the storm events in 1996 (Fig. 14).

Water temperatures in 1996 on West River, Antigonish, were occasionally above 28°C but were generally not believed to be limiting with respect to the upper lethal temperature for juvenile Atlantic salmon (Garside 1973; Fig. 15).

Acknowledgements

V. Crowell participated in most aspects of the data collection and field programs and D. Stewart summarized the angler catch and effort data. Charles MacInnes provided the temperature record and direction and personnel support for the electrofishing work on West River, Antigonish. M. MacAdam of the Atlantic Salmon Federation assisted on the electrofishing surveys on the Wallace

River. The Nova Scotia Salmon Association coordinated the input of volunteers for some of the North NS program, and C. Purcell participated in snorkel dives on the East River and River Philip. The Pictou County Rivers Association, and in particular, B. Ferguson, deserve credit for the help they provided during our adult survey on East River and for the smolt and adult work on Middle River. T. Gloade and A. Gloade of Millbrook First Nation assisted on the Middle River smolt survey and the East and Philip river adult surveys. Pictou Landing First Nation contributed data on East River, Pictou, trap catches and riverside support for the East River and Sutherlands River adult counts. R. Jones and P. LeBlanc participated in the snorkel-diver surveys of River Philip and East River. Thanks are also due to the many anglers who recorded their catch and effort data on license stubs and to those who participated in the diary program.

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RECORD OF CLIENT CONSULTATION

<p>SPECIES / STOCK: Atlantic salmon in the Northumberland Strait area of Nova Scotia</p> <ul style="list-style-type: none"> • (mainland portion of SFA 18)
<p>ARRANGEMENTS:</p> <p>DATE: December 9, 1996</p> <p>TIME: 6:30 p.m.</p> <p>LOCATION: Museum of Industry, New Glasgow, Nova Scotia</p>
<p>FORM OF CONSULTATION</p> <ul style="list-style-type: none"> • Science and management participated in a joint consultative meeting
<p>PARTICIPANTS</p> <ul style="list-style-type: none"> • Bob Ferguson, President, Pictou County Rivers Association • Parker Wong, Pictou County Rivers Association • Benvie Cummings, Pictou County Rivers Association • Garfield Morash, Pictou County Rivers Association • Richard Kellock, Pictou County Rivers Association • Ken Trefry, Pictou County Rivers Association • Terry MacIntyre, Nova Scotia Salmon Association • Jason LeBlanc, Nova Scotia Department of Fisheries • Don MacLean, Nova Scotia Department of Fisheries • Shane F. O'Neil, Diadromous Fish Division, Science Branch, Fisheries and Oceans • Carolyn Harvie, Diadromous Fish Division, Science Branch, Fisheries and Oceans • Warren Parsons, Fisheries and Habitat Management Branch, Fisheries and Oceans • Leroy MacEachern, Area Managers Office, Fisheries and Oceans
<p>CONCERNS RAISED BY CLIENTS</p> <ul style="list-style-type: none"> • Validity of angling statistics; anglers tasked to communicate need for accurate data to fellow anglers. • Many anglers did not buy salmon licenses; how can that be corrected? C&P and province will have to discuss this winter - licensing controlled by province. • Hatchery closures - how can they act to ensure programs such as Middle River do not die in mid-program; No action required, client told to coordinate through NSSA or local association re expressions of interest. • How can anglers help in assessments or to improve runs? O'Neil to work on list of areas and provide to incoming president of Pictou County Rivers Association by spring 1997. • Providing list of surplusses may leave rivers vulnerable for additional directed harvest - Is this a good practice? Explained open assessment process is to allow client/co-manager to better understand, contribute, etc. No action required

RECOMMENDATIONS:
a.) Pertaining to Assessment
<ul style="list-style-type: none"> • Client advised not to state surplus but to restrict assessment output to having met or not met conservation requirement. • Want some action taken to improve angling statistics through licensing related to anglers hooking and releasing salmon without a license under the guise of trout fishing so data are not forthcoming from those individuals
b.) Pertaining to next year's workplans
<ul style="list-style-type: none"> • Provide detailed list of actions that clients can take to contribute to assessments and workplans. • DFO and province to work out temporary closure of Middle River to angling to allow stocked smolt to migrate from river to headpond.
Other Concerns:
<ul style="list-style-type: none"> • Client group agreed that rotating the client consultation meeting within the area would facilitate participation from clients from Cumberland and Antigonish counties. • Poor weather probably prevented many from attending; M. MacAdam from the Atlantic Salmon Federation could not make it, requested the information and will provide comment.
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Shane F. O'Neil

Shane F. O'Neil

NAME OF PRESENTER

NAME OF RAPPORTEUR

Table 1. Atlantic salmon sportcatch and effort for Northumberland Strait, Nova Scotia rivers for the years 1995, 1996 and mean values 1991-1995.

River	1996 Preliminary				1995				1991 - 95 means							
	Grilse		Salmon	Effort	Grilse		Salmon	Effort	Grilse				Salmon		Effort	
	retained	released	released		retained	released	released		retained	95% C.I.	released	95% C.I.	released	95% C.I.	roddays	95% C.I.
Northumberland Shore																
Barney's	11	3	9	32	1	0	0	5	2	4	1	2	4	5	41	47
East: Pictou Co.	31	38	281	840	22	16	48	459	42	33	28	22	233	213	931	519
French: Col. Co.	1	0	17	46	1	0	1	17	1	3	0	1	3	4	21	5
French: Pictou Co.	1	0	9	10	0	0	0	0	0	N/A	0	N/A	0	N/A	0	N/A
Middle: Pictou Co.	0	0	0	0	0	0	0	0	0	N/A	1	N/A	1	N/A	4	N/A
Pomquet	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pugwash	0	0	0	0	0	0	0	0	0	N/A	0	N/A	0	N/A	0	N/A
River John	20	12	121	268	10	2	17	121	15	10	4	4	56	35	182	54
River Philip	172	61	604	1804	105	33	235	1501	109	45	38	24	298	118	1417	269
Shinimikas	0	0	0	0	0	0	0	1	0	N/A	0	N/A	0	N/A	1	N/A
South	11	16	24	113	1	2	0	65	3	4	4	3	6	5	56	24
Sutherlands	0	0	0	3	1	0	0	3	1	2	0	0	0	1	10	14
Tidnish	0	0	0	0	0	0	0	0	0	N/A	0	N/A	0	N/A	0	N/A
Tracadie	0	0	0	0	0	0	0	0	0	N/A	0	N/A	0	N/A	3	N/A
Wallace	20	5	90	437	16	11	26	615	18	7	12	2	73	40	557	236
Waugh	26	4	133	445	14	9	37	217	12	5	7	3	48	42	183	87
West: Antigonish Co.	116	186	498	1017	50	35	142	610	46	22	33	21	217	96	756	141
West: Pictou Co.	62	27	199	765	26	10	38	464	24	15	8	4	100	83	476	201
Wright	0	0	0	0	0	0	0	0	0	N/A	0	N/A	0	N/A	1	N/A
Totals	471	352	1985	5780	247	118	544	4078	274		135		1040		4638	

Table 2. First Nation Atlantic salmon harvest allocations and reported harvests in the Northumberland Strait, Nova Scotia, area in 1996.

First Nation	River/area	Harvest plan or license allocation		Reported harvest	
		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	2	45
	Wallace - spring	5	20		
	- fall	25	30		
	Waugh - spring	5	20		
	- fall	10	15		
Pictou Landing	East, Pictou ^a	35	140	11	49
	Merigomish Hbr.	10	30		
	River John	10	24		
	West, Pictou	8	16		
Native Council	SFA 18	1820 ^b			

a In addition to the harvest on East River noted, 3 fish of unknown size were also harvested and at least three fish were released.

b Tags available for issue but not necessarily issued.

Table 3. The drainage basin areas, habitat areas, egg requirements and spawner requirements for the Northumberland Strait, Nova Scotia, area rivers.

River	Drainage basin area (m ² x 10 ²)	Reference river for area estimate	Habitat area ¹ (m ² x 10 ²)	Egg requirements		
				@240 eggs/100 m ² (in 1000s of eggs)	Spawner requirements ²	
				Grilse	Salmon	
Afton River	432,526	South	189	45	0	14
Barney's River	1,564,104	Philip	2,128	511	17	79
East River, Pictou	5,359,716	Philip	7,291	1,750	57	271
French, Colchester	2,060,853	Philip	2,804	673	22	104
French River, Pictou	1,278,680	Philip	1,740	417	14	65
Middle River, Pictou	2,170,644	Philip	2,953	709	23	110
Pomquet River	1,756,531	South	769	185	1	57
Pugwash River	1,815,574	Philip	2,470	593	19	92
River John	2,920,443	Philip	3,973	954	31	148
River Philip	7,259,707	Philip	9,621	2,309	75	358
South River	2,170,158	South	950	228	0	70
Sutherlands River ³			666	160	5	25
Tracadie (Monastery) Ri	1,202,519	South	526	126	1	39
Wallace River	4,578,838	Philip	6,229	1,495	49	232
Waugh River	2,301,964	Philip	3,132	752	25	116
West River, Antigonish	3,530,382	Philip	4,803	1,153	1	353
West River, Pictou	2,445,182	Philip	3,326	798	26	124
Totals			53,570	12,857	365	2255

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 Spawner requirements based on biological characteristics from East River, Pictou, except for the Afton, Pomquet, South and Tracadie rivers which have spawner requirements based on data from South River.

³ Area below falls, from Chaput and Jones 1994.

Table 4. 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 5. Number of fry and parr caught within five minutes of electrofishing on several Northumberland Strait, Nova Scotia, rivers, 1992-1996. Data for 1992-1994 from Chaput and Jones (1994) and Claytor et.al. (1995).

River	Site	Fry (0+ parr) caught in 5 minutes					Parr (1+ and 2+) caught in 5 minutes				
		1992	1993	1994	1995	1996	1992	1993	1994	1995	1996
River Philip	1										
	2				7				1		
	3				104				20		
	4										
	5		4					3			
	6		90					33			
Wallace	1		14		26	31		10	12	12	
	2		11		50			3	2		
	3		37		26	48		31	17	5	
	4		24		16	14		26	11	12	
	5		25		16	12		14	6	20	
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) (all sites fished 10 min. except 96.5 fished 15 min.)	95.1				0				3	6	
	95.2				0	3			3	7	
	95.3				0				0	4	
	95.4				0	0			0	0	
	96.5									5	
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	30	28		42	24	28
	2	0			0		0		0		
	3	91		100	61	42	17		27	12	19
French	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		

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 1996. Data for 1978 from Cameron and Gray (1979) and for 1991 to 1994 from Chaput and Jones (1994) and Claytor et. al. (1995). The 95% confidence intervals are given in brackets under the density value for those sites fished by the current authors. The rivers are listed geographically from west to east.

River	Site	Fry (0+ parr) per 100 m ²							Parr (1+ and 2+) per 100 m ²						
		1978	1991	1992	1993	1994	1995	1996	1978	1991	1992	1993	1994	1995	1996
River Philip	1				0.0		21.6 ^a				36.0		53.5		
													(52.0-54.7)		
Wallace	3 ^b	56.9						7.9							
	6 ^c	65.3					86.1	20.4					10.4		
							(69.7-106.3)						(4.7-18.4)		
	7						7.9						17.8		
							(2.8-14.4)						(10.7-28.4)		
East River, Pictou	3	41.7	116.8		34.0	104.8		39.6		30.1	27.0	28.3			
							(85.6-126.9)					(18.6-40.4)			
	4		342.5	64.0	169.0	123.6				84.0	34.0	40.6			
							(102.7-147.4)					(29.4-55.6)			
	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	1	64.2					110.2	5.1					28.0		
													(18.6-40.4)		
	2	24.6	268.1		238.0	195.5	182.7	24.6	86.6	145.0	126.8	179.2			
													(153.9-207.4)		
	3	29.1					62.1	0.5					20.9		
													(13.0-32.0)		
	4	71.8	226.4	244.8	165.0	275.0	237.2	356.9	52.5	67.7	78.2	51.0	71.0	78.6	165.3
														(141.0-192.5)	
	5						113.0						42.8		
							(119.1-106.8)						(41.5-44.0)		
Pomquet	6		3.2		0.0					20.5	13.0				

a Regression was not possible to estimate density; estimate calculated using the parr capture rate and the actual number of fry caught (20).

b named site 6 in 1978

c named site 4 in 1978

Table 7. Atlantic salmon mark and count data during the mark-and-recapture surveys (snorkel-diver surveys) on East River, Pictou, and River Philip in 1996.

East River, Pictou

Marks (tags) applied Oct. 28/96 Snorkel-diver survey Nov. 4/96

Sections	Tags ¹	Diver survey (captures)		
		Large salmon	Grilse	Recaptures
Section A: Sunnbrae to St. Pauls	2	14	4	3
Section B: St. Pauls to Springville	51	44 ²	4	4
Section C: 0.5 km above Iona Church Bridge to Eureka, West Branch	14	29	2	2
Total	67	87	10	9

¹ Location of tags applied: Section A: lower end of section; Section B: 27 marked in mid-section and 24 at lower end of section; Section C: 0.5 km below top of section.

² One large salmon counted at lower end of section near Springville; not included in minimum population estimate.

River Philip

Marks (tags) applied Nov. 5/96 Snorkel-diver survey Nov. 6/96

Sections	Marks	Diver survey (captures)		
		Large salmon	Grilse	Recaptures
Section A: Thompson Rd. Bridge to Williamsdale	13	86	14	5
Section B: Williamsdale to River Philip Centre	6	103	5	4
Section C: River Philip Centre to Oxford Junction	14	191	15	3
Total	33	380	34	12

Table 8a. Mark-and-recapture data and minimum estimates of adult Atlantic salmon returns to East River, Pictou, in 1996.

Marks applied = 43 (41 large salmon and 2 grilse)
 Captures = 96
 Recaptures = 9

	Petersen (corrected)		Bayesian	
	Estimate	90% C.I.	Estimate	90% C.I.
Post-fishery estimate	426	202 - 1040	457	317 - 1003
Retained grilse	31		31	
5% hook-and-release mortality ¹	16		16	
Pre-fishery estimate	473	249 - 1087	504	364 - 1050

¹ Preliminary 1996 angling catch reported by anglers on license stubs was 319 released grilse and salmon.

Table 8b. Mark-recapture data and maximum estimates of adult Atlantic salmon returns to the East River, Pictou, in 1996.

Marks applied = 67 (63 large salmon and 4 grilse)
 Captures = 97
 Recaptures = 9

	Petersen (corrected)		Bayesian	
	Estimate	90% C.I.	Estimate	90% C.I.
Post-fishery estimate	665	316 - 1624	723	499 - 1570
Retained grilse	31		31	
5% hook-and-release mortality ¹	16		16	
Pre-fishery estimate	712	363 - 1671	770	546 - 1617

¹ Preliminary 1996 angling catch reported by anglers on license stubs was 319 released grilse and salmon.

Table 9. Calculation of pre-angling fishery returns and the proportion of Atlantic salmon at age (grilse and large salmon) from the mark-and-recapture data (snorkel-diver survey results) and population estimates for East River, Pictou, and River Philip in 1996.

East River, Pictou

Assumed 5% hook-and-release mortality

Population estimates (from Table 8a,b)		Angling catch	
Minimum post-fishery population estimate	457	Grilse retained	31
Maximum post-fishery population estimate	723	Grilse released	38
		Large salmon released	281

	Minimum pop. est.		Maximum pop. est.	
	Formula	Result	Formula	Result
# grilse counted in snorkel survey (post-fishery) =		10		10
# large salmon counted in snorkel survey (post-fishery) =		87		87
% of pop. est. counted in survey (post-fishery) =	$(10 + 87) / 457$	= 21.2%	$(10 + 87) / 723$	= 13.4%
Estimate of fish removed from pop. by angling fishery =	$31 + 5\% * (38 + 281)$	= 47	$31 + 5\% * (38 + 281)$	= 47
Pre-angling fishery population estimate =	$457 + 47$	= 504	$723 + 47$	= 770
Pre-angling fishery survey estimate =	$504 * 21.2\%$	= 107	$770 * 13.4\%$	= 103
Estimate of grilse removed by angling fishery =	$31 + 5\% * 38$	= 33	$31 + 5\% * 38$	= 33
Estimate of grilse in pre-angling fishery survey =	$10 + 21.2\% * 33$	= 17	$10 + 13.4\% * 33$	= 14
% grilse in pre-angling fishery population =	$17 / 107$	= 15.9%	$14 / 103$	= 14.0%
% large salmon in pre-angling fishery population =	$(107 - 17) / 107$	= 84.1%	$(103 - 14) / 103$	= 86.0%
Pre-angling fishery returns estimate by size =				
	Grilse:	80	Grilse:	107
	Large salmon:	424	Large salmon:	663

River Philip (calculations as above)

Assumed 5% hook-and-release mortality

Population estimate (from Table 9)		Angling catch	
Post-fishery population estimate	1140	Grilse retained	172
		Grilse released	61
		Large salmon released	604

	Population estimate	
	Formula	Result
% of pop. est. counted in survey (post-fishery) =	$(34 + 380) / 1140$	= 36.3%
Pre-angling fishery population estimate =	$1140 + 205$	= 1345
% grilse in pre-angling fishery population =	$98 / 489$	= 20.0%
% large salmon in pre-angling fishery population =	$(489 - 98) / 489$	= 80.0%
Pre-angling fishery returns estimate by size =		
	Grilse:	269
	Large salmon:	1076

Table 10. Estimated numbers of large salmon illegally removed from rivers of the Northumberland Strait, Nova Scotia, area in 1995 and 1996.

River	Number of MSW salmon ¹	
	1995	1996
Afton	5	5
Barney's	25	25
East, Pictou	75	125
French, Colchester	20	20
French, Pictou	25	25
Pomquet	20	20
Pugwash	50	50
River John	60	100
River Philip	100	100
Shinimicas	30	30
South	20	10
Sutherlands	10	20
Tracadie	20	30
Wallace	40	40
Waugh	40	40
West, Antigonish	20	15
West, Pictou	30	50
Total	590	705

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

Table 11. Atlantic salmon spawner requirements (habitat areas, eggs, and adults), returns, escapements and returns relative to conservation requirements (surplus or deficit) for Northumberland Strait, Nova Scotia, rivers in 1996^a.

River	Habitat area (m ² *10 ²)	Requirements		Catch						Estimated returns		Estimated escapement		Capture rate ^c	Surplus or deficit ^d			
		Eggs x 10 ³	Spawners		Preliminary angling catch			First Peoples' harvest ^b		Grilse	Salmon	Grilse	Salmon		Grilse	Salmon	Grilse	Salmon
			Grilse	Salmon	grilse	Salmon	retained	Grilse	Salmon									
Afton	189	45	0	14	0	0	0				N/A	N/A				N/A	N/A	
Barney's	2,128	511	17	79	11	9	14				N/A	N/A				N/A	N/A	
East River, Pictou	Min^e 7,291	1,750	57	271	69	281	31	11	49		91	473	47	410	0.69	-10	139	
	Max^e 7,291	1,750	57	271	69	281	31	11	49		118	712	75	648	0.45	18	377	
	Mean^e 7,291	1,750	57	271	69	281	31	11	49		105	592	61	529	0.57	4	258	
French, Colchester	2,804	673	22	104	1	17	1				N/A	N/A						
French, Pictou	1,740	417	14	65	1	0	1				N/A	N/A						
Middle, Pictou	2,953	709	23	110	0	0	0				N/A	N/A						
Pomquet	769	185	1	57	0	0	0				N/A	N/A						
Pugwash	2,470	593	19	92	0	0	0				N/A	N/A						
River John	3,973	954	31	148	32	121	20				53	202	33	196	(0.60)	2	48	
River Philip	9,621	2,309	75	358	233	604	172	2	45		269	1077	94	1046	0.62	19	688	
South	950	228	0	70	27	24	11				45	40	33	39	(0.60)	33	-31	
Sutherlands ^f	666	160	5	25	0	0	0				19	59	19	59		14	34	
Tracadie (Monastery)	526	126	1	39	0	0	0				N/A	N/A						
Wallace River	6,229	1,495	49	232	25	90	20				42	150	22	146	(0.60)	-27	-86	
Waugh	3,132	752	25	116	30	133	26				50	222	24	216	(0.60)	-1	99	
West River, Antigonish	4,803	1,153	1	353	302	498	116				505	832	379	807	(0.60)	378	454	
West River, Pictou	3,326	798	26	124	89	199	62				149	333	85	323	(0.60)	59	199	
Average expl. rate														0.60				

- a No catch was reported so returns and escapements could not be calculated for Afton; Barney's; French, Colchester; French, Pictou; Middle, Pictou; Pomquet; Pugwash; and Tracadie (Monastery) rivers.
- b First Peoples' harvest on East River occurred in the estuary below any angling fishery and the River Philip harvest occurred after the angling fishery, within the river, but after the fish had spawned; harvest values were included in the returns estimates and in the case of River Philip would also be in the escapement estimate. The Native harvest on River Philip was not subtracted from the returns estimate to arrive at escapement as the fish had spawned before they were harvested.
- c Capture rates calculated from mark-and-recapture population estimates and reported angling catch on East River (2 expl. rates) and River Philip; the average of the calculated expl. rates was used for the other rivers in the area and those values are enclosed in brackets.
- d Surplus large salmon may preclude the need for any grilse as all eggs are expected to come from large salmon; grilse spawners are only required to provide males to ensure a 1:1 ratio of male to female.
- e Two population estimates were done based on a mark-recapture experiment and the snorkel-diver count data. The mean return, escapement, and capture rate is the average of the two estimates derived from the mark-recapture data. For an explanation refer to text.
- f Escapement for Sutherlands River was based on a snorkel-diver survey.

Table 12. Mark-and-recapture data and estimates of adult Atlantic salmon returns to River Philip in 1996.

Marks applied =	33			
Captures =	414			
Recaptures =	12			
	Petersen (corrected)		Bayesian	
	Estimate	90% C.I.	Estimate	90% C.I.
Post-fishery estimate	1084	563 - 2391	1140	800 - 2190
Retained grilse	172		172	
5% hook-and-release mortality ¹	33		33	
Pre-fishery estimate	1289	845 - 2164	1345	945 - 2655

¹ The preliminary 1996 angling catch reported by anglers on license stubs was 665 released grilse and salmon.

Table 13. Estimates of returns, escapements and percentage of conservation requirements achieved with five year (1992-96) means for East River, Pictou; River Philip; and West River, Antigonish. Estimates for 1992-1994 are revised from Claytor et al. (1995) to reflect changes in habitat areas; the 1995 figures are from O'Neil et al. (1996); and the 1996 figures are based on a mark-recapture experiment (East and Philip) or a capture rate (West).

Year	Grilse				Large salmon			
	Returns		Escapement		Returns		Escapement	
	Number	% of requirement	Number	% of requirement	Number	% of requirement	Number	% of requirement
East River, Pictou								
1992	251	440 %	184	323 %	523	193 %	519	192 %
1993	127	223 %	92	161 %	456	168 %	313	115 %
1994	60	105 %	41	72 %	265	98 %	123	45 %
1995 ^a	152	267 %	127	223 %	141	52 %	111	41 %
1996 ^{a,b}	105	184 %	61	107 %	592	218 %	529	195 %
Mean 1992-1996	139	244 %			395	146 %		
River Philip								
1992	398	531 %	292	389 %	461	129 %	457	128 %
1993	373	497 %	276	368 %	474	132 %	469	131 %
1994	198	264 %	137	183 %	281	78 %	264	74 %
1995 ^a	568	757 %	430	573 %	572	160 %	508	142 %
1996	269	359 %	94	125 %	1076	301 %	1046	292 %
Mean 1992-1996	361	482 %			573	160 %		
West River, Antigonish								
1992	312	- ^c	233	- ^c	398	113 %	395	112 %
1993	148	- ^c	108	- ^c	339	96 %	335	95 %
1994	105	- ^c	77	- ^c	181	51 %	180	51 %
1995	315	- ^c	266	- ^c	307	87 %	300	85 %
1996	505	- ^c	379	- ^c	832	236 %	807	229 %
Mean 1992-1996	277	- ^c			411	117 %		
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 on East River and River Philip. The 1996 return estimate includes First Nation catches on East River only.

b The 1996 return estimate is based on the mean population estimate.

c 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.

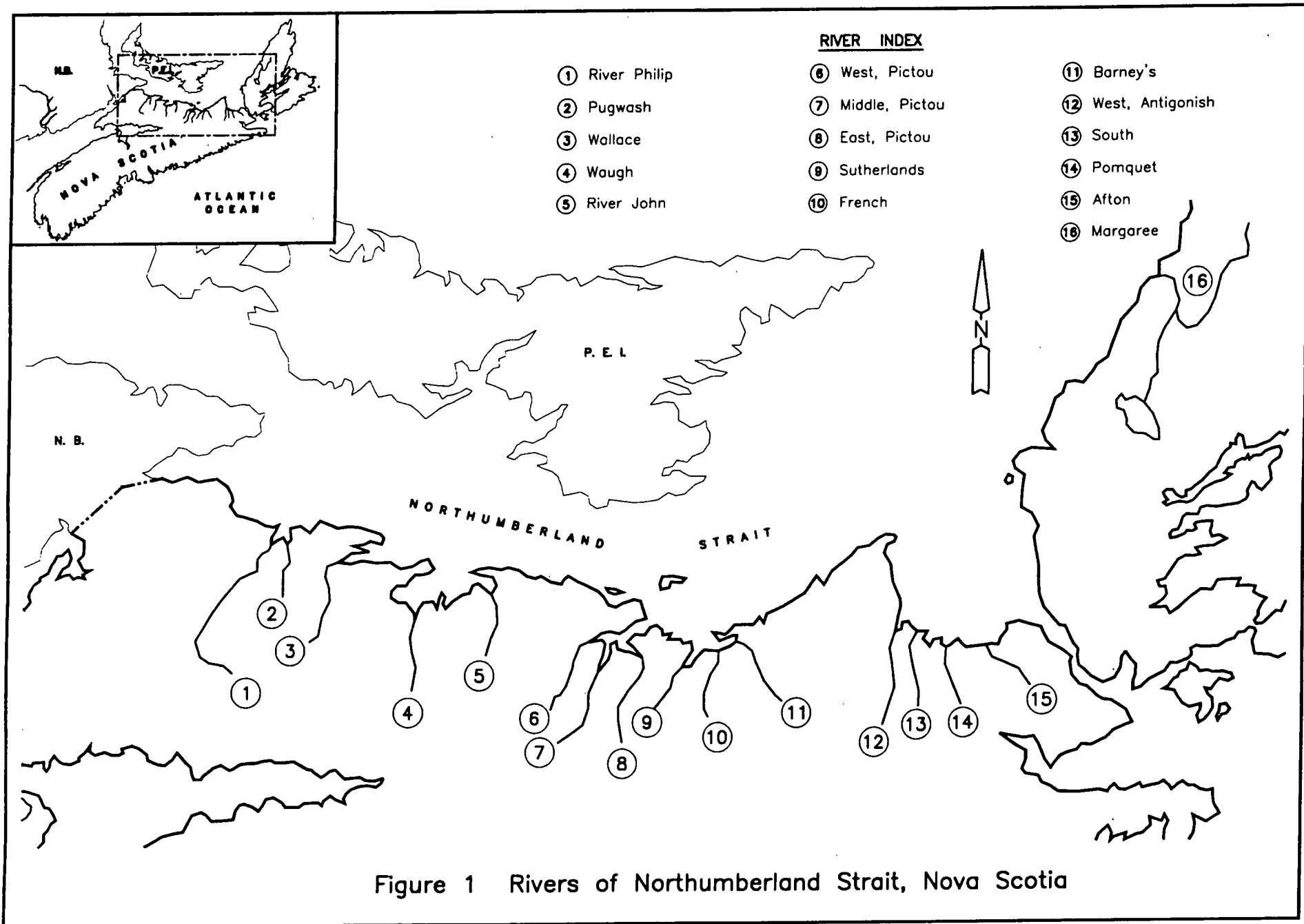


Figure 1 Rivers of Northumberland Strait, Nova Scotia

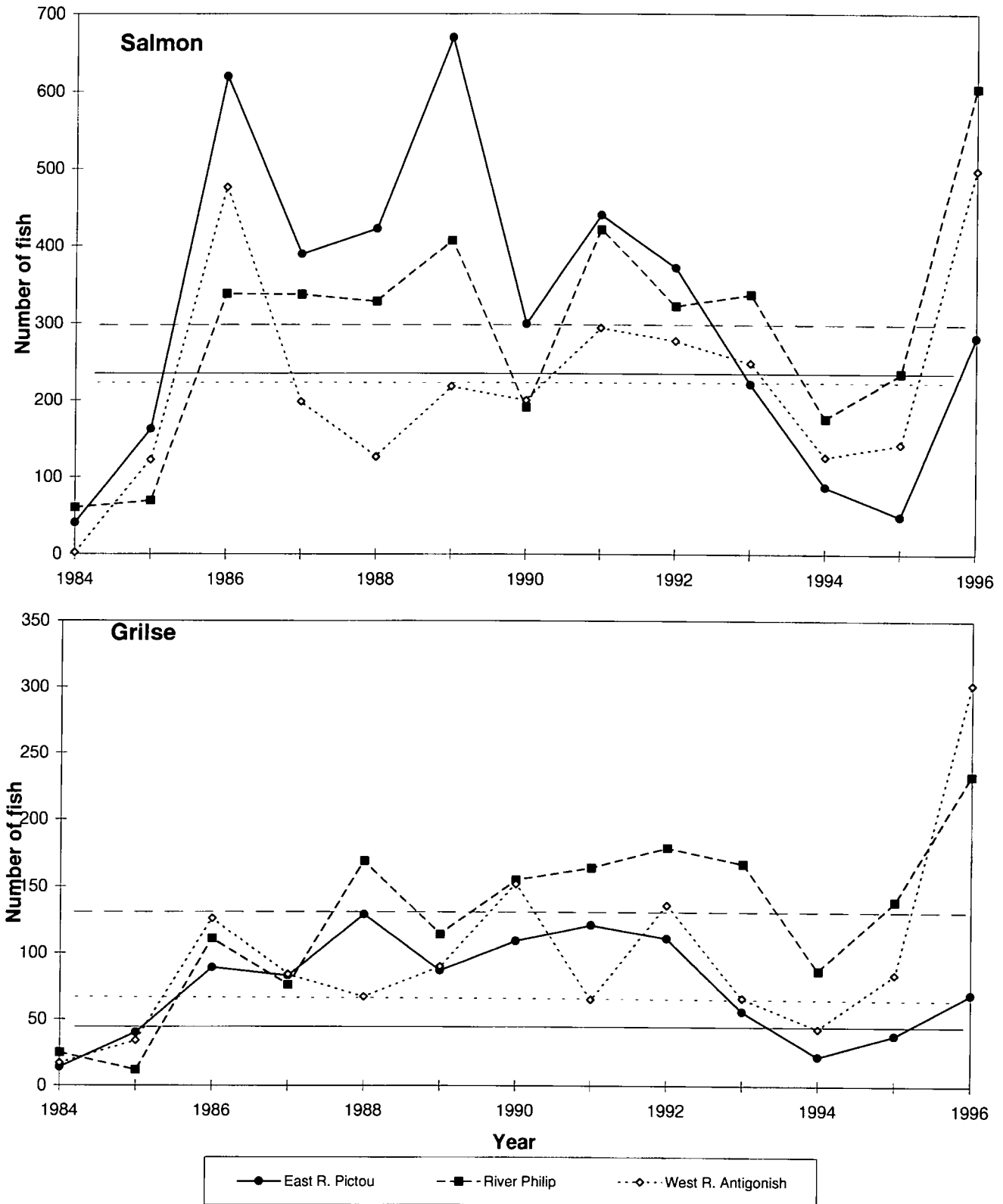


Figure 2. The number of salmon and grilse (retained plus released) angled on the three principal rivers of the Northumberland Strait, Nova Scotia, area, 1984-96. Data are from license stub reports. The horizontal lines represent the five-year mean catch (1991-95) for each river.

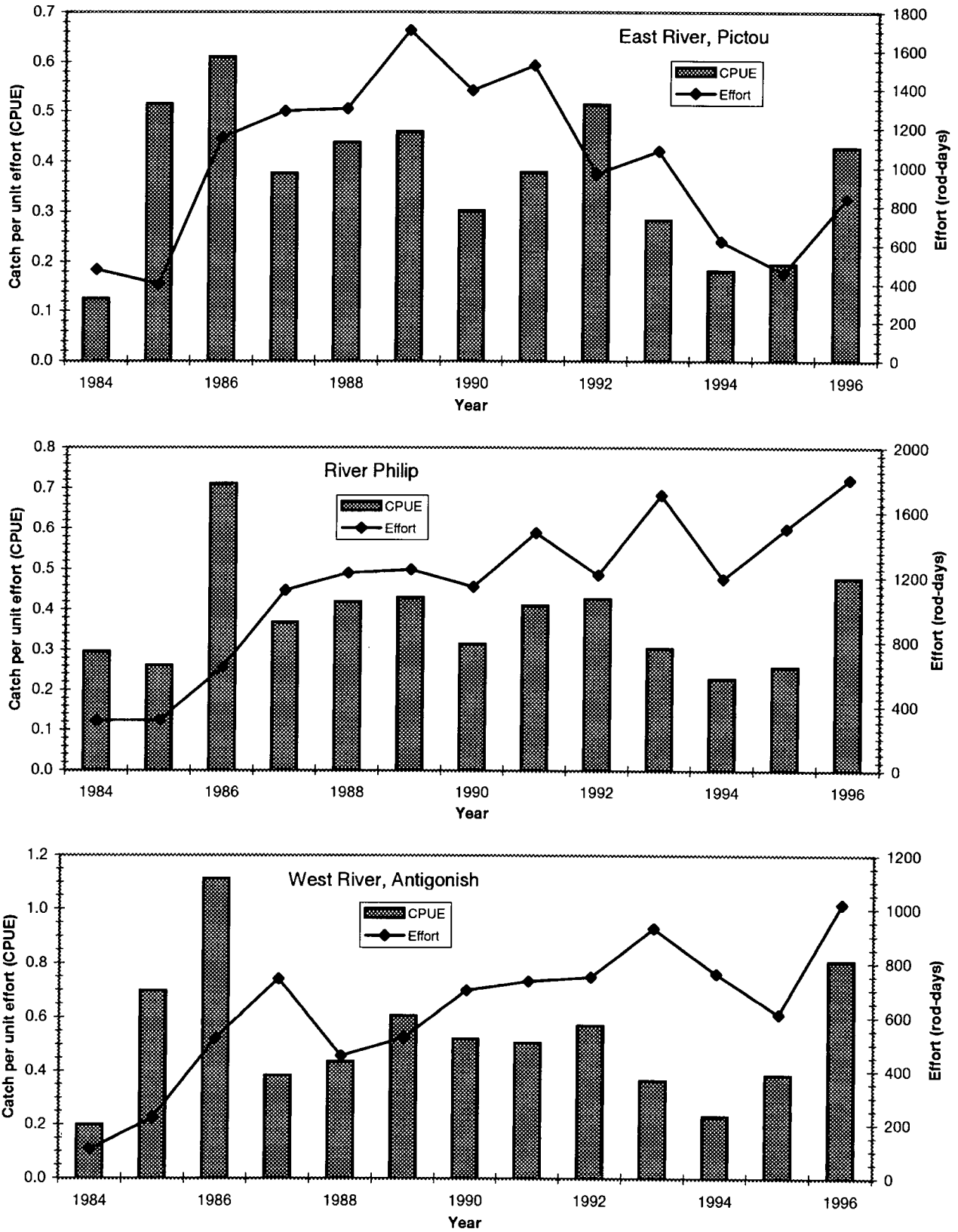


Figure 3. Catch per unit effort and effort from license stub data for 3 rivers in the Northumberland Strait, Nova Scotia, area, 1984-1996.

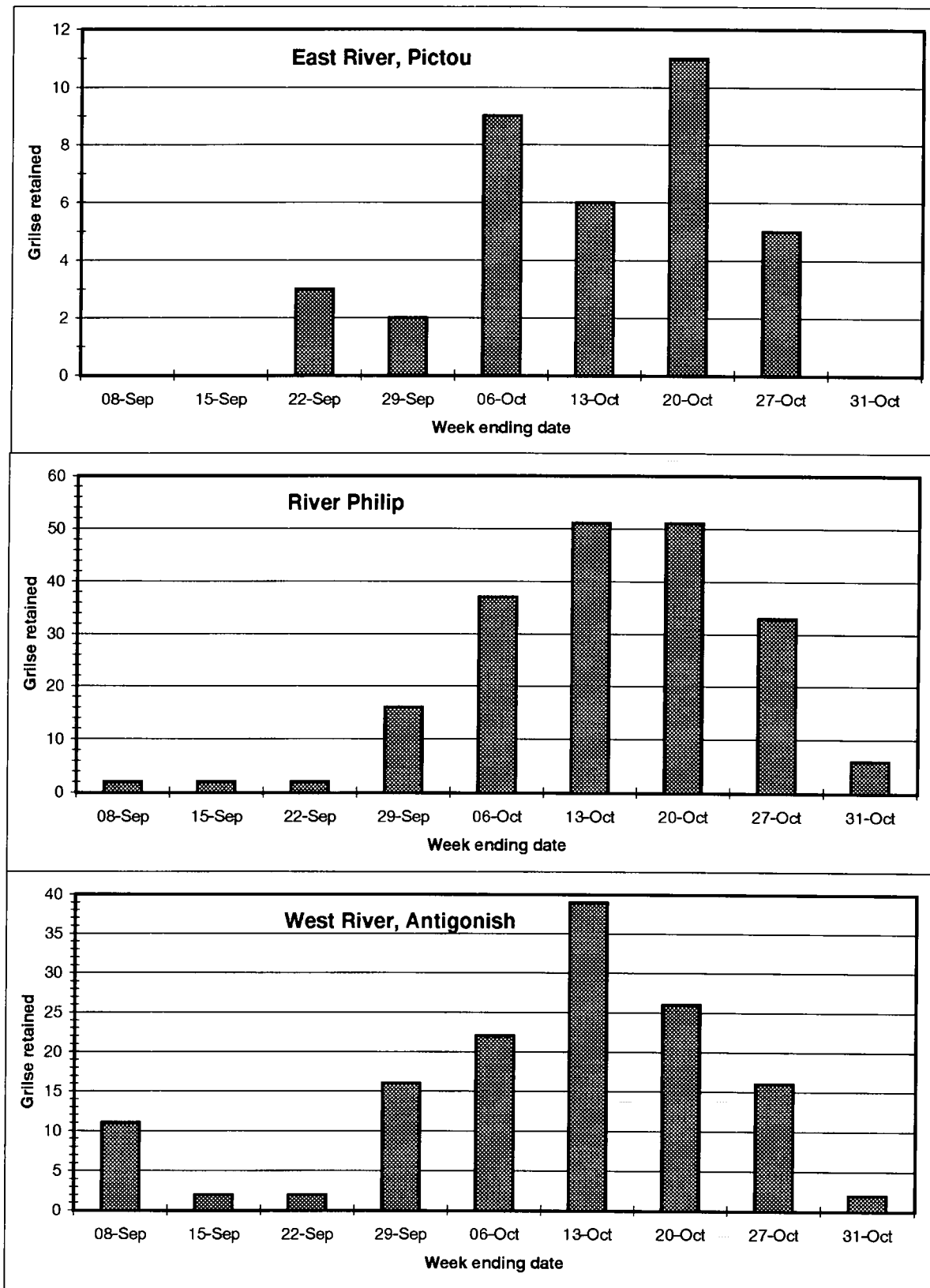
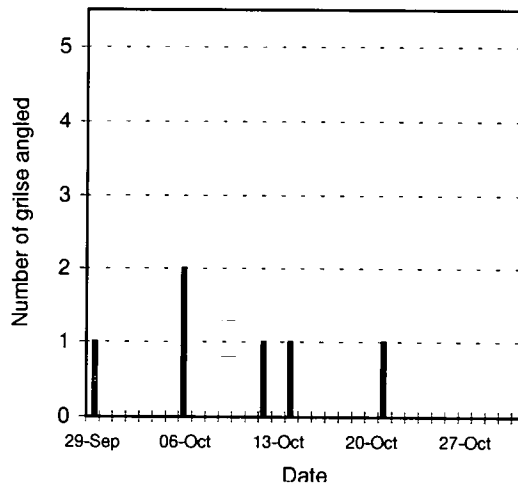
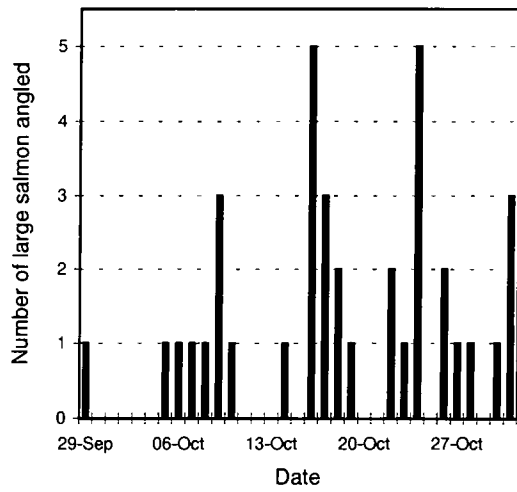
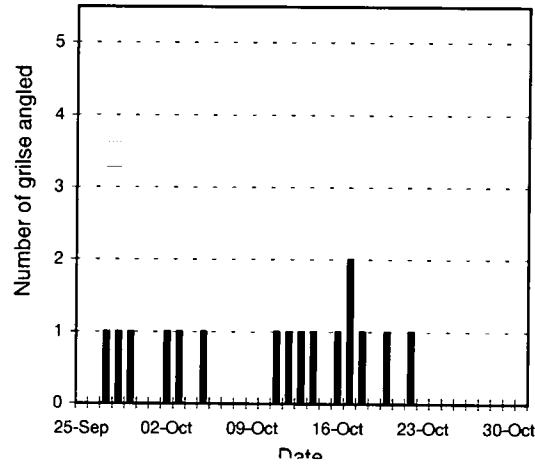
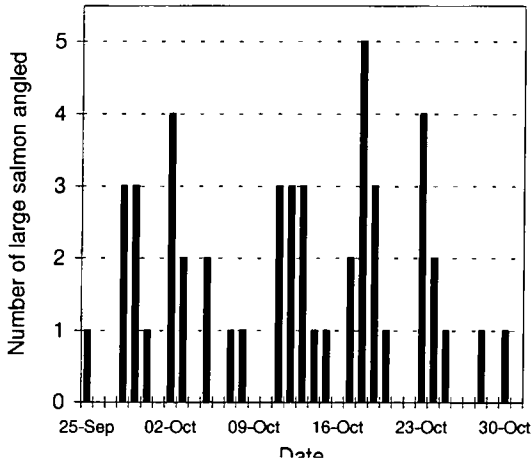


Figure 4. Retained angling catches of grilse by week as reported on license stubs on the East River, Pictou; River Philip; and West River, Antigonish, in 1996.

East River (Pictou)



River Philip



West River (Antigonish)

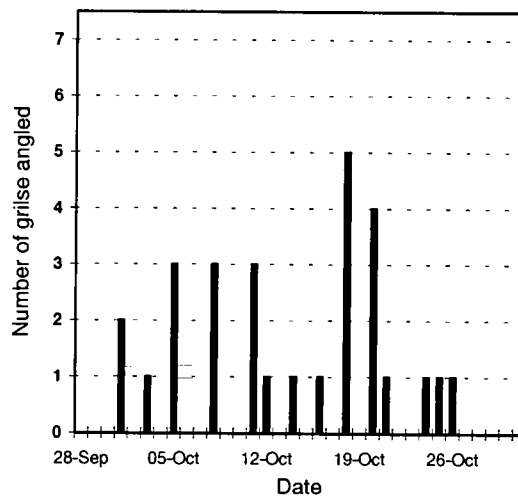
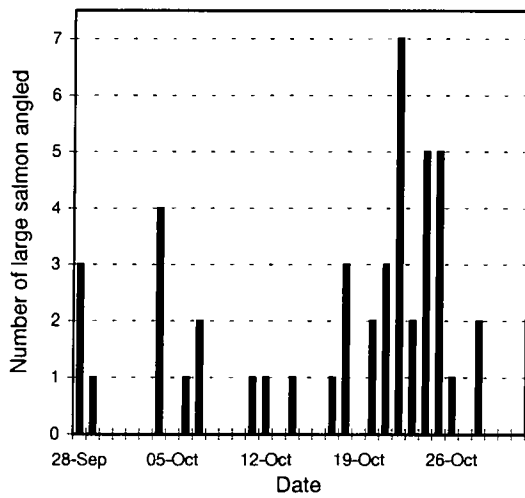


Figure 5. Run timing of large salmon and grilse based on dated catch reports from logbooks, on East River, Pictou; River Philip and West River, Antigonish, in 1996.

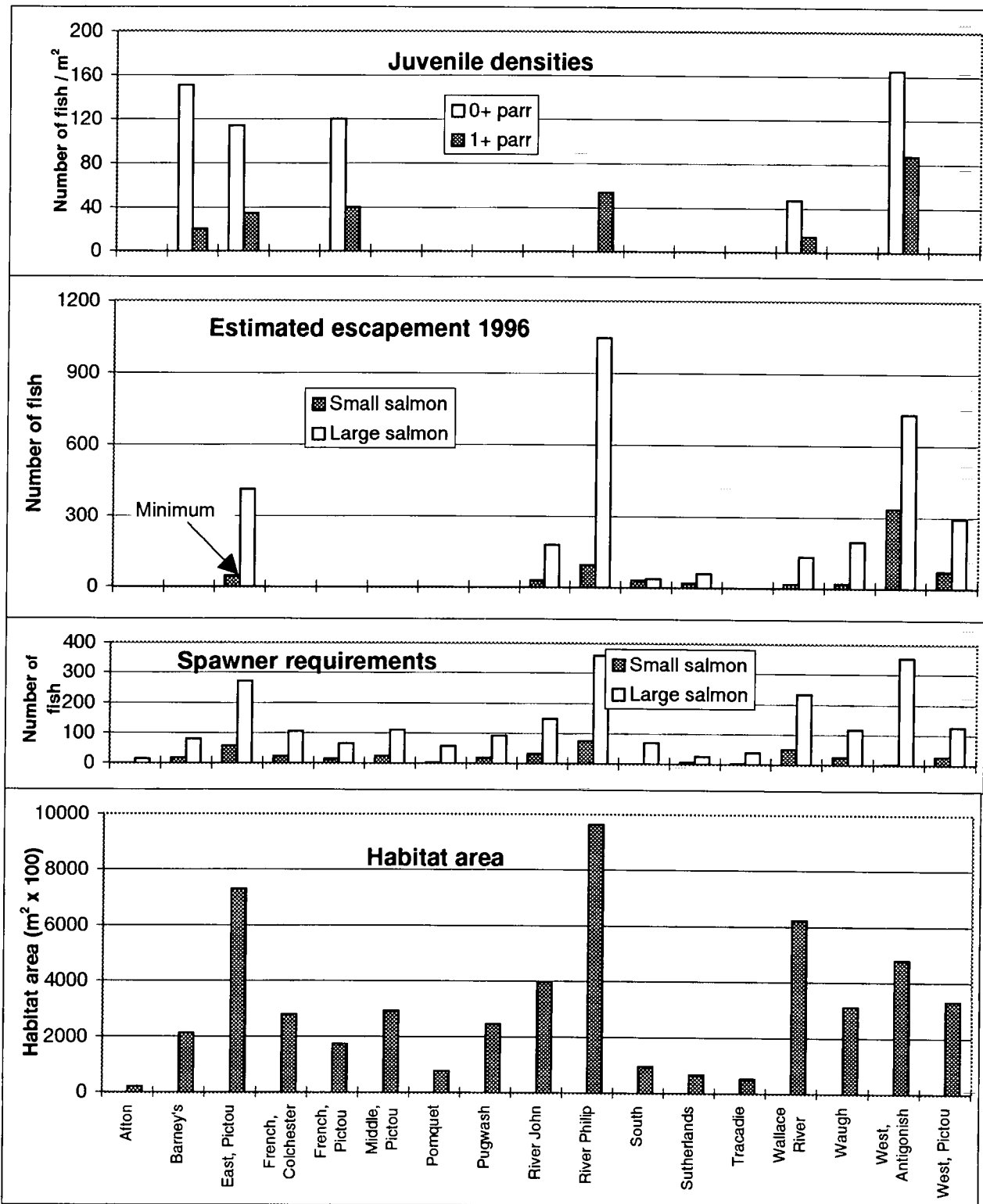


Figure 6. Habitat areas, spawner requirements, estimated escapements in 1996, and the juvenile densities (most recent year) for several salmon rivers on the Northumberland Strait area of mainland Nova Scotia. The minimum figure for East River, Pictou, for the 1996 escapement estimate is the lower of the two estimates provided in the text.

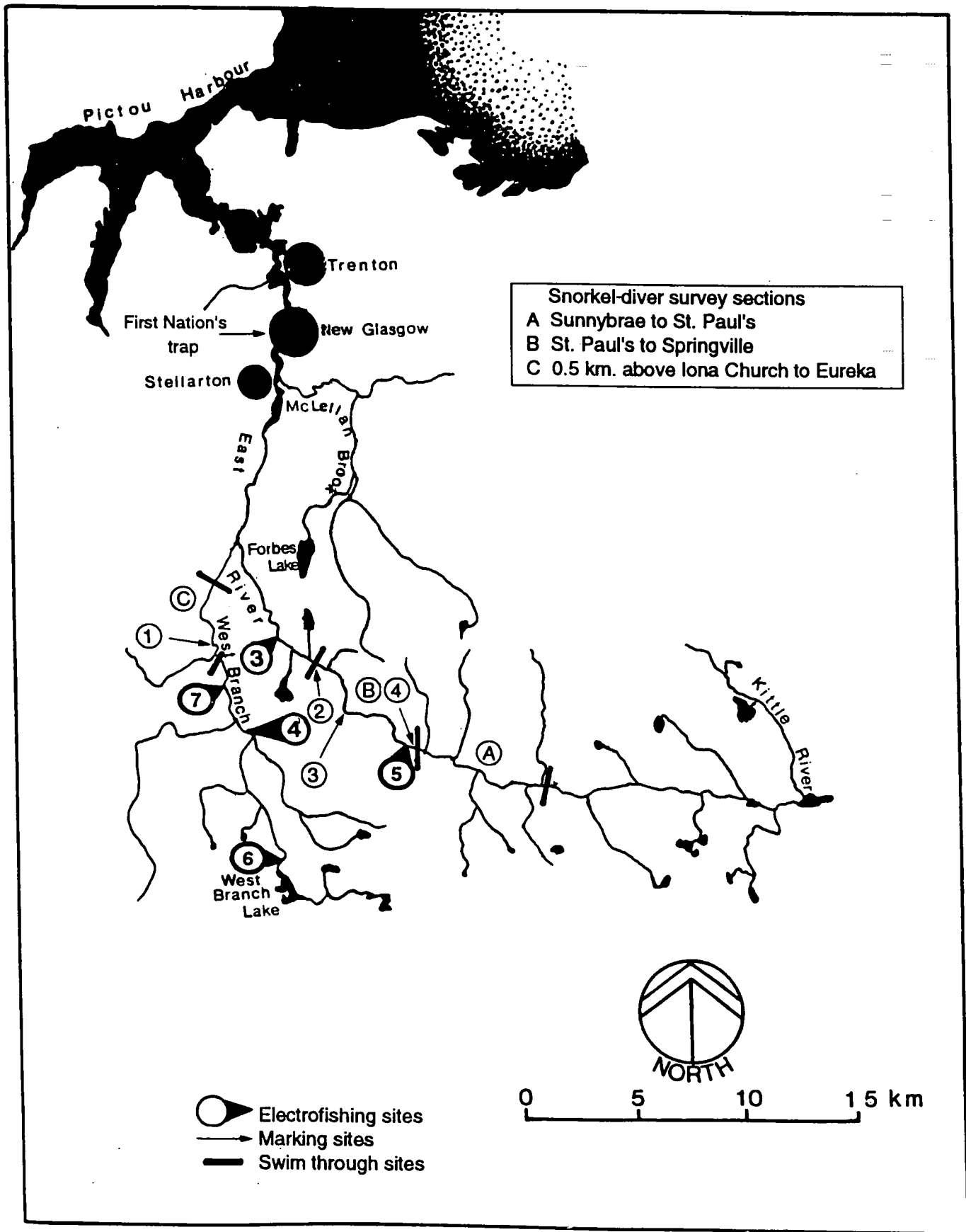


Figure 7. Electrofishing site locations and the Atlantic salmon marking sites and snorkel-diver survey areas for the mark-and-recapture experiment to estimate the adult salmon population in 1996.

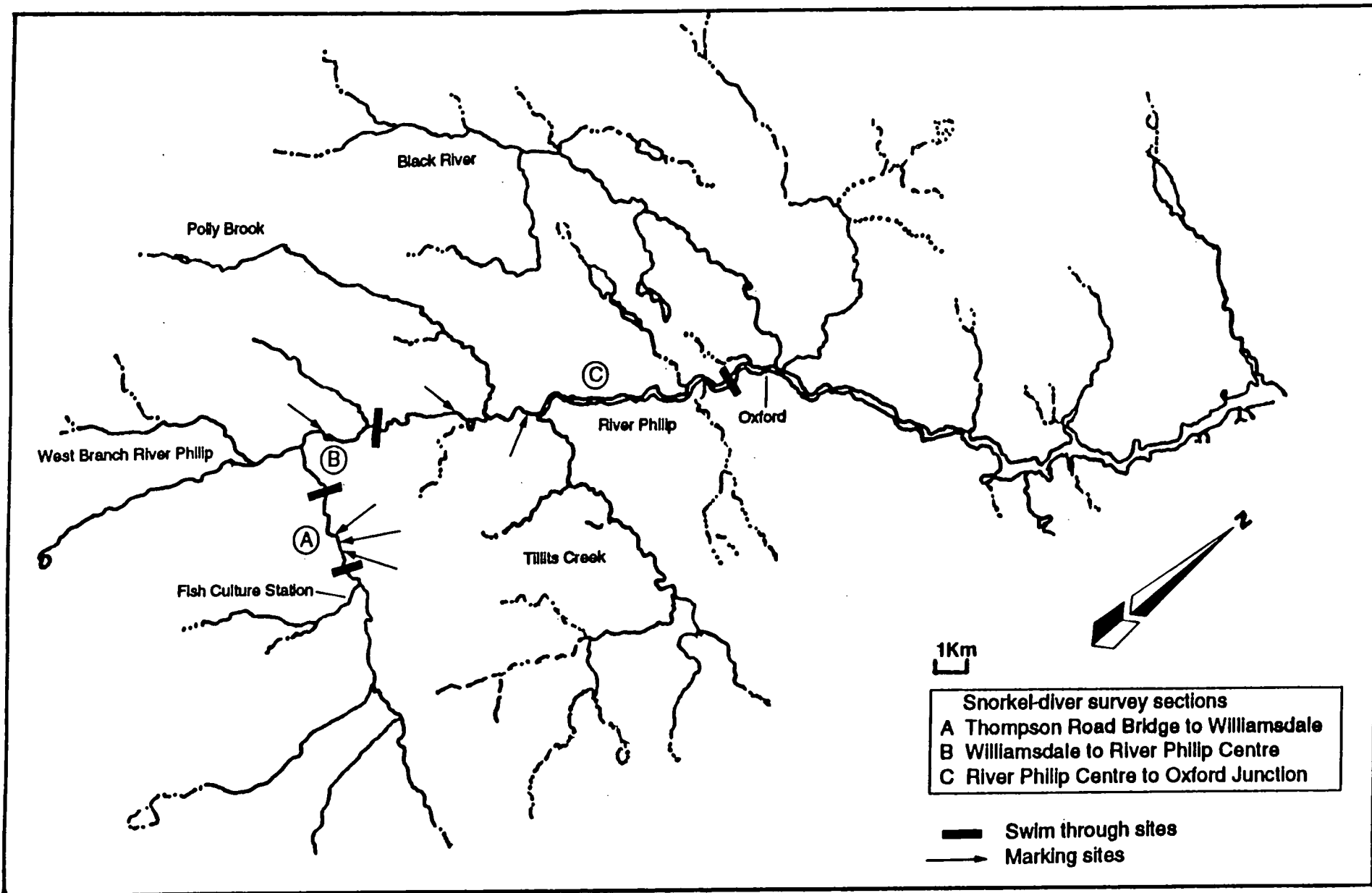


Figure 8. Atlantic salmon marking sites and snorkel-diver survey sections covered during the mark-and-recapture experiment to estimate the adult salmon population on River Philip in 1996.

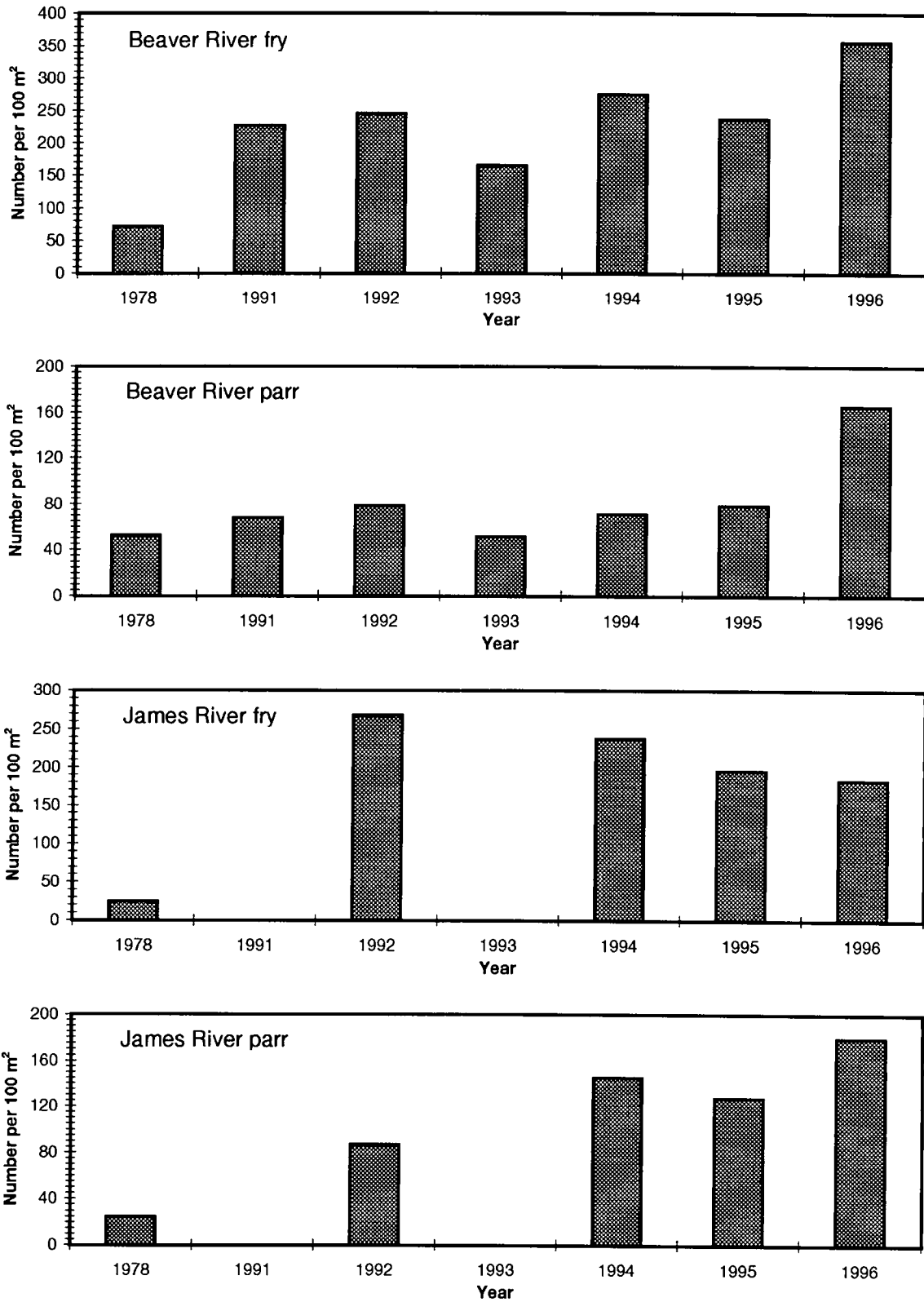


Figure 9. Densities of juvenile Atlantic salmon caught by electrofishing at two sites on West River, Antigonish, at Beaver River (site 4) and at James River (site 2), in 1996. Habitat improvements were completed at the James River site during 1989 and 1990.

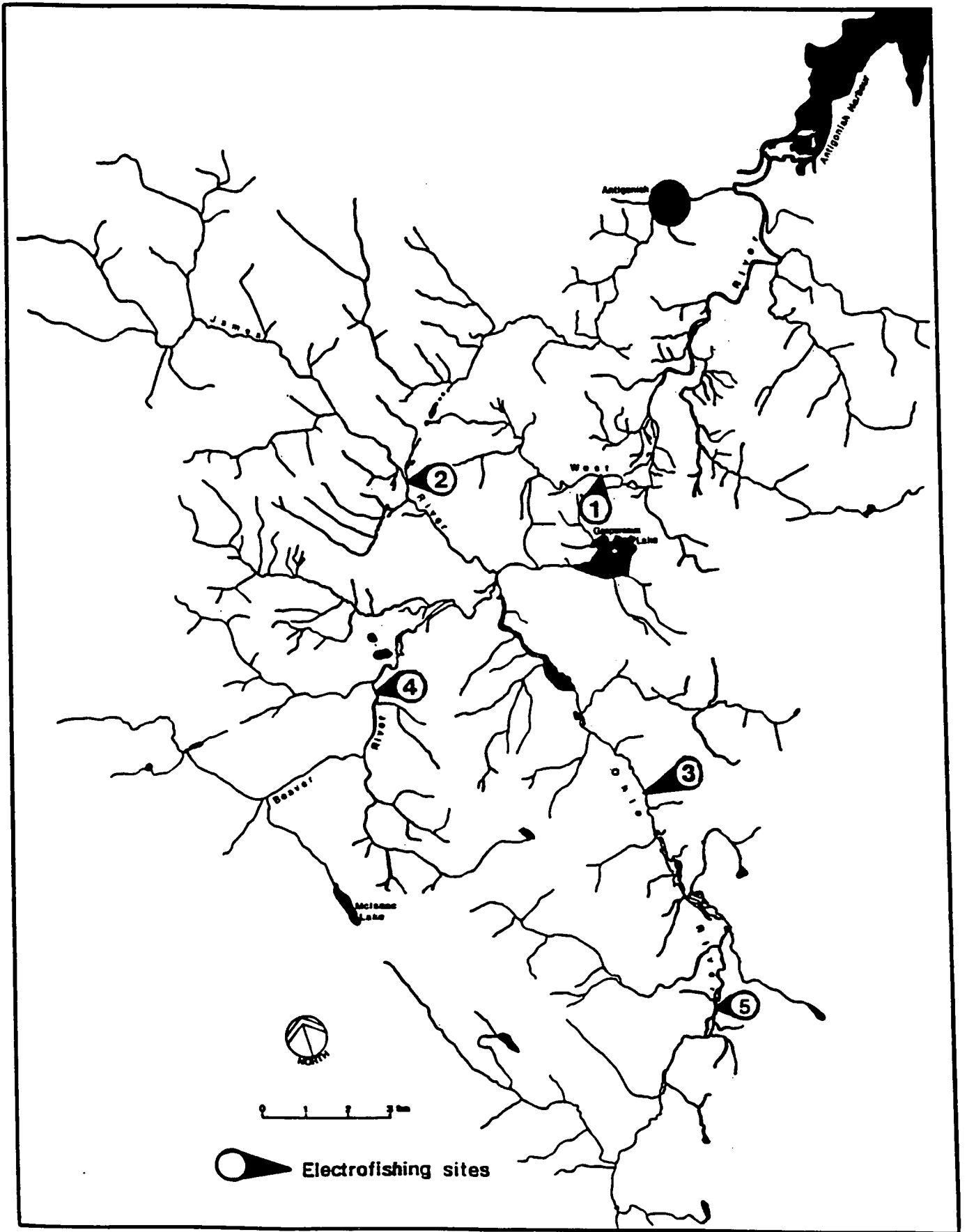


Figure 10. Electrofishing sites fished in 1996 on West River, Antigonish.

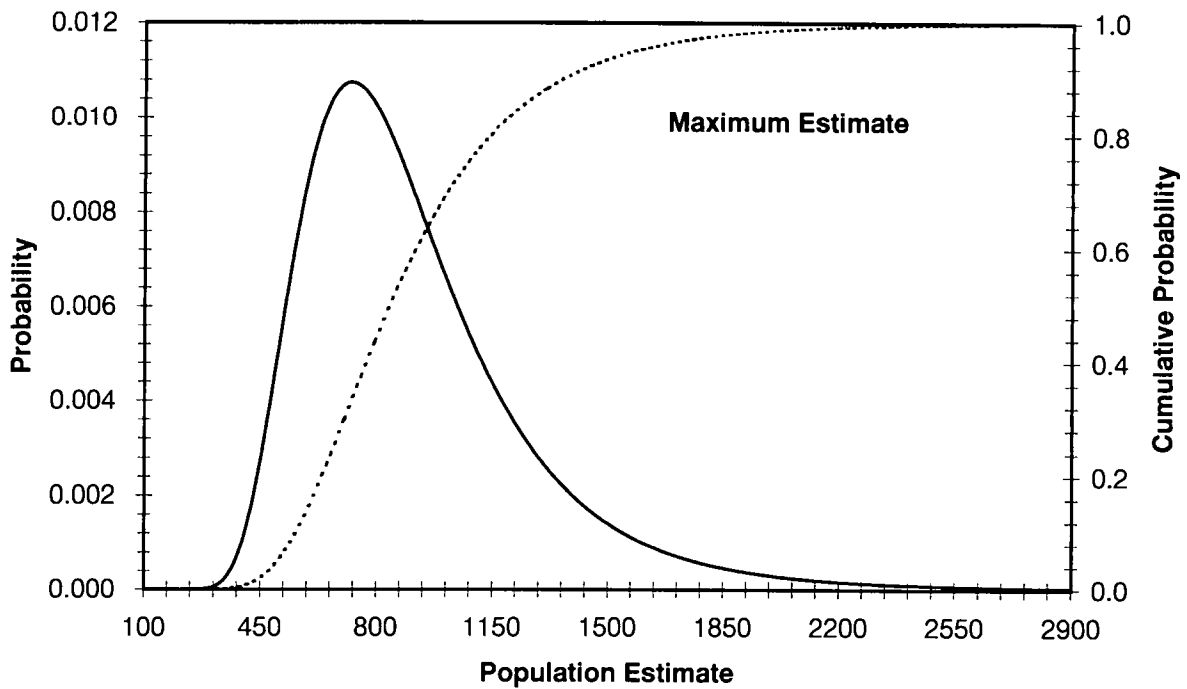
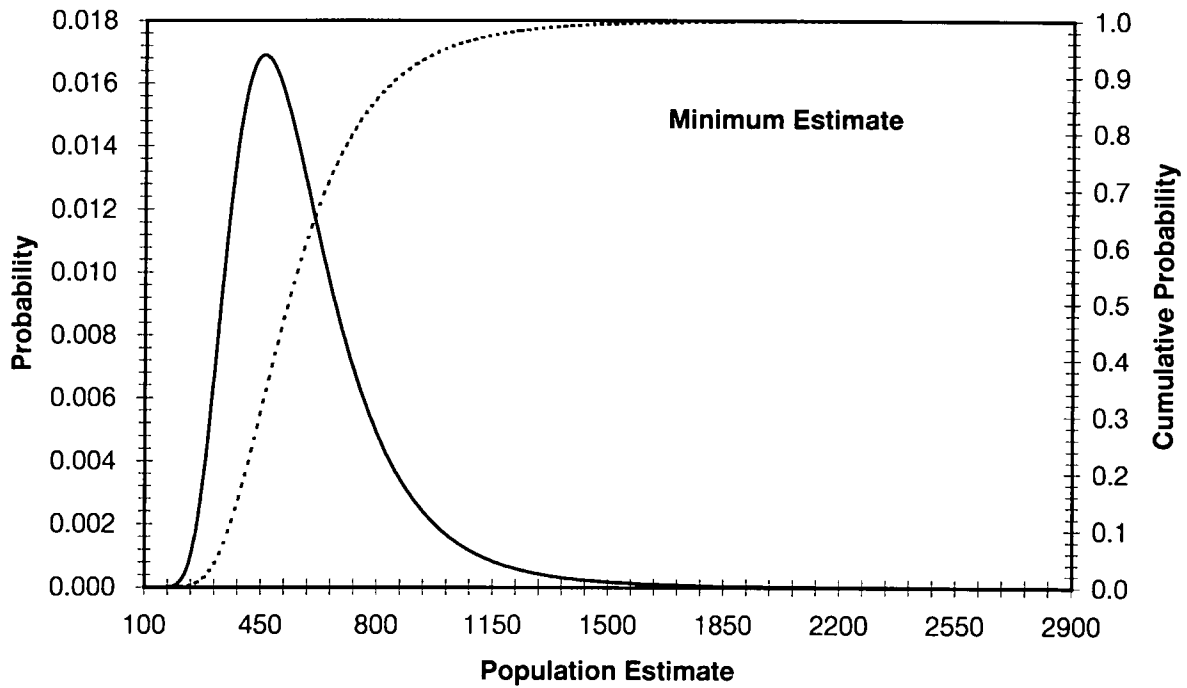


Figure 11. Probability (solid line) and cumulative probability (dashed line) distributions of the pre-fishery population estimates of Atlantic salmon returns to the East River, Pictou, in 1996, based on mark-recapture data. Minimum and maximum estimates are based on differing numbers of marks and captures. Refer to text.

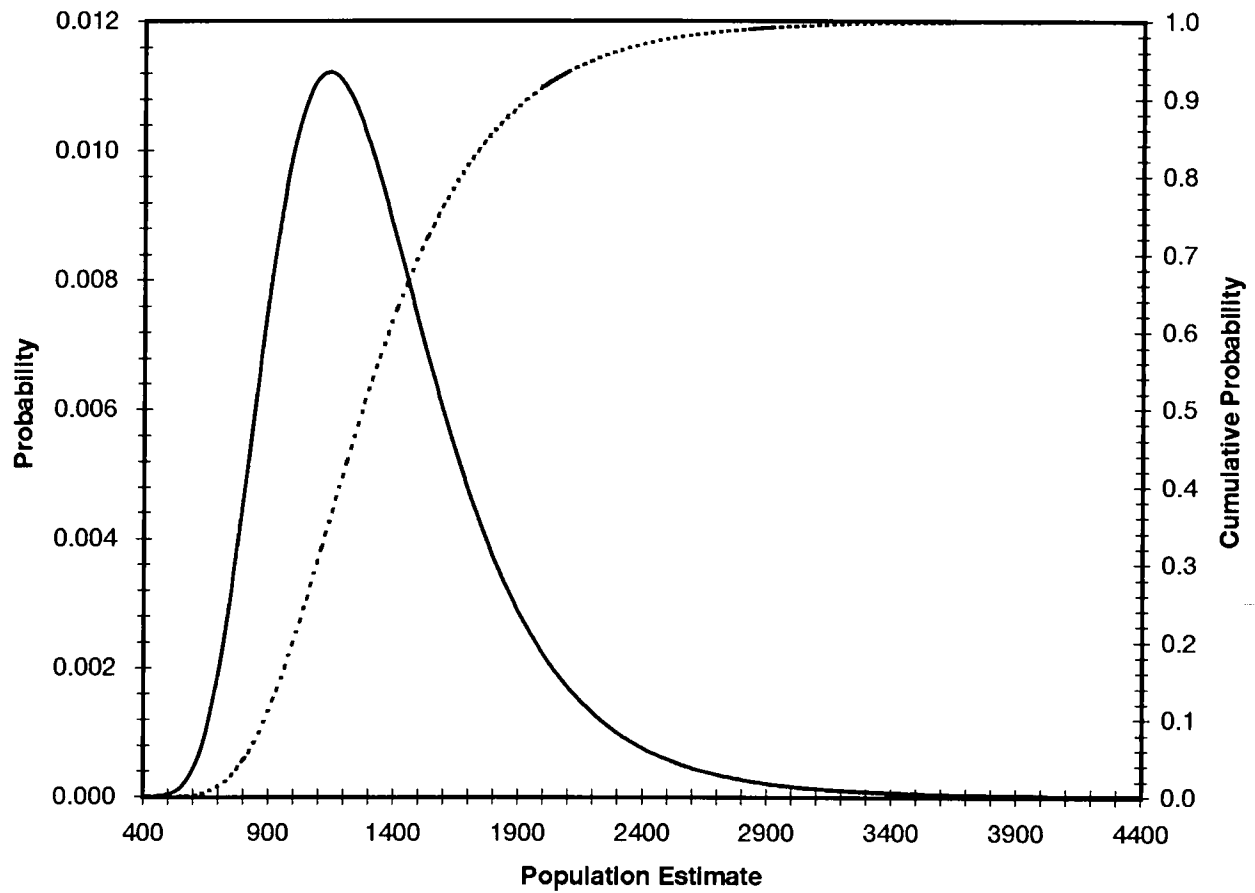


Figure 12. Probability (solid line) and cumulative probability (dashed line) distributions of the pre-fishery population estimates of Atlantic salmon returns to River Philip in 1996 based on mark-recapture data.

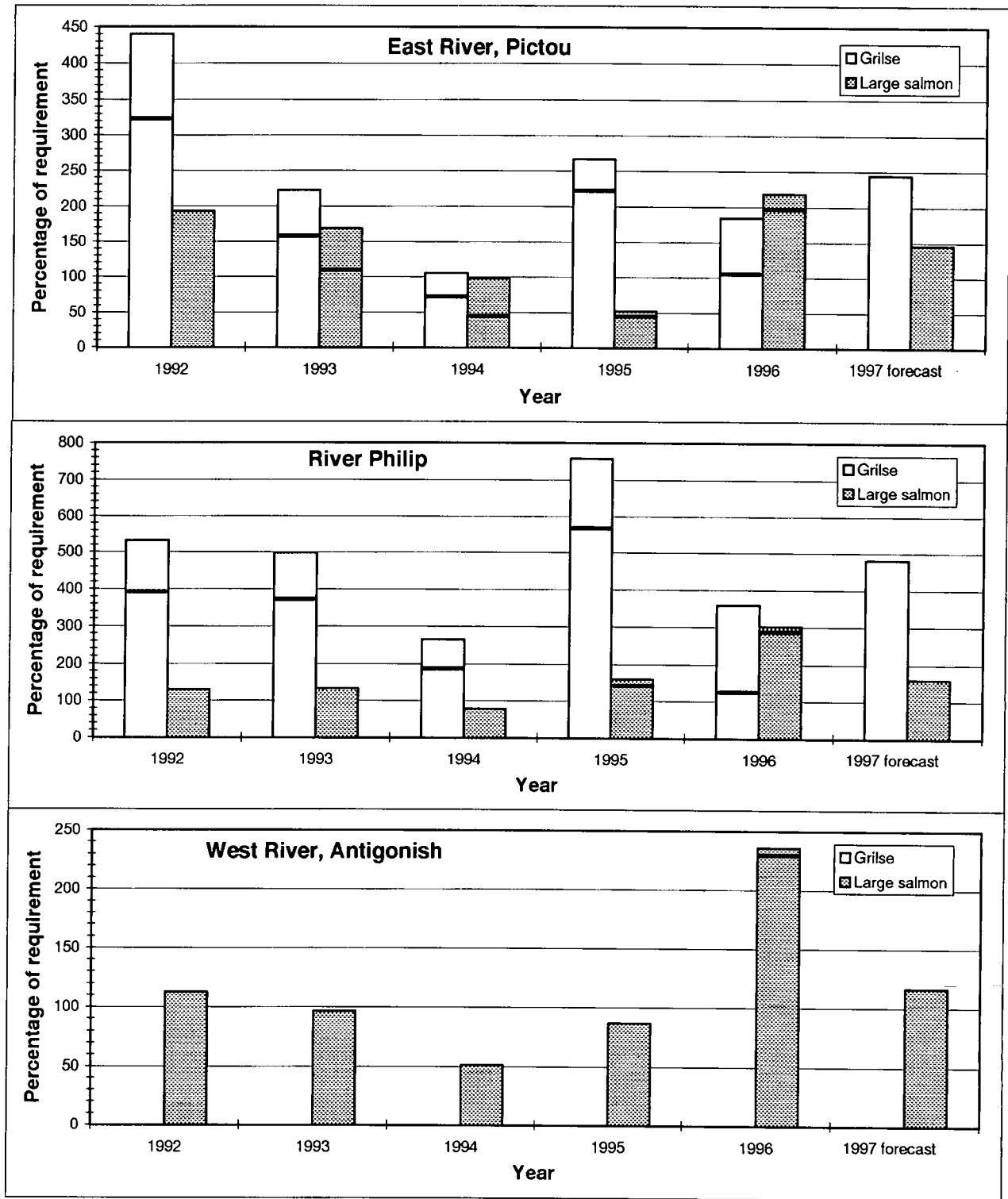


Figure 13. Percentage of conservation requirement achieved by returns and escapements (dark lines on bars) on three Northumberland Strait, Nova Scotia, area rivers, 1992-1996, and the 1997 forecast based on the mean of those values. The escapements for the years 1992-94 were estimated with adjusted sportcatches and a range of exploitation rates; for 1995, the catch data were not adjusted and the exploitation rate was calculated from the 1995 Margaree River data; the 1996 figures are based on a mark-recapture experiment (East and Philip rivers) or capture rate (West River).

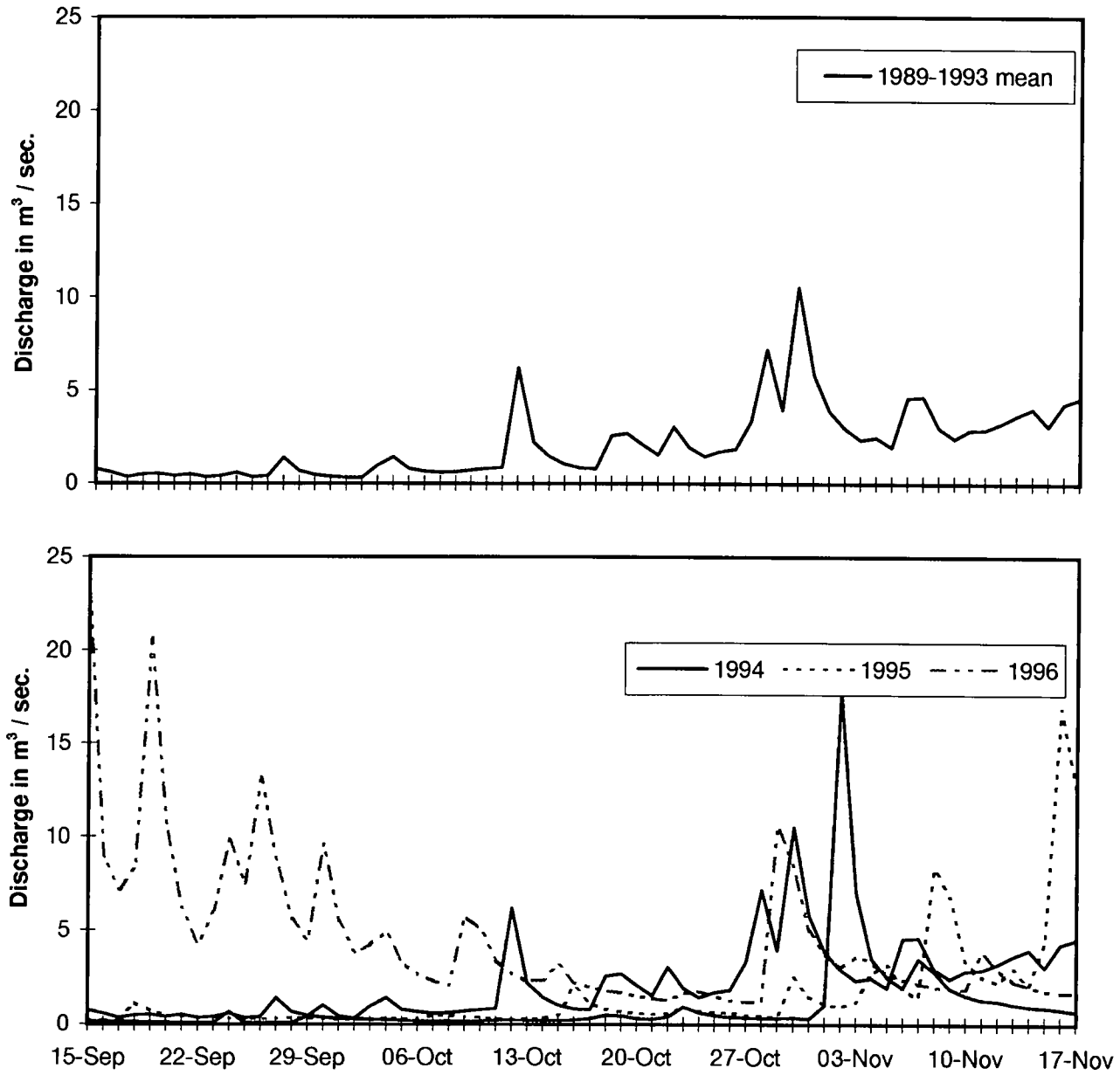


Figure 14. Daily discharge in cubic meters per second for Middle River, Pictou, at Rocklin, as a mean for 1989-1993 and annually for 1994 to 1996.

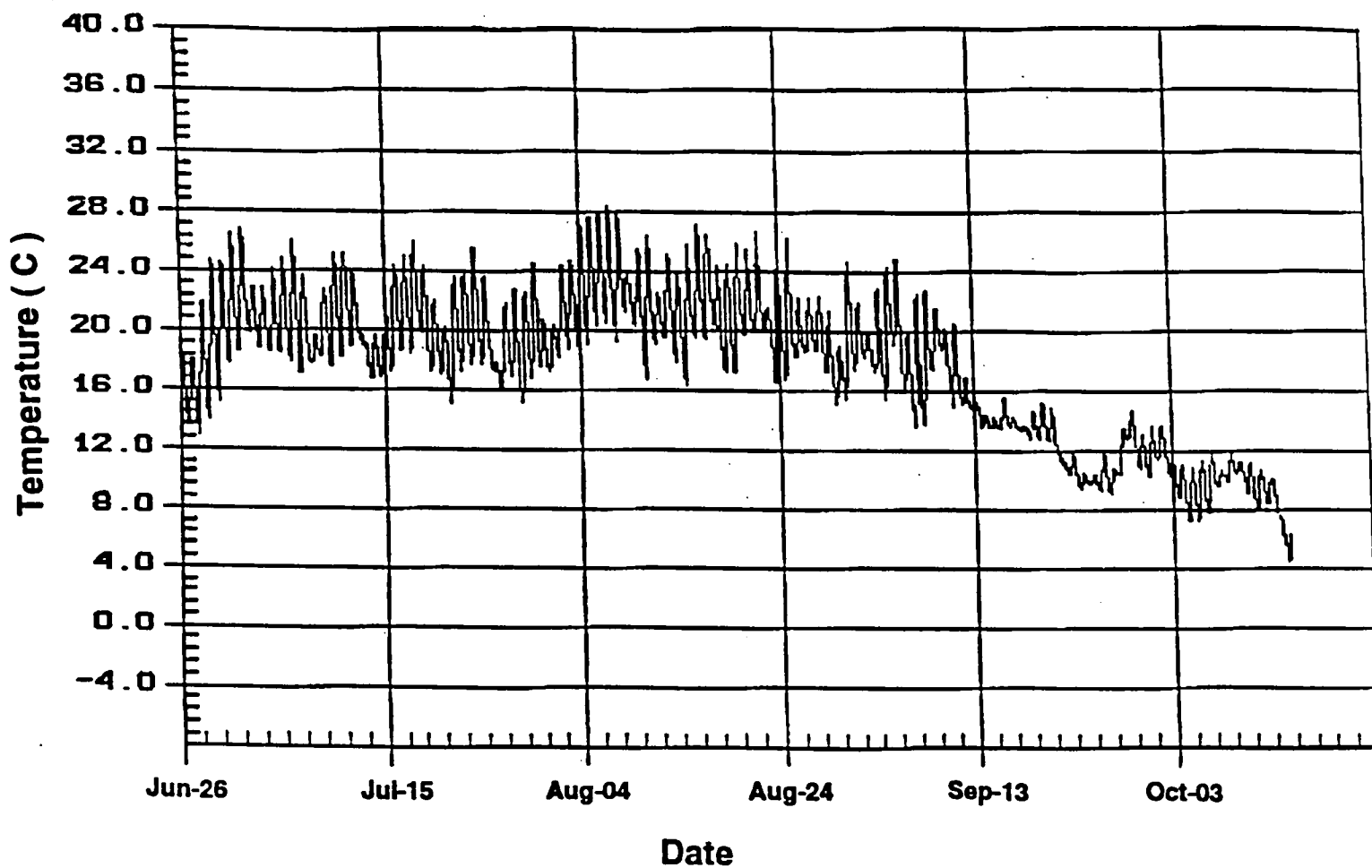


Figure 15. Daily water temperatures on the main stem of West River, Antigonish, just above the head of tide, June to November, 1996.