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Stock Status of Atlantic Salmon (*Salmo salar* L.) on the Eastern Shore of Nova Scotia, Salmon Fishing Area 20, in 1996

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Abstract

Atlantic salmon returns to rivers located on the Eastern Shore of Nova Scotia are described in the context of recent abundance of salmon in those rivers. Anglers were permitted to keep grilse (salmon <63 cm in length) only on East River, Sheet Harbour, where natural production of salmon does not occur due to hydroelectric dams. The other rivers were limited to hook-and-release angling for the second consecutive year in 1996. Angling and First Nation catches were among the lowest recorded during the past two decades for the rivers of the area in 1996. Good water levels throughout the angling season and lower than usual angling effort paradoxically resulted in higher than usual catch rates on many rivers, and in particular, on the Musquodoboit River and St. Mary's River.

Rivers on the Eastern Shore of Nova Scotia can generally be divided into two categories, acid-stressed and non-acid-stressed. Salmon returns to the acid-stressed rivers have been declining. A spawning requirement has not been defined for these rivers. Returns of wild fish to Liscomb River in 1996 were the lowest since 1981 when returns were still building after the opening of the fishway in 1979. Inference about returns to the other acid-stressed rivers on the Eastern Shore is made from the Liscomb River where potential egg deposition from spawners was only 15% of the spawning requirement for a non-acidic Liscomb River.

Research data indicates that juvenile salmon numbers on 3 non-acid-stressed rivers in the area were similar in 1996 to numbers observed during the 1980s. Juvenile numbers on the acid-impacted West River, Sheet Harbour, reflect the low spawner numbers. Several of the sites fished had no salmon or the absence of one of the 3 year classes typically found in salmon-producing streams of this area. The acidic water on West River, Sheet Harbour, has been treated at two sites with the distribution of limestone gravel and age 0+ and 1+ parr were found at those sites in numbers greater than elsewhere.

Recent low return rates of hatchery smolts released in Liscomb River imply that factors in the ocean are having a negative impact on returns of Atlantic salmon to this portion of the coast of Nova Scotia. These data are similar to those observed at the counting facility located on the LaHave River at Morgan Falls where return rates for hatchery fish have declined parallel to those of the Liscomb River.

The estimated post-fishery adult salmon population size on the Musquodoboit River in 1996 was 520 fish, or 0.96 million eggs, 51% of the requirement for conservation. The estimated number of spawners in the St. Mary's River achieved approximately 30% of the conservation requirement with only a 1% probability that conservation levels were exceeded. In-season forecast models for the St. Mary's River were found to be of limited application due to the nature of the model and uncertainty in the parameters. The number of large salmon forecast to return to the St. Mary's River in 1997, based on a relationship with wild grilse returns to the LaHave River, was not expected to exceed conservation levels.

Management considerations are described for the acidic and non-acidic rivers for the Eastern Shore. Recommendations for additional research are also given.

Résumé

Les retours de saumon atlantique vers les cours d'eau de la côte est de la Nouvelle-Écosse sont décrits dans le contexte de l'abondance récente de saumon dans ces cours d'eau. Les pêcheurs à la ligne n'avaient le droit de garder que les madeleineaux (saumon < 63 cm de longueur) capturés dans la rivière East, Sheet Harbour, où il n'y a pas de production naturelle de saumon à cause de barrages hydroélectriques. Pour la deuxième année consécutive, seule une pêche avec remise à l'eau était permise dans les autres cours d'eau en 1996. Les prises sportives et les prises des Premières nations récoltées en 1996 s'inscrivaient parmi les plus faibles enregistrées au cours des deux dernières décennies pour les cours d'eau de la région. Paradoxalement, des niveaux d'eau adéquats pendant toute la saison de pêche sportive et un effort de pêche à la ligne plus faible que d'habitude ont entraîné des taux de capture plus élevés que d'habitude dans de nombreux cours d'eau et, en particulier, dans la rivière Musquodoboit et la rivière St. Mary's.

Les cours d'eau de la côte est de la Nouvelle-Écosse peuvent généralement être divisés en deux catégories : ceux qui sont affectés par la pollution acide et ceux qui ne le sont pas. Le nombre de saumons retournant aux cours d'eau affectés a diminué. Les besoins en géniteurs de ces cours d'eau n'ont pas été définis. Les retours de saumons sauvages dans la rivière Liscomb en 1996 étaient les plus faibles depuis 1981, période où les retours augmentaient encore à la suite de l'ouverture de la passe migratoire en 1979. Les données de la rivière Liscomb, où la ponte potentielle ne représente que 15 % des besoins de reproduction d'une Liscomb non-acidifiée, ont servi à l'interprétation des retours dans les autres cours d'eau affectés de la côte est.

Les données de recherche indiquent que le nombre de saumons juvéniles présents en 1996 dans trois cours d'eau de la région non affectés par la pollution acide était semblable au nombre observé dans les années 1980. Le nombre de juvéniles dans la rivière West, Sheet Harbour, affectée par la pollution acide, réflète le faible nombre de géniteurs. A plusieurs des endroits pêchés, il n'y avait aucun saumon ou absence de l'une des trois classes d'âge typiquement présentes dans les rivières à saumon de la région. Après le traitement au gravier calcaire de deux endroits acides de la rivière West, Sheet Harbour, on y a trouvé des tacons de 0+ et 1+ an en plus grand nombre qu'ailleurs.

Récemment, les faibles taux de retours de smolts d'élevage libérés dans la rivière Liscomb laissent supposer que des facteurs océaniques ont une incidence négative sur les retours de saumons atlantique dans ce secteur de la côte de la Nouvelle-Écosse. Ces données sont semblables à celles observées à l'installation de dénombrement située sur la rivière LaHave au niveau des chutes Morgan, où les taux de retour du poisson d'élevage ont diminué parallèlement à ceux observés dans la rivière Liscomb.

La taille estimative post-pêche de la population de saumon adulte présente dans la rivière Musquodoboit en 1996 se situait à 620 poissons, ou 0,96 millions d'œufs, soit 51 % du besoin de la conservation. Le nombre estimatif de géniteurs dans la rivière St. Mary's a satisfait à environ 30 % du besoin au titre de la conservation, la probabilité que les niveaux aient été dépassés ne s'élevant qu'à 1 %. Les modèles de prédiction en saison pour la rivière St. Mary's se sont révélés d'une application limitée à cause de leur nature et de l'incertitude des paramètres. On ne s'attendait pas à ce que le nombre prévu de gros saumons revenant à la rivière St. Mary's en 1997, nombre basé sur une relation avec les retours de madeleineaux sauvages dans la rivière LaHave, soit supérieur aux niveaux nécessaires à la conservation.

On décrit des facteurs à considérer dans la gestion des cours d'eau de la côte est de la Nouvelle-Écosse affectés ou non par la pollution acide. Des recommandations de recherche complémentaire sont aussi formulées.

Introduction

Salmon Fishing Area 20 (SFA 20) is located on the eastern shore of Nova Scotia between the city of Dartmouth and the causeway across the Strait of Canso (Fig. 1). Historically, Atlantic salmon anglers have fished as many as twenty-nine rivers on the eastern shore. More recently, however, less than 20 rivers have been fished with any regularity (Table 1).

This document summarizes information relevant to the Atlantic salmon stock status for rivers within the eastern shore area. Particular attention is paid to the (arranged alphabetically below) East Sheet Harbour, Liscomb, Musquodoboit, St. Mary's, Salmon Guysborough and West Sheet Harbour rivers.

Many of the rivers in SFA 20 are acid stressed (Table 2). The acidification of some rivers has resulted in partial, or in at least one case, the Tangier River, total loss of the salmon production potential.

Description of fisheries and fishery data

The fisheries of SFA 20 in 1996 included Native and recreational harvests but was predominantly a hook-and-release recreational fishery. There were some changes to angling seasons in 1996 as a result of consultations with clients. The angling season on 3 rivers in the area was extended: East River, Sheet Harbour -extended one month to September 30; Liscomb River -extended 17 days to September 15; and St. Mary's River -opened May 10 until Sept. 30, a season 46 days longer than in 1995 (Table 2). West River Sheet Harbour was closed for salmon fishing for the third year in a row.

Fisheries regulations permitted the harvest of one-sea-winter salmon or grilse (fish<63 cm. in length) on only East River, Sheet Harbour, within SFA 20. Recreational anglers were restricted to hook-and-release of grilse and large salmon or multi-sea-winter fish (fish >=63 cm. in length) on the other rivers in the area.

Source and quality of recreational catch data

The recreational catch information was obtained from the SALMO-NS program where anglers purchasing a salmon license receive a card (license stub) on which they are directed to report their catch and effort data (O'Neil *et al.* 1986). The precision and accuracy of the data have been reviewed in O'Neil and Harvie (1993). Confidence limits (95%) for the provincial catch estimates for previous years are within 10% of the estimated value (O'Neil, unpublished data). The 1996 angling data which were received and processed prior to the writing of this report represented a preliminary response rate of 40% of licensees. Response rates typically range from 65 to 75% once all angler cards are received. Extrapolation of the data to account for non-response was accomplished with the review of several previous years of data when response rates were near 100% to obtain an adjustment factor to apply to the early returns in 1996. The procedure was previously described by O'Neil *et al.* (1989). It is not known if recent changes to the angling regulations (mandatory release of all fish in SFA 20 except on East River, Sheet Harbour) impacted on the response pattern of anglers. That possibility will be examined once all angler data is received.

Native fishing plans and licenses allocated 50 grilse to Millbrook First Nation on East River, Sheet Harbour, and a number of tags to the Native Council for use on rivers on the eastern shore and elsewhere in the province (Table 3). Indian Brook First Nation had a license to take 100 grilse from the Musquodoboit River. The only reported harvest was for Millbrook First Nation which harvested 13 grilse from East River, Sheet Harbour.

Anglers reported catching 884 grilse and 334 large salmon on rivers in SFA 20 in 1996 (Table 1). Only 21 grilse of the nearly 900 angled were retained due to the regulation change to a hook-and-release season in 1996. The 1996 grilse catch was 78% of the grilse catch in 1995 and 73% of the five-year (1991-1995) mean catch of 1,210 one-sea-winter salmon. The large salmon angling catch of 335 fish in 1996 was also approximately 78% of the 1995 catch and 75% of the 1991-1995 mean catch of 447 large fish (Table 1).

Salmon fishers spent a total of 2,185 rod-days fishing on the rivers of SFA 20. The angler effort in 1996 was only 24% of the 1995 estimate and 20% of the previous five-year mean of 10,739 rod-days. The decrease in effort is assumed to be due to the change in the fishery regulations which limited fishing on all but one river to hook-and-release. Angler effort on the Musquodoboit River was down by 68% in 1996 from 1995 but catch increased 36%. A similar angler success profile was also noted for the St. Mary's River where angler effort decreased considerably (by 79%) but catch, while not increasing, only declined by 18%.

Catch per unit of effort (CPUE) or fish per rod-day increased by a factor of 3 from 0.174 in 1995 to 0.557 in 1996. A similar positive difference occurred relative to the five-year (1991-95) mean of 0.154 fish per rod-day. The CPUE increase indicates the degree of success which anglers experienced in 1996 relative to recent years and demonstrates that although angler visits to the river were down, the decrease could not be attributable just to low fish abundance.

East River, Sheet Harbour

East River, Sheet Harbour, has been largely inaccessible to anadromous fishes since the early 1920s because of a series of water storage and hydroelectric dams (Fig. 2). Proximate physical habitat surveys conducted in the 1960s and 1970s estimated a total rearing habitat area of 489,000 m^2 (Ducharme 1972). The area estimate included only 8 of the main tributaries and is less than the 3 million m^2 measured by remote sensing techniques (P. Amiro, unpublished data[1]). Ninety-five percent of the habitat in the system is above an impassable hydroelectric dam located at Malay Falls.

A five-year management plan for the anadromous fisheries resources of the river was implemented in 1994. The "plan", which was described in detail in O'Neil *et al.* (1997a), involved Millbrook First Nation, Eastern Shore Wildlife Association, Nova Scotia Power Inc. and Fisheries and Oceans (DFO). The overall objective of the plan is to maintain the anadromous resources in existence in the system until 1998 after which Nova Scotia Power Inc. will consider construction of fish passage around the Malay Falls and Marshall Falls dams.

In 1996, a trap was constructed at the Ruth Falls diversion dam by DFO and client groups (Fig. 2). The Ruth Falls dam is about 4 km upstream from head of tide where the Barrier Dam is located. Fish were previously captured at the Barrier Dam (enumeration of adult salmon in 1994 and 1995) which is downstream of any angling fishery on the system. In 1996, anglers could harvest fish in the lower 4 km of river prior to any fish being counted or removed for broodstock or food. Fish captured at the Ruth Falls trap were either (1) removed to serve as broodstock; (2) taken for food; (3) trucked to Fifteen Mile Stream and released; or (4) released above Ruth Falls to ascend the river to Grant River or Malay Falls (free swim). Millbrook First Nation operated the trap under DFO supervision and with financial support from Nova Scotia Power Inc.

There is no conservation requirement for East River, Sheet Harbour, because the salmon resource in the river was destroyed by the construction of dams for hydroelectric power production over 70 years ago. The Department of Fisheries and Oceans management plan in place for the river was unique among eastern shore rivers and a harvest of grilse was allowed throughout the system in 1996. The current management regime recognizes that the river is 100% dependent on stocking from the federal fish hatcheries. The five-year plan committed to by DFO in 1993 (to begin in 1994) included the stocking of approximately 20,000 to 25,000 smolts per year by DFO for at least a five-year period.

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[1] Peter Amiro, Fisheries and Oceans, Halifax, N.S.

A Ryan Tempmentor water temperature recorder was positioned just above the Barrier Dam at the lower end of the river. Daily minimum and maximum temperatures were recorded from May 3 through November 7, 1996.

Assessment results

Anglers reported harvesting 21 grilse (preliminary data) on East River, Sheet Harbour (Table 1). A total of 146 grilse were counted at the trap on the river, 77 of which were taken for broodstock (Tables 4 and 5). Millbrook First Nation trucked 59 fish to Fifteen Mile stream, up from the 40 fish released there in 1995 and 24 fish in 1994. The 17 large salmon counted in 1996 was the highest of the 3-year enumeration period; previous counts were 6 fish in 1995 and 5 in 1994 (Table 5). Prior to 1996, the fish were counted at the Barrier Dam where fish can bypass the fishway under high water conditions.

The return rate of hatchery smolt (unadjusted for angling catch) to the East River, Sheet Harbour, fishway as 1SW fish increased from 0.36% in 1995 to 0.42% (Fig. 3). The return rate of hatchery smolt is low relative to rates observed previously in some other rivers such as the Liscomb River when hatchery grilse returns were near 3% in 1987. Recent low returns throughout the Maritime Provinces and particularly to Atlantic coast rivers are an indication of the low survival of smolts at sea relative to historic survival rates (Anon. 1996).

Water temperatures at the Barrier Dam on East River, Sheet Harbour, in 1996 were seldom over 20°C and such occurrences were short lived (Fig. 4).

Liscomb River

The Liscomb River drains an area of 400 km^2 and has been the site of an Atlantic salmon development project since 1977. Since 1979, a fish trap has been operated in the fishway at Liscomb Falls. The river is acid stressed (Table 2) and contains some tributaries which can not support Atlantic salmon ($pH<4.7$).

The Diadromous Fish Division has participated in the planning for an acid mitigation project with the Liscomb River Association. Plans are in place for the application of crushed limestone to the ice surface of Big Liscomb Lake, which is in the headwaters of the main branch of the river, during 1997. Previous plans to lime the lake in 1996 were unsuccessful because of safety reasons and poor ice conditions in the winter of 1995-96.

Conservation requirements

Habitat

The riverine habitat of the Liscomb River was surveyed in 1955 by MacEachern and the rearing area estimated and summarized by Gray (1976) to be 1,685,600 m^2. Approximately 91% of the habitat area is above the fishway at Liscomb Falls where DFO has enumerated adult salmon since 1979.

Egg and adult requirement

Liscomb River is acid stressed and two options exist to modify the conservation requirement to account for the portions of the river which are acid stressed: (1) Qualify the habitat according to the acidity so that areas of the river are eliminated from the habitat area estimate; or (2) Assume that a certain percentage of the young salmon die or adults spawn unsuccessfully as a result of the acidity, estimate that loss through survivor - pH relationships, and set a requirement equal to the 2.4 eggs per m^2 plus the additional eggs to account for the loss. Neither approach is ideal but both have to be considered before a revised conservation requirement can be defined, hence, the conservation requirement is under review. The non-acid-impacted conservation requirement above Liscomb Falls (above the trap) would be 3,692,000 eggs. Semple and Cameron (1990) estimated required spawners at 1,908 1SW fish and 280 MSW fish based on data collected at the trap at Liscomb Falls between 1979 and 1986. The wild returns composition has changed since 1986. A revised adult requirement has been calculated as 2,113 grilse and 194 large salmon (Table 6a).

Estimation of stock parameters

A total of 313 grilse were counted at the trap at Liscomb Falls in 1996, 228 hatchery fish and 85 wild fish (Table 7a). Only 14 large salmon were counted at the trap, 5 hatchery and 9 wild. These numbers are consistent with the recent low returns relative to the numbers counted in the mid-1980s (Table 7a and 7b; Fig. 5).

The Liscomb River wild large salmon count is significantly correlated with the previous year wild grilse count in either the long-term 1982-1996 ($p=0.044$, $R^2adj.=0.237$, $n=14$) or short-term 1989-1995 ($p=0.012$, $R^2adj.=0.70$, $n=7$) regressions. The regression equations are:

Long term: 1982-1995

$$\text{Liscomb wild MSW returns}_{(i+1)} = 20.7 + 0.049 \text{ x Liscomb wild 1SW returns}_{(i)}$$

Short term: 1989-1995

$$\text{Liscomb wild MSW returns}_{(i+1)} = 5.1 + 0.042 \text{ x Liscomb wild 1SW returns}_{(i)}$$

Although the short-term regression is more representative of recent returns, the relationship is significant due to the weight of the relatively high 1990 grilse return (955 fish) and the large number of recent data points at the low end of the relationship (Fig. 6).

Assessment results

The number of adult salmon which returned to the Liscomb River in 1996 was only a small fraction of the number needed to meet the non-acid-impacted (nominal) spawning requirement. The estimated egg deposition from the spawners counted at the trap was 569,400 eggs (this number includes the eggs from the 80 fish removed for broodstock). This represents 15.4% of the eggs required to meet the nominal conservation level for the area above Liscomb Falls. No attempt was made to discount habitat which is not considered capable of supporting Atlantic salmon by virtue of the water quality.

Forecast

The regression of large salmon on grilse for the Liscomb River, based on the return of wild fish to Liscomb Falls, has become progressively more influenced by the low returns of recent years. Consequently, the number forecast from the low grilse returns is so low that it is of limited practical value. Nevertheless, the relationship indicates that the low returns of recent years are likely to continue into 1997. The short-term time series forecasts a return of 9 large salmon based on the return of 85 wild grilse in 1996. The decline in wild grilse returns from over 900 fish in 1990 to less than 100 fish in 1996 (Fig. 5) is due to the lowered survival at sea noted for hatchery fish but probably also due to the progressive acidification of the system.

Musquodoboit River

The Musquodoboit River is the closest major river of SFA 20 to the metropolitan area of Halifax-Dartmouth. The lower-most angling pools on the river are located approximately 40 km from the city (Fig. 1). The headwaters of the river drain an area underlain with limestone so the river is not as affected by the acidic precipitation which has caused many of the rivers on the southern uplands of Nova Scotia to become acidified. The pH of the Musquodoboit River is around 6.5 (Table 2). Portions of the river over its 95 km length flow through areas which are almost exclusively forest cover, particularly the upper reaches and the longer tributaries. The lower two-thirds of the system is relatively low gradient and flows through cultivated land and several small communities.

Conservation requirements

Habitat

In 1955, a proximate survey of the river was conducted by Edwards and Wilson (1955) in which primary spawning and rearing areas were identified. Their data were used to produce an estimate of rearing area of 1.0 million square meters (Atlantic Salmon Review 1978). During the early 1980s, the habitat was measured using an alternate remote sensing technique wherein aerial photographs and orthophotos were used to quantify riverine area by gradient (the orthophoto method). Juvenile Atlantic salmon distributions are known to be highly influenced by gradient so quantifying the areas by gradient allows selective exclusion of portions of streams usually avoided by juvenile Atlantic salmon in Nova Scotia such as stillwaters or in-stream ponds (areas of less than 0.12% grade) or steep rapids or waterfalls (gradient > 5%; Amiro 1993). The Musquodoboit River juvenile salmon rearing area, as measured by the orthophoto method and exclusive of those areas less than 0.12% grade or greater than 5% grade, is 791,900 m^2.

The orthophoto method of habitat measurement is usually more comprehensive than on-site surveys because of the limitations of measuring the entire length of each tributary while conducting on-site measurements. The practical difficulties of locating and measuring each small stream limit the coverage which can be obtained. In the case of the Musquodoboit River, the on-site survey provides a rearing area estimate of 1.0 million m^2 as compared with the approximately 0.8 million m^2 of gradient-qualified area estimated from the orthophoto measure. The difference is caused by the relatively low gradient of much of the Musquodoboit River, particularly in the lower one-half to two-thirds of the system. The on-site survey included much of the low gradient areas in the total habitat measure. The orthophoto measure for the entire river was 2.3 million m^2 but 1.5 million m^2 of that area was excluded because it was below 0.12% grade.

Biological characteristics

Biological characteristics have not been previously described for the Musquodoboit River stock. The adult sample data available may be biased because of the method of collection but have been used to estimate the number of adults necessary to meet the spawning requirement in the absence of data from a neighboring stock with similar characteristics. The sample data collected from the Musquodoboit River fish were obtained during broodstock collections. Those collections, since 1988, have involved either an electrofishing boat or the use of seine nets. Often, the broodstock collections were directed towards a specific age group or sex of fish. In order to reduce the possible influence of the non-random nature of the collections on the data used, age and proportion female were derived from samples collected in 1988, 1989 and 1996 which were known to be random samples (1988 and 1989 by electrofishing boat and 1996 by net). The length-at-age information was derived from the entire data set (Table 8).

Eggs per female of mean fork length	Proportion female	Proportion in run[2]	Egg deposition per fish
1SW: 58.2 cm =3,672 2SW: 74.9 cm =6,720 Average eggs per fish	0.10 0.79	0.60 0.40	220 2,097 2,317
Fecundity[3]	Eggs = $446.54e^{0.0362FL}$		

Number of eggs and adults required

Habitat area =	791,900 m^2	
Conservation eggs =	2.4 eggs per square meter	
Total eggs required =	2.4 x 791,900 =	1,900,560 eggs
Average eggs per adult fish =	2,317	
Number of fish required =	1,900,560/2,317 =	820 fish
Proportion of 1SW fish in run	0.60	
Required number of grilse and large salmon	Grilse: 492 (9.5% of eggs)	Large salmon: 328 (90.5% of eggs)

The number of eggs required to meet the conservation level of 2.4 eggs per m^2 is 1.9 million. The estimate of adults required is a preliminary estimate only and may change once additional adult sample data are collected.

Research data

Juvenile salmon densities

Several sites were electrofished in 1996 to determine whether juvenile Atlantic salmon densities remained similar to data obtained previously (Fig. 7). The electrofishing sites were fished using a mark-recapture technique (Amiro *et al.* 1989), and adjusted Petersen population estimates (Ricker 1975) were calculated for 0+, 1+ and 2+ parr. The 0+ parr densities were estimated by counting the number of 0+ parr on the mark run and applying the 1+ parr capture efficiency rate.

The mean densities of 0+, 1+ and 2+ parr in 1996 were 28.1, 12.2, and 5.2 fish per 100 m^2, respectively (Tables 9, 10 and 11). Previous annual means (7 previous years of data, 1988 to 1993; P. G. Amiro[4], unpublished data) for 1+ parr have ranged from a low of 8.1 in 1991 to a high of 24.8 in 1990.

The 1996 data were pooled with data collected annually from 1988 to 1993. To compare juvenile densities across years, the sites which were common to all years were selected for inclusion in the analysis. The sites chosen were numbers 7.5, 8.2, 12.1, 12.2, 15.1, 19.2, 20.1, and 21.6 (Tables 9, 10 and 11; Fig. 7). Comparison of 0+, 1+ and 2+ parr densities over the years that electrofishing data were available, on the sites common to all years, was carried out by a repeated measures analysis of variance (SYSTAT 1996). Assumptions of analysis of variance were met by using the natural logarithm of the densities.

Densities of 0+ parr showed significant differences across years (p=0.003; Table 12). Paired comparisons between years indicated that densities in 1990 were significantly lower than in 1989, 1991, 1992 and 1996. No linear trend over years was evident.

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[2] The proportion of run data is based on the proportion of grilse and salmon reported in the angling fishery from 1983 to 1996.

[3] Cutting et. al. (MS1987) produced a fecundity relationship for the LaHave River which was used to estimate eggs per female for these data.

[4] P. G. Amiro, Diadromous Fish Division, Science Branch, Fisheries and Oceans, Halifax, N.S.

Densities of 1+ parr also showed significant differences across years (p=0.017; Table 12). Paired comparisons between years indicated that densities in 1990 were significantly higher than in 1988, 1991 and 1996. A significant (p=0.016) negative linear trend was found across years (Fig. 8).

Densities of 2+ parr did not show any differences across years (p=0.465; Table 12).

The relationship between densities of 0+ parr in year i and densities of 1+ parr in year i+1, for all sites where both measurements were taken, was examined through regression analysis. Assumptions of regression analysis were met by using the natural logarithm of the densities. An examination of a plot of the data (Fig. 9) indicated that only a relatively small amount of the variation in the data was explained by the regression (R^2 adj. = 0.219), yet the analysis indicated a highly significant (p<0.001, n=92; Table 12) positive relationship. The regression equation is:

$$\mathrm{Ln}(1^{+}\ \text{parr density}+1)_{yr\ i+1} = 1.635 + 0.2975 * \mathrm{Ln}(0^{+}\ \text{parr density}+1)_{yr\ i}$$

Estimation of stock parameters

In 1996, a mark-and-recapture program was initiated on the Musquodoboit River in an attempt to estimate the adult salmon population size. Fisheries and Oceans (DFO) officers from the Musquodoboit DFO office coordinated the marking of adult salmon caught in the sport fishery. Five anglers and the two officers participated in the program. The anglers recruited for the experiment were chosen based on their past interest and participation in previous initiatives on the river.

Fish were marked with a paper hole punch by punching a hole in the upper lobe of the caudal fin. A total of 36 fish angled during the season were punched and released. One marked fish was angled a second time and received a second punch in the upper caudal fin. A hole punch in the tail fin was used as the marking technique because previous experience assured us that there would be no tag loss (except for mortalities), regardless of the length of time between the marking and recapture. A similar application of tail punches on the LaHave River indicated that 100% of the marks could be identified on fish which were carefully examined (E. Jefferson[5], pers. comm.).

The recapture occurred on October 23 during the broodstock collection on the river. Staff from the Diadromous Fish Division of DFO conducted the recapture using tangle nets over a 4 kilometer section of the river (Fig. 7). A total of 49 fish were caught during the recapture, 3 of which were marked (Table 13a).

The population estimate for the Musquodoboit River was calculated using the adjusted Petersen (Ricker 1975) and Bayesian (*loc. cit.* Gazey and Staley 1986) techniques. An assumed 10% hook-and-release mortality was used to reduce the number of marks available (marks were applied to "angled" fish which were assumed to die at the same rate as non-marked angled fish). The sample data, adjusted for hook-and-release mortality, were used to generate a post-fishery population estimate, which was added to the 10% hook-and-release mortality applied to the number of fish reported released to obtain a pre-fishery (returns) population estimate. Although multiple captures of the same fish were known to occur (e.g., a tail-punched fish was angled), no measure of the frequency of occurrence was available, so multiple captures were ignored for the purposes of this experiment. The returns estimate was determined for total fish and the number of large salmon and grilse was estimated by applying the proportion of the two age classes from a combination of the 1988 broodstock collection and the 1996 recapture sample (Table 13b).

An attempt to relate grilse to salmon the next year with angling data was not successful; the regression of MSW fish on 1SW fish the previous year, for the years 1983-96, was not significant (p>0.05). The failure to find a significant relationship between grilse and large salmon is not surprising because the relationship examined did not attempt to incorporate the effect of the stocking program; from 11,600 to 27,300 smolts

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have been stocked annually during the last 5 years (Table 14). The contribution of hatchery fish to the angling fishery on the river is known to be substantial through anecdotal angler information. The broodstock collection data can be used to arrive at a rough estimate of the proportion of hatchery fish in the returns. As mentioned previously, the collections were not random with the exception of 3 years so could not be pooled to estimate the hatchery contribution. The data obtained from the 1988, 1989 and 1996 collections indicated that hatchery fish comprised 42% of grilse returns and 18% of large salmon returns (Table 8).

Assessment results

The estimated post-fishery population size for the Musquodoboit River in 1996 was 520 fish (Bayesian mode estimate; Table 13b). The Petersen estimate of 412 fish is much lower and would be expected to be as the procedure tends to underestimate when the sample sizes are small such as in this example. Accordingly, the Bayesian estimate is preferred. The small number of recaptures results in an estimate with wide bounds; the 5th and 95th percentiles are 320 and 3,680, respectively. Based on the proportion of fish of each size class in the recapture, the population consisted of 170 large salmon and 350 grilse. Assuming a 10% hook-and-release mortality, the pre-fishery population estimate (returns) for the river was 554 fish (Table 13b).

The estimated egg deposition in 1996 was 962,472 eggs, or 51% of the conservation requirement.

Anglers reported catching 230 grilse and 107 large salmon in 1996 for a total of 337 fish. Although these angling data are preliminary, when applied against the population estimate of 554 fish, anglers caught and released 61% of the fish in the system. In a hook-and-release fishery, some fish are caught more than once. Consequently, the catch rate of 61% is not equivalent to an exploitation rate but would be more appropriately described as a capture rate.

Consequences of low sample size

The low number of recaptures in the Musquodoboit River mark-and-recapture experiment resulted in an estimate with wide confidence limits. The mark-and-recapture estimation procedure is highly sensitive to low numbers of recaptures relative to marks applied. In the Musquodoboit River example, had the recapture been one fewer, the population estimate would have been around 800 fish; if one additional marked fish had been captured, the population estimate would have been around 400 fish. Thus, although the procedure results in a population estimate with 5th and 95th percentiles of 320 and 3,680 fish, respectively, anglers caught and released 337 fish which supports the knowledge that the run size was at least greater than 400 fish. The angling exploitation rate often used for summer run rivers is around 35%. If anglers, in fact, only hooked 35% of the fish in the river, the returns estimate would have been around 960 fish (337 / 0.35). Although the angler capture rate of 61% seems high when compared with the exploitation rates typically used for the angling fishery (~30-40%), the capture rate estimated for 3 rivers in Salmon Fishing Area 18 in 1996 were also near 60% (S. O'Neil, unpublished data; L. Marshall[6], pers. comm.). The water levels in 1996 were optimal for angling for much of the angling season. The calculated exploitation rate may have been higher than expected due to those conditions.

In 1996, the exploitation rate calculated for the recreational fishery on the LaHave River was 44.3% (see St. Mary's River assessment results below). The estimate was derived from angler catch data and returns of fish to Morgan Falls. This figure is well below the exploitation rate calculated for the Musquodoboit River based on the population estimate. Application of the LaHave River exploitation rate to the preliminary sport catch data for the Musquodoboit River of 337 fish results in a return estimate of 761 fish or approximately 93% of the 820 fish conservation requirement. The preliminary catch per unit effort for Musquodoboit River anglers for 1996, 0.563, was high relative to typical values over the past 5 years

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when the mean catch per rod-day was 0.117 (can be calculated from Table 1). The high success rate on the Musquodoboit River in 1996 lends support to the high capture rate estimated from the mark-and-recapture experiment of 61%.

Forecast

There are no relationships from which to forecast grilse or large salmon returns to the Musquodoboit River. Anglers reported catching 61% of the estimated return of salmon to the river in 1996. An estimate of returns for several previous years could be calculated by using the 1996 capture rate as the tool to expand the angling data to a total return. This was not attempted for 3 reasons: (1) The summer water levels in 1996 were consistently higher than has been the case in recent years so the capture rate in 1996 would have been positively affected; (2) 61% exceeds previous estimates of exploitation rates for Atlantic coast rivers such as the 28.9% estimated for the LaHave River in 1995 (Amiro *et.al.* 1996) and the 44.3% rate estimated for 1996 (Amiro and Jefferson 1997); and (3) the 1996 angling fishery was limited to hook-and-release which may have influenced the capture rate.

Juvenile salmon densities have been observed to decline since 1988 so the forecast for returns for the next one to three years would not be expected to increase unless a change in the survival rate of fish at sea occurs. In 1996, 21,800 smolts were released into the system which was fewer than the 27,300 smolts released in 1995 (Table 14). Consequently, given a return rate consistent with the 1996 rate, the number of hatchery fish which would return as grilse in 1997 would be less.

St. Mary's River

The St. Mary's River is the largest river in SFA 20 and the third largest in habitat area, with 3,078, 500 m^2 of rearing habitat, on the Atlantic coast of Nova Scotia (Fig. 1). The system contains two main branches, West River and East River which are 56 and 27 km in length, respectively. The two branches meet 19 km above the head of tide (Fig. 10). The east branch of the river has a spawning stock of 3-sea-winter fish which is unique because it is the only stock remaining on the Atlantic coast of Nova Scotia with a 3-SW component. A stocking program, aimed at augmenting the 3-SW component of the run of salmon to the East River St. Mary's, was discontinued after 1995 because of a concern about possible negative genetic impacts on the stock (Table 14).

The two branches of the river also have differing underlying geologies. The West River has similar geology to many of the other acid-stressed streams of the southern uplands of Nova Scotia. As a result the water is tea colored and the pH on at least 5 tributaries is affected (pH<5.4; Buckland-Nicks 1995). The East River, on the other hand, is more like the streams that drain towards the Northumberland Strait which have ample buffering and pH levels in the 6-7 range.

The status of the stock was previously reviewed by Marshall (1986), O'Neil and Harvie (1995) and O'Neil *et al.* (1997a) and this report presents additional data relevant to those assessments.

The angling fishery on the St. Mary's River was a hook-and-release fishery in 1996. DFO fishery officers from the town of Sherbrooke, located at the mouth of the river, and anglers who frequented the system in 1996 noted that a high proportion of people fishing for salmon did not have a salmon license. According to DFO officers elsewhere, the practice of fishing for salmon under the guise of fishing for trout was a common practice on rivers closed to harvest but open for hook-and-release salmon fishing. There was no attempt made to estimate the number of salmon anglers fishing without a license, but license sales in Nova Scotia dropped from over 4,500 in 1995 to approximately 3,600 in 1996, and angler effort on the St. Mary's was only 18% of the previous five-year average (Table 1). The consequence of this practice to the assessment process is the loss of some of the data normally received from the anglers on license stubs.

Some attempt has been made to limit the effect that an underestimate of the angling catch would have on the 1996 assessment for the St. Mary's River in the appropriate sections below.

Conservation requirements

Habitat

The conservation requirements for the St. Mary's River are based on the habitat area as measured during an on-site survey by MacEachern (1955) to be 3,078,500 m^2. Habitat has also been measured by a more standardized and comprehensive technique using orthophotos which results in a rearing area 29% larger than that measured by MacEachern. The on-site habitat measure has been used for assessing the St. Mary's River salmon stock since 1986 (Marshall 1986) when the first assessment for the river was completed. A complex group of factors has precluded moving to the orthophoto measure of habitat area to estimate the conservation requirement. Among those factors is the evidence that the river has been producing parr at a rate far below many rivers in eastern Nova Scotia and well below any normal rate of production as described by Elson (1967).

Egg and adult requirements

The number of eggs required to meet the conservation level of 2.4 eggs per m^2 (Anon. 1991a and 1991b) for the habitat area of 3,078,500 m^2 is 7,388,400 (Table 6b). The biological characteristic data available for the system can be used to estimate the required number of spawners: 2,437 small salmon and 718 large salmon (Table 6b).

Research data

Several electrofishing sites previously established to monitor juvenile Atlantic salmon densities were revisited in 1996 to: (1) determine if the apparent low adult returns in 1994 resulted in low 1+ parr numbers; and (2) to supplement the density data for the two main branches in the system, the East River and West River, to attempt to isolate the source for the low parr production described by O'Neil *et al.* (1997a). Fry (0+ parr; Table 15a) and parr densities (Tables 15b and 15c) were also examined in relation to spawner eggs.

The electrofishing methodology was previously described by O'Neil and Harvie (1995). Although the stocking of parr raised at a hatchery occurred during the years 1982-1994, juvenile densities derived from electrofishing were not believed to be influenced by the hatchery stocking for several reasons: hatchery fish were released in locations other than the electrofishing sites with only a few exceptions; all hatchery parr were adipose clipped to be recognizable; and the frequency of capture of hatchery parr during electrofishing was negligible.

Comparison of parr densities across years

The mean parr densities for the river in 1996 were 3.7 - 1+ and 5.1 total parr per 100 m^2 (Table 15b and 15c). Atlantic salmon parr distributions are highly influenced by gradient (Amiro 1993). There is a curvilinear (quadratic) relationship between total parr ($p=0.001$) and 1+ parr ($p=0.007$) densities and gradient (Table 16; Fig. 11). Gradient was included in the analysis to compare densities across years. The natural logarithms of the densities were used in all analyses to meet assumptions. The densities of 1+ parr and total parr were found to differ among the years. Multiple comparisons indicated that the density of total parr in 1992 was lower than in 1985 and 1990 and 1+ parr numbers were significantly lower in 1992 than in 1985 or 1994; in addition, the 1991 density of 1+ parr was lower than in 1985 (Table 16).

Not all sites were fished in all years. In an attempt to standardize sites across years, the most frequently fished sites were selected for separate analysis. The sites chosen were those common to most years when fishing occurred, 1985, 1986 and 1990 through 1996, and included the sites numbered 4, 5, 8, 10, and 23 (Fig. 10). Gradient was found to be significantly correlated with the selected sites so was included in the analyses. A significant difference in 1+ parr density (p=0.036) was noted among the years, but multiple comparisons failed to show any difference in densities between specific years (Table 16). The same comparison with total parr as the dependent variable could not be tested because of interaction effects between the covariables year and gradient.

Source of low parr production: East River or West River

Previous research found that the production of parr in the St. Mary's River was found to be lower than in two other mainland rivers (Musquodoboit and Stewiacke) in spite of having a larger proportion of optimum gradient habitat (Amiro 1993). A potential source for the apparent low production was the main stem of the West River, a wide channel which becomes low and warm in the summer months. Water temperature spikes have reached 32° C on occasion (Buckland-Nicks 1995). Electrofishing was carried out in 1994 and 1995 to supplement data collected previously in 1985, 1986, and 1990 through 1993, to examine whether the low production of parr could be ascribed to either the East River or West River tributaries or subsets of those tributaries within the system (O'Neil *et al.* 1997a). An analysis of the data for the years prior to 1996 indicated that the 1+ parr densities were significantly lower on the East River main stem (2.6 per 100 m^2) than on the tributaries of the East River St. Mary's (5.9 per 100 m^2; O'Neil *et al.* 1997a). Although the mean 1+ parr density was only slightly higher on the West River main stem (3.3 per 100 m^2), it was not found to differ significantly from the parr numbers elsewhere within the system. The 1996 electrofishing data were combined with the data from earlier years, and similar analyses conducted to again look for differences between the branches (Tables 15a-d).

The gradient of sites was found to differ between branches of the river (p<0.001; Table 16) so the analyses of a difference in parr density between the east and west branches was done with gradient as a covariate . The differing relationships between of parr density and gradient for the two branches prevented a statistically valid comparison.

The results of the analyses conducted in O'Neil *et al.* (1997a) to examine the differences in parr densities between river subsets were supported with the inclusion of the 1996 electrofishing data; namely, the 1+ parr densities were significantly lower on the East River main stem (2.3 parr per 100 m^2) than on tributaries of the East River (5.9 parr per 100 m^2). Total parr densities were not found to significantly differ between river subsets (Table 16).

A further analysis of the various river system subsets of the data was completed after excluding the sites where the parr densities were zero. The reason for doing so was based on the premise that a density of zero could occur as a result of a variety of causes unrelated to spawner abundance or juvenile survival, such as an irregular distribution of spawners due to partial barriers which act as barriers only during periods of low flow or dewatering or scouring of redds in smaller tributaries, etc. The mean density of 1+ parr on the East River (5.4 per 100 m^2) was found to be significantly lower than on the West River (6.2 fish per 100 m^2). The East River main stem 1+ parr density (2.4 fish per 100 m^2) was lower than the density noted in the tributaries on both the East River (6.0 per 100 m^2) and West River (6.8 per 100 m^2; Tables 15a-d and 16).

Collectively, these data are in keeping with those documented by O'Neil *et al.* (1997a) in that the lowest mean density, overall, was on the East River main stem and that parr densities on both the East River main stem and West River main stem were lower than those found on the tributaries.

Estimation of stock parameters

Index river for estimating future returns of large salmon

A significant predictive relationship was found between the multi-sea-winter salmon sportcatch on the St. Mary's River and LaHave River wild 1SW salmon counts the previous year (O'Neil and Harvie 1995; O'Neil *et al.* 1997a). The relationship described previously was reinforced with the addition of the 1995 LaHave trap and 1996 St. Mary's sportcatch data (p=0.0003; R^2adj.= 0.72; N=12). The regression equation is based on the period from 1982-95 (1SW or grilse years) and is of the form (Fig. 12):

STM MSW sport catch$_{(i+1)}$ = -13.80 + 0.204 x LaHave (at Morgan Falls) wild 1SW trap counts$_{(i)}$

This equation is exclusive of the 1984 and 1985 grilse year points because of bias in the large salmon angling data during the 1985 and 1986 angling years (O'Neil *et al.* 1997a).

Parr density relationship to escapement or number of spawners

Fry (0+ parr) and 1+ parr densities were examined for a relationship with the appropriate previous-year spawner eggs. The number of spawners was estimated using a 30% exploitation rate in the angling fishery and a 10% hook-and-release mortality rate on any fish released. The number of spawner eggs was estimated by attributing approximately 1,600 eggs to each grilse spawner and 4,800 eggs to each large salmon spawner (O'Neil *et al.* 1997a). The regression of fry densities in year (i+1) on spawner eggs in year (i) was not significant (p=0.619). A similar regression of 1+ parr (which included gradient as a covariable because of the significant gradient effect) was also not significant (p=0.743; Table 17).

The West River stock of salmon is a repeat-spawning grilse stock. The West River juvenile salmon densities were examined separately for a relationship with total-spawner and grilse-spawner eggs from the appropriate previous year; no significant relationships were found (Table 17). Additional regressions were tested for fit between grilse spawner eggs and juvenile densities (0+ and 1+) in the West River tributaries, exclusive of the main stem data, and also found to be not significant (p=0.737).

Assessment results and discussion

In-season return estimates

Two in-season tools have been described for use in estimating the number of grilse which return to the St. Mary's River (O'Neil *et al.*, 1997a).

1. The river association has developed an in-season forecast tool using the catch of grilse at the Flat Rock and Ford pools combined (Buckland-Nicks 1995). On average, 9% (range 8.1 to 10.6%) of the grilse angled on the system for the entire season were angled on the two pools between June 15 and July 15. The forecast tool was developed using numbers based on a harvest fishery from 5 separate years of data where the information was complete (1974, 1977, 1978, 1979, and 1984), and it is uncertain how this method might work with hook-and-release numbers. In an attempt to use the data the association have generated from their on-site creel survey, the index pool estimate was calculated in spite of the uncertainty surrounding the use of catch-and-release data. For 1996, the river association recorded the catch and release of grilse on the 2 pools from June 15 to July 15 and counted a total of 74 grilse. Using the number to reconstruct a possible run size:

74 grilse released at Ford and Flat Rock pools x 11.1= 821 grilse
(Range : 698 to 913 grilse)
Assuming a 44.3% capture rate: 821/0.443= 1,853 grilse
(Range : 1,576 to 2,061)

This procedure would forecast a total grilse catch of 821 fish for a forecast return of 1,853 grilse. The derivation of the capture rate of 44.3% is described below.

Assuming a 10% hook-and-release mortality from the catch derived from license stub data, the grilse escapement in 1996 could be forecast to be 1,813 fish.

The number of eggs which would be deposited in the system by grilse would be 2,950,839 or 40% of the requirement.

1,813 grilse x 0.52% female x 3,130 eggs per female= 2,950,839.

2. The number of wild grilse which return to the Liscomb Falls counting trap is significantly correlated with the number of grilse angled on the St. Mary's River. The relationship is as follows:

Equation "A":

St. Mary's catch (retained plus released grilse) = 185.34 + 1.680 x Liscomb wild grilse count

R^2 adj. = 0.599, p=0.0019; n=12; 1983 to 1995 exclusive of 1987 (Fig. 13).

The 1996 wild grilse count at Liscomb Falls was 85 fish which, when applied to the equation, results in a predicted St. Mary's River grilse sportcatch in 1996 of 328 fish. This number is reasonably close to the preliminary estimate of 400 fish reported by anglers. The 1996 figures are a close fit to the regression line described by the 1983 to 1995 data, and if included in the relationship, result in a regression with a higher adjusted coefficient of multiple determination (p=0.0007; R^2adj.=0.631; N=13; Fig. 13).

The return of wild grilse to Liscomb Falls by July 15 is correlated to the return at the end of the run.

Equation "B":

Total number of wild grilse = 149.91 + 1.338 x number of wild grilse counted by July 15
R^2adj.= 0.928, p<0.001, n=13; 1982 to 1995 exclusive of 1991 when no fish had arrived at the trap by July 15

This relationship (Equation "B") can be employed during mid-season (i.e., by July 15) to estimate the total wild grilse return for the year and that value used to predict the grilse sportcatch on the St. Mary's with regression equation "A". This could be used to provide an in-season review of returns if management was faced with an option to open or close the river for harvest based on such a review. For example, for 1996, 39 wild grilse returned to the fishway by July 15. Substituting 39 into equation "B" results in a predicted wild grilse return to Liscomb River of 202 fish as compared with the count at season end of 85 wild grilse. Substituting 202 wild grilse into equation "A", the predicted sport catch of grilse on the St. Mary's River would have been 525 fish. The preliminary license stub derived grilse catch on the St. Mary's River was 400 fish (Table 1).

Exploitation or capture rate estimation

An estimated exploitation rate for salmon of the LaHave River in 1996 was also applied to the St. Mary's River sportcatch data to estimate total returns. It was assumed for this analysis that the estimated exploitation rates of the LaHave River were applicable to the St. Mary's River. The procedure employed to derive the LaHave River salmon exploitation rate was as follows (Amiro *et al.* 1996): A mark-recapture was conducted in 1983 on the LaHave River where marks were applied in the estuary and captures made at the Morgan Falls trap. A probability distribution of the population estimate was constructed using Bayes algorithm (*loc. cit.*, Gazey and Staley 1986). The 1983 probability distribution was assumed to be unbiased with respect to the 1983 population so it was calibrated to the 1983 count at Morgan Falls to produce the probability distribution for the 1996 population size based on the 1996 count at Morgan Falls. A probability distribution for the 1996 exploitation rate estimates was calculated by dividing the 1996 population estimates into the angling catch. The most likely (maximum probability) angling exploitation rate estimate was 44.3% (5th and 95th percentiles: 33.9 and 53.6%, respectively; Amiro and Jefferson 1997).

Total returns, using the preliminary 551 fish caught on the St. Mary's River and the 0.443 capture rate derived from the LaHave River, was 1,050 fish (5th and 95th percentiles: 380 and 2,250). An escapement of 995 fish was estimated as 1,050 fish minus a 10% hook-and-release mortality for large salmon (15 fish) and grilse released (40 fish). This escapement estimate is 31% of the conservation requirement in terms of numbers of fish. The probability that the returns exceeded 3,209 fish (the escapement conservation requirement of 3,154 fish plus the hook-and-release mortality of 55 fish) was less than 1% (Fig. 14). In terms of egg deposition, the escapement was only 32% of the requirement (Table 4).

In order to explore the possibility that the sportcatch was much higher than reported, the Bayes probability distribution was generated for an angling catch estimate of 1,102 fish which was twice the preliminary reported figure of 551 fish. The resulting mode from the probability distribution was 2,100 fish with 5th and 95th percentiles of 320 and 3,300 fish, respectively. In spite of doubling the catch, the escapement would have still been only 64% of the conservation requirement.

In past assessments, an estimated exploitation rate of 30-35% was used to arrive at a rough evaluation of the number of fish which returned to the St. Mary's River. For the purposes of comparison, a similar estimation of returns based on a 30% exploitation rate (capture rate) was calculated. In 1996, using the preliminary catch of 551 fish and an exploitation rate of 30%, 1,837 fish returned to the system, roughly 58% of the 3,155 fish requirement.

Juvenile densities and spawner eggs

Regressions of fry (0+ parr) or 1+ parr densities with spawner eggs from the appropriate previous year were not significant (Table 17).

A significant relationship was found between fry from one year and 1+ parr densities the following year. Hence, the low numbers of parr and fry are consistent but are not significantly linearly correlated with spawner eggs based on estimated returns. These findings provide evidence of either higher than normal mortality of eggs or sac fry (i.e., low redd emergence) or escapements which are far below those estimated with a 30% exploitation rate on angling catch. Escapement estimates based on the angling data for the mid-1980s would have exceeded the conservation requirement (O'Neil *et al.* 1997a) yet juvenile densities have remained consistently low relative to those on many other river systems.

One objective of the 1996 electrofishing survey was to ascertain whether the apparent extremely low returns in 1994, as depicted by the lowest angling catch in at least 22 years (Fig. 15), would be reflected in the juvenile densities. Although the density at most of the sites fished in 1996 was below the multi-year averages for those sites, they were well within the range of densities found for each site (Fig. 16). The analyses also failed to find a significantly lower density for the 1996 data relative to the previous years (Table 16).

Discussion

In 1995, the capture rate estimated from the LaHave River was 28.9% or approximately 30%. The exploitation rate used for assessments of the St. Mary's River stock status in 1994 and 1995 was also 30% (O'Neil and Harvie 1995; O'Neil *et al.* 1997a). The capture rate on the LaHave River may differ from that on the St. Mary's because of the difference in regulations; a one-fish daily bag limit was in place on the LaHave River in 1996. The capture rate estimated for the Musquodoboit River in 1996 was 61% and for River Philip and East River, Pictou around 56% (O'Neil *et al.* 1997b). Capture rates were higher than previously estimated on several rivers in 1996. Optimal water conditions for angling salmon in 1996 may have resulted in abnormally high catch rates. The catch per unit effort for several eastern shore rivers was high compared with CPUEs observed in past years. Thus, although the capture rate for the St. Mary's River is not known, a rate higher than 30% seems likely for the 1996 sport fishery.

Forecast

Large salmon forecast

A forecast of 136 large salmon to the recreational salmon fishery in 1997 was calculated from the regression relationship between the wild grilse counts on the LaHave River and the St. Mary's River large salmon catch. Applying a 44.3% exploitation rate (capture rate) to the forecast catch results in a return forecast of 307 fish, approximately 43% of the conservation requirement. A Bayesian probability distribution based on the predictive relationship between the LaHave grilse counts and St. Mary's MSW sportcatch and standard error of estimate for the regression was used to estimate the probability that the 1997 forecast would exceed the spawning requirement (after adjustment using the 44.3% capture rate). The probability that the forecast would be greater than 318 fish (i.e., 718 large salmon required x 0.443=318) was 2.3%. Repeating the exercise for a capture rate of 30% (to provide an estimate consistent with the 30% exploitation rate used in past assessments) results in a probability of 20.3% that the forecast would have exceeded the conservation requirement for large fish.

In order to accommodate client concern that the sportcatch was higher in 1996 than our records indicate, the same regression relationship between LaHave wild grilse and the St. Mary's MSW sportcatch was run with a catch of large salmon in 1996 which was double the reported figure (302 fish instead of 151). The resulting equation (regression was still significant, $p=0.002$; R^2adj.=0.60) forecast a large salmon catch in 1997 of 162 fish and a return which would be 75.2% of the requirement (using the same 30% capture rate).

Grilse forecast

The five-year average grilse catch was used to forecast the sportcatch in 1997 and the 30% and 44.3% capture rates applied to that catch to forecast returns:

Capture rate	5-year average grilse catch (1992-96)	Estimate of returns	Percentage of grilse spawning requirement met	Probability that return est. meets requirement[a]
30%	443	1,477	61%	19.9%
44.3%	443	1,000	41%	2.5%

a The probability that the return estimate meets the requirement is estimated from a Bayes probability distribution generated from the five-year average and standard deviation.

Thus, the forecast grilse return in 1997 will achieve from 41 to 61% of the conservation requirement in terms of numbers of fish.

Evaluation of the grilse forecast based on the five-year average

The practical usefulness of the five-year grilse average to forecast sportcatch for the subsequent year was examined by looking at historical catch data for the St. Mary's River. Running averages (5-year) of grilse catches on the St. Mary's River were calculated for the years 1974 to 1995 and compared with the actual grilse catch in the subsequent year (Fig. 17). A total of 18 comparisons were made and in five cases the actual grilse catch would have exceeded or fallen short of the average by at least 50%. In other words, 28% of the cases examined would have differed from the forecast number by over 50%.

The smoothing effect of the five-year average data indicated that three general trends in grilse sportcatch have occurred over the 22-year period. Catches were generally on the rise from the mid-1970s until the early 1980s, remained relatively stable until 1990 and have declined steadily since 1990 (Fig. 17). The trend for the latter years is the more pronounced. The last 6 years of grilse catches (forecast years 1991-1996) have fallen short of their respective preceding five-year averages except the 1991-95 average where the 1996 grilse catch was similar.

The five-year average data provide insight into general trends but have not proven particularly effective at forecasting an individual years' grilse sportcatch.

Returns forecast in eggs

The 1997 returns forecast to the St. Mary's River, in terms of eggs, ranges from a low of 41.6% (based on a 44.3% capture rate) to a high of 61.4% (based on a 30% capture rate) of the conservation requirement.

Salmon River, Guysborough

Salmon River, Guysborough, is located at the eastern end of SFA 20, drains an area of 347 km^2 and discharges into Chedabucto Bay (Fig. 1). The river drains an area underlain by geology more typical of the rivers on the Northumberland Strait area of Nova Scotia and is not affected by acidic precipitation as are many of the rivers in SFA 20 (Table 2).

The lowermost non-tidal pools on the river are several kilometers above the location where the river discharges through a short crescent beach to Chedabucto Bay. Much of the angler effort occurs at the juncture of ocean and estuary where the fish frequently stage, often for weeks, before entering the river. Entry of the fish into the river seems to be largely governed by the water temperature and discharge although we do not have data to support that general observation.

The river contains a run of sea-run brown trout which are fished almost as avidly as salmon and often at the same locations.

The review committee at the 1995 DFO regional assessment process for anadromous stocks recommended that additional data be collected on the salmon stock of the Salmon River, Guysborough, in order to provide some indication of the stock status. The purpose of this section of the report is to describe action taken in 1996 to address the recommendation and to summarize the available data.

Conservation requirements

Habitat

The orthophoto-measured rearing habitat area for the Salmon River, Guysborough, is 1,178,900 m^2. This area measure is exclusive of the river and stream areas less than 0.12% gradient. There are several large lakes in the system.

Egg and adult requirements

The number of eggs necessary to meet the conservation requirement of 2.4 eggs per m^2 is 2,829,360 (Table 4).

Adult biological characteristic data are not available for Salmon River, Guysborough. A sample of 21 fish was captured in a tangle net in September of 1994 but because the mesh of the net was believed to be selective, the sample cannot be considered unbiased. Four of the 8 fish which were grilse or grilse repeats were female. These data indicated that a substantial contribution of eggs may come from grilse in this stock. Also, 40% of the angling catch averaged over the period 1983-96 was large salmon (Table18). Thus, the adult proportion-at-age composition may be similar to that observed for the Musquodoboit River stock but the high proportion of females in the limited grilse sample available is dissimilar to that stock. Additional data will have to be collected in order to determine the number of adults required to meet the conservation requirement.

Research data

In 1984, 20 sites were electrofished for 10 minutes each (600 seconds on the electrofishing timer) to provide an index of fry (0+ parr) and total (age 1+ and 2+) parr numbers (J. Cameron[7], unpublished data). The area covered at each site was dependent on the depth, substrate, and number of fish. Thirteen of those sites were visited again in 1996 and fished for 10 minutes to provide a comparison of juvenile numbers (Table 19; Fig. 18). The mean fry density in 1996 of 10.8 fry per 10 minutes of fishing was slightly higher than the density observed in 1984 of 9.1 fish per 10 minutes of fishing. Total parr numbers per 10 minutes fishing were also higher in 1996 (5.69 fish per 10 minutes fishing) than in 1984 (4.35 fish per 10 minutes).

Assessment results

The overall trend in angling catch on the river has tracked in a manner similar to the St. Mary's River (Fig. 15). Large salmon catches have generally fluctuated less on Salmon River than on the St. Mary's but the recent trend has been a declining catch for both rivers.

West River Sheet Harbour

The West River, Sheet Harbour, has yielded as many as 600 salmon a season to the angling fishery since record keeping began in 1951. The watershed, which shares an estuary with East River, Sheet Harbour, was the site of a wood pulp producing plant until a flood destroyed the plant in 1971. The system is seriously acid stressed (pH~4.9) except for one tributary, the Little West, where the level of winter pH is near 5.2 (determined from 2 samples).

In 1995, the local association initiated a liming program, with guidance from DFO, as a means of preserving the West River stock. The catch of fish in the sport fishery indicated that returns of wild fish to the system may have been as low as 40 fish in 1993. As a result, the river was closed to angling for the past 3 years (1994 -1996) as a means of protecting the stock. Limestone rock has been spread in 3 areas in the river over the past 2 years. A total of 1.2 Kms of river length has been treated.

The number of returning salmon to West River, Sheet Harbour, can not be estimated directly because of the closure of the fishery and the absence of any adult monitoring program. However, the return of wild fish to the similarly acid-stressed Liscomb River (described above), which has been steadily declining, could be used as an indicator of returns to the West River.

The conservation requirement calculations for West River, Sheet Harbour, were provided in O'Neil and Harvie (1995). The requirement for a non-acid-impacted West River was estimated at 797 grilse.

Research data

Several sites were electrofished in 1996 to determine the density of juvenile salmon for the purposes of monitoring the stock status and the effects of the liming program. The density of fry (0+ parr) and parr (total parr includes 1+ and 2+) increased in 1996 from the densities observed in 1994 and 1995 (Fig. 19).

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[7] Data currently held by S. F. O'Neil, Diadromous Fish Division, Science Branch, Fisheries and Oceans, Halifax, N.S.

The increase in density was noted at the limed site and a site on the less acid-impacted Little West River. At several of the sites visited, the densities remained zero fish per unit or too few to conduct a mark-and-recapture.

Management considerations

The management plan in place in 1996 which limited fishing to reduce or eliminate harvest was timely and in concert with the scientific data. Forecasts from the 1995 assessment for the eastern shore indicated that conservation requirements would not be met on any rivers assessed. The data available for 1996 reinforces those findings; conservation requirements were not met in 1996. This is in contrast to returns to rivers on the Northumberland Strait shore of mainland Nova Scotia where numbers surplus to requirements occurred on most rivers (O'Neil *et al.* 1997b).

The forecasts available which provide some insight into returns in 1997 clearly show that conservation requirements will not be met on the rivers of SFA 20.

At client meetings in four locations in December 1996 and January 1997 there was a concerted request for Fisheries and Oceans and the provincial Department of Fisheries to solve the problem of salmon anglers fishing for salmon without a salmon license under the guise of fishing for trout. The associations involved asked that some solution be found and put in place in time to stop the practice before the 1997 sport fishing season.

<u>East River, Sheet Harbour</u>

There is no conservation requirement for East River, Sheet Harbour, because the river is impounded and the stock is 100% dependent on enhancement. A total of 18,700 smolts were released in the river in 1996 which would contribute to returns in 1997. A harvest fishery for grilse is a component of the five-year management plan in place for the river.

<u>Liscomb River</u>

Only a fraction of the required number of spawners for a non-acid-impacted Liscomb River returned in 1996. The weak but significant regression between grilse and salmon results in a forecast of only 9 large salmon to return to the river in 1997. The stock cannot sustain a harvest on either the wild or hatchery returns unless a decision is made to eliminate or qualify the number of spawners required for the acid-impacted habitat.

<u>Musquodoboit River</u>

The 1996 escapement estimate was 51% of the conservation requirement. Although no forecasting ability exists for the Musquodoboit River, the angling catch over the past 5 years has been similar to or lower than the 1996 catch. Capture rates would have had to be less than one-half of the 1996 estimated rate of 61% for a surplus to have been achieved during those years. It is unlikely that returns in 1997 will increase sufficiently to result in roughly twice the number of fish estimated to have returned in 1996 and provide a surplus to the conservation requirement.

<u>St. Mary's River</u>

The return of large salmon forecast for 1997 for the St. Mary's River system will achieve only 41 to 61% of the conservation requirement. Similarly, the five-year average grilse catch of 443 fish, expanded to a return estimate using a capture rate, is only 61% (high estimate of two provided above) of the grilse spawner requirement.

Anglers reported good fishing success on the East River and Main branches of the river in 1996 via diaries submitted which provided details of their catch. That was not the case on the West River branch of the system. The West River, St. Mary's, salmon run is a repeat-spawning grilse run so more vulnerable to a grilse-only harvest.

The last release of hatchery smolts in the system occurred in 1995 which would contribute to 2-sea-winter salmon returns to the East River, St. Mary's, in 1997. Management may want to consider action to orient the fishing pressure and any potential mortality to the East River branch in 1997.

Salmon River Guysborough

Only a preliminary review of the stock was completed in this document. Sufficient data were available to indicate that the stock is not performing out of synchronization with the neighboring St. Mary's River stock. The available data and recommendations from anglers local to the area support managing the river in a manner consistent with the St. Mary's River.

West River Sheet Harbour

There are no means to estimate the number of adult fish in West River, Sheet Harbour, since the angling fishery closed in 1994. The critically low number of adults noted in 1993, the low pH of the water in the system and the low number of juveniles (many sites had no fish) preclude a stock recovery in the short term. The stock could not sustain a harvest so the river should not be open for even the most limited harvest potential. An extension of the closure to salmon fishing on the system may be the only way to protect the stock.

Research recommendations

SFA 20

Review of the spawning requirements for acid-stressed rivers is still pending. Providing alternate conservation requirements for those rivers would allow resource users and managers some view of long-term prospects for the resource.

Musquodoboit River

Recent releases of hatchery smolts into the Musquodoboit River have averaged over 20,000 fish (1990-1996; Table 14). The contribution of hatchery fish to the spawning requirement and the number of hatchery smolts which might be required for the enhancement program need to be determined.

St. Mary's River

Sufficient data have been obtained on the juvenile salmon densities of the St. Mary's River to clearly show that the system does not support densities similar to the optimal numbers reported by Elson (1975). An alternate spawner requirement estimate should be developed which takes into account the known capabilities of the system. One option would be to model the production of the system based on a process which estimates production based on the capability of the habitat to produce fish, incorporates survival rates, and so on. Such a model would optimize production based on capability and not use a uniformly applied conservation requirement for all rearing area regardless of habitat type. The means to estimate spawning requirement with such a model is being developed (P. Amiro[8], pers. comm.). Among the data which would be required to facilitate such a modeling exercise would be the size of smolts from various areas in the system because available data indicate that smolt survival is size dependent.

Certain habitat areas in the St. Mary's River system, particularly the main stem of both the East River, St. Mary's, and West River, St. Mary's, have been observed to have lower densities of juveniles than elsewhere in the system. The St. Mary's River Association has asked Fisheries and Oceans to recommend a course of action to increase Atlantic salmon production from the system and, in particular, from those areas which seem to support low numbers of juveniles. Additional work is warranted to recommend habitat restoration or modification or a water management scheme which would restore the thalweg or habitat quality on the main stems of the two branches.

Acknowledgements

V. Crowell collected or helped with the collection of much of the data contained in this report. T. Gloade and A. Gloade from Millbrook First Nation provided field support and also contributed to the data used in this document. Thanks are also due to the many anglers who reported their catch and effort data. Guidance and advice were provided by the Eastern Shore Wildlife Association, the Musquodoboit River Association, the Liscomb River Association and anglers representing interests on the Salmon River, Guysborough. Angler diaries were completed by several individuals who fished the St. Mary's River.

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RECORD OF CLIENT CONSULTATION

1. SPECIES / STOCK: Salmon Fishing Area 20, Eastern Shore Nova Scotia
-

2. ARRANGEMENTS:
   DATE: December 19, 1996
   TIME: 7:00 p.m.
   LOCATION: Sheet Harbour at the Eastern Shore Wildlife Association's hall

3. FORM OF CONSULTATION
- Science and management consultation meeting
-
-

4. PARTICIPANTS (Name and Affiliation)
- Jack MacDonald, Eastern Shore Wildlife Association
- Gerald Hardy, Eastern Shore Wildlife Association
- Stan MacDonald, Eastern Shore Wildlife Association
- Bob Dunn, Eastern Shore Wildlife Association
- Allan MacPherson, Salmon River Guysborough
- John Sullivan, Salmon River Guysborough
- Jim O'Melia, Musquodoboit River Association
- Marie O'Melia, Musquodoboit River Association
- Wayne Higgins, Musquodoboit River Association
- Steve McClair, Musquodoboit River Association
- Bob Bancroft, Nova Scotia Department of Fisheries
- Greg Stevens, Fisheries and Oceans, Fisheries and Habitat Management Branch
- Alex Mac Isaac, Fisheries and Oceans, Area Managers Office
- Paul McClung, Brian Gillis, Sherbrooke Conservation and Protection Office, DFO
- Kevin Juteau, Rick Devine, Musquodoboit Conservation and Protection Office, DFO
- Gordon Holman, Eastern Shore Wildlife Association
- Cyril Murphy, Eastern Shore Wildlife Association

5. NEW INFORMATION BROUGHT FORWARD
- A. MacPherson: Anglers on Salmon River caught fish throughout the river not just at tide as in the recent past. Believes the fish caught right at salt water and released probably die due to scale loss etc.
- R. Devine, DFO officer from Musquodoboit: There were only 36 fish marked in the mark recapture on the river, not 37 because one of the fisherman marked a previously marked fish. This will affect your estimate.
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6. CONCERNS RAISED BY CLIENTS
- Hatchery programs: divestiture will cause us to lose our fisheries on at least 2 and possibly 3 rivers. What can we do about it? Eastern Shore Wildlife Association (ESWA)or others to contact Dr. J. Ritter of DFO, Atlantic Salmon Federation, NSSA or other groups to develop a strategy to maintain their fisheries.
- Angling data is obviously important so what can we do to ensure anglers fishing for salmon buy licenses and submit their catch and effort information? Do you have a procedure planned or in place to enforce the purchase of salmon licenses by those who fish salmon rather than letting them hook-and-release salmon under the guise of fishing for trout? DFO is reviewing the problem and will discuss with the province (G. Stevens, DFO to action).
- Will DFO begin collecting broodstock on West River S.H. and grow fish to release as smolt to help restore the stock there? DFO is not initiating any new programs under the current divestiture process so the ESWA was directed to present their request to the incoming managers of the enhancement facilities.
- Liming on East River in 1997 will not proceed unless an advance from the coop agreement can be arranged. S. O'Neil to contact K. Rodman of DFO to determine whether the application was received and is being actioned.
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7. RECOMMENDATIONS:
a.) Pertaining to Assessment
• Ensure salmon anglers buy licenses if they intend to fish for salmon otherwise any assessment which relies on exploitation rate to estimate returns, such as on the St. Mary's River, may be inaccurate. •
b.) Pertaining to next year's workplans
• Attempt to complete a more robust mark and recapture on the Musquodoboit River similar to the 1996 program; begin organizing same earlier in the year. • Other Concerns: •

Shane F. O'Neil

NAME OF PRESENTOR

Alex MacIsaac ; Shane F. O'Neil

NAME OF RAPPORTEUR

Table 1. Atlantic salmon sportcatch and effort for rivers in Salmon Fishing Area 20, eastern shore, Nova Scotia, for 1996 (preliminary), 1995, and mean catches, 1991-95.

River	1996 Preliminary				1995				1991-1994 means[b]							
	Grilse		Salmon		Grilse		Salmon		Grilse				Salmon		Effort	
	retained	released	released	Effort	retained	released	released	Effort	retained	95% C.I.	released	95% C.I.	released	95% C.I.	roddays	95% C.I.
Clam Harbour	0	0	0	0				0	0	N/A	0	N/A	0	N/A	4	N/A
Cole Harbour	0	0	0	0				0	5	N/A	0	N/A	2	N/A	33	N/A
Country Harbour	0	0	0	0	21	9	5	188	15	19.8	3	4.9	4	6.5	104	94.0
East Sheet Harbour	21	0	0	194	0	1	0	15	15	18.0	2	3.1	2	3.3	141	162.8
Ecum Secum	0	25	2	101	21	0	2	335	31	27.0	2	3.8	4	4.8	382	170.3
Gaspereau Brook	0	0	0	0	0	0	0	3	0	0.6	0	0.0	0	0.0	12	14.9
Guysborough	0	0	0	0	1	0	2	14	1	2.0	0	0.0	2	1.8	10	7.5
Halfway Brook	0	0	0	0	1	0	0	13	1	0.8	0	0.0	0	0.0	9	7.3
Isaac's Harbour	0	0	0	12	2	2	0	24	4	3.9	0	1.1	0	0.0	42	31.0
Kirby	0	0	0	0				0	2	2.0	0	0.0	0	0.0	22	19.5
Larry's	0	0	0	0				0	0	N/A	0	N/A	0	N/A	1	N/A
Lawrencetown Lake	0	0	0	0	0	0	0	4	1	2.2	1	1.6	0	0.0	14	24.6
Liscomb	0	0	0	7	20	9	1	251	22	16.9	8	8.8	1	2.6	409	193.0
Little Salmon	0	19	12	105				0	0	N/A	0	N/A	1	N/A	3	N/A
Moser	0	44	0	91	69	2	0	541	74	48.1	16	19.2	5	6.9	760	396.6
Musquodoboit	0	230	107	599	106	26	116	1873	93	43.6	22	12.9	88	60.8	1737	1192.3
Necum Teuch	0	0	0	0				0	0	N/A	0	N/A	0	N/A	0	N/A
New Harbour	0	2	0	35	22	4	0	142	20	5.5	3	3.5	0	0.7	258	164.8
Port Dufferin	0	0	0	0	11	0	0	45	8	8.3	0	1.1	0	0.6	120	65.9
Porters Lake (East Brook)	0	0	0	0				0	0	N/A	0	N/A	0	N/A	0	N/A
Quoddy	0	0	0	0				0	0	N/A	0	N/A	0	N/A	14	N/A
Rocky Run Porters Lake	0	0	0	0				0	0	N/A	0	N/A	0	N/A	0	N/A
Saint Francis	0	0	0	0				0	0	N/A	0	N/A	0	N/A	1	N/A
Saint Mary's	0	400	151	754	394	150	131	3623	436	385.1	122	111.5	195	173.7	4204	2297.7
Salmon: Guysborough Co.	0	143	62	287	191	51	166	1655	178	100.8	60	70.9	135	65.6	1533	514.6
Salmon: Halifax Co.	0	0	0	0	1	0	0	12	2	2.1	0	0.0	0	0.0	22	14.9
Ship Harbour Lake Charlotte	0	0	0	0	14	4	5	244	8	10.8	2	2.7	2	2.9	275	102.5
Tangier	0	0	0	0	0	0	0	3	0	0.0	0	0.0	0	0.0	6	7.9
West Sheet Harbour	0	0	0	0	River close	0	0	5	48	44.7	6	6.1	5	5.0	627	714.3
Totals	21	863	334	2185	874	258	428	8990	963		247		447		10739	
1996 total as a percent of 1995	2%	334%	78%	24%												
1996 total as a percent of 1991-95 mean	2%	350%	75%	20%												

a The 1994 sportfishing season was limited to hook and release for SFA 20 for the period July 21-Aug. 11.

b Confidence intervals were not calculated for means which included fewer than 3 data points greater than zero.

Table 2. The habitat areas, pH, and 1996 angling seasons for the Atlantic salmon rivers of SFA 20, eastern shore Nova Scotia.

River	Habitat area [1] m^2*10^2	Winter pH taken 1986 unless date specified: pH [2]	D-M-Y	Dates for the 1996 angling seasons
Clam Harbour	2,736	4.85		June 01 - Aug. 29
Cole Harbour	1,244	4.54		June 01 - Aug. 29
Country Harbour	3,270	5.91		June 24 - Sept. 22
East Sheet Harbour	29,749	5.13[7]	19-11-96	June 01 - Sept. 30
Ecum Secum	7,663	5.44		June 01 - Aug. 29
Gaspereau Brook	2,823	5.05	13-01-88	June 01 - Aug. 29
Guysborough	4,217	6.58		June 24 - Sept. 22
Halfway Brook	1,604	5.17		June 01 - Aug. 29
Isaac's Harbour	2,043	4.82		June 01 - Aug. 29
Larry's	2,410	4.61		June 01 - Aug. 29
Lawrencetown Lake	6,446	4.52		June 01 - Aug. 29
Liscomb	16,856 [3]	4.88[7]	21-11-96	June 01 - Sept. 15
Little Salmon	750	4.93		June 01 - Aug. 29
Moser	15,208	5.46	22-12-88	June 01 - Aug. 29
Musquodoboit	7,919	6.48		June 01 - Aug. 29
New Harbour	3,148	4.84		June 01 - Aug. 29
Port Dufferin	5,389	5.15		June 01 - Aug. 29
Porters Lake (East Brook)	2,332	4.75		June 01 - Aug. 29
Quoddy	6,849	5.44		June 01 - Aug. 29
Saint Mary's	30,785 [4]	5.98		May 10 - Sept. 30
Salmon: Guysborough Co.	11,789	6.12		June 24 - Sept. 22
Salmon: Halifax Co.	2,811	4.15	23-02-93	June 01 - Aug. 29
Ship Harbour Lake Charlotte	19,615	5.54		June 01 - Aug. 29
Tangier	13,583	4.80		June 01 - Aug. 29
West Sheet Harbour	3,700 [5]	5.06[7]	18-11-96	closed
Total	204,939			

[1] Unless otherwise specified, area greater than 0.12% gradient was estimated from aerial photographs and orthophotos using methods descibed by Amiro 1993.

[2] Data from 1986. More current data available for summer pH's only. Winter pH's are not expected to have changed more than 0.1 or 0.2 pH units since 1986 (W. Watt, pers. comm[6].).

[3] Habitat area estimated from on-site proximate survey and reported by Semple and Cameron (1990).

[4] Area estimate based on proximate survey conducted by MacEachern (1955).

[5] Habitat area estimated from proximate survey by Ducharme (1972).

[6] Dr. Walton Watt, Diadromous Fish Division, Science Branch, Fisheries and Oceans, Halifax, N.S.

[7] Data obtained from Dr. Gilles LaCroix, Fisheries and Oceans, St. Andrews, N.B.

Table 3. First Nations fishing plan or communal license harvest allocations and reported harvests for Salmon Fishing Area 20, 1996.

First Nation	Harvest allocation	Reported harvest
Millbrook	East River SH - 50 grilse	13 grilse
Indian Brook	Musquodoboit - 100 grilse	None reported
Native Council	Entire area - 730 grilse tags	0

Table 4. Habitat areas, spawning targets, adult requirements, angling catches, returns, estimated escapements, and surplus/deficits for the Eastern Shore (SFA 20) and several SFA 20 rivers.

	Habitat area	Required eggs at 240 eggs	Spawner requirements		Angling catch - 1996[f]			Returns			Broodstock removed		Native harvest		Escapement		Surplus/deficit	
					Grilse		Salmon											
River/ area	$m^2 x10^2$	per 100 m^2	Grilse	Salmon	retained	released	released	Grilse	Salmon		Grilse	Salmon	Grilse	Salmon	Grilse	Salmon	Grilse	Salmon
Salmon Fishing Area 20[a]	116,070	27,856,800	9190	1690	21	862												
East Sheet Harbour	29,749	7,139,760	N/A	N/A	21	1	0	146	17	b	60	17	13	0	73	6	N/A	N/A
Liscomb (acid)	16,856	4,045,440	2113	194	0	3	1	313	14	b	66	14			247	0	-1,866	-194
Musquodoboit[c]	7,919	1,900,560	523	348	0	230	107	373	181		15	16			350	170	-173	-178
Saint Mary's	30,785	7,388,400	2437	718	0	400	151	903	341	d					863	326	-1,574	-392
Salmon Guysborough[c]	11,789	2,829,360			0	143	52											
West Sheet Hrbr (acid)	3,700	888,000	797	0	closed to fishing			N/A	N/A	e					N/A	N/A	N/A	N/A

N/A Not applicable
a Baseline data for habitat areas and spawning requirements for SFA 20 were obtained from Anon 1978.
b Fishway count
c Biological characteristics for Salmon River not available so adult requirements were no estimated; Musquodoboit River data based on limited sample data.
d Exploitation rate of 44.3% derived from the LaHave River for 1996 used to estimate returns based on the license stub reported angling catch
e Closed to angling 1994-1996. No estimate of returns possible.
f 1996 angling data are preliminary
acid - Rivers acid impacted and spawning requirements are under review; the requirements included in this table assume no acid impact.

Table 5. Numbers of smolts released, numbers counted at the fishway, return rate, and destiny of Atlantic salmon captured at Ruth Falls fishway, East River, Sheet Harbour, 1992-1996.

	Smolts	Number of fish counted at fishway [a]						Return rate in percent		Destiny of returns			
	released	Hatchery		Wild		Total		1SW	MSW		Released		
Year	year i	1SW	MSW	1SW	MSW	1SW	MSW	yr(i+1)	yr(i+2)	Broodstock	15 Mile Stream	Free swim	Food fishery
1992	26977												
1993	26900												
1994	26700	85	3	17	2	102	5	0.32	0.01	57	24	11	15
1995	36890	96	4	27	2	123	6	0.36	0.02	57	40	12	18
1996[b]	18700	135	16	11	1	146	17	0.37	0.06	77	59	14	13

a. The barrier dam is passable under high water conditions so these counts are not complete.

b The barrier dam fish lift was only operated for part of the 1996 run; most fish were captured at the Ruth Falls diversion dam fishway which is located 4 km above the head of tide and above the majority of the angling fishery which harvested grilse. Preliminary angler reports indicate a harvest of 21 grilse; applying the proportion hatchery fish noted at the fishway (0.92) results in 19 hatchery grilse harvested so 135+19= 154, a reconstructed return of 154 fish and a revised return rate of 0.42%.

Table 6a. Calculation of the number of spawners required for a non-acid impacted Liscomb River.

Eggs per fish:

	Eggs per wild female		Proportion female (wild)		Proportion in run		
MSW:	5611	x	0.67	x	0.084 [1]	=	316
1SW:	3017	x	0.52	x	0.916 [1]	=	1437
					Average egg deposition per fish	=	1,753

Spawning requirement:

Area		Habitat (m^2)	Eggs at 2.4 eggs/m^2	Number of fish at 1,753 eggs per fish	Spawners 1SW	Spawners MSW
Above Liscomb Falls		1,538,500	3,692,400	2,106	1,929	177
Below Liscomb Falls		147,100	353,040	201	184	17
	Total	1,685,600	4,045,440	2,307	2,113	194

1 Based on returns 1987-95.

Table 6b. Target egg and adult spawner requirement calculations for the Atlantic salmon stock on the St. Mary's River (adapted from Marshall 1986).

Biological characteristics:

Fecundity: where FL= fork length $Fec=340.832e^{0.0389FL}$

Size group	Eggs/female	Proportion female	Proportion of run	Eggs
57 cm; 1SW and small repeats	3,130	0.52	0.78	1,270
74 cm; small MSW	6,060	0.57	0.14	484
85 cm; large MSW	9,300	0.73	0.09	611
		Average egg deposition per fish =		2,365

Spawning requirements:

Habitat area (m^2)	Eggs at 2.4 eggs/m^2	Total fish required (eggs÷2,365)	Spawners 1SW (3,124x0.78)	Spawners Small MSW (3,124x0.14)	Spawners Large MSW (3,124x0.09)
3,078,500	7,388,400	3,124	2,437	437	281

For a total of 2,437 grilse and 718 large salmon.

Table 7a. Counts of wild and hatchery Atlantic salmon at the fishway trap at Liscomb Falls, Liscomb River, 1979-1996.

	SFA 20 Liscomb Returns			
	Wild		Hatchery	
Year	1SW	MSW	1SW	MSW
1979	60		485	2
1980	111	0	931	51
1981	76	6	241	49
1982	252	10	827	41
1983	520	15	594	63
1984	606	48	331	42
1985	507	87	175	49
1986	736	117	766	108
1987	1614	88	523	54
1988	477	76	431	44
1989	532	75	288	71
1990	955	44	438	22
1991	586	38	178	22
1992	145	27	125	12
1993	134	11	128	12
1994	134	10	119	8
1995	150	6	98	7
1996	85	9	228	5
Means:				
1991-95	230	18	130	12
1986-95	546	49	309	36
1996 as % of:				
1991-95	37%	49%	176%	41%
1986-95	16%	18%	74%	14%

Table 7b. Number of 1SW and 2SW returns from hatchery-reared smolts released at or above Liscomb Falls, Liscomb River, 1978-1994.

Smolt year i	Smolts (1000s)	1SW returns (year i+1)	% 1SW returns	MSW returns (year i+2)	% MSW returns
1978	47.4	485	1.02	51	0.11
1979	57.7	931	1.61	49	0.08
1980	26.9	241	0.90	41	0.15
1981	42.4	827	1.95	63	0.15
1982	43.8	594	1.36	42	0.10
1983	58.2	331	0.57	49	0.08
1984	50.0	175	0.35	108	0.22
1985	29.6	766	2.59	54	0.18
1986	19.0	523	2.75	44	0.23
1987	31.3	431	1.38	71	0.23
1988	48.4	288	0.60	22	0.05
1989	28.0	438	1.56	22	0.08
1990	22.4	178	0.79	12	0.05
1991	25.1	125	0.50	12	0.05
1992	30.5	128	0.42	8	0.03
1993	21.4	119	0.56	7	0.03
1994	28.8	98	0.34	5	0.02
1995	35.7	228	0.64		

Table 8. Age, spawning history, sex, and origin of Atlantic salmon captured with tangle nets during broodstock collections on the Musquodoboit River in 1996 and with the electrofishing boat in 1988 and 1989.

Sea age	Spawning history	Origin[1]	Sex[2]	Number	Percent of sample
1		H	F	3	4.4
1		W	F	1	1.5
1		H	M	14	20.6
1		W	M	21	30.9
2	1	W	M	1	1.5
2		H	F	3	4.4
2		H	M	2	2.9
2		W	F	16	23.5
2		W	M	4	5.9
4	2	W	F	2	2.9
5	3	W	F	1	1.5
Totals				68	100.0

Summary data

	Female		Male				Fish of hatchery origin	
	Number	Percent	Number	Percent	Total	Percent of run	Number	Percent
Grilse and grilse repeats	4	10.0	36	90.0	40	58.8	17	42.5
Large salmon	22	78.6	6	21.4	28	41.2	5	17.9
Total	26	38.2	42.0	61.8	68	100.0	22	32.4

1 H - hatchery; W - wild
2 F - female; M - male

Table 9. Densities of age 0+ Atlantic salmon parr by location, site and year for sites electrofished on the Musquodoboit River, 1988-1993[a] and 1996.

Site number	0+ parr per 100 m² 1988	1989	1990	1991	1992	1993	1996	Mean
1.2	5.8	10.9	1.6	4.0	21.1	12.9		9.4
1.4	7.5	0.0	3.8	1.5	54.5	8.9		12.7
2.1	19.5		0.0	6.3	0.0	0.8		5.3
2.4	18.8		0.0	1.4	0.0	0.0		4.0
3.1	4.1		0.0	0.0	0.0	0.0		0.8
4.1	31.7		4.1	13.5	60.1	146.0	1.6	42.8
4.2	42.9		0.6	58.5	24.7	61.9	0.9	31.6
5.3	b		0.0	0.0				0.0
6.1	4.3		0.0	0.0	0.0	17.2		4.3
7.1	11.8		18.9					15.4
7.5	13.3	71.4	4.8	9.5	68.0	87.2	63.8	45.4
7.6				2.2	131.7	106.9		80.3
8.2	62.4	204.5	0.0	15.5	80.6	85.5	45.1	70.5
8.3	37.6		1.2	0.0	67.8	120.2	49.9	46.1
9.1	17.5		0.0	0.0	0.0	22.7		8.0
9.2	43.1		0.0	0.9	28.9	73.2		29.2
10.1	20.8	165.3	0.0					62.0
10.3				45.0	19.8	0.0		21.6
11.1	5.2	61.6	0.0					22.3
11.2				b				
11.3					74.9	b	23.7	49.3
12.1	0.9	59.2	0.0	19.1	36.7	0.0	34.8	21.5
12.2	2.0	0.0	2.7	85.7	40.1	0.0	22.5	21.9
13.2	0.0							0.0
14.1	0.0		0.0					0.0
15.1	28.3	116.8	23.0	23.5	73.8	28.8	19.9	44.9
15.2	b							
16.8	0.0							0.0
17.3	0.0							0.0
18.4	0.0							0.0
19.2	20.1	118.4	0.6	0.0	19.9	4.6	1.4	23.6
20.1	70.2	71.7	0.0	28.0	38.8	21.3	39.8	38.5
21.6	53.1	80.8	10.8	118.3	62.6	10.6	33.5	52.8
22.1			0.0	5.2	0.0	0.0		1.3
23.1				5.6	44.0	b		24.8
23.2				b	0.0			0.0
24.1					0.0			0.0
24.2					0.0			0.0
Mean for all sites	19.3	80.1	2.9	18.5	35.1	36.8	28.1	22.0

a Previously unpublished data obtained from P.G. Amiro, Fisheries and Oceans, Halifax, N.S.

b Present but no estimate possible because there were not sufficient fish to conduct a recapture.

Table 10. Densities of age 1+ Atlantic salmon parr by location, site and year for sites electrofished in the Musquodoboit River, 1988-1993[a] and 1996.

Site number	1+ parr per 100 m^2 1988	1989	1990	1991	1992	1993	1996	Mean
1.2	3.2	2.5	1.7	1.9	2.9	2.2		2.4
1.4	5.2	b	0.6	1.5	2.1	2.9		2.5
2.1	6.7		3.9	0.8	4.8	3.9		4.0
2.4	3.9		5.6	0.6	5.8	3.3		3.8
3.1	7.0		2.1	0.0	2.3	5.3		3.3
4.1	31.7		57.3	26.2	28.5	34.7	24.4	33.8
4.2	30.8		56.3	20.3	24.3	22.2	24.4	29.7
5.3	0.5		0.0	0.0				0.2
6.1	7.6		5.7	11.8	4.2	21.5		10.2
7.1	3.4		23.3					13.4
7.5	2.8	19.7	43.5	12.0	6.4	15.5	7.3	15.3
7.6				4.2	9.3	8.6		7.4
8.2	11.4	29.7	70.6	26.4	18.1	19.8	12.1	26.9
8.3	8.1		44.2	15.0	12.9	28.3	14.3	20.5
9.1	9.9		14.3	0.0	3.3	18.8		9.3
9.2	19.1		19.7	3.6	1.6	21.3		13.1
10.1	14.3	18.6	44.9					25.9
10.3				13.6	17.7	19.8		17.0
11.1	5.5	4.7	6.7					5.6
11.2				0.0				0.0
11.3					12.6	2.0	3.2	5.9
12.1	18.6	9.4	58.6	21.9	32.9	7.6	18.8	24.0
12.2	10.3	8.1	59.5	21.9	33.5	14.5	13.2	23.0
13.2	3.3							3.3
14.1	0.4	0.0	0.0					0.1
15.1	10.8	10.7	15.3	6.0	8.0	5.8	4.0	8.7
15.2	b							
16.8	b							
17.3	0.0							0.0
18.4	0.0							0.0
19.2	22.9	46.8	31.0	0.0	25.1	34.8	4.8	23.6
20.1	5.4	32.4	25.1	1.9	7.4	15.0	5.3	13.2
21.6	16.1	22.4	22.5	11.8	23.1	9.4	14.1	17.1
22.1			6.5	8.9	9.3	10.0		8.7
23.1				0.4	0.2	0.3		0.3
23.2				0.0	0.0			0.0
24.1					0.1			0.1
24.2					0.7			0.7
Mean for all sites	9.6	17.1	24.8	8.1	11.0	13.6	12.2	10.4

a Previously unpublished data obtained from P.G. Amiro, Fisheries and Oceans, Halifax, N.S.
b Present but no estimate.

Table 11. Densities of age 2^+ Atlantic salmon parr by location, site and year for sites electrofished on the Musquodoboit River, 1988-1993[a] and 1996.

Site number	2^+ parr per 100 m^2							
	1988	1989	1990	1991	1992	1993	1996	Mean
1.2	0.3	2.4	0.0	0.2	0.1	0.2		0.5
1.4	0.1	b	0.0	0.1				0.1
2.1	0.8		2.9	4.0	0.0	1.1		1.8
2.4	1.7		2.0	0.4	0.0	0.2		0.9
3.1	3.5		0.3	0.0	0.0	0.0		0.8
4.1	3.5		7.0	5.3	7.9	8.1	5.0	6.1
4.2	1.2		5.8	4.2	9.3	5.9	4.6	5.2
5.3	5.3		0.0	0.0				1.8
6.1	6.2		1.3	0.0	0.0	1.3		1.8
7.1	3.1		1.2					2.2
7.5	1.0	2.1	2.8	0.0	3.5	1.7	1.4	1.8
7.6				0.0	2.0	1.2		1.1
8.2	5.3	4.3	13.6	6.4	8.4	4.1	5.0	6.7
8.3	0.9		8.8	0.7	3.4	4.1	5.8	4.0
9.1	4.8		7.4	0.5	0.7	4.4		3.6
9.2	3.6		2.5	0.0	0.0	1.1		1.4
10.1	3.7	4.1	1.5					3.1
10.3				4.7	4.3	4.6		4.5
11.1	0.9	1.4	1.2					1.2
11.2				1.8				1.8
11.3					0.4	1.2	0.7	0.8
12.1	0.6	7.1	3.5	6.6	2.5	13.4	9.4	6.2
12.2	1.7	10.3	4.6	4.4	3.9	10.1	12.0	6.7
13.2	0.0							0.0
14.1	6.7	b	0.0					3.4
15.1	1.1	7.0	0.2	3.7	1.1	0.9	2.7	2.4
15.2	0.0							0.0
16.8	0.0							0.0
17.3	0.0							0.0
18.4	0.0							0.0
19.2	8.0	9.4	11.9	0.0	0.0	0.0	9.5	5.5
20.1	11.0	1.0	1.9	2.2	0.0	1.2	1.6	2.7
21.6	9.0	6.4	8.8	10.4	4.1	5.6	4.3	6.9
22.1			0.0	0.7	0.9	0.9		0.6
23.1				0.0	0.0	0.0		0.0
23.2				0.0	0.0			0.0
24.1					0.0			0.0
24.2					0.0			0.0
Mean for all sites	2.9	5.0	3.6	2.2	2.0	3.1	5.2	2.2

a Previously unpublished data obtained from P.G. Amiro, Fisheries and Oceans, Halifax, N.S.
b Present but no estimate.

Table 12. Summary of analyses of juvenile Atlantic salmon densities for eight selected sites[1] on the Musquodoboit River, 1988-1993[2] and 1996.

Dependent variable	Factor	N	P-value	Significant factor pairs
Ln(fry density + 1)	Year (1988-1993, 1996)	48	0.003	1989/90, 1990/91 1990/92, 1990/96
Ln(fry density + 1)	Linear trend across years		0.664	
Ln (1^+ parr density + 1)	Year (1988-1993, 1996)	48	0.017	1988/90, 1990/91 1990/96
Ln(1^+ parr density + 1)	Linear trend across years		0.016	
Ln (2^+ parr density + 1)	Year (1988-1993, 1996)	48	0.465	
Ln(2^+ parr density + 1)	Linear trend across years		0.935	
Ln(1^+ parr + 1) in year i+1	Ln(fry density + 1) in year i	92	0.000	

1 The eight selected sites were those fished most consistently over the years electrofishing occured and include sites 7.5, 8.2, 12.1, 12.2, 15.1, 19.2, 20.1, and 21.6.

2 Previously unpublished data obtained from P.G. Amiro, Fisheries and Oceans, Halifax, N.S.

Table 13a. Number of fish marked and captured on the Musquodoboit River during the mark-and-recapture experiment to estimate the population size of adult Atlantic salmon in 1996.

Marks applied by anglers= **36**
Adjusted marks = **36-4=32**
Captures during broodstock collections= **49**
Recaptures = **3**

Assumed 10% hook-and-release mortality = **4**

Capture date: October 23, 1996

	Hatchery				Wild				
	Salmon		Grilse		Salmon		Grilse		
	Male	Female	Male	Female	Male	Female	Male	Female	**Total**
Capture	2		14	2	3	11	17		49
Fish taken from capture sample to hatchery for broodstock	2		1		3	11	14		31

Table 13b. Estimates of adult Atlantic salmon returns to the Musquodoboit River based on the mark-and-recapture data in 1996.

	Petersen (corrected)		Bayesian	
	Estimate	95% C.I.	Estimate	90% C.I.
Post-fishery estimate	412	167 - 1030	520	320 - 3680
10% hook-and-release mortality[1]	34		34	
Pre-fishery estimate	446	201 - 1064	554	354 - 3714

[1] Preliminary 1996 angling catch reported by anglers on license stubs was 337 fish.

Table 14. Number and age of Atlantic salmon juveniles reared at fish culture stations and released into rivers of SFA 20, 1990-96.

River		Age	1990	1991	1992	1993	1994	1995	1996
East River Sheet Harbour		0+ parr	14055	35910	40210	25060	6000	26863	26000
		1+ smolt	10449	21450	26978	26576	26771	26187	18700
		2+ smolt						10790	
Liscomb		0+ parr	35832	69750	54485	40305	51325	30321	46000
		1+ parr			6318	1323			
		1+ smolt	11557	17027	19236	11121	18966	35738	27500
		2+ smolt	10836	8104	11279	10114	9258		
Moser		0+ parr	11200	13942					
		1+ smolt	21361	9608	19563				
Musquodoboit		0+ parr	8000	31146	31572	14600	37802	28316	17000
		1+ smolt	23236	11672	22815	21464	11680	27359	21800
St. Mary's	Main River	0+ parr				5008			
	West Branch	2+ smolt	5538						
	East Branch	0+ parr	25060		43315	63471			
		1+ parr	2565	7820	15293	10815	9561		
		2+ smolt	18201	20683		19638	19755	25900	
West River Sheet Harbour		0+ parr	10035						
		1+ smolt	9598	9999		16704	9918		

Table 15a. Mean Atlantic salmon fry (0+ parr) densities per 100 m^2 for various sub-drainage portions of the St. Mary's River and the entire river, 1985, 1986 and 1990-1996. The number of sites electrofished in each case is given (N).

Area	1985		1986		1990		1991		1992		1993		1994		1995		1996		All Years	
	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N
West River tributaries & main	7.3	19	13.5	19	7.9	3	11.5	8	8.4	11	17.3	4	42.7	7	15.3	9	11.2	3	13.8	83
West River tributaries	4.6	15	12.9	15	7.9	3	11.5	8	9.7	9	17.3	4	49.1	5	8.0	7	11.2	3	12.6	69
West River main	17.1	4	15.8	4					2.8	2			26.6	2	40.9	2			19.4	14
East River tributaries & main	6.6	6	10.1	16	5.3	11	3.3	9	3.3	16	17.3	5	24.6	8	18.5	14	14.8	7	10.7	92
East River tributaries	6.6	6	12.0	12	6.4	9	3.3	9	2.9	11	17.3	5	24.6	8	24.2	10	14.8	7	12.1	77
East River main			4.2	4	0.4	2			4.3	5					4.1	4			3.7	15
Main River tributaries	0.2	3	0.0	2	4.2	2	0.2	4	0.3	2	0.0	1							0.7	14
St. Mary's River system	6.4	28	11.3	37	5.7	16	5.8	21	5.0	29	15.6	10	33.0	15	17.2	23	13.7	10	11.3	189

Table 15b. Mean Atlantic salmon 1+ parr densities per 100 m^2 for various sub-drainage portions of the St. Mary's River and the entire river, 1985, 1986 and 1990-1996. The number of sites electrofished in each case is given (N).

Area	1985		1986		1990		1991		1992		1993		1994		1995		1996		All Years	
	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N
West River tributaries & main	7.8	19	4.8	19	7.7	3	2.9	9	4.2	11	10.2	4	4.6	7	5.4	9	3.2	3	5.6	84
West River tributaries	9.0	15	4.4	15	7.7	3	2.9	9	5.1	9	10.2	4	5.7	5	6.2	7	3.2	3	6.0	70
West River main	3.4	4	6.5	4					0.5	2			2.1	2	2.7	2			3.6	14
East River tributaries & main	4.9	6	5.1	16	7.2	13	6.0	9	2.5	16	7.0	5	8.1	8	4.8	14	3.9	8	5.2	95
East River tributaries	4.9	6	5.7	12	9.9	9	6.0	9	3.1	11	7.0	5	8.1	8	5.2	10	3.9	8	5.9	78
East River main			3.2	4	1.0	4			1.4	5					3.9	4			2.3	17
Main River tributaries	9.1	3	7.2	2	8.9	2	4.1	4	4.2	2	7.7	1							6.6	14
St. Mary's River system	7.3	28	5.1	37	7.5	18	4.4	22	3.3	29	8.4	10	6.5	15	5.1	23	3.7	11	5.5	193

Table 15c. Mean Atlantic salmon total (1+ and 2+) parr densities per 100 m^2 for various sub-drainage portions of the St. Mary's River and the entire river, 1985, 1986 and 1990-1996. The number of sites electrofished in each case is given (N).

Area	1985		1986		1990		1991		1992		1993		1994		1995		1996		All Years	
	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N
West River tributaries & main	8.8	19	6.3	19	10.5	3	3.7	9	5.1	11	10.8	4	5.3	7	6.3	9	3.7	3	6.6	84
West River tributaries	10.1	15	6.1	15	10.5	3	3.7	9	6.1	9	10.8	4	6.6	5	7.2	7	3.7	3	7.1	70
West River main	4.1	4	7.1	4					0.7	2			2.2	2	3.2	2			4.1	14
East River tributaries & main	5.0	6	6.4	16	9.6	13	6.8	9	3.3	16	7.3	5	8.4	8	5.9	14	5.6	8	6.3	95
East River tributaries	5.0	6	7.3	12	12.7	9	6.8	9	3.9	11	7.3	5	8.4	8	6.3	10	5.6	8	7.0	78
East River main			3.9	4	2.5	4			1.9	5					4.7	4			3.2	17
Main River tributaries	10.1	3	7.9	2	11.5	2	6.1	4	4.7	2	8.1	1							7.9	14
St. Mary's River system	8.1	28	6.4	37	10.0	18	5.4	22	4.1	29	8.8	10	7.0	15	6.0	23	5.1	11	6.6	193

Table 15d. Mean Atlantic salmon 1+ parr densities per 100 m^2 for sites with non-zero densities and various sub-drainage portions of the St. Mary's River and the entire river, 1985, 1986 and 1990-1996. The number of sites electrofished in each case is given (N).

Area	1985		1986		1990		1991		1992		1993		1994		1995		1996		All Years	
	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N
West River tributaries & main	7.8	19	5.4	17	7.7	3	3.8	7	5.8	8	13.6	3	4.6	7	5.4	9	4.8	2	6.2	75
West River tributaries	9.0	15	5.1	13	7.7	3	3.8	7	7.6	6	13.6	3	5.7	5	6.2	7	4.8	2	6.8	61
West River main	3.4	4	6.5	4					0.5	2			2.1	2	2.7	2			3.6	14
East River tributaries & main	4.9	6	5.4	15	7.2	13	6.0	9	2.7	15	7.0	5	8.1	8	4.8	14	3.9	8	5.4	93
East River tributaries	4.9	6	5.7	12	9.9	9	6.0	9	3.4	10	7.0	5	8.1	8	5.2	10	3.9	8	6.0	77
East River main			4.2	3	1.0	4			1.4	5					3.9	4			2.4	16
Main River tributaries	9.1	3	7.2	2	8.9	2	4.1	4	4.2	2	7.7	1							6.6	14
St. Mary's River system	7.3	28	5.5	34	7.5	18	4.9	20	3.8	25	9.3	9	6.5	15	5.1	23	4.1	10	5.8	182

Table 16. Summary of ANOVAs for various comparisons in juvenile Atlantic salmon densities (1+ and total parr) as parr per 100 m^2, on the St. Mary's River.

Sites/areas	Dependent variable	ANOVA/regression effect(s)	N	P-value	Significant effect pairs
All sites	Total parr	Gradient	189	0.001	
		Gradient^2		0.004	
		Overall regression		0.001	
All sites	1+ parr	Gradient	189	0.003	
		Gradient^2		0.011	
		Overall regression		0.007	
All sites	Total parr	Year (1985, 86, 90-96)	189	0.001	1985/92, 1990/92
		Gradient		<0.001	
		Gradient^2		0.003	
All sites	1+ parr	Year (1985, 86, 90-96)	189	<0.001	1985/91, 1985/92, 1992/94
		Gradient		0.001	
		Gradient^2		0.007	
Sites 4, 5, 8, 10, 23	Total parr	Year (1985, 86, 90-96)	62		Interaction
		Site			
		Gradient			
		Gradient^2			
Sites 4, 5, 8, 10, 23	1+ parr	Year (1985, 86, 90-96)	62	0.036	None
		Site		0.367	
		Gradient		0.002	
		Gradient^2		0.024	
All sites	Gradient	River branch	189	<0.001	All
East, West	Total parr	River branch	175		Interactions
		Gradient			
		Gradient^2			
East, West	1+ parr	River branch	175		Interactions
		Gradient			
		Gradient^2			
East, West, tribs and main	Total parr	River branch	175	0.429	
		Area within branch		0.066	
		Gradient		0.014	
		Gradient^2		0.028	
East, West, tribs and main	1+ parr	River branch	175	0.243	
		Area within branch		0.026	East trib/East main
		Gradient		0.041	
		Gradient^2		0.065	
East, West, tribs and main with non-zero densities	1+ parr	River branch	164	0.031	All
		Area within branch		0.014	East trib/East main East main/West trib
		Gradient		0.001	
		Gradient^2		0.017	

Table 17. Summary of ANOVA and regressions for various comparisons in juvenile Atlantic salmon densities (0+ and 1+parr) as parr or fry (0+ parr) per 100 m^2, on the St. Mary's River. Eggs refers to spawner eggs deposited in the system and a description of how the eggs were estimated is provided in the text.

Sites/areas	Dependent variable	ANOVA/regression effect(s)	N	P-value	Significant effect pairs
All sites	Fry (0+ parr)	Year (1985, 86, 90-96)	189	0.000	1985/94, 1991/94, 1992/94
All sites	Mean of fry at year i+1	Eggs at year i	9	0.619	
West	Mean of fry at year i+1	Eggs at year i	9	0.877	
West	Mean of fry at year i+1	Grilse eggs at year i	9	0.823	
West tribs	Mean of fry at year i+1	Eggs at year i	9	0.737	
West tribs	Mean of fry at year i+1	Grilse eggs at year i	9	0.979	
All sites	Mean of 1+ parr adjusted for gradient at year i+2	Eggs at year i	9	0.743	

Table 18. Angling catches of grilse and salmon, effort, catch per unit effort and proportions of grilse to salmon for Salmon River, Guysborough, 1983 to 1996.

Year	Angling catch			Effort	Catch per unit effort	Proportion grilse to salmon
	Grilse		Salmon			
	Retained	Released	Released			
1983	41	4	20	1164 *	0.056	2.25
1984	217	42	39	1621 *	0.184	6.64
1985	160	17	345	1129	0.462	0.51
1986	67	4	152	1129	0.198	0.47
1987	167	5	52	1015	0.221	3.31
1988	230	7	122	1485	0.242	1.94
1989	255	12	211	1761	0.271	1.27
1990	250	34	226	1787	0.285	1.26
1991	190	23	148	1809	0.200	1.44
1992	279	34	197	1892	0.270	1.59
1993	179	33	103	1454	0.217	2.06
1994	52	161	63	854	0.323	3.38
1995	191	51	166	1655	0.247	1.46
1996	0	143	62	348	0.589	2.31
Totals	2278	570	1906	19103	0.249	1.49
Means					Mean proportion of salmon, 1983-96	
1991-95	178	60	135	1533		
1986-95	186	36	144	1484		**0.402**

* Salmon numbers include some retained catch.

Table 19. Number of Atlantic salmon fry (0+ parr) and parr (total parr including age 1+ and 2+ fish) captured during ten minutes of electrofishing at several sites on Salmon River, Guysborough, in 1984 and 1996.

	Number of fish			
	1984		1996	
Site	Fry	Parr	Fry	Parr
1	11	4		
2	3	3		
3	15	4		
4	16	4		
5	17	3	11	1
6	17	2	15	0
7	9	5	5	4
8	1	4	3	8
9	1	0	0	2
10	23	4	15	6
11	16	5	12	6
12	0	0		
13	0	4	0	7
14	2	1	0	4
15	1	13		
16	10	7	8	18
17	5	11	26	7
18	20	13	16	4
19	15	0	29	7
20	0	0		
Mean	9.1	4.35	10.8	5.69

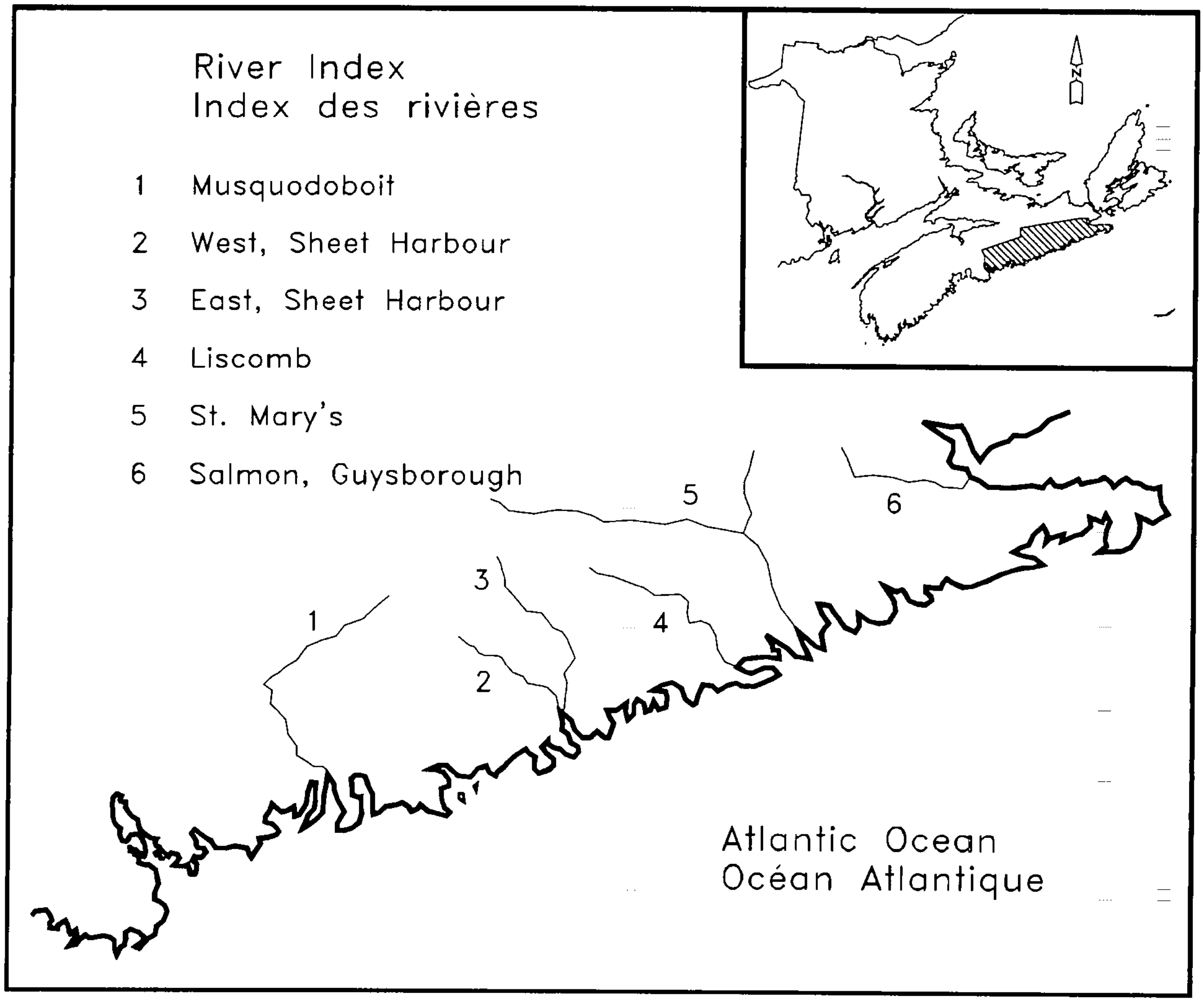

Figure 1. Key rivers of Salmon Fishing Area 20, Eastern Shore, Nova Scotia.

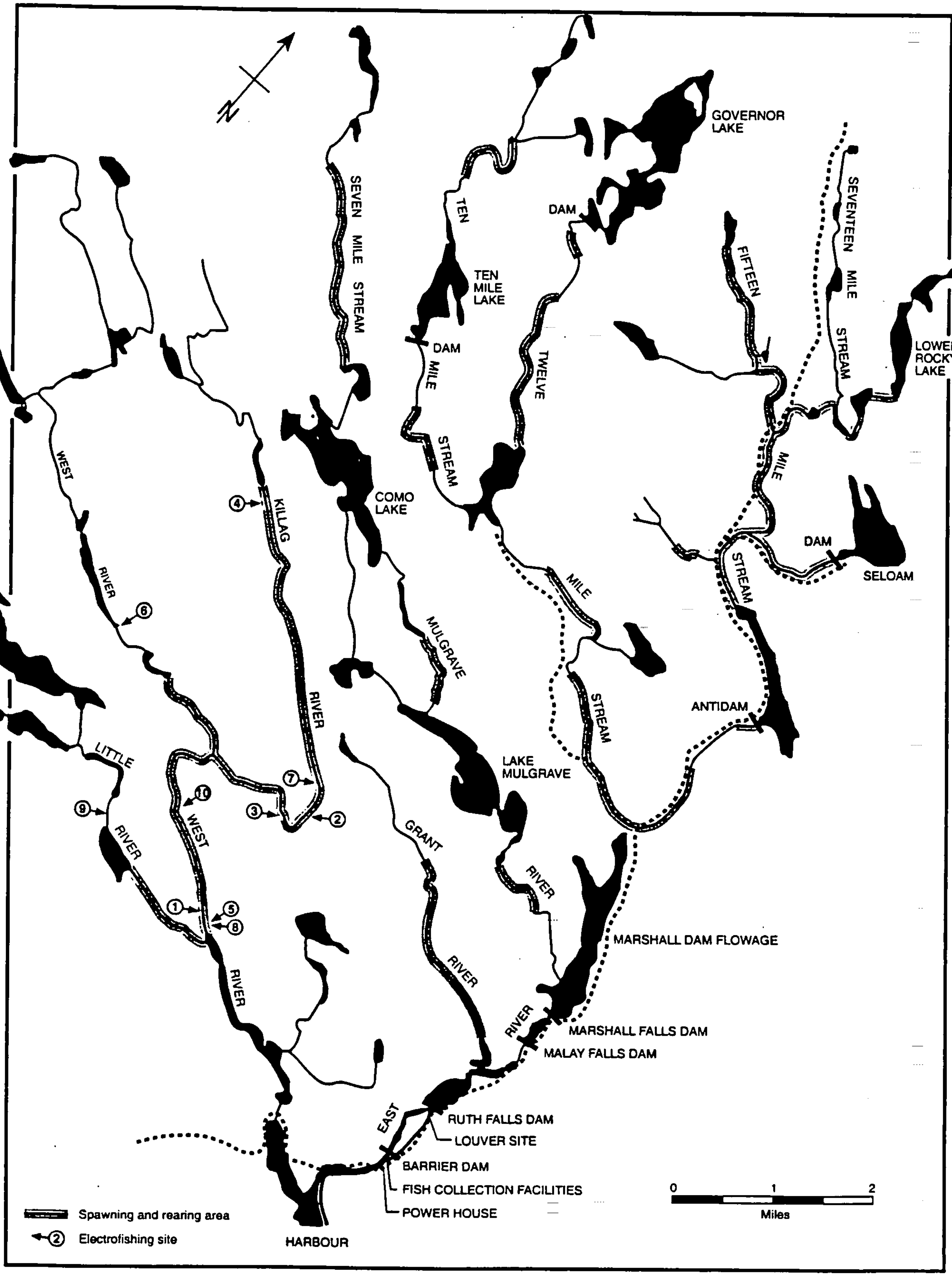

Figure 2. The dams and traps on East River, Sheet Harbour, and the electrofishing sites on West River, Sheet Harbour.

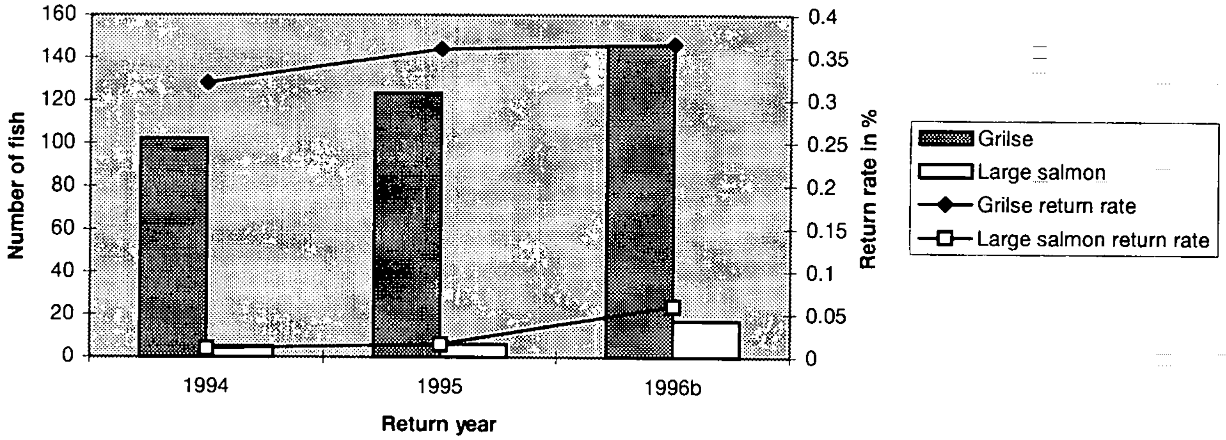

Figure 3. Number and rate of return for smolts as large salmon and grilse to the counting facility at East River, Sheet Harbour.

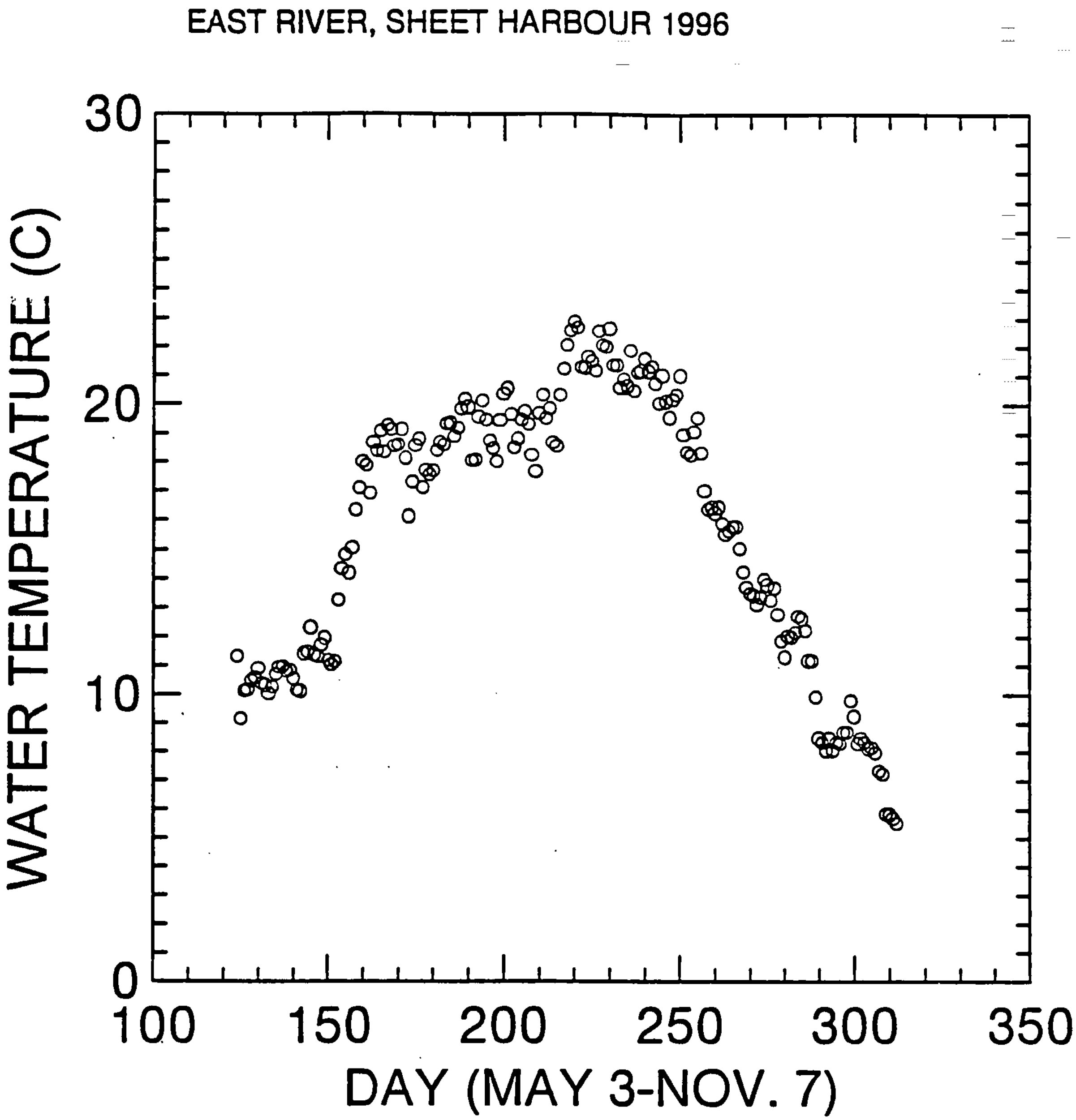

Figure 4. Temperature of the East River, Sheet Harbour, near the mouth of the river in 1996. Daily minimum and maximum points are plotted.

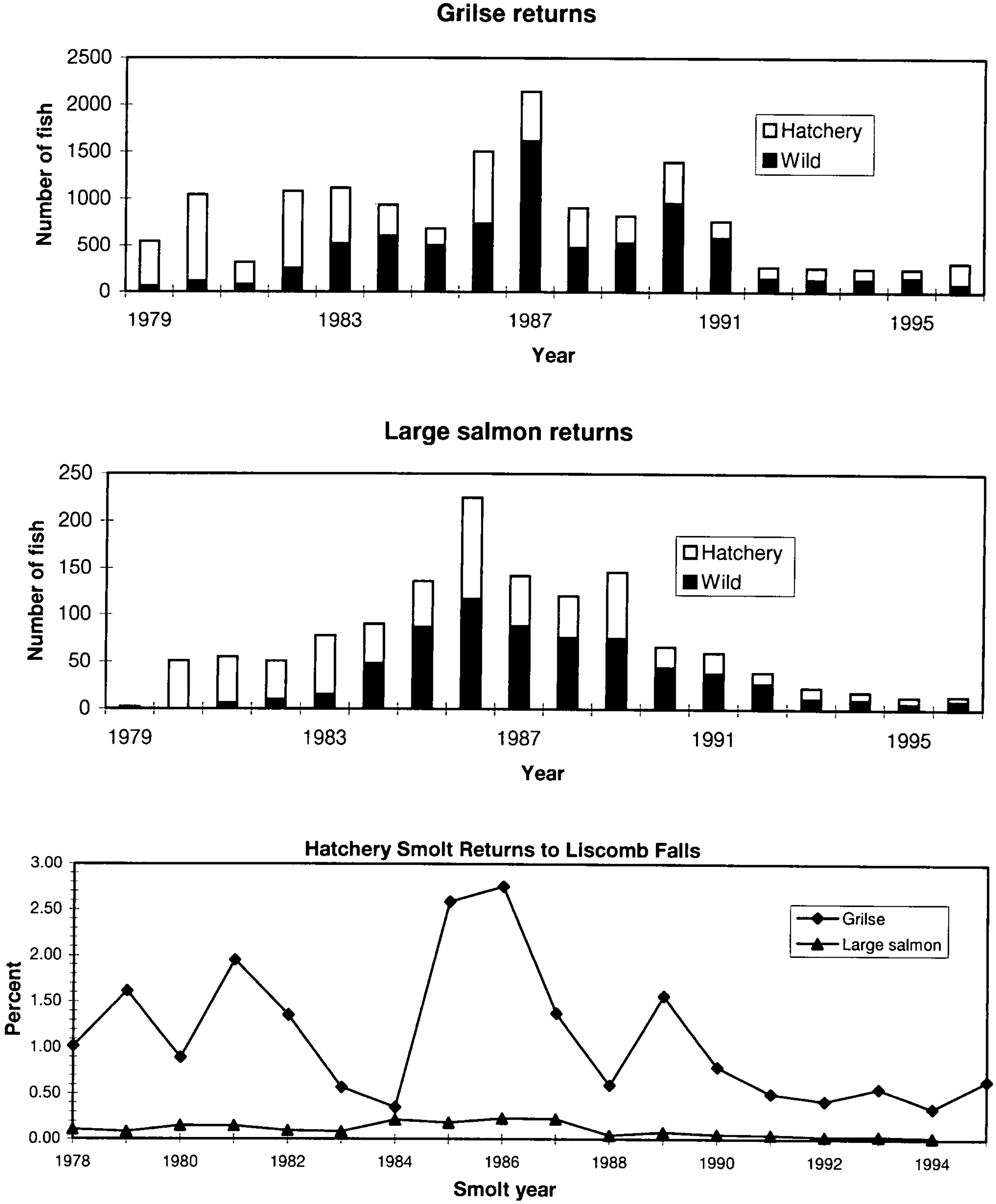

Figure 5. Counts of wild and hatchery salmon and percent return from hatchery smolts at the Liscomb Falls fish counting facility in recent years.

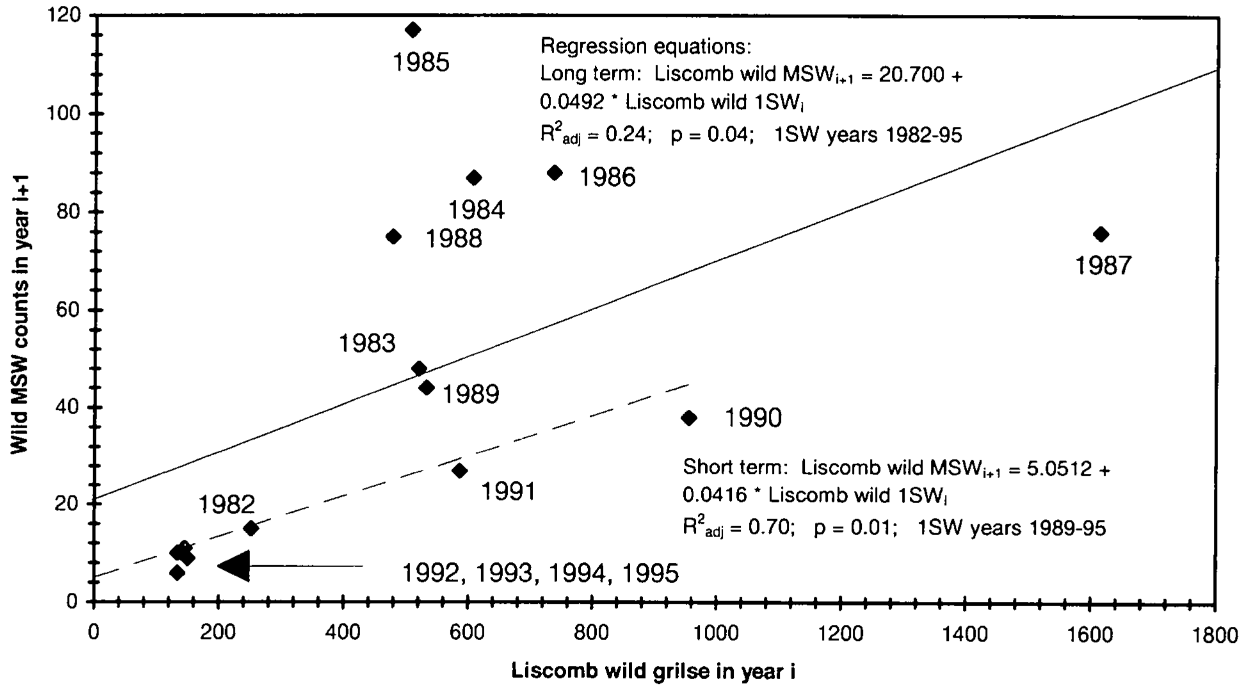

Figure 6. Scatter plot of the Liscomb River wild large salmon returns (year i+1) and wild grilse returns (year i) the previous year. The solid line represents the longer time series regression (1982-95) and the dashed line represents the 1989-95 time series regression fit to the data.

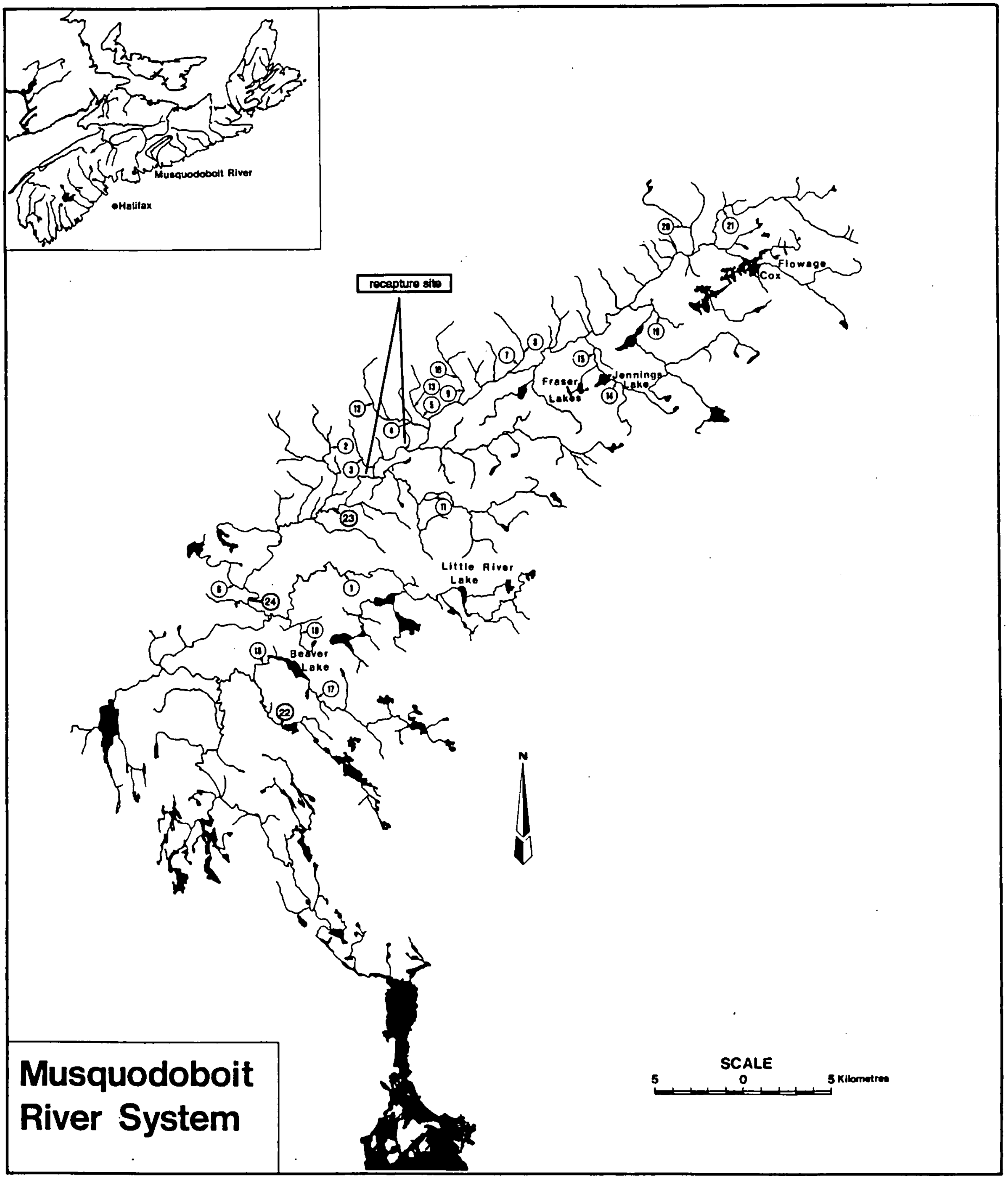

Figure 7. Map of the Musquodoboit River system with the 1996 recapture site (associated with the mark-and-recapture estimate) marked and the electrofishing sites used to estimate juvenile salmon densities.

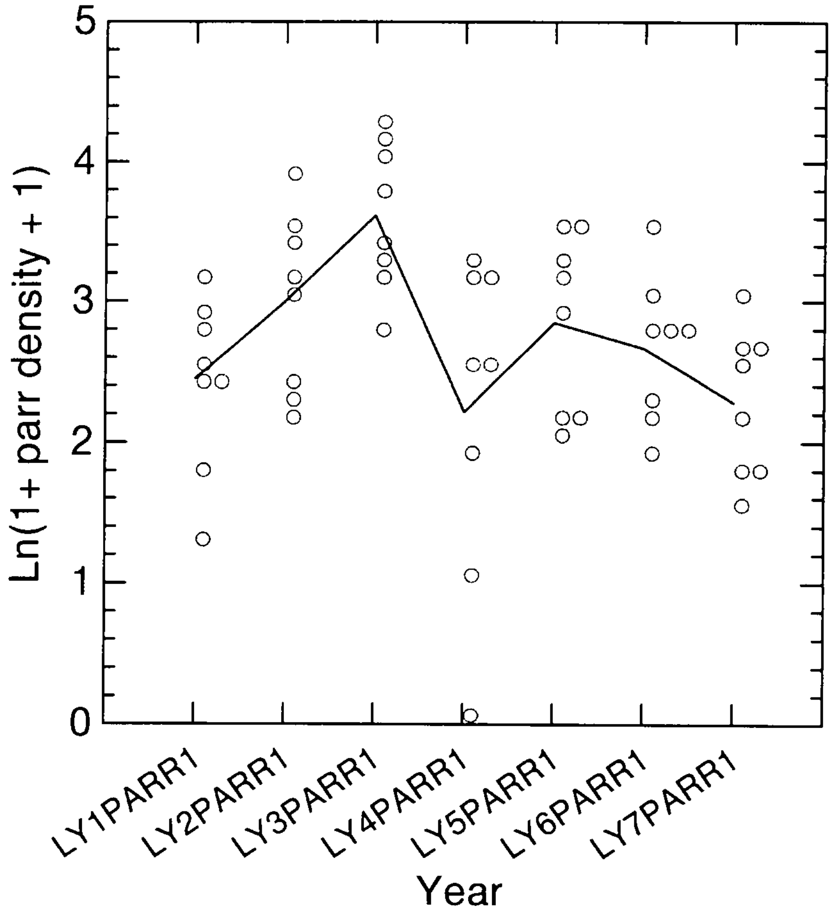

Figure 8. Plot of the natural logarithm of 1+ parr density across years when fishing occurred, 1988-93 and 1996, Musquodoboit River. The solid line connects the means of each year.

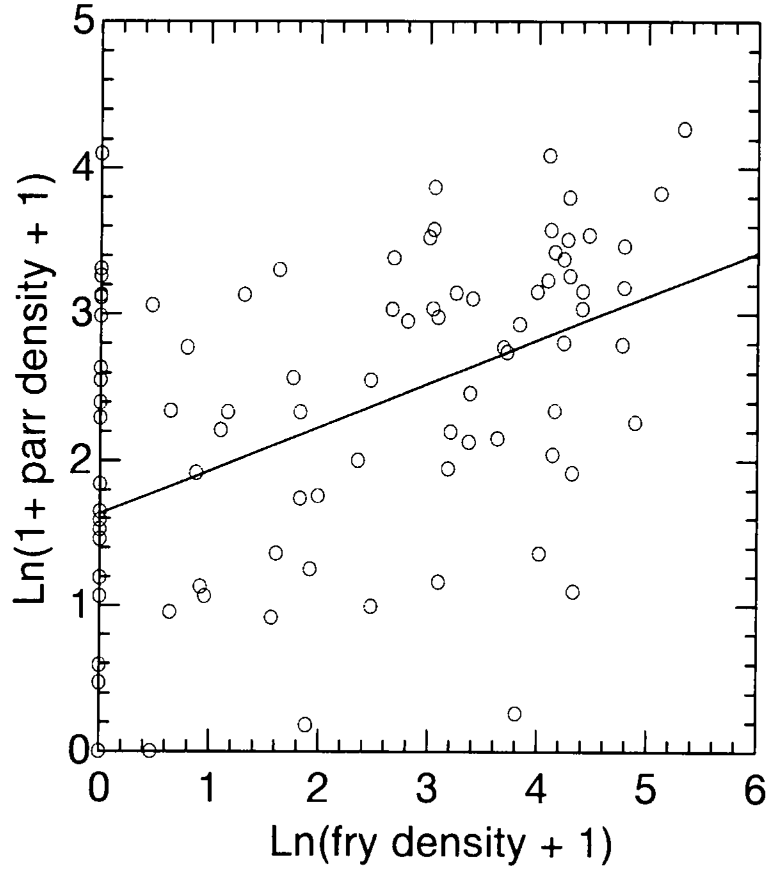

Figure 9. Plot of the natural logarithms of the density of 1+ parr in year i+1 and 0+ parr (fry) the previous year (i) for paired sites on the Musquodoboit River. Electrofishing took place annually from 1988 to 1993 and again in 1996. The solid line is the regression line.

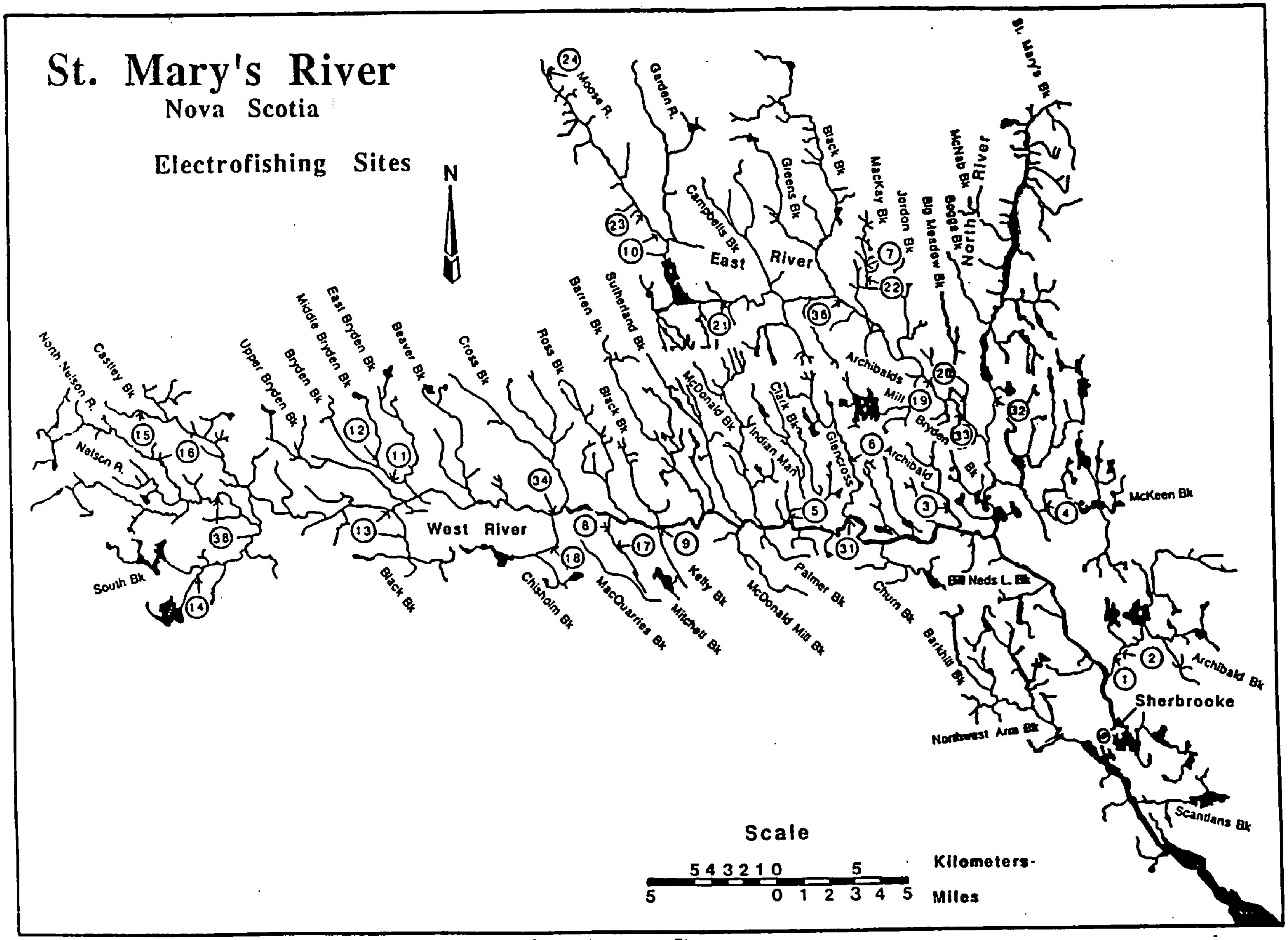

Figure 10. Map of the St. Mary's River system with electrofishing sites indicated.

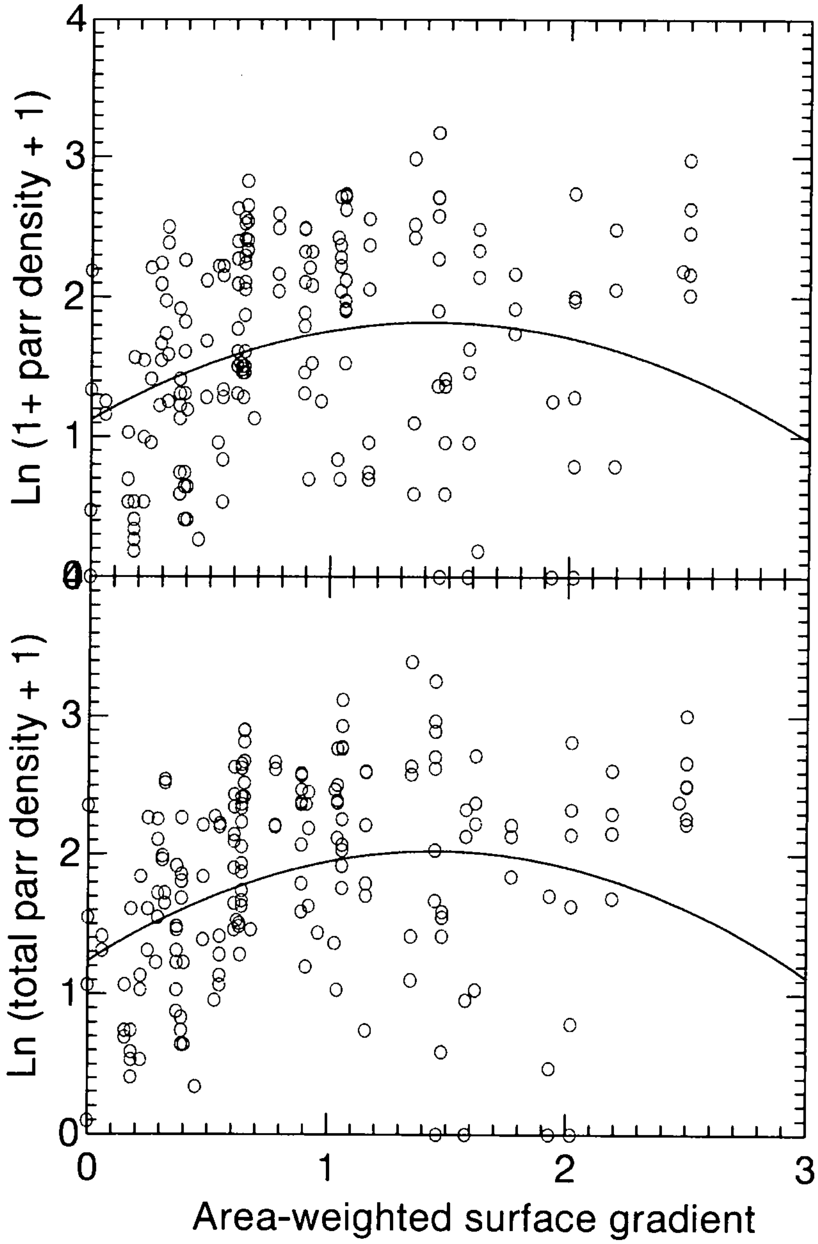

Figure 11. Plot of the natural logarithms of parr densities against area-weighted gradient for several years of density data on the St. Mary's River. The solid lines are the quadratic regression lines.

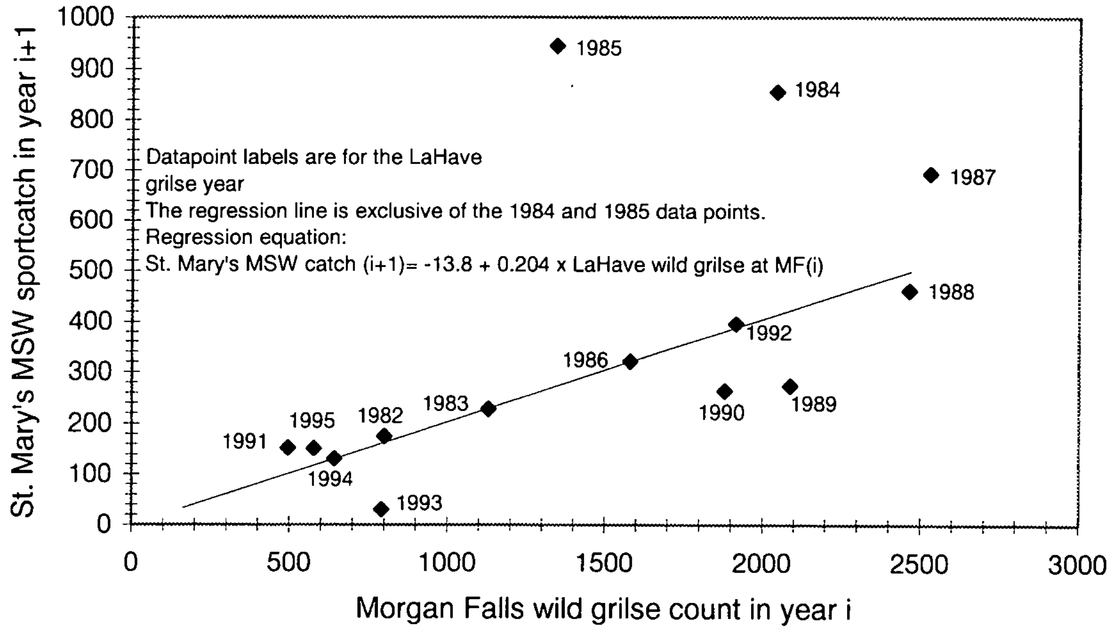

Figure 12. Scatter plot of the wild grilse counts at Morgan Falls on the LaHave River and the St. Mary's River large salmon sportcatch the next year with a fitted regression line, for the years 1982 to 1995 (grilse year on graph).

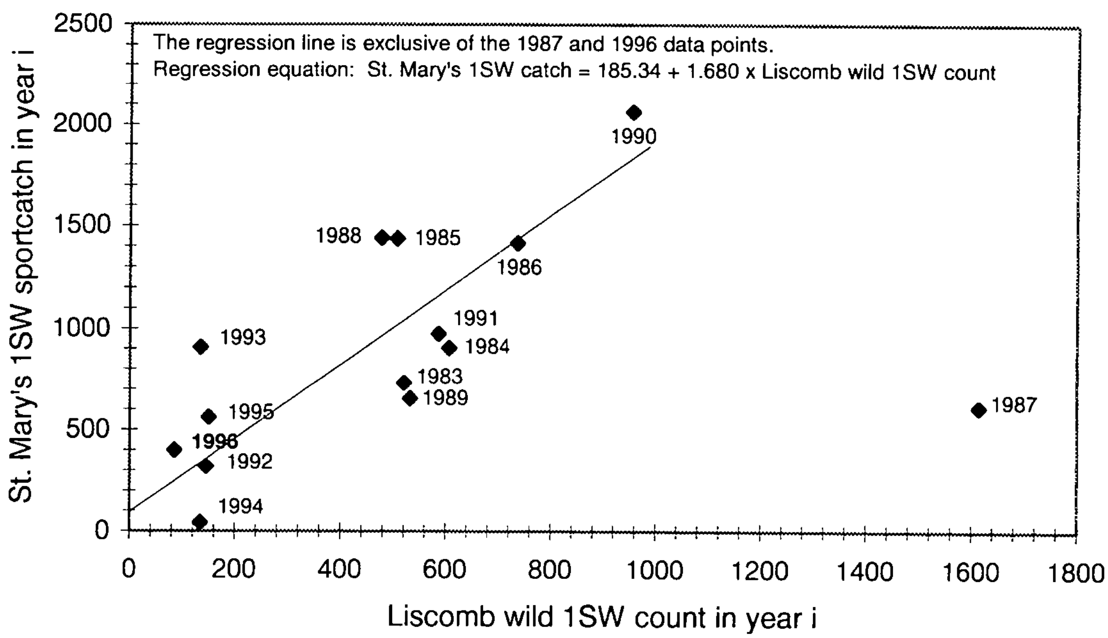

Figure 13. Scatter plot of the wild grilse returns to Liscomb River and the grilse sportcatch on the St. Mary's River with a fitted regression line, for the years 1983 to 1996.

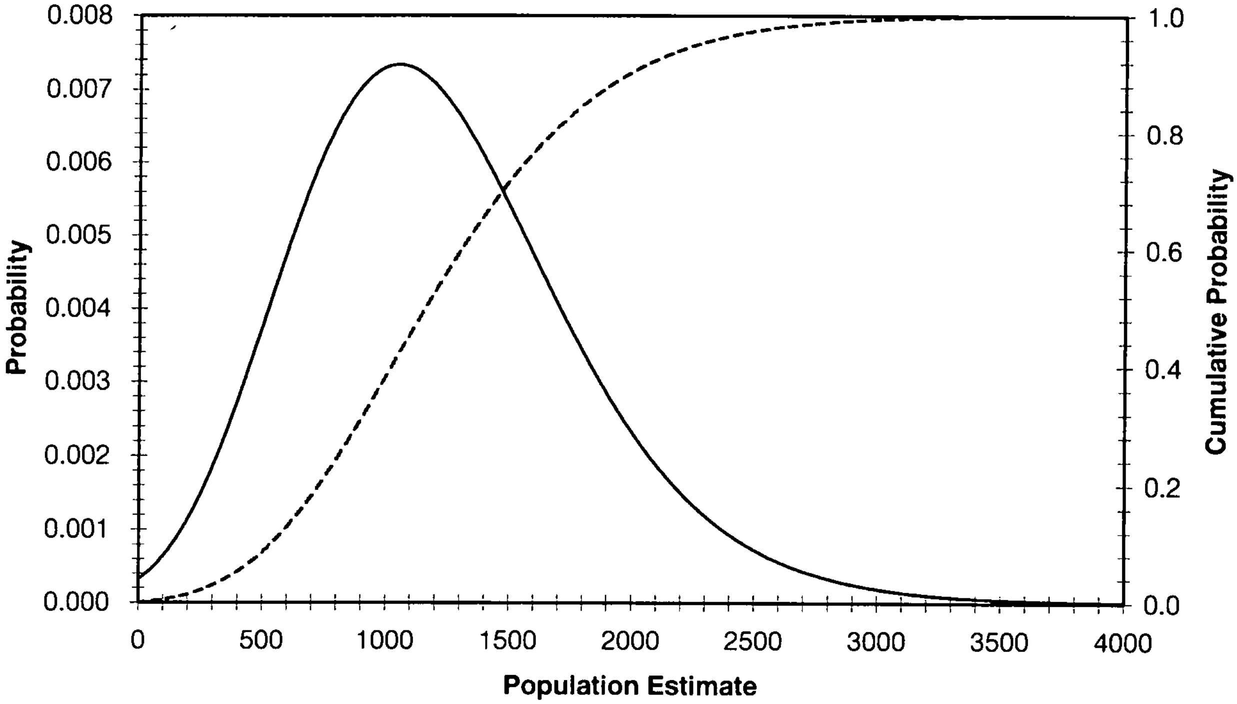

Figure 14. Probability (solid line) and cumulative probability (dashed line) distributions of total Atlantic salmon re to the St. Mary's River in 1996 based on the LaHave River 1996 exploitation rate (see text) and the total angling on the St. Mary's River in 1996.

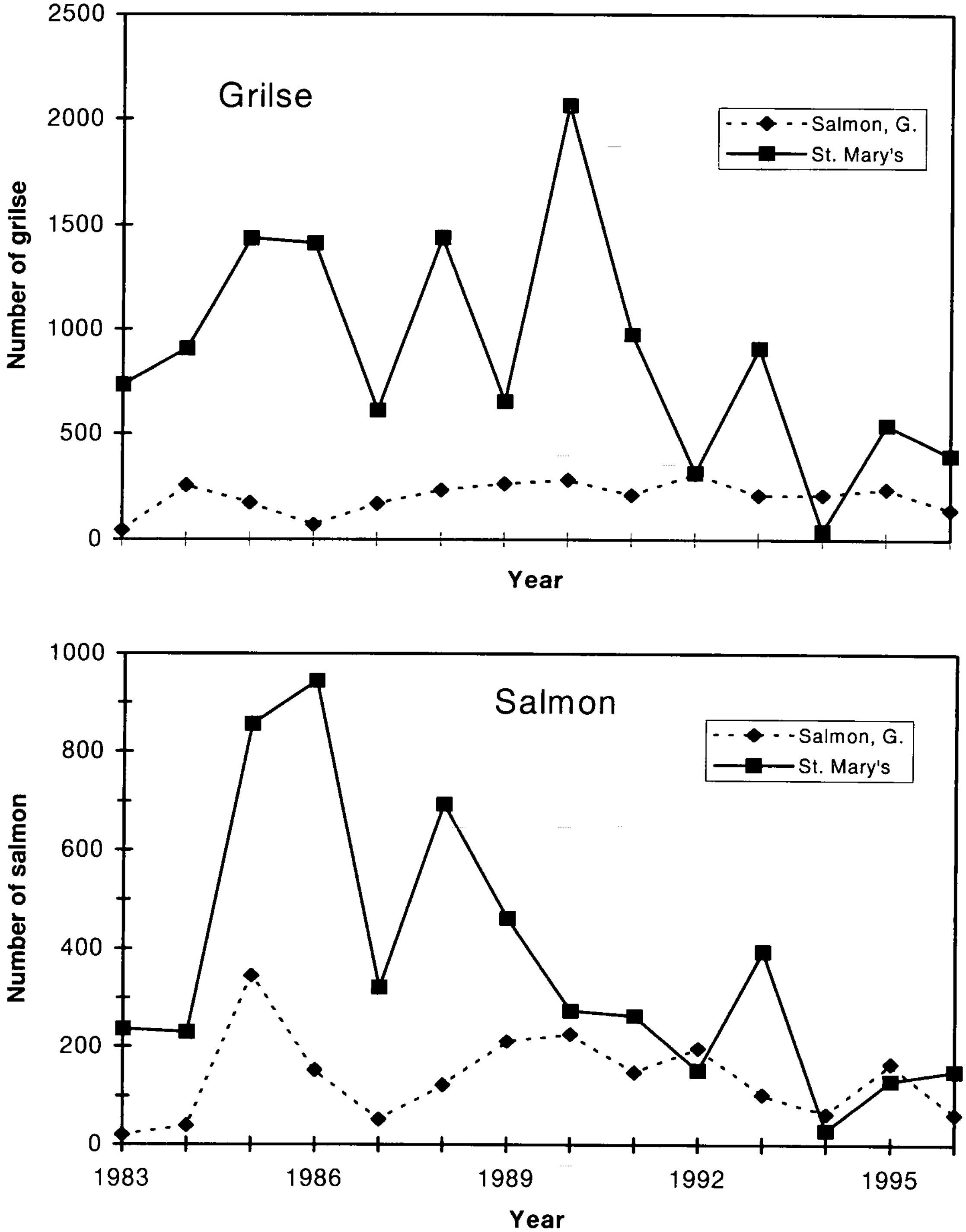

Figure 15. Atlantic salmon sportcatch on Salmon River, Guysborough, and St. Mary's River, 1983-1996. Catches include retained and released fish.

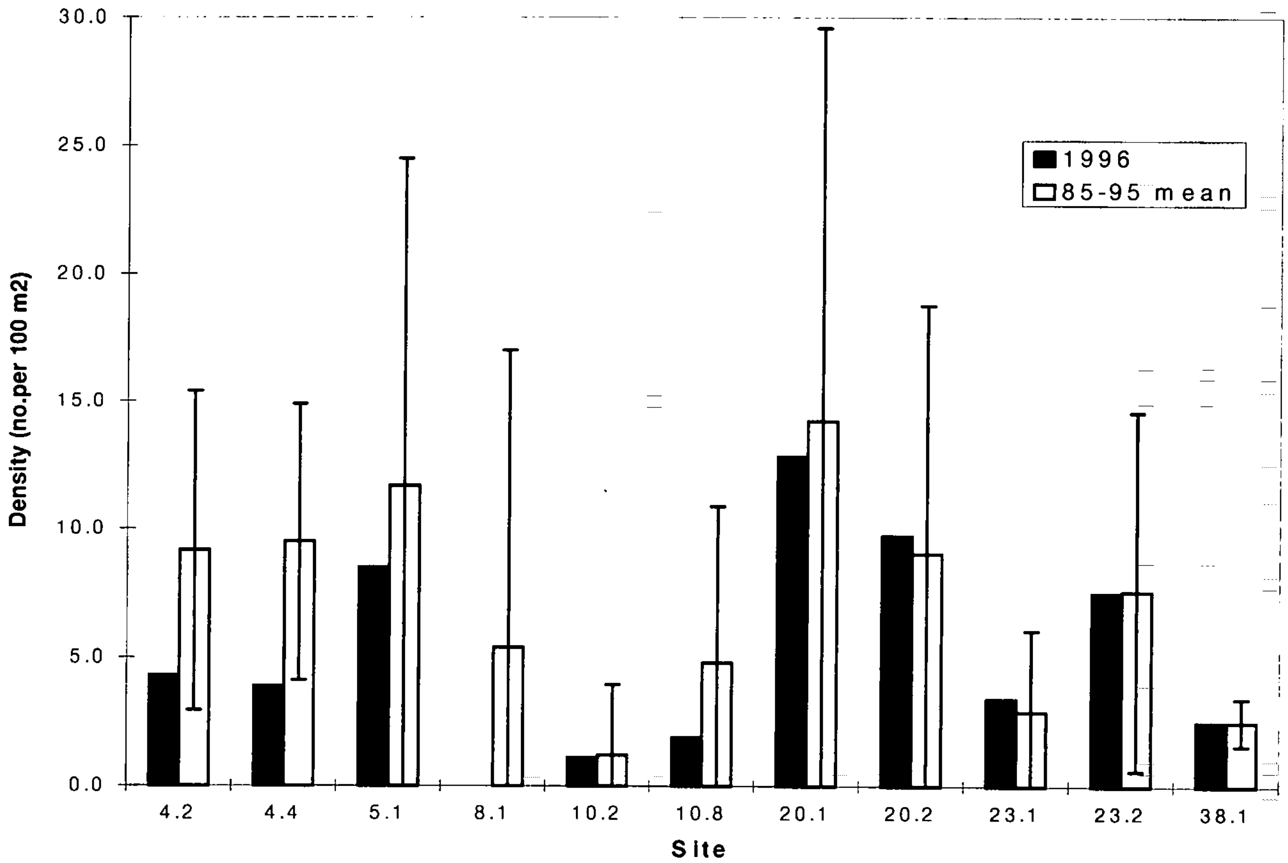

Figure 16. Saint Mary's River total parr densities for 1996 and mean densities for 1985, 1986 and 1990-1995 on 11 sites fished in 1996. Error bars represent 2 * standard deviation.

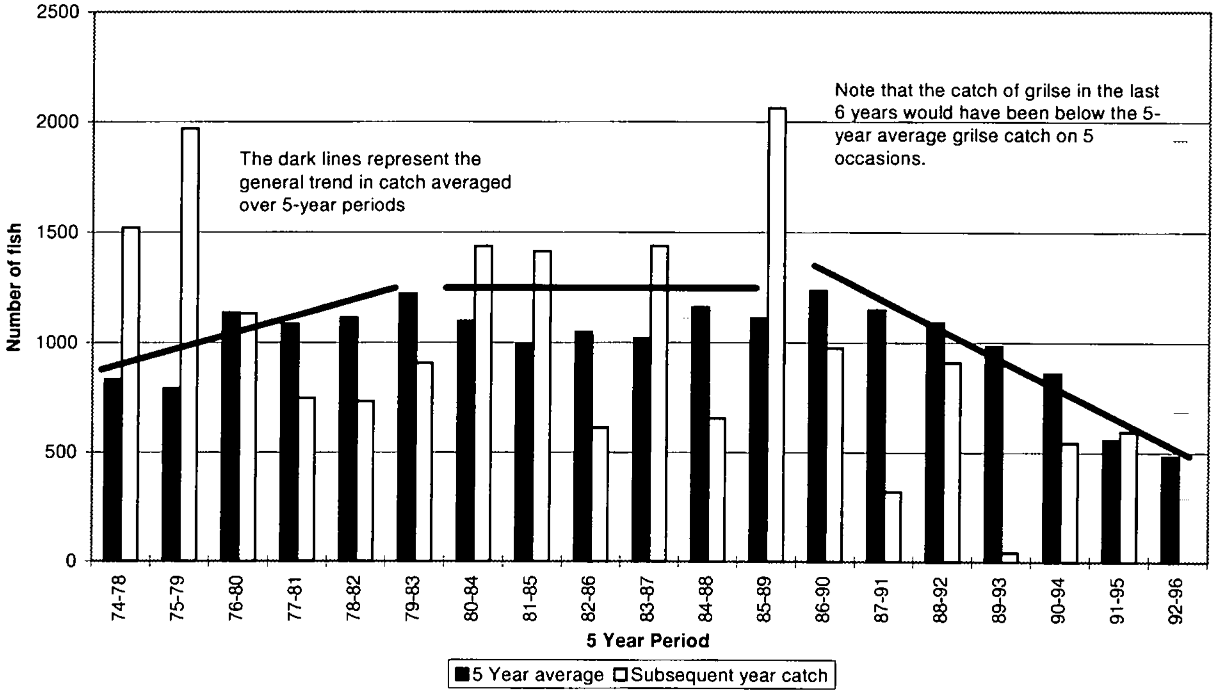

Figure 17. Five-year average grilse catches on the St. Mary's River from 1974 to 1996 (shaded bars) and the subsequent-year catch (clear bars).

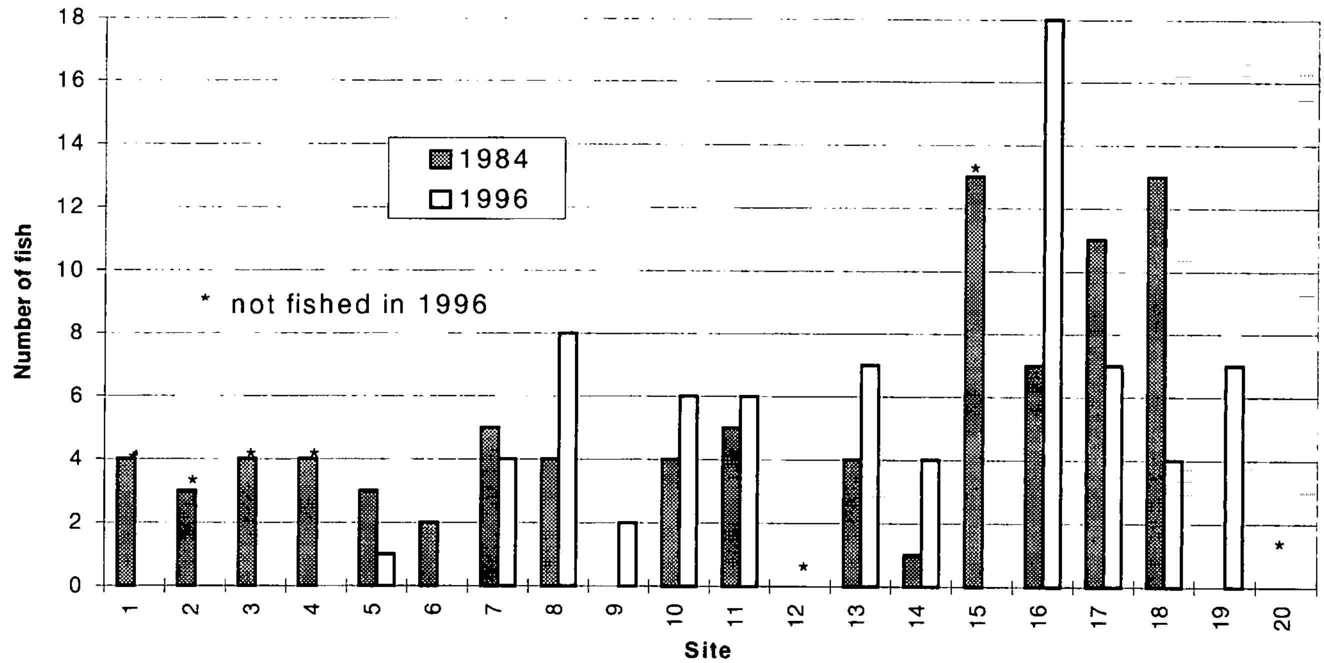

Figure 18. Juvenile Atlantic salmon numbers (total of 1+ and 2+ parr) captured during 10 minutes of electrofishing at several sites on Salmon River, Guysborough, in 1984 and 1996. Sites which were fished but no fish were captured can be noted by the absence of a bar; sites not fished in 1996 are marked with an asterisk.

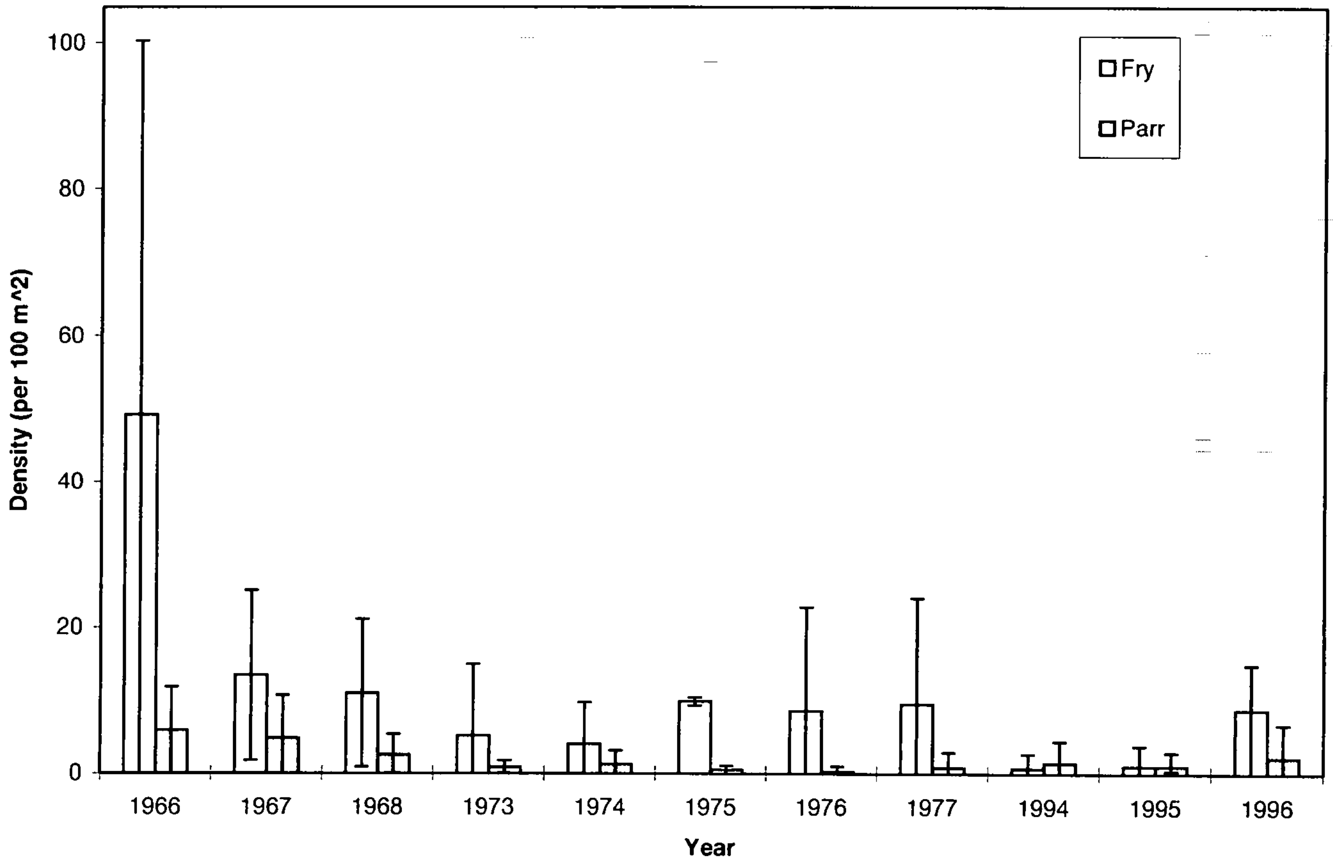

Figure 19. Fry (0+ parr) and parr (1+ and 2+) Atlantic salmon densities and error bars (2*SD), on the West River, Sheet Harbour, for some years, 1966-1996.