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Stock Status of Atlantic Salmon on the Eastern Shore of Nova Scotia, Salmon Fishing Area 20, in 1995

by

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Abstract

The sport catch of Atlantic salmon on Salmon Fishing Area 20 (SFA 20) rivers, the eastern shore of Nova Scotia, in 1995, was considerably higher than in 1994. However, sport catch was low relative to the previous five-year and ten-year means.

The count of wild and hatchery grilse at Liscomb Falls on the Liscomb River in 1995 of 248 fish was similar to the previous low noted in 1994 of 253 fish. The rate of return for hatchery fish returning as grilse to the Liscomb River trap was only 0.34% - well below the previous low since 1984 of 0.42% which occurred in 1993. The return rate has been consistently low for the last four to five years and the lowest of any consecutive year period since the trap began operating in 1979, thus indicating a decrease in survival of smolts at sea.

Many rivers in SFA 20 are acid-stressed and continue to receive additional acid input through precipitation. It is difficult to determine optimum spawning requirements on the rivers where acidity affects the survival of salmon juveniles.

The return of salmon to East River, Sheet Harbour, is 90% or more of hatchery origin because of the hydroelectric dams on the system. Consequently there is not a conservation concern for the East River stock.

The salmon stock on West River, Sheet Harbour, is believed to be threatened because of the acidity of the water and the low number of juveniles detected there.

The number of salmon which returned to the Liscomb River in 1995 represented 12% of the nominal conservation requirement.

The only indicator of returns to the St. Mary's River in 1995 was the angling fishery; 691 fish were reported harvested or released. The estimated spawning escapement based on a 30% exploitation rate contributed 59% of the eggs needed to meet the conservation requirement.

Résumé

Les captures de saumon atlantique de la pêche sportive dans les rivières de la zone de pêche du saumon 20 (ZPS 20), sur la côte est de la Nouvelle-Écosse, en 1995 ont été de beaucoup plus importantes qu'en 1994, mais demeuraient faibles comparativement aux moyennes des cinq et des dix années antérieures.

La valeur du dénombrement de saumoneaux sauvages et de pisciculture à Liscomb Falls, sur la rivière Liscomb, de 248 poissons en 1995 était semblable à la faible valeur notée en 1994, de 253 poissons. Le taux de retour des poissons de pisciculture, revenant sous forme de saumoneaux au piège de la rivière Liscomb, n'était que de 0,34 %, ce qui est bien en deçà de la valeur la plus faible notée depuis 1984, soit de 0,42 % en 1993. Ce taux a été constamment faible depuis quatre

ou cinq ans et le plus faible de toute période d'années consécutives depuis le début du fonctionnement du piège en 1979. Cela indique une baisse de la survie des saumoneaux en mer.

Bon nombre de rivières de la ZPS 20 sont acidifiées et continuent de recevoir des précipitations acides. Il est difficile de déterminer les besoins de géniteurs optimums des rivières où l'acidité nuit à la survie des juvéniles.

La remontée de saumons de la rivière East, à Sheet Harbour, est composée à au moins 90 % de poissons de pisciculture à cause de la présence de barrages hydro-électriques dans le réseau. Cela n'est donc pas un problème de conservation pour le stock de la rivière East.

Le stock de saumon de la rivière West, à Sheet Harbour, apparaît menacé car les eaux sont acidifiées et l'on a décelé très peu de juvéniles.

Le nombre de saumons qui sont revenus dans la rivière Liscomb en 1995 ne représentait que 12 % des besoins nominaux de la conservation.

Le seul indicateur des remontées de la rivière St.Mary's en 1995 est constitué des résultats de la pêche à la ligne. On signale que 691 poissons ont été récoltés ou remis à l'eau. L'échappée de géniteurs estimée, basée sur un taux d'exploitation de 30 %, représentait 59 % de la ponte nécessaire aux besoins de conservation.

Summary sheet for Liscomb River

STOCK: Atlantic salmon - Liscomb River above Liscomb Falls Fishway (SFA 20)
CONSERVATION REQUIREMENT: Acid-stressed, currently under development; nominal egg requirement above Liscomb Falls is 3.69 X 10^6 eggs (1,929 small and 177 large salmon).

Year	1990	1991	1992	1993	1994	1995	MIN[1]	MAX[1]	MEAN[1]
Recreational catch									
Small[2]	176	64	19	14	24	24	14	289	110
Counts									
Wild small	955	586	145	134	134	150	134	1614	582
Wild large	44	38	27	11	10	6	6	117	57
Hatchery small	438	178	125	128	119	98	119	766	305
Hatchery large	22	22	12	12	8	7	8	175	53
Total	1459	824	309	285	271	261	271	2279	996
Egg depositions / m^2 (above fishway)									
	1.6	0.9	0.4	0.34	0.32	0.30	0.32	2.5	1.13
Return rate of hatchery smolts									
Small (%)	1.56	0.79	0.50	0.42	0.56	0.34	0.35	2.75	1.15
Large (%)	0.05	0.08	0.05	0.05	0.03	0.03	0.03	0.23	0.12

[1] For the period 1985-1994
[2] Below fishway 1985-92; for the entire river 1993-95; numbers include harvest and releases.

Description of fishery and fishery data: The fishery on Liscomb River was limited to a recreational harvest of grilse or hook-and-release of large salmon. All large salmon caught in the recreational fishery have had to be released since 1984. Angling data are obtained from license stubs. Small salmon catches (1985-1995) have ranged from 14 fish in 1993 to 289 fish in 1987. The entire Liscomb River was open for angling during the 1993-1995 seasons; prior to 1993 the recreational fishery was limited to the five km of river below the fishway. The largest tributary to the main river, Little Liscomb, has pH levels below 4.8 and is assumed to be incapable of sustaining salmon.

Estimation of stock parameters: Counts of adult fish are obtained at Liscomb Falls fishway. Return rates are based on adults returning from 28,800 one- and two-year-old smolts reared at the Cobequid or Mersey Fish Culture Stations and released in the Liscomb River at various locations.

Assessment results: The nominal conservation egg requirement of 2.4 eggs/m^2 has been met only once since 1979 (1987). A significant contribution to egg deposition comes from hatchery-origin fish of Liscomb River stock. The 1995 escapement resulted in egg deposition of approximately one-eighth (12%) of the nominal egg requirement.

Forecast for 1996: Although forecast models for small salmon returns do not exist, low hatchery return rates, no significant increase in smolt stocking in 1995, low pH values of ~4.8-5.0 throughout the river, and low returns of wild small salmon since 1991 suggest that returns of small salmon in 1996 will be well below conservation requirements. A relationship between small salmon returns in year i and large salmon returns in year i + 1 for the period 1989-94 predicts a return of 12 large salmon (p=0.03; adj. R^2=0.6; n=6; 90% C.I.0-35) in 1996.

Management considerations: The consistently low return rate for hatchery fish to the Liscomb Falls trap and the current acidity problem on the river strongly suggest that returns in 1996 will not meet the conservation egg requirement. Angler concern has prompted initiation of a liming project for winter 1996. The potential of the Liscomb River requires reevaluation considering the severity of acid impact throughout the system.

Summary sheet for St. Mary's River

STOCK: Atlantic salmon - St. Mary's River (SFA 20)
CONSERVATION REQUIREMENT: 7.4 x 10^6 eggs (2,436 1SW fish; 437 2SW salmon and 281 3SW plus repeat-spawning salmon)

Year	1990	1991	1992	1993	1994	1995	MIN[1]	MAX[1]	MEAN[1]
Recreational catch									
Small[2]	2,063	975	319	909	42	560	42	2,063	986
Large	274	264	152	396	30	131	30	944	434
Effort (rod days)	6,536	5,486	4,288	6,199	1,423	3,543	1,423	8,183	5,734
Escapement (based on 30% exploitation rate in the recreational fishery)									
Small	3,761	1,736	663	1,722	124	1,461	124	3,761	1,867
Large	886	854	491	1,019	97	424	97	3,052	1,394
Egg deposition/m^2	3.4	2.2	1.1	2.5	0.1	1.0	0.1	6.1	3.1
Stocking									
Main River									
0+ parr				5,008					
West Branch									
2+ smolt	5,538								
East Branch									
0+ parr	25,060		43,315	63,471					
1+ parr	2,565	7,820	15,293	10,815	9,561				
2+ smolt	18,201	20,683		19,638	19,755	25,900			

[1] For the period 1985-1994
[2] Numbers include harvests and releases

Description of fishery and fishery data: Harvest and hook-and-release fisheries occurred in the recreational fishery only. Large salmon have not been retained since 1984. Angling data were obtained by license stubs. Small salmon catches (1985-1994) have ranged from 42 in 1994 to 2,063 in 1990. The 1995 recreational fishing season opened with retention of grilse, closed July 21-August 11, and subsequently reopened but was limited to a hook-and-release fishery. The 1995 large salmon catch of 131 fish was well below the 1985-94 mean of 434 fish. The small salmon catch (harvest plus those released) of 560 fish was also well below the ten-year mean of 986 fish.

Research data: Low juvenile densities in 1995 of about six parr per 100m^2 did not vary substantially from those estimated since 1985.

Estimation of stock parameters: The St. Mary's River sport catch was used as an indicator of returns to the St. Mary's River. The large salmon sport catch of the St. Mary's River is correlated with the LaHave River wild small salmon returns the previous year (p=0.001). Biological characteristics are based on sample data collected from the recreational fishery between 1972 and 1984. Recent adult data from the West Branch suggest that a repeat-spawning 1SW stock inhabits that branch. Total returns to the St. Mary's River are estimated using an exploitation rate of 30% on the sport catch.

Assessment results: At an exploitation rate of 30%, the St. Mary's River escapement, when converted to total eggs, would not have met the conservation requirement in either 1994 or 1995 but would have approximately met requirements in 1993. The 1995 estimated escapement would have achieved 42% of the desired conservation level.

Future prospects: Small salmon returns, based on a five-year average, are forecast at 1,870 fish in 1996, or approximately 75% of the small salmon conservation requirement. The relationship between St. Mary's River large salmon sport catch and LaHave River wild small salmon returns the previous year forecasts a large salmon sport catch in 1996 of 93 fish (p=0.001; 90% C.I. 0-293), which when expanded to a return estimate using a 30% exploitation rate is 43% of the conservation requirement.

Management considerations: Forecasts for 1996 indicate spawning escapements will not be met on the St. Mary's River for the third year in a row. Juvenile densities are low relative to other rivers where escapements have met conservation levels. However, parr densities on the St. Mary's River have been consistently low since 1985 despite conservation requirements having been achieved in some years according to the angler exploitation rate method.

Introduction

Salmon Fishing Area 20 (SFA 20) is located on the eastern shore of Nova Scotia between the Canso causeway in the east and Halifax in the west (Fig.1). Typically there are 15 to 20 rivers fished for Atlantic salmon in this area and 18 had catch or effort reported in 1995 (Table 1; Fig. 2a and 2b). Many of the rivers of the area are acid-stressed (Table 2) and the current state of those stocks has been negatively affected by the acid stress (Korman *et al.* 1994). This document describes the general status of Atlantic salmon stocks for SFA 20 and provides more specific information for the East, Sheet Harbour; Liscomb; St. Mary's; and West, Sheet Harbour, rivers.

East River, Sheet Harbour

The 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. 3). Proximate physical habitat surveys conducted in the 1960s and 1970s estimated a total rearing habitat area (above and below the dams) of 489,000 m^2 (Ducharme 1972). The area estimate included only eight of the main tributaries and is less than the 3 million m^2 measured by remote-sensing techniques (P. Amiro[1], unpublished data). A trap located in the lower-most partial barrier in the system - the Barrier Dam, which is located at the head-of-tide, has been operated for the collection of broodstock for the development program and, in 1994 and 1995, for the enumeration of adults.

A multi-faceted Atlantic salmon development program is being jointly conducted by Millbrook First Nation, the Eastern Shore Wildlife Association, Nova Scotia Power Inc. (NSPI) and the Department of Fisheries and Oceans (DFO). The overall objective is to maximize the sustainable benefits (economic and social) from all the fisheries resources of the East River, Sheet Harbour, and West River, Sheet Harbour. Included in the work plan is an application of limestone to Governor Lake, a headwater lake of Twelve Mile Stream, the largest tributary in the system.

The recreational fishing group from the Sheet Harbour area, the Eastern Shore Wildlife Association, has lobbied Nova Scotia Power for construction of fish passage around the last two impassable barriers to migrating fish from the sea on East River, Sheet Harbour, at Malay Falls and Marshall Falls (Fig. 3). The estimated cost of one million dollars was considered prohibitive, so, at the request of NSPI and the angling association, DFO examined the potential of the system which was known to be compromised by the acidity of the water and the downstream passage of smolts around the storage and power dams. The overall review resulted in a development plan which included an interim trapping and trucking component to provide an increased angling opportunity for the local anglers. The "plan" stipulated that until the pH of the system improved, NSPI would arrange to trap returning adult salmon from DFO's enhancement program (20,000+ smolts released per year) surplus to broodstock requirements and the First Nation harvest at the Barrier Dam and truck them for release in Fifteen Mile Stream, the most accessible and highest pH (winter pH ~ 5.1) tributary in the system. These fish would be available for angling.

A key component of the plan was the suspension of an estuarial gill net fishery by Millbrook First Nation in exchange for a harvest from the Barrier Dam trap at the head-of-tide on the East River. Millbrook also agreed to operate the trapping and trucking program for NSPI. Millbrook ceased fishing in the estuary, which is common to the East and West rivers, after the 1993 season.

In 1995, a study was completed on East River, Sheet Harbour, related to the release of the fish trucked from the Barrier Dam to Fifteen Mile Stream. The project was jointly conducted

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

by DFO, Millbrook First Nation, and NSPI. The objective of the study was to determine if the salmon released in Fifteen Mile Stream would be available to anglers. Marshall Flowage, the largest reservoir in the system, is located just downstream of the release site on Fifteen Mile Stream. NSPI wanted to ensure that fish were not dropping downstream from the release site to the reservoir where they would not be available for angling. Ultrasonic tags were inserted into 12 salmon prior to release in Fifteen Mile Stream. Although data were only collected from five of the fish tagged, none of these fish moved downstream into Marshall Flowage. Considerable movement of the tagged fish was noted in the pools in Fifteen Mile Stream which satisfied officials with NSPI that the fish would have been available for anglers.

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. Ninety percent of the rearing habitat in the river is above the falls. The river is acid-stressed (Table 2) and contains some tributaries which cannot support Atlantic salmon (pH<4.7).

The Diadromous Fish Division has participated in the planning for an acid mitigation project with the recently formed river association. Plans are in place for the application of crushed limestone to the surface of Big Liscomb Lake on the headwaters of the main branch of the river during 1996.

Salmon River, Guysborough

Salmon River, Guysborough, located at the eastern end of SFA 20, drains an area of 347 km^2 and discharges into Chedabucto Bay (Fig. 1). An estuarine tributary, Dickie Brook, is used for hydroelectric power generation and does not currently support an anadromous fish resource. Consequently, it is not considered a part of the Salmon River when estimating habitat area.

The salmon resource of Salmon River, Guysborough, may be unique on the eastern shore: 1. The river has a pH in the range of 5.9-6.2 so is not subject to the acid-induced mortalities common to most of the other rivers on the eastern shore. 2. The sport fishery often takes place in tidal waters of the river, and is usually sustained well into September. The local anglers are concerned that this concentrated harvest may be more efficient than the typical river fishery which occurred prior to the early 1980s when the estuarine fishery began in earnest. 3. The salmon of Salmon River, Guysborough, are reported to have a localized migration within Chedabucto Bay, but this is unconfirmed.

A review of the status of the stock in the river began in 1994 with a limited sampling program and compilation of available data. Collection of additional information is required before the status of the stock can be determined.

St. Mary's River

The St. Mary's River, with 3,078,500 m^2 of rearing habitat, is the largest river in SFA 20 and the third largest in habitat area on the Atlantic coast of Nova Scotia. 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. 4). For the purposes of clarity and to avoid confusion with East River, Sheet Harbour and West River, Sheet Harbour, the two branches of the St. Mary's River are named East River, St. Mary's and West River, St. Mary's throughout the remainder of this report. East River, St. Mary's has a spawning stock of three-sea-winter (SW) fish which is unique because it is the only stock remaining on the Atlantic coast of Nova Scotia with a three-SW component.

The two branches of the river also have differing underlying geologies. The West River, St. Mary's, 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 five tributaries is affected (pH<5.4; Buckland-Nicks 1995). The East River, on the other hand, is more like those streams that drain towards the Northumberland Strait which have ample buffering and pH levels in the 6-7 range.

Attempts to separate the two branches for the purposes of assessment have been unsuccessful (Marshall 1986; O'Neil and Harvie 1995). The status of the stock was previously reviewed by Marshall (1986) and O'Neil and Harvie (1995) and this report presents additional data relevant to those prior assessments.

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 pH is near 5.2.

In 1995, the local association initiated a liming program, with assistance 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 in 1994 and 1995 as a means of protecting the stock.

Description of fisheries and fishery data

The fisheries of SFA 20 in 1995 included recreational and First Nations' harvests. Angling seasons were similar to those of recent years (Table 2). Most rivers of the area were open from June 1 to August 29 but those which drain into Chedabucto Bay had open seasons of June 24 to September 22. West River, Sheet Harbour, was closed to harvest fisheries for the second year in a row. Bag limits remained unchanged from the modifications introduced in 1992 : two fish < 63 cm per day up to a maximum of eight per year.

Recreational catch statistics are estimated by the SALMO-NS program from data provided by anglers who purchase a salmon license and return a completed license stub (O'Neil *et al.* 1986). The precision and accuracy of the data have been reviewed in O'Neil and Harvie (1993). The 1995 angling data which were received and processed prior to the writing of this report were based on a response rate of 65% of licensees (Table 1; Fig. 2a and 2b). Additional data may be received which would cause the catch and effort estimates to be modified slightly subsequent to the preparation of this report.

The retained grilse catch for all rivers of SFA 20 of 891 fish was 65% of the previous five-year mean of 1,381 fish (Table 1; Fig. 2a). However, the mean includes the 1994 value which was the lowest on record. Comparison of the 1995 retained grilse catch to the 1989-1994 mean retained catch (six-year mean) of 1,464 1SW salmon indicates the degree to which recent returns of salmon have declined. The 1995 retained catch was only 49% of the previous ten-year mean (1985-94) of 1,801 fish (Table 3).

The recent downturn in returns to Atlantic coast Nova Scotia rivers was most evident in 1994 when sport catches reached an all-time low and river closures were common. The recent grilse catches in SFA 21, located in southwestern Nova Scotia, were reduced similarly to those observed in SFA 20 (harvest fisheries were closed on most rivers in SFA 21 after July 5, 1994; Table 3).

The collective catch of large salmon from SFA 20 rivers in 1995 was 412 fish (Fig. 2a). This value is considerably below the five-year average, 1990-94 of 498 fish, and likewise low relative to any longer-term average; the ten-year mean MSW catch was 869 fish (Table 3). Anglers reported releasing 174 fish on Salmon River, Guysborough, which is nearly one-half the MSW catch for the entire area.

Harvest allocations included an agreement by Millbrook First Nation to limit harvest to 50 grilse on East River, Sheet Harbour, and a 100-grilse quota for Indian Brook First Nation on the Musquodoboit River. The Native Council of Nova Scotia received 730 tags for distribution to fisheries interested in the retention of grilse (Table 4).

The First Nations' harvests reported to date were 18 grilse from East River, Sheet Harbour, by the Millbrook Band and six grilse on three different rivers by the Native Council of Nova Scotia (Table 4).

East River, Sheet Harbour

Angling catches on the river prior to 1994 between the head-of-tide and the Malay Falls Dam but primarily below the Ruth Falls Dam varied from few fish to as high as 160 or more (Fig. 2a and 3). Recent catches have declined largely as a result of the management plan in place for the river. This operating regime effect is expected to be temporary.

Anglers reported catching only a single grilse on East River, Sheet Harbour, and collectively spent 16 angler-days for salmon in 1995 (Table 1). Millbrook First Nation harvested 18 fish from the fishway at the Barrier Dam. The fishing plan for Millbrook included an agreement to harvest up to 50 fish on the river (Table 4).

St. Mary's River

The principal, if not entire, component of the spawning stock of Atlantic salmon on the west branch of the St. Mary's River is 1SW fish (O'Neil and Harvie 1995). The sport fishery on the St. Mary's River harvests grilse on both the main and west branches from those fish that would ultimately make up the escapement to the west branch (Fig. 4). Thus, the grilse harvest may have a greater impact on the west branch than either the main stem or east branches but the available sport catch data do not permit review of catch by branch. In 1995 the St. Mary's River Association proposed an in-season indicator to monitor grilse harvest to ensure conservation concerns would be addressed (Buckland-Nicks 1995). The basis for the index was DFO data contained in reports of catch by pool, sporadically maintained over the years by the local fishery officers. The association selected data from two pools after reviewing several options, Ford and Flat Rock. The time period within the season had to be early enough to allow management decisions which would impact on total harvest. The time period chosen was June 15 to July 15. The collective catch on the two pools was found to be closely related to the total retained grilse for all years where the data were sufficient to generate a comparison (Buckland-Nicks 1995). A total of five years of data was considered complete enough to use in the process, 1974, 1977, 1978, 1979, and 1984. The proportion of the total grilse catch for the river which occurred during the sample period on the two pools ranged from 8.1% to 10.6% (mean 9.02%). The association conducted a creel survey in 1995 to contribute to their database and to generate support within DFO for the use of their pool index. The grilse catch on the Ford and Flat Rock pools in 1995, as determined by the creel survey, was 56 fish (R. Webber[2], pers. comm.).

[2] Ralph Webber, President, St. Mary's River Association, Box 179, Sherbrooke, N.S. B0J 3C0.

Conservation requirements

SFA 20

The conservation requirement for SFA 20 is derived from a habitat area estimate of 11,607,000 m^2 and the conservation 2.4 eggs per m^2 (Anon. 1991) for an egg requirement of 27.8 million eggs (Atlantic Salmon Review 1978). The adult spawners required, as reported in the Atlantic Salmon Review, is 1,690 MSW salmon and 9,190 1SW salmon (Table 5). Three separate egg requirement estimates were reported for SFA 20 by O'Neil and Harvie (1995). All three assumed no acid impact. A true egg requirement cannot be estimated without regard for the impact that the acidity has on most streams in the area. However, a revised egg requirement has not been developed so the more conservative number reported by the Atlantic Salmon Review (1978) has been used for the purposes of this report.

Liscomb River

Liscomb River is acid-stressed so the egg requirement is under review. The non-acid impacted egg requirement above Liscomb Falls (above the trap) is 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 spawner requirement (above the falls) has been calculated as 1,929 one-sea-winter fish and 177 large salmon (Tables 5 and 6).

St. Mary's River

The habitat area for the St. Mary's River differs depending on the source of the data. MacEachern (1955) conducted a walking survey in which many stream widths and lengths were physically measured to arrive at an estimate of the Atlantic salmon rearing area of 3,078,500 m^2. A second, more comprehensive method used aerial photographs and orthophotographic maps (1:10000 scale) of the entire drainage to remotely measure widths and stream lengths (Amiro 1993). The entire watershed was surveyed in this fashion and the appropriate corrections made for unusable habitat areas, stream cover by vegetation, etc. The remotely surveyed estimate of rearing area for the St. Mary's River, after eliminating that area which is less than 0.12% gradient (i.e., still waters), is 3,985,400 m^2. The latter area represents a habitat that is 29.5% larger than that measured by MacEachern (1955).

Habitat area estimation: On-site versus remote measure

Quantification of rearing habitat has long been a contentious issue because of the subjective nature of evaluation. Considerable resources have been expended to obtain an accurate measure of the physical area of streams both with proximate surveys and remotely using aerial photography. The former method involves a subjective evaluation of habitat as suitable for rearing and the latter takes advantage of gradient data to qualify areas suitable for rearing. Much of the watershed was not measured in 1955 by MacEachern during the walking survey because of the time and logistical constraints on such a survey. Conducting the on-site assessment of the area provided insight regarding the nature of the habitat in the various streams. The remote habitat assessment relies on aerial photography to measure area and on gradient data to qualify the habitat. Some streams are not visible from the air due to the canopy provided by vegetation. Consequently, much of the area cannot be measured. Yet, the remote area estimate is 29% larger than the on-site measure. The two methods for measuring rearing habitat for the St. Mary's River have not yet been reconciled. For the purposes of this assessment, the rearing area measured and reported by MacEachern (1955) was used to estimate spawning requirements.

Egg and adult requirements

The conservation level of 2.4 eggs per square meter (Anon.1991) and the MacEachern (1955) estimate of rearing area (3,078,500 m^2) were used to calculate the number of eggs necessary to meet the conservation requirement for the river of 7,388,400 eggs. The number of fish required to provide the eggs for the St. Mary's River is 2,437 grilse and 718 large salmon (Tables 5 and 7). The stock characteristics used were those of Marshall (1986) given that a more recent biological sample and angling data were not appreciably different.

West River, Sheet Harbour

The conservation requirement for the West River, Sheet Harbour, is presently 880,000 eggs or 797 1SW fish (Table 5; O'Neil and Harvie 1995). These values are "interim" because no allowance has been made for the significant acidification and consequent reduced production capacity of the drainage.

Research data

St. Mary's River

The density of Atlantic salmon parr in the St. Mary's River system is low relative to the densities found in the Stewiacke and Musquodoboit rivers (Amiro 1993), and in many other systems such as River Philip (Chaput and Jones 1994) and West, Antigonish (Cameron and Gray 1979; Claytor *et al.* 1995). In fact, densities are one-half to one-quarter of those reported on various systems by Elson (1967). Concern over the apparent low production of salmon on the river caused attention to be focused on the west side because of the frequent low water levels and warm summer water temperatures in the West River, St. Mary's, main stem and the general belief that returns were dwindling there.

In 1995, 22 sites were electrofished with the objective of contributing to the data available from electrofishing from the previous several years and teasing out whether there was a difference in juvenile production between branches. 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. In most years 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.

Procedures for forecasting adult returns

SFA 20

Total returns to the eastern shore rivers were estimated by using sport catch data and angling exploitation rates ranging from 25 to 45% (O'Neil and Harvie 1995).

Forecasts of MSW salmon returns to SFA 20 were examined by regression of the total MSW angling catch in year i+1 for SFA 20 on wild 1SW returns in year i to the Liscomb trap for the years 1981 to 1995.

Liscomb River

A forecast of returns of large salmon to the Liscomb River can be derived from the relationship between fish of the same smolt year-class; the wild large salmon returns in a given year

are correlated with the wild 1SW returns the previous year. The long-term and short-term time series regression equations are as follows:

1979-94 time series, exclusive of 1987: Liscomb wild MSW $count_{(i+1)}$= 4.259 + 0.089 x Liscomb wild 1SW $count_{(i)}$; p=0.007; adj. R^2=0.40; n=15.

1989-94 time series: Liscomb wild MSW $count_{(i+1)}$= 5.877 + 0.041 x Liscomb wild 1SW $count_{(i)}$; p=0.032; adj. R^2= 0.654; n=6.

The shorter time series is more reflective of recent changes in the proportions of large and small salmon in the stock.

St. Mary's River

Estimation of returns of fish to the St. Mary's River were derived from the sport fishery data and an exploitation rate. A series of exploitation rates ranging from 25 to 45% was used by O'Neil and Harvie (1995) to estimate escapements and eggs available relative to requirements. The range of exploitation rates was drawn from the available literature for data on other rivers along the Atlantic coast of Nova Scotia. A reasonable estimate of an exploitation rate for the St. Mary's River was believed to be 30%.

Based on an assumed 30% angling exploitation rate, the egg deposition was 4.4 million eggs in 1995 (Table 8). Ten percent of the egg requirement (7.4 million) for the river was removed by anglers.

An estimated exploitation rate for salmon of the LaHave River in 1995 was also applied to the St. Mary's River sport catch data to estimate returns. The assumption was 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 (P.Amiro[3], pers. comm): A mark-recapture was conducted in 1983 on the LaHave River where marks were applied in the estuary and captures were 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 1995 population size based on the 1995 count at Morgan Falls. A probability distribution for the 1995 exploitation rate estimates was calculated by dividing the 1995 population estimates into the angling catch. The most likely (maximum probability) angling exploitation rate estimate was 28.9% (confidence interval: the 5th and 95th percentiles were 20.7% and 37.4%, respectively).

Assessment results and discussion

SFA 20

Escapements for SFA 20 in 1995 (2,676 grilse; 1,640 large salmon), based on a conservative 25% exploitation rate, indicate that the Atlantic Salmon Review conservation requirements of 9,190 grilse and 1,690 large salmon would have been short by over 6,500 grilse and would approximately have met the MSW value (Table 9). The catch on the St. Mary's; Salmon River, Guysborough; and Musquodoboit rivers alone accounts for 96% of the catch of MSW salmon in the area. Thus, the remaining rivers in the area were short of the requirement for MSW fish by almost 100%. The contribution of hatchery fish to the angling fishery on the eastern shore is not known even

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

though returns to several rivers, the Musquodoboit; East, Sheet Harbour; Liscomb; and St. Mary's, would have included returns from hatchery smolts released in 1994 or earlier (Table 10).

The regression of large salmon returns to the angling fishery on SFA 20 rivers on the wild grilse count at Liscomb Falls the previous year, 1981-1995, was not significant with or without the 1987 (drought year) in the time series ($p>0.05$).

East River, Sheet Harbour

A total of 129 fish was counted at the Barrier Dam (Fig. 3) at the head-of-tide on East River, Sheet Harbour, in 1995. In 1994, a total of 107 fish was trapped at the barrier (Table 11). Eighty percent of the salmon which return to the Barrier Dam trap are of hatchery origin. The accessible habitat area (approximately five percent of the river system) above the barrier trap and below the first hydroelectric dam is acidic (pH approx. 4.8) and not thought to be sufficient to account for 20% of returns (i.e., wild fish), so some straying of fish from the West River, Sheet Harbour, may be contributing to wild returns to the Barrier Dam.

The salmon which return to the barrier have various destinies governed by the management plan for the river (Table 11). In 1995, 40 fish were trucked upriver for release in Fifteen Mile Stream.

Liscomb River

The nominal egg requirement for Liscomb River above the falls of 3.7 million eggs was not met in 1995 (12% of requirement) and has been met only once since 1979 (Table 12).

Consistent low returns of hatchery fish since 1989 (Table 13; Fig. 5) prompted action to explore options to maximize the advantage for the fish in 1995 by two changes in release practice. Hatchery smolts were released late in the evening to avoid at least some of the cormorant predation (Milton *et al.* 1995). As a result of concern that the acid waters of the Liscomb River (spring pHs around pH 4.9; S. O'Neil, unpublished data) may affect the condition of the fish or imprinting, fish were released nearer the head-of-tide to reduce the residence time in the acidic water.

St. Mary's River

Juvenile densities

The mean parr densities for the river in 1995 were 5.24 age 1+ and 6.21 total parr per 100 m^2. These densities were similar to those observed in previous years (Table 14; Fig. 6). Not all sites were fished in all years. To compare juvenile densities across years, the sites which were common to the majority of years were selected for inclusion in analysis of variance (SYSTAT 1992). The sites chosen were numbers 4, 5, 8, 10, and 23 (Fig. 4). Comparison of 1+ and total parr densities over the years that electrofishing data were available, 1985, 1986 and 1990 to 1995, on the sites common to most years, failed to show any statistical difference in densities between the years ($p>0.05$ for both; Table 15).

Atlantic salmon parr distributions are highly influenced by gradient (Amiro 1993). The St. Mary's River parr densities were significantly correlated with gradient ($p\leq0.001$ for age 1+ and total parr). As a result, the gradient of sites was examined for differences between East River, St. Mary's, and West River, St. Mary's, branches and the main stem and was also found to be significant ($p<0.001$). Consequently, analysis of a difference in parr density between the East and

West, St. Mary's, branches was done with gradient as a covariate. Densities were found not to differ between branches ($p>0.05$ for both age 1+ and total parr; Table 15 and 16).

The electrofishing data were further subdivided into West River, St. Mary's, main stem and tributaries, and the East River, St. Mary's main stem and tributaries in an attempt to determine if the source for the relatively low parr densities in the system could be isolated. The density of 1+ parr on the main stem of the East River, St. Mary's, branch was found to be significantly lower than the 1+ parr densities on the tributaries of the same branch ($p=0.043$). Gradient was used as a covariate in the river subset parr density comparisons (SYSTAT 1992). Total parr could not be tested in a similar manner because there was a significant river subset x gradient interaction effect ($p=0.031$; Table 15).

These results are somewhat surprising. We had hypothesized that the densities of the main stem of the West River, St. Mary's, would stand out as low relative to other parts of the system. Instead, the lowest mean density, overall, was on the East River, St. Mary's, main stem. Nevertheless, parr densities on both the East and West river main stems were lower than those found on the tributaries (Table 16).

Several tributaries (6 have been identified by Buckland-Nicks 1995) on the West River, St. Mary's, are impacted by acid precipitation and have had episodic decreases in level of pH to around 5.0 (Buckland-Nicks 1995). Examination of a plot of the parr densities, by year, for those affected tributaries indicated only one (Indian Man) with any apparent steady decline in density which might possibly be related to the acidification (Fig. 7). Use of the data from the remote survey of habitat permits quantification of the habitat area potentially negatively impacted by acid precipitation. The collective area for those tributaries with episodic levels of pH as low as 5.0 is 9.7 % of the watershed. No correction factor has been included in the estimation of the spawner requirement to account for a possible impact because the water chemistry data are insufficient to quantify the juvenile mortality.

Adult returns and escapement

Index pool catch estimate

The St. Mary's River Association estimated the total catch of grilse at the two index pool areas between June 15 and July 15, 1995, to be 56 fish. The historical catch data indicate that 9.02% of the grilse taken on the river in a year are angled at the Ford and Flat Rock pools between those dates. Thus, the in-season forecast for the total catch of grilse was 620 fish ($56 \div 0.0902$) from the index pool count. These data can be compared with the catch of grilse derived from the license stub returns from anglers which resulted in an estimated catch of 560 grilse; 406 retained and 154 released. The index pool estimate was greater than the license stub estimate by 11%.

Exploitation rate derived returns estimates

The total return of fish to the St. Mary's River in 1995, using the 691 fish caught on the St. Mary's River and the 0.289 exploitation rate derived from the LaHave River, was estimated at 2,390 fish (5th and 95th percentiles:1,710, and 3,580). An escapement of 1,956 fish was estimated as 2,390 fish minus the grilse harvest (406 fish) and a 10% hook-and-release mortality for large salmon (13 fish) and grilse released (15 fish). This escapement estimate is 62% of the conservation requirement. The probability that the returns exceeded 3,588 fish (the escapement spawner requirement of 3,154 fish plus the harvest of 434 fish) was only 4.98% (Fig. 8). In terms of egg deposition, the escapement (using the generic 30% exploitation rate) was only 59% of the requirement (Table 8).

Large salmon forecasts

A significant ($p=0.001$; $R^2_{adj}=0.712$; $n=11$) predictive relationship was found between the multi-sea-winter salmon sport catch on the St. Mary's River and LaHave wild 1SW salmon counts (Table 17). The regression equation is based on the period from 1982-94 (1SW or grilse years) and is of the form:

$$\text{STM MSW sport catch}_{(i+1)} = -29.528 + 0.212 \text{ LaHave (at Morgan Falls) wild 1SW trap counts}_{(i)}$$

This equation is exclusive of the 1984 and 1985 grilse years. Those values were removed after an examination of scatter plots of the St. Mary's River MSW sport catch and the wild 1SW LaHave or Liscomb river trap counts (Fig. 9). The plots indicated that both the 1984 and 1985 grilse years (i.e., the points for the MSW sport catch in 1985 and 1986) were outliers. Justification for removal of those points is based on the known phenomenon that angler reports were biased upwards for large salmon during the first few years after the release of large salmon became mandatory. Attempts to quantify that bias and account for it in a systematic fashion were not successful (O'Neil and Harvie 1995) but the phenomenon has been documented (Claytor and O'Neil 1991).

A forecast of 90 MSW fish to the St. Mary's River sport fishery in 1995 was based on the 1982-93 time period, exclusive of 1985 (grilse year; O'Neil and Harvie 1995). The revised regression, exclusive of the 1984 and 1985 data points, forecasts a sport catch in 1995 of 99 MSW salmon. The 1995 estimate of MSW catch was 131 fish and is comparably close to the 99 fish forecast from the revised regression as evidenced by the range in large salmon catch on the St. Mary's River from less than 100 fish on several occasions to over 900 fish (Table 17).

The relationship between the St. Mary's River MSW sport catch and LaHave wild grilse counts for the longer-term time series (1974-94) was also significant ($p=0.003$; $R^2_{adj}=0.345$; $n=21$). The longer time period was not used for forecasting because it involved using angling data collected by two different methods over the time series. The license stub data collection began in 1983.

West River, Sheet Harbour

An index of returns to West River, Sheet Harbour, in the absence of a sport fishery (no fishery on West River, Sheet Harbour, in 1994 or 1995), was sought by examining the relationship between the West River sport catch prior to the closure (1982-93) and wild grilse counts at Liscomb River (Fig. 2b and 5). Regressions of West River, Sheet Harbour, grilse harvest on wild 1SW Liscomb River returns for the period 1982-93, either with or without the 1987 drought year included, were not significant ($p>0.05$).

Four sites were electrofished on the West River, Sheet Harbour, in 1995. The recent juvenile density data (1994 and 1995) could not be statistically compared with the historical data because of a difference in fishing techniques, site sizes and site locations. Graphical representation of the data with mean densities and error bars (2 x std. dev.) indicates that recent fry densities are low relative to historical values (Fig. 10). Parr densities are also low relative to those observed during the 1960s but similar to densities reported in the 1970s (Gray *et al.* 1978). The low parr numbers noted from 1973-77 cannot be explained by any obvious environmental or physical occurrences. Low pH levels are known to affect the production of juveniles (Lacroix 1989) which would account, at least in part, for the recent low numbers of juveniles on the West River, Sheet Harbour, where current winter pH levels have been pH 4.9 (O'Neil, unpublished data).

Ecological considerations

SFA 20

The acid precipitation impact on the eastern shore rivers has become increasingly apparent over the last decade. A more extensive review of that impact is currently under way.

Angling associations, alarmed at the potential loss of unique salmon stocks and their opportunity for a recreational fishery, have become involved in several acid mitigation projects. A one-kilometer riffle area of the main West River, Sheet Harbour, was covered with limestone gravel in 1995. The objective is to create a series of refuges in the system for juveniles to survive the decreases common in winter pH levels. Limestone powder was spread on the ice on Governor Lake, East River, Sheet Harbour, in February of 1995. The pH level of the outlet from Governor Lake has increased from a spring and autumn pH level near 4.9 the previous year to pH 5.6. The association plans to continue liming over the next few years.

Liscomb River

The 10-meter Liscomb River falls was circumvented with the construction of the fishway in 1978 and stocking of salmon resulted in a return of hatchery and wild fish that numbered as high as 2,279 (1,702 wild fish) in 1987. Those numbers rapidly declined paradoxically coincident with the reduction of high seas fisheries for salmon but also coincident with an acid impact which may have been worsening. The pH data available are incomplete but levels of pH reported for the Little Liscomb River have declined from pH 5.13 in August, 1985 (Ashfield *et al.* 1993), to pH 4.58 in January, 1996 (S. O'Neil, unpublished data). The uncertainty surrounding the interpretation of the pH data is the seasonal variability which could explain some of the change in pH level noted. The local association has proposed a liming project for the main branch of the Liscomb River to begin in February of 1996. The association believes that without some sort of intervention, the salmon stock in the river may soon be lost.

St. Mary's River

Water temperature extremes on the main stem of the West River, St. Mary's, have been recorded at over 30°C (MacEachern 1955; Buckland-Nicks 1995). Recent temperature records indicate that when temperatures exceed 30°C on the West River, St. Mary's, main stem they are 3-4°C cooler on the east branch (Buckland-Nicks 1995). The many lakes on the East River, St. Mary's, provide some moderation in temperature swings. Although daily maximum temperatures have exceeded the upper lethal temperature of 27°C for Atlantic salmon (Garside 1973), the minimum temperatures on the same day were much cooler (Buckland-Nicks 1995). The impact of broad temperature swings on the survival of salmon parr has not been determined although anecdotal reports of parr mortalities are fairly common.

Future prospects

SFA 20

Forecasts of total returns to the eastern shore area in 1996 have not been developed. Estimates of sport catch in 1996 may approximate the five-year average catch (1991-95) for SFA 20 of 953 grilse retained and 441 large salmon released. These numbers are in keeping with the recent trend in catches for the area (Fig. 2a). However, most of the large salmon catch in recent years has occurred on the St. Mary's; Salmon, Guysborough; and Musquodoboit rivers so the

average fails to emphasize the low number of large salmon which were angled on many of the other rivers in SFA 20.

Liscomb River

The estimate of large salmon returns in 1996 based on the regression equation of wild large salmon counts at Liscomb and wild grilse counts the previous year (based on recent year data, 1989-1994) is 12 large salmon in 1996 from a grilse count of 150 fish in 1995. The forecast is approximately 7% of the revised spawner requirement for large fish. No forecast is available for grilse unless the previous five-year-average count is used. The 1991-95 average count of wild grilse was 230 fish which is 12% of the conservation level for the area above Liscomb Falls.

St. Mary's River

The relationship between the large salmon sport catch on the St. Mary's River and the LaHave wild grilse returns can be used to predict a large salmon angling catch on the St. Mary's River in 1996. Substitution of the Morgan Falls count of 577 wild grilse in 1995 in the equation yields a salmon catch of 93 fish (90% C.I. 0-293) in 1996. A return estimate for 1996 based on the forecast catch and an exploitation rate of 30% would be 310 fish which is less than one-half of the 718 MSW fish conservation requirement.

Management considerations

Habitat area can vary considerably depending on the method used to estimate the rearing area available for Atlantic salmon juveniles. In addition, the methodology is not uniform for qualifying that habitat. Assessments on Atlantic salmon rivers in Atlantic Canada depend largely on partial area proximate surveys with subjective ratings of habitat quality. An obvious gap in the procedural approach to the assessments on the SFA 20 rivers is the question of habitat measurement. Some resolution of the difference in measurement approaches would aid in determining a more objective and refined estimate of the number of spawners required for a particular river.

The St. Mary's River Association proposed the in-season indicator based on the two index pools on the river, the Ford and Flat Rock, so that if catch was monitored from June 15 to July 15, the total harvest could be forecast and management decisions made on that basis. An in-season index has merit because it provides managers a tool with which to ensure conservation concerns are met. However, an indicator which is based on a harvest, such as this one is, runs the risk of allowing fish to be harvested when there are no fish surplus to requirement. Allowing a catch and release during the "indicator" period may accomplish the same purpose but without the risk. Comments from the local association suggest that the hook-and-release only option would not be a favorable one. They suggest that a hook-and-release fishery may not be comparable to the retention fishery due to reduced effort and render the index invalid.

References

Amiro, P.G. 1993. Habitat measurement and population estimation of juvenile Atlantic salmon (*Salmo salar*), p.81-97. In R.J. Gibson and R.E.Cutting [ed.], Production of juvenile Atlantic salmon, *Salmo salar*, in natural waters. Can. Spec. Publ. Fish. Aquat. Sci. No.118.

Amiro, P.G., A.J. McNeill and D.A. Longard. 1989. Results of surveys of electrofishing in the Stewiacke River, 1984 to 1988 and St. Mary's River, 1985 and 1986. Can. Data. Rept. Fish. Aquat. Sci. No. 764. 55p.

Anon. 1991. Definition of conservation for Atlantic salmon. CAFSAC Advisory Document 91/15. 4p.

Ashfield, D., G.J. Farmer, and D.K. MacPhail. 1993. Chemical characteristics of selected rivers in mainland Nova Scotia, 1985. Can. Data Rep. Fish. Aquat. Sci. No. 913. v + 15p.

Atlantic Salmon Review Task Force. 1978. Biological Conservation Subcommittee Report. Fisheries and Oceans, Halifax, N.S. 203p.

Buckland-Nicks, L.H. 1995. A community-based management plan for the fisheries in the St. Mary's River. St. Mary's River Association, Box 179, Sherbrooke, N.S. B0J 3C0. 169p.

Cameron, J.D. and R.W. Gray. 1979. Estimated densities of juvenile Atlantic salmon and other freshwater fishes in selected Nova Scotia streams, 1978. Can. Data Rept. Fish. Aquat. Sci. No. 163. 43 p.

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

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

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

Ducharme, L.J.A. 1972. Atlantic salmon (*Salmo salar*) rehabilitation in the East River, Sheet Harbour, Nova Scotia - Project description and initial results. Environment Canada Resource Development Branch, Fisheries Service Progress Report No. 4. 31p.

Elson, P.F. 1967. Effects on wild young salmon of spraying DDT over New Brunswick forests. J. Fish. Res. Bd. Canada, 24(4). 37p.

Garside, E.T. 1973. Ultimate upper lethal temperature of Atlantic salmon *Salmo salar* L. Can. J. Zool. 51:898-900.

Gazey, W.J. and M.J. Staley. 1986. Population estimation from mark-recapture experiments using a sequential Bayes algorithm. Ecology, 67(4): 941-951.

Gray, R.W., J.D. Cameron, and E.M. Jefferson. 1978. Population densities of juvenile Atlantic salmon in several Nova Scotia streams. Fisheries and Marine Serv. Data Rep. No. 105. 53p.

Korman, J., D.R. Marmorek, G.L. Lacroix, P.G. Amiro, J.A. Ritter, W.D. Watt, R.E. Cutting, and D.C.E. Robinson. 1994. Development and evaluation of a biological model to assess regional-scale effects of acidification on Atlantic salmon (*Salmo salar*). Can. J. Fish. Aquat. Sci. 51: 662-680.

Lacroix, G.L. 1989. Production of juvenile Atlantic salmon (*Salmo salar*) in two acidic rivers of Nova Scotia. Can. J. Fish. Aquat. Sci. 46: 2003-2018.

MacEachern, N.E. 1955. St. Mary's River salmon survey, p. 94-110. In MacEachern et al. Survey reports Atlantic salmon rivers. Maritime Area. MS Rep. Resource Develop. Br. No. 55-6.

Marshall, T.L. 1986. Estimated spawning requirements and indices of stock status of Atlantic salmon in the St. Mary's River, Nova Scotia. CAFSAC Res. Doc. 86/22. 19p.

Milton, G. Randy, P.J. Austin-Smith, and G.J. Farmer. 1995. Shouting at shags: A case study of cormorant management in Nova Scotia. Colonial Waterbirds 18 (Spec. Publ. 1): 91-98.

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

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

O'Neil, S.F. and C.J. Harvie. 1995. Estimates of Atlantic salmon stock status on the eastern shore of Nova Scotia, Salmon Fishing Area 20, in 1994. DFO Atlantic Fisheries Res. Doc. 95/132. 28p.

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

Semple, J.R. and J.D. Cameron. 1990. Biology, exploitation and escapement of Atlantic salmon (*Salmo salar*), Liscomb River, N.S. Can. Man. Rept. Fish. Aquat. Sci. No. 2077. 39p.

SYSTAT. 1992. The System for Statistics. Evanston, Illinois: SYSTAT, Inc.

Appendix 1

Client Service Consultations for SFA 20, Eastern Shore Nova Scotia, 1995

Client meetings were attended by Diadromous Fisheries Division staff to deal with specific client issues or general stock assessment matters as follows:

Client group	Date	Purpose
Eastern Shore Wildlife Association	Jan. 12	Liming East and West Rivers; stock status
Eastern Shore Wildlife Association	Feb. 16 Feb. 18	Finalize stock status update; liming Assisted liming
Musquodoboit River Association	Mar. 7	Special seasons; stock status
Millbrook First Nation	Mar. 8	Fishing plans; projects for 1995
Liscomb River Association	Mar. 15	Trap operation; acid stress situation on river; stock status
St. Mary's River Association	Mar. 28	River-specific management
Liscomb River Association	Apr. 7	Future enhancement; operation of trap and liming
Eastern Shore Zone Management Committee	Apr. 19	Overview of stock status and discussion of management issues for 1995
St. Mary's River Association	May 25	Stock assessment approach and SMR concerns; index pools, etc.
Liscomb River Association	Jun. 5	Trap visit and operation plans, etc.
Eastern Shore Wildlife Association	Jun. 14	Water quality and stock status; electrofishing plans; NS Power; liming West River
Millbrook First Nation	Jul. 5	East River program
Liscomb River Association	Sep. 27	Trap count; water quality; liming benefit/cost
Eastern Shore Wildlife Association	Jan.11/96	Results of 1995 work; update on stock status; water quality report

Appendix 1 continued

Meetings preparatory to the Peer Review exercise were scheduled for December 20 and January 3. Both meetings were canceled because of the weather. Consequently, the information to be presented at the meetings was sent to clients who were asked to provide feedback. The list of clients mailed packages is included at the end of the appendix. The comments provided by interested groups are noted below.

Eastern Shore Wildlife Association

Comments:

- No catch and release figures show on the graphs or tables for West River, Sheet Harbour.
- more areas should be electrofished on the West River, Sheet Harbour, and particularly places like Rocky Brook
- First Nation catches and trap counts should be published
- Additional liming should be done on both the East and West rivers
- Fish should be allowed to free swim above the Barrier Dam on the East River, Sheet Harbour, to sustain the interests of the anglers
- Consideration should be given to a fall fishery possibly hook-and-release
- Recommend that broodstock be collected on the West River, Sheet Harbour, to enhance and sustain the stock on the West
- West River, Sheet Harbour, should be scheduled fly-fishing only
- Pleased to see the community so involved in liming to sustain stocks

St. Mary's River Association

Comments:

- Scale samples and creel survey results were forwarded for DFO to analyze
- The exploitation rate is probably too high because the water was too high early in the season, for one week during mid-season and too low after mid-July so anglers had low catch rates
- Water run-off in the system is rapid and must be dealt with
- The index pool system should be used for the next two years which will give us a total of three for us to effectively monitor or evaluate the system. Can the cooperative recreational fisheries agreement fund us for the next two years to evaluate the program.
- The creel survey for the index pool estimated 56 grilse caught.

Distribution list for Client Services Information Packages, Eastern Shore Nova Scotia

Name	Affiliation
Mike O'Brian	Musquodoboit River Association
Ralph Webber	St. Mary's River Association
Eldon Day	Musquodoboit River Association
Allen MacPherson	Salmon River, Guysborough
Jack Legge/ Rick Draper	Liscomb River Association
Jack MacDonald	Eastern Shore Wildlife Association
Charles Widgery	Musquodoboit River Association
Robin Archibald	St. Mary's River Association
Don MacLean	N.S. Department of Fisheries
Corey Francis	Native Council of Nova Scotia
Alex Denny	Union of Nova Scotia Indians
Don Julian	Confederacy of Mainland MicMacs
Mr. Alex Cope	Millbrook First Nation
Mr. Walter Regan	Sackville Rivers Association (SFA 21)

Table 1. Atlantic salmon sportcatch and effort for rivers in Salmon Fishing Area 20, eastern shore, Nova Scotia, for 1994, 1995, and mean catches, 1990-1994.

River	1995 Preliminary				1994a				1990 - 94 means							
	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									1.0	N/A	0.0	N/A	0.0	N/A	10.3	N/A
Cole Harbour									5.3	N/A	0.3	N/A	1.7	N/A	24.3	N/A
Country Harbour	22	9	5	198	0	1	0	8	17.2	22.0	4.2	6.8	4.4	6.6	102.6	91.0
East Sheet Harbour	0	1	0	16	0	0	0	38	18.8	15.0	3.2	5.1	2.2	3.3	178.0	138.5
Ecum Secum	22	0	3	320	9	7	1	169	45.4	42.1	3.4	5.3	4.6	4.7	504.2	350.5
Gaspereau Brook	0	0	0	3	0	0	0	8	0.8	1.6	0.0	0.0	0.0	0.0	22.2	26.5
Guysborough	1	0	3	15	0	0	2	5	1.6	2.3	0.0	0.0	3.0	2.8	12.0	9.9
Halfway Brook	1	0	0	13	0	0	0	13	0.3	0.7	0.0	0.0	0.0	0.0	5.3	7.7
Isaac's Harbour	3	3	0	26	0	0	0	15	10.2	16.2	0.2	0.6	0.2	0.6	65.8	59.3
Kirby					1	0	0	1	2.6	2.3	0.0	0.0	0.0	0.0	22.8	15.2
Larry's									0.0	N/A	0.0	N/A	0.0	N/A	2.0	N/A
Lawrencetown Lake	0	0	0	4	0	1	0	9	1.8	3.1	1.4	1.9	0.2	0.6	20.8	26.8
Liscomb	21	3	1	229	14	10	1	308	51.2	80.7	8.2	9.0	2.4	3.6	506.6	225.2
Little Salmon									0.0	N/A	0.0	N/A	0.3	N/A	4.0	N/A
Moser	68	3	0	540	11	36	0	425	104.4	93.5	22.2	18.5	9.4	9.4	899.6	435.6
Musquodoboit	99	26	90	1767	62	16	53	905	123.2	101.0	30.6	28.9	90.6	63.7	2051.6	1533.6
Necum Teuch									0.0	N/A	0.0	N/A	0.0	N/A	0.0	N/A
New Harbour	24	4	0	150	17	5	0	138	35.2	45.3	3.0	3.5	1.0	1.5	355.6	239.9
Port Dufferin	9	0	0	27	4	2	0	124	11.6	13.4	1.2	2.2	0.2	0.6	149.4	50.7
Porters Lake (East Brook)									0.0	N/A	0.0	N/A	0.0	N/A	0.0	N/A
Quoddy									0.3	0.7	0.0	0.0	0.0	0.0	16.8	9.8
Rocky Run Porters Lake									0.0	N/A	0.0	N/A	0.0	N/A	1.5	N/A
Saint Francis									0.0	N/A	0.0	N/A	0.0	N/A	0.3	N/A
Saint Mary's	406	154	131	3543	19	24	30	1423	679.4	752.6	182.4	216.3	223.2	171.7	4786.4	2567.4
Salmon: Guysborough Co.	200	54	174	1706	52	161	63	854	190.0	108.7	57.0	72.4	147.4	82.7	1559.2	531.6
Salmon: Halifax Co.	1	0	0	12					6.8	13.3	0.0	0.0	0.8	2.1	50.0	70.4
Ship Harbour Lake Charlotte	14	4	5	255	1	0	0	215	10.0	13.9	0.8	2.2	1.6	2.3	284.4	100.4
Tangier	0	0	0	3	0	0	0	3	0.0	0.0	0.0	0.0	0.0	0.0	7.8	8.8
West Sheet Harbour	River closed				River	closed			68.0	66.6	6.2	5.1	5.6	4.5	846.4	596.1
Totals	891	261	412	8827	190	263	150	4661	1381.0		324.2		497.8		12458.2	

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

Table 2. The habitat area, level of pH, and 1995 angling season for the Sackville River and 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 of 1995 angling seasons
Clam Harbour	3,009	4.85		June 01 - Aug. 29
Cole Harbour	2,730	4.54		June 01 - Aug. 29
Country Harbour	3,457	5.91		June 24 - Sept. 22
East Sheet Harbour	30,501	4.94	14-02-90	June 01 - Aug. 29
Ecum Secum	9,894	5.44		June 01 - Aug. 29
Gaspereau Brook	2,826	5.05	13-01-88	June 01 - Aug. 29
Guysborough	4,322	6.58		June 24 - Sept. 22
Halfway Brook	1,604	5.17		June 01 - Aug. 29
Isaac's Harbour	2,469	4.82		June 01 - Aug. 29
Larry's	2,632	4.61		June 01 - Aug. 29
Lawrencetown Lake	7,493	4.52		June 01 - Aug. 29
Liscomb	34,960	4.82		June 01 - Aug. 29
Little Salmon	750	4.93		June 01 - Aug. 29
Moser	15,270	5.46	22-12-88	June 01 - Aug. 29
Musquodoboit	23,125	6.48		June 01 - Aug. 29
New Harbour	3,148	4.84		June 01 - Aug. 29
Port Dufferin	7,954	5.15		June 01 - Aug. 29
Porters Lake (East Brook)	2,394	4.75		June 01 - Aug. 29
Quoddy	6,849	5.44		June 01 - Aug. 29
Sackville	6,000	4.80 [3]	01-91	June 01 - Aug. 15
Saint Mary's	58,717	5.98		June 01 - Sept. 15
Salmon: Guysborough Co.	18,861	6.12		June 24 - Sept. 22
Salmon: Halifax Co.	2,834	4.15	23-02-93	June 01 - Aug. 29
Ship Harbour Lake Charlotte	20,518	5.54		June 01 - Aug. 29
Tangier	22,717	4.80		June 01 - Aug. 29
West Sheet Harbour	17,050	4.92		closed
Total	312,084			

[1] Estimated from aerial photographs and orthophoto maps by Amiro (unpublished data) according to the procedures described in Amiro 1993. (P.G. Amiro, Fisheries and Oceans, Halifax, Nova Scotia)

[2] Data from 1986. More current data available for summer pHs only. Winter pHs are not expected to have changed more than 0.1 or 0.2 pH units since 1986 (W. Watt, pers. comm., Fisheries and Oceans, Halifax, Nova Scotia).

[3] Upper one quarter of system, pH 4.8. Remainder of system, pH 5.6.

Table 3 . Numbers of 1SW salmon retained, MSW salmon retained and released, and effort, in the sport fisheries of Salmon Fishing Areas 20 and 21, 1974-1995.

	SFA 20				SFA 21			
	Catch			Effort	Catch			Effort
		MSW		in		MSW		in
Year	1SW	Retained	Released	rod-days	1SW	Retained	Released	rod-days
1974	3,462	434		24,977	2,462	397		13,236
1975	694	94		8,455	1,416	656		8,286
1976	2,652	219		18,530	2,474	321		16,026
1977	1,639	422		14,364	3,434	643		20,278
1978	396	272		12,403	460	481		9,748
1979	2,178	267		22,312	2,969	374		14,834
1980	3,483	469		25,458	2,773	1,104		25,682
1981	2,556	581		30,840	4,342	1,284		38,111
1982	1,657	201		28,187	1,847	494		28,351
1983	1,363	401		37,352	471	409		13,743
1984	1,744	128	282	14,426	2,159	232	316	18,868
1985	2,555	0	1,713	17,578	2,790	0	1,567	18,863
1986	2,268	0	1,622	20,150	3,110	0	1,583	23,240
1987	1,771	0	686	13,251	4,395	0	799	24,593
1988	2,641	0	1,223	20,483	2,907	0	812	26,131
1989	1,874	0	953	17,908	4,073	0	1,166	27,981
1990	3,029	0	696	17,787	3,497	0	933	29,029
1991	1,390	0	604	13,133	557	0	313	13,411
1992	905	0	400	11,482	2,229	0	349	21,284
1993	1,391	0	642	15,224	1,623	0	415	22,948
1994	190	0	150	4,676	302	0	222	11,356
1995 *	891	0	412	8,827	999	0	367	13,253
Means								
1980-94	1,921			19,196	2,472			22,906
1985-94	1,801		869	15,167	2,548		816	21,884
1990-94	1,381		498	12,460	1,642		446	19,606

* Preliminary

Table 4. First Nations' fishing plan or communal license harvest allocations and reported harvests for Salmon Fishing Area 20, 1995.

First Nation	Harvest allocation	Reported harvest
Millbrook	East River SH - 50 grilse	18 grilse
Indian Brook	Musquodoboit - 100 grilse	None reported
Native Council	Entire area - 730 grilse tags available for distribution	6 grilse

Table 5. Habitat area, spawning target, adult requirement, angling catch, returns, estimated escapements, and surplus/deficits for SFA 20, several rivers within SFA 20, and the Sackville River.

River/ area	Habitat area m^2x10^2	Target eggs at 240 eggs per 100 m^2	Spawner requirements		Angling catch			Returns		Broodstock removed		Native harvest		Escapement		Surplus/deficit based	
					Grilse		Salmon										
			Grilse	Salmon	Retained	Released	released	Grilse	Salmon	Grilse	Salmon	Grilse	Salmon	Grilse	Salmon	Grilse	Salmon
SFA 20[a]	116,070	27,856,800	9190	1690	891	261	412	3,291	1,177 c			24	0	2,350	1136	-6,840	-554
East Sheet Harbour	29,022	6,965,280	6565	0	0	1	0	122	6 d	51	6	18	0	104	6	N/A	N/A
Liscomb[b]	16,856	4,045,440	2113	194	21	3	1	248	13 d	26	19			248	13	-1,865	-181
Sackville	1,600	384,000	283	12	20	4	3	387	15 e	20	4			367	15	84	3
Saint Mary's	30,785	7,388,400	2437	718	406	154	131	1938	453 f					1516	440	-920	-278
West Sheet Harbour[g]	3,700	888,000	797	0	0	0	0	N/A	N/A g					N/A	N/A	N/A	N/A

a Baseline data for habitat areas and spawning requirements for SFA 20 were obtained from the Atlantic Salmon Review 1978.
b The Liscomb River egg requirement above the falls is 3,692,400 eggs; below the falls, 353,040 eggs.
c Estimated based on an exploitation rate of 35%.
d Fishway count
e Estimated returns based on mark-recapture at the fence and through seining
f Exploitation rate of 28.9% derived from the LaHave River for 1995 used to estimate returns based on the license stub reported angling catch
g Closed to angling 1994 and 1995. No estimate of returns possible

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

	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
				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 7. Egg and adult spawner requirement calculations for the Atlantic salmon stock on the St. Mary's River (adapted from Marshall 1986).

Biological characteristics:

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

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 eggs per salmon =		2,365

Spawning requirements:

			Spawners		
Habitat area (m^2)	Eggs at 2.4 eggs/m^2	Total fish required (eggs÷2,365)	1SW (3,124x0.78)	Small MSW (3,124x0.14)	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 8. Atlantic salmon sport catch and estimate of returns, escapement and proportion of egg requirement achieved and harvested for the St. Mary's River, 1974-95. Returns and escapement are based on an assumed 30% exploitation rate.

	Grilse[a]		Large salmon[a]		Grilse		Large salmon		Estimated egg	Surplus/deficit eggs relative	Percent of egg requirement	Percent of egg requirement lost
Year	Retained	Released	Retained	Released	Returns	Escapement	Returns	Escapement	deposition	to requirement[b]	acheived	due to angling[c]
1974	1735		217		5782	4047	722	505	8992876	1604476	122	52.2
1975	238		73		792	554	242	169	1708738	-5679662	23	9.9
1976	1386		128		4620	3234	427	299	6686307	-702093	90	38.8
1977	605		158		2015	1411	528	370	4055600	-3332800	55	23.5
1978	199		128		664	465	427	299	2178429	-5209971	29	12.6
1979	1521		87		5069	3548	290	203	6743440	-644960	91	39.1
1980	1969		201		6565	4595	669	468	9708623	2320223	131	56.3
1981	1133		359		3775	2643	1197	838	8288826	900426	112	48.1
1982	747		81		2490	1743	268	188	3731883	-3656517	51	21.6
1983	663	69	175	61	2440	1770	787	606	5763615	-1624785	78	26.4
1984	709	197	65	165	3020	2291	767	685	6990945	-397455	95	21.3
1985	1182	255	0	856	4790	3583	2853	2768	19003953	11615553	257	32.1
1986	1126	288	0	944	4713	3559	3147	3052	20319029	12930629	275	31.5
1987	524	88	0	321	2040	1507	1070	1038	7393088	4688	100	13.8
1988	1209	230	0	694	4797	3565	2313	2244	16482156	9093756	223	31.6
1989	575	80	0	462	2183	1600	1540	1494	9714337	2325937	131	15.8
1990	1612	451	0	274	6877	5220	913	886	12713611	5325211	172	38.3
1991	744	231	0	264	3250	2483	880	854	8104444	716044	110	18.6
1992	284	35	0	152	1063	776	507	491	3601947	-3786453	49	7.3
1993	738	171	0	396	3030	2275	1320	1280	9796961	2408561	133	19.2
1994	19	24	0	30	143	122	100	97	660130	-6728270	9	0.7
1995	406	154	0	131	1867	1445	437	424	4368648	-3019752	59	10.1

a Sportcatch for the years prior to the use of the stub system was converted to "stub equivalents" by multiplying by 1.32.
b The egg requirement is based on the MacEachern (1955) habitat area for a total requirement of 7,388,400 eggs.
c Estimates of the percentage of eggs lost to harvest includes fish harvested plus an additional 10% hook-and-release mortality for large salmon and grilse.

Table 9. SFA 20 sport catch, escapement based on three exploitation rates (25%, 35%, and 45%), and surplus or deficit spawners based on the Atlantic Salmon Review (1978) spawning requirements.

Year	SFA 20 sport catch		Escapement based on exploitation rates[a]						Atlantic Salmon Review spawner requirements and surplus or deficit based on 25% expl. rate[b]	
			25%		35%		45%			
	1SW retained	MSW ret.&rel.	1SW	MSW	1SW	MSW	1SW	MSW	1SW	MSW
1974	3462	434	10386	1302	6429	806	4231	530	1196	-388
1975	694	94	2082	282	1289	175	848	115	-7108	-1408
1976	2652	219	7956	657	4925	407	3241	268	-1234	-1033
1977	1639	422	4917	1266	3044	784	2003	516	-4273	-424
1978	396	272	1188	816	735	505	484	332	-8002	-874
1979	2178	267	6534	801	4045	496	2662	326	-2656	-889
1980	3483	469	10449	1407	6468	871	4257	573	1259	-283
1981	2556	581	7668	1743	4747	1079	3124	710	-1522	53
1982	1657	201	4971	603	3077	373	2025	246	-4219	-1087
1983	1363	401	4089	1203	2531	745	1666	490	-5101	-487
1984	1744	410	5232	1640	3239	1171	2132	911	-3958	-50
1985	2555	1713	7665	6852	4745	4894	3123	3807	-1525	5162
1986	2268	1622	6804	6488	4212	4634	2772	3604	-2386	4798
1987	1771	686	5313	2744	3289	1960	2165	1524	-3877	1054
1988	2641	1223	7923	4892	4905	3494	3228	2718	-1267	3202
1989	1874	953	5622	3812	3480	2723	2290	2118	-3568	2122
1990	3029	696	9087	2784	5625	1989	3702	1547	-103	1094
1991	1390	604	4170	2416	2581	1726	1699	1342	-5020	726
1992	905	400	2715	1600	1681	1143	1106	889	-6475	-90
1993	1391	642	4173	2568	2583	1834	1700	1427	-5017	878
1994	190	151	570	604	353	431	232	336	-8620	-1086
1995[c]	892	410	2676	1640	1657	1171	1090	911	-6514	-50

a Escapement is calculated as ((catch/expl. rate)- retained catch).

b Spawner requirements are based on Atlantic Salmon Review (1978); refer to text.

1SW	MSW
9190	1690

c 1995 data are preliminary.

Table 10. Number and age of Atlantic salmon juveniles reared at fish culture stations and released into the Sackville River (SFA 21) and rivers of SFA 20, 1990-95.

River		Age	1990	1991	1992	1993	1994	1995
East River, Sheet Harbour		0+ parr	14055	35910	40210	25060	6000	26863
		1+ smolt	10449	21450	26978	26576	26771	26187
		2+ smolt						10790
Liscomb		0+ parr	35832	69750	54485	40305	51325	30321
		1+ parr			6318	1323		
		1+ smolt	11557	17027	19236	11121	18966	35738
		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
		1+ smolt	23236	11672	22815	21464	11680	27359
Sackville		0+ parr	10012	35020	31584	20700	3500	25100
		1+ smolt	10000	16184	10902	10003	16001	17102
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 11. Numbers of smolts released and return rates, and the number and destiny of adult Atlantic salmon captured at the Barrier Dam fishway, East River, Sheet Harbour, 1992-1995.

Year	Smolts released year i	Number of fish counted at fishway [a]						Return rate in percent		Destiny of returns			
		Hatchery		Wild		Total		1SW	MSW		Released		
		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

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

Table 12. Counts of wild and hatchery Atlantic salmon at the fishway trap at Liscomb Falls, Liscomb River, and the estimated number of eggs from total returns, 1979-1995.

Year	SFA 20 Liscomb Returns				Estimated number of eggs from total returns, in thousands
	Wild		Hatchery		
	1SW	MSW	1SW	MSW	
Egg requirement above Liscomb Falls assuming no acid impact: 3,692 x 10^3 eggs					
1979	60	0	485	2	800
1980	111	0	931	51	1,901
1981	76	6	241	49	728
1982	252	10	827	41	1,673
1983	520	15	594	63	2,672
1984	606	48	331	42	1,342
1985	507	87	49	175	1,607
1986	736	117	766	108	3,447
1987	1614	88	523	54	3,886
1988	477	76	431	44	1,876
1989	532	75	288	71	1,835
1990	955	44	438	22	2,434
1991	586	38	178	22	1,424
1992	145	27	125	12	570
1993	134	11	128	12	498
1994	134	10	119	8	465
1995	150	6	98	7	438
Means:					
1990-94	391	26	198	15	1,078
1985-94	582	57	305	53	1,804
1995 as % of:					
1990-94	38%	23%	50%	46%	41%
1985-94	26%	10%	32%	13%	24%

Table 13. Number and rate of 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		

Table 14. Mean Atlantic salmon parr densities (1+ parr and total parr) per 100 m^2 for various sub-drainage portions of the St. Mary's River and the entire river, 1985, 1986 and 1990-1995. The number of sites electrofished in each case is given as N.

Area	1985			1986			1990			1991			1992			1993			1994			1995			All Years		
	Total	1+	N	Total	1+	N	Total	1+	N	Total	1+	N	Total	1+	N	Total	1+	N	Total	1+	N	Total	1+	N	Total	1+	N
West River tributaries & main	9.0	7.6	19	6.6	5.1	18	10.7	7.9	3	3.7	3.1	9	5.1	4.2	11	10.8	10.2	4	5.3	4.6	7	6.9	5.9	8	6.9	5.8	79
West River tributaries	10.0	9.0	15	6.5	4.7	14	10.7	7.9	3	3.7	3.1	9	6.1	5.0	9	10.8	10.2	4	6.6	5.7	5	8.1	7.0	6	7.5	6.3	65
West River main	5.0	2.6	4	7.0	6.5	4							0.8	0.5	2				2.2	2.1	2	3.2	2.7	2	4.3	3.3	14
East River tributaries & main	4.7	4.5	6	6.4	5.1	16	9.0	6.7	14	6.9	6.0	9	3.3	2.6	16	7.6	7.3	5	6.4	6.0	13	5.9	4.8	14	6.2	5.2	93
East River tributaries	4.7	4.5	6	7.3	5.7	12	11.6	8.9	10	6.9	6.0	9	4.0	3.1	11	7.6	7.3	5	7.0	6.6	10	6.3	5.2	10	7.0	5.9	73
East River main				3.8	3.2	4	2.5	1.0	4				1.9	1.4	5				4.3	4.1	3	4.8	3.9	4	3.3	2.6	20
Main River tributaries	10.1	9.1	3	7.9	7.2	2	11.2	8.9	2	6.2	4.1	4	4.7	4.2	2	8.4	7.7	1							7.9	6.6	14
St. Mary's River system	8.2	7.1	28	6.6	5.2	36	9.5	7.1	19	5.4	4.5	22	4.1	3.3	29	9.0	8.5	10	6.0	5.5	20	6.2	5.2	22	6.6	5.5	186

Table 15. 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 effect(s)	N	P-value	Significant effect pairs
Sites 4, 5, 8, 10, 23	Total parr	Year (1985, 86, 90-95)	36	0.627	
Sites 4, 5, 8, 10, 23	1+ parr	Year (1985, 86, 90-95)	36	0.753	
All sites	Total parr	Year (1985, 86, 90-95)	186	0.008	1990/92
All sites	1+ parr	Year (1985, 86, 90-95)	186	0.009	1985/92, 1993/92
All sites	Total parr	Gradient	183	0.000	
All sites	1+ parr	Gradient	183	0.001	
All sites	Gradient	River branch	183	0.000	All
East, West	Total parr	River branch Gradient	183	0.871 0.000	
East, West	1+ parr	River branch Gradient	183	0.906 0.001	
East, West, tribs and main	Total parr	River branch Area within branch Gradient	169	N/A N/A N/A	Significant (p=0.031) branch x gradient interaction effect
East, West, tribs and main	1+ parr	River branch Area within branch Gradient	169	0.474 0.014 0.017	East trib/East main

Table 16. Means (and st. dev.) of total and 1+ parr densities for the St. Mary's River and various subsets of the river system based on electrofishing data collected in 1985, 1986, and 1990-1995.

River subset	Mean (st. dev.)		N
	Total parr	1+ parr	
East main	3.3 (2.8)	2.6 (2.5)	20
East tributaries	7.0 (5.6)	5.9 (4.7)	73
West main	4.3 (3.1)	3.3 (2.9)	14
West tributaries	7.5 (5.6)	6.3 (4.9)	65
Stem tributaries	7.9 (3.3)	6.6 (3.2)	14
St. Mary's system	6.6 (5.2)	5.5 (4.5)	186

Table 17. St. Mary's River sport catch data and possible related variables for examination of indices of the returns to the St. Mary's River.

Year	LaHave wild 1SW	LaHave wild MSW	Liscomb wild 1SW	Liscomb wild MSW	St. Mary's River sportcatch[a] 1SW (ret.)	St. Mary's River sportcatch[a] MSW (total)	St. Mary's MSW catch year i+1[b]
1974	29	2			1735	217	73
1975	38	5			238	73	128
1976	178	23			1386	128	158
1977	292	25			605	158	128
1978	275	67			199	128	87
1979	856	67	60	0	1521	87	201
1980	1637	288	111	0	1969	201	359
1981	1866	366	76	6	1133	359	81
1982	799	256	252	10	747	81	175
1983	1129	213	520	15	663	175	228
1984	2043	384	606	48	698	228	856
1985	1343	638	507	87	1182	856	944
1986	1579	584	736	117	1126	944	321
1987	2529	532	1614	88	524	321	694
1988	2464	390	477	76	1209	694	462
1989	2087	511	532	75	565	462	274
1990	1880	396	955	44	1612	274	264
1991	495	236	586	38	744	264	152
1992	1915	215	145	27	284	152	396
1993	791	112	134	11	738	396	30
1994	641	128	134	10	19	30	131
1995	577	143	150	6	406	131	

[a] Catch prior to 1983 was collected by DFO officers, not via license stubs. Those values have been converted to license stub equivalents by multiplying by 1.32.

[b] MSW salmon sport catch lagged one year so that the 1975 MSW catch is matched with the 1974 1SW catch.

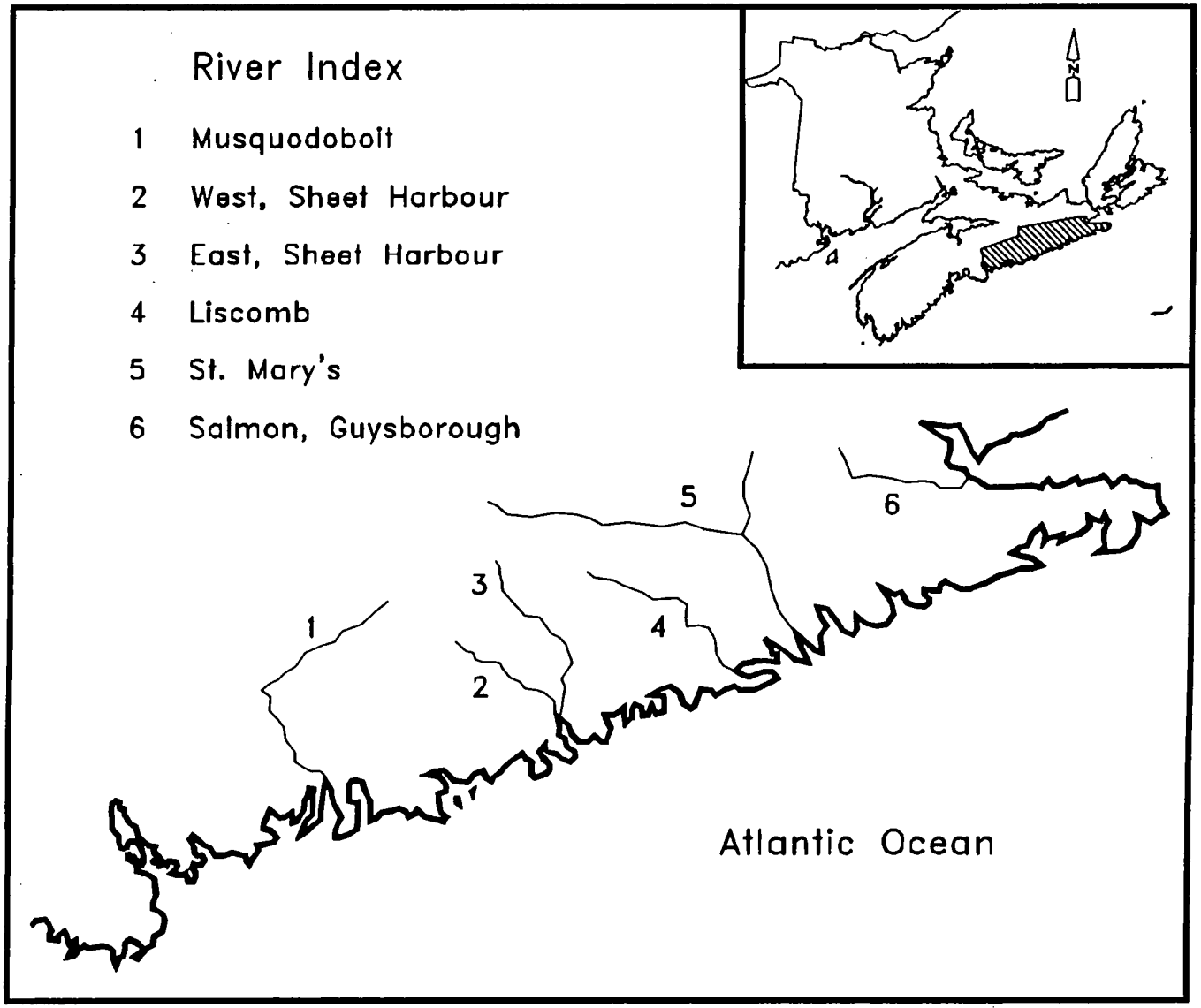


Figure 1. Principal rivers of Salmon Fishing Area 20, Eastern Shore, Nova Scotia.

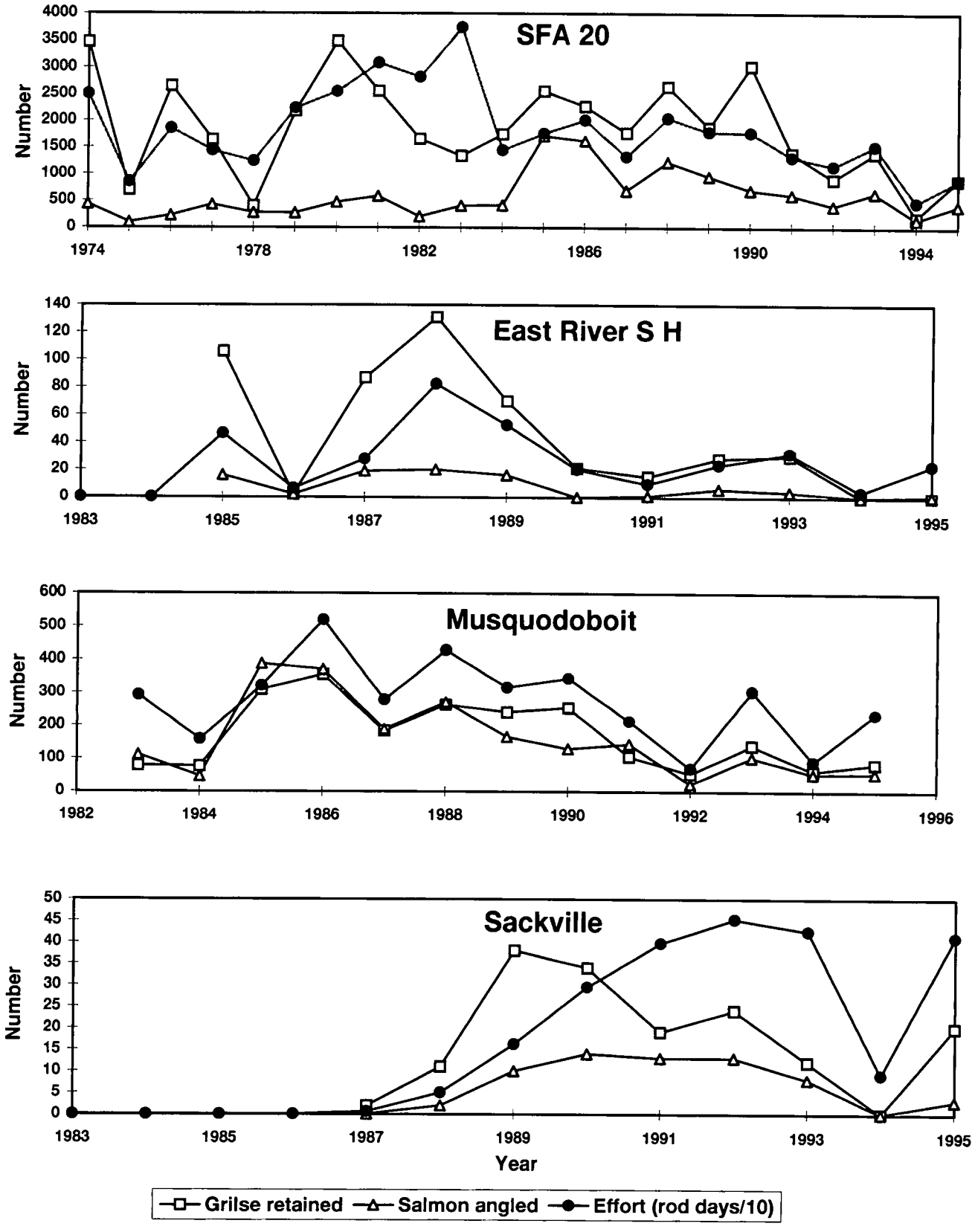


Figure 2(a). Atlantic salmon sport catch (grilse retained and large salmon released) and effort (divided by 10) combined for rivers in SFA 20 (top panel) 1974-1995, and for selected rivers, 1983-1995.

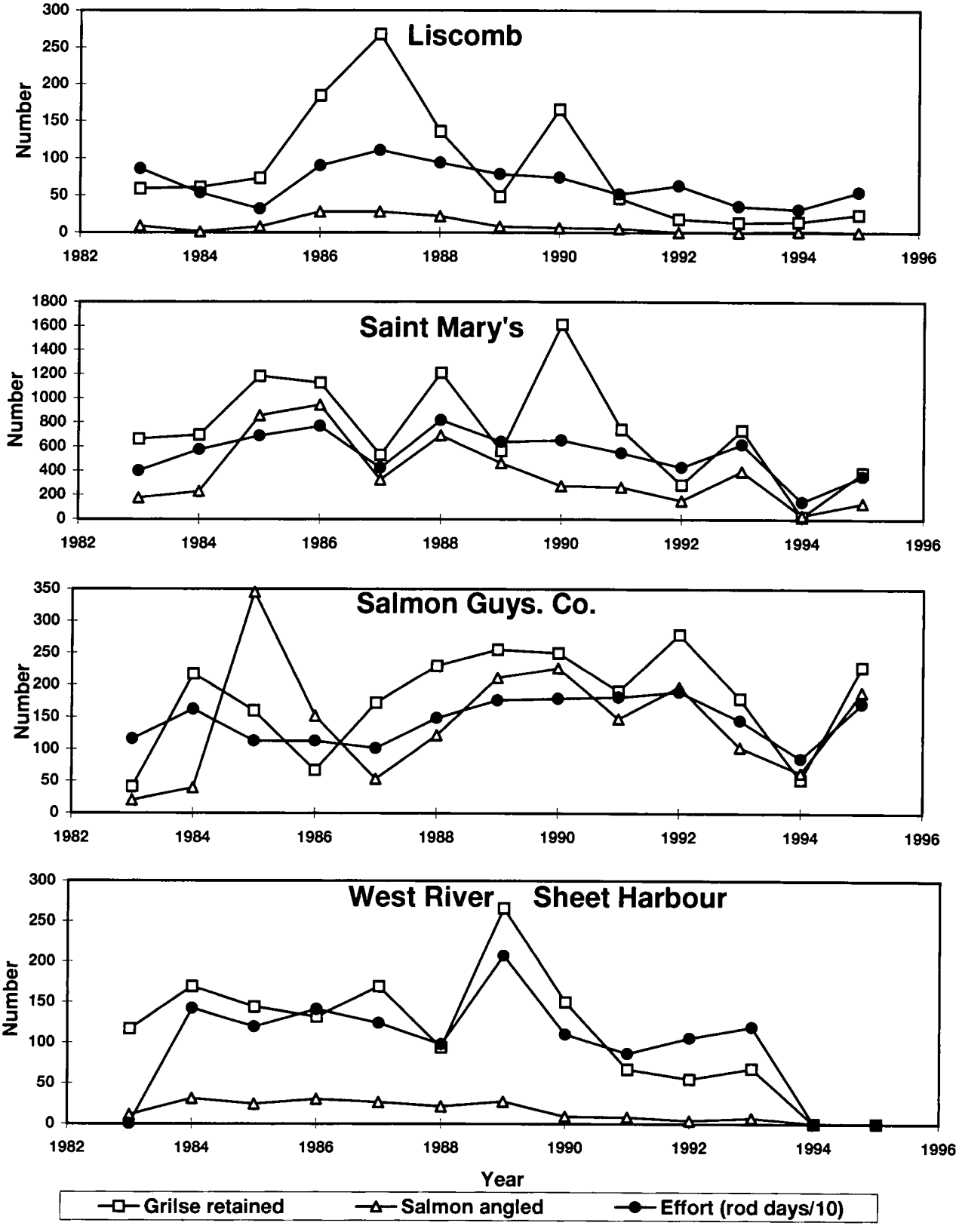


Figure 2b. Atlantic salmon sport catch (retained grilse and large salmon released) for selected rivers of SFA 20, 1983-1995.

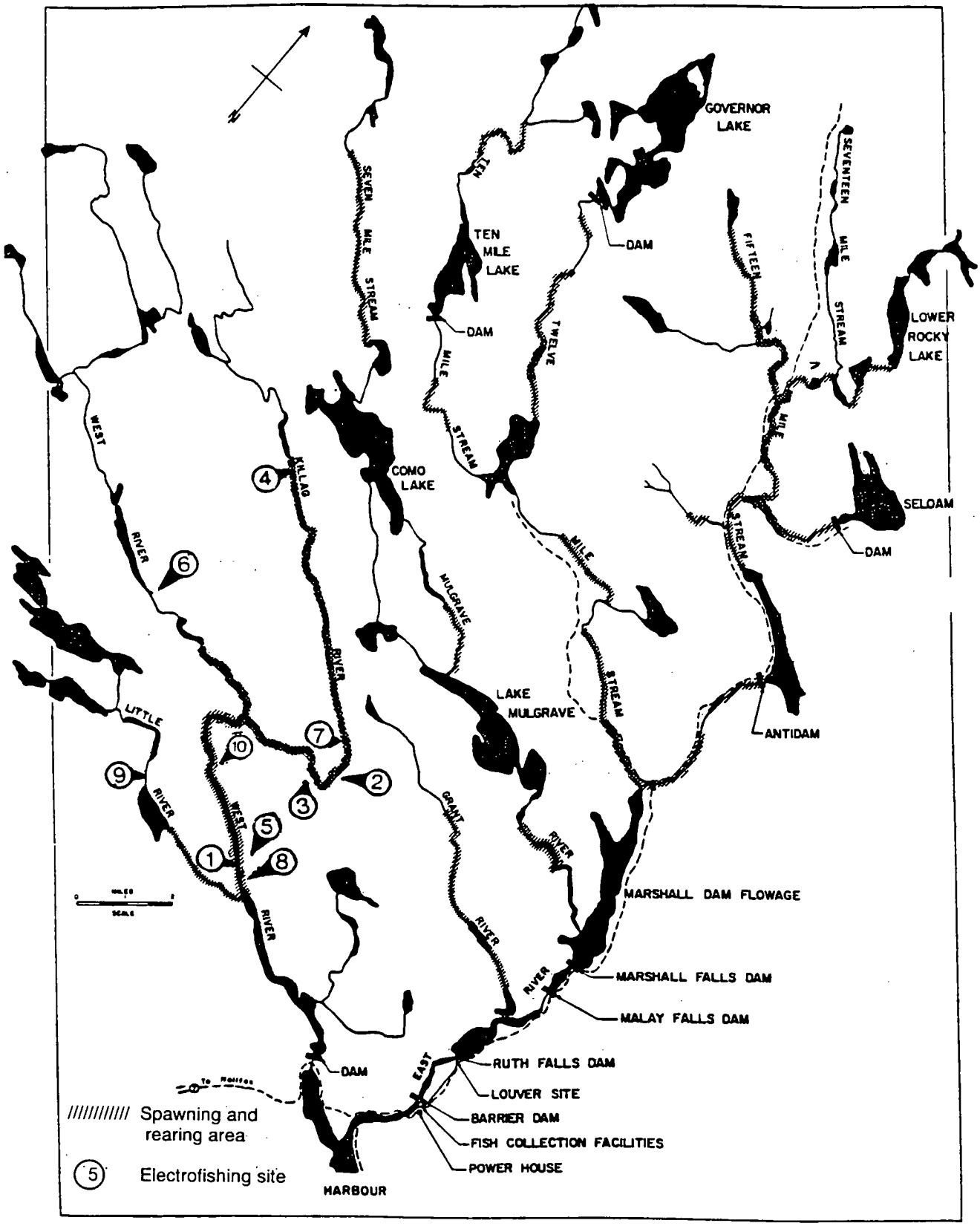


Figure 3. East and West rivers at Sheet Harbour with locations of dams, traps and electrofishing sites.

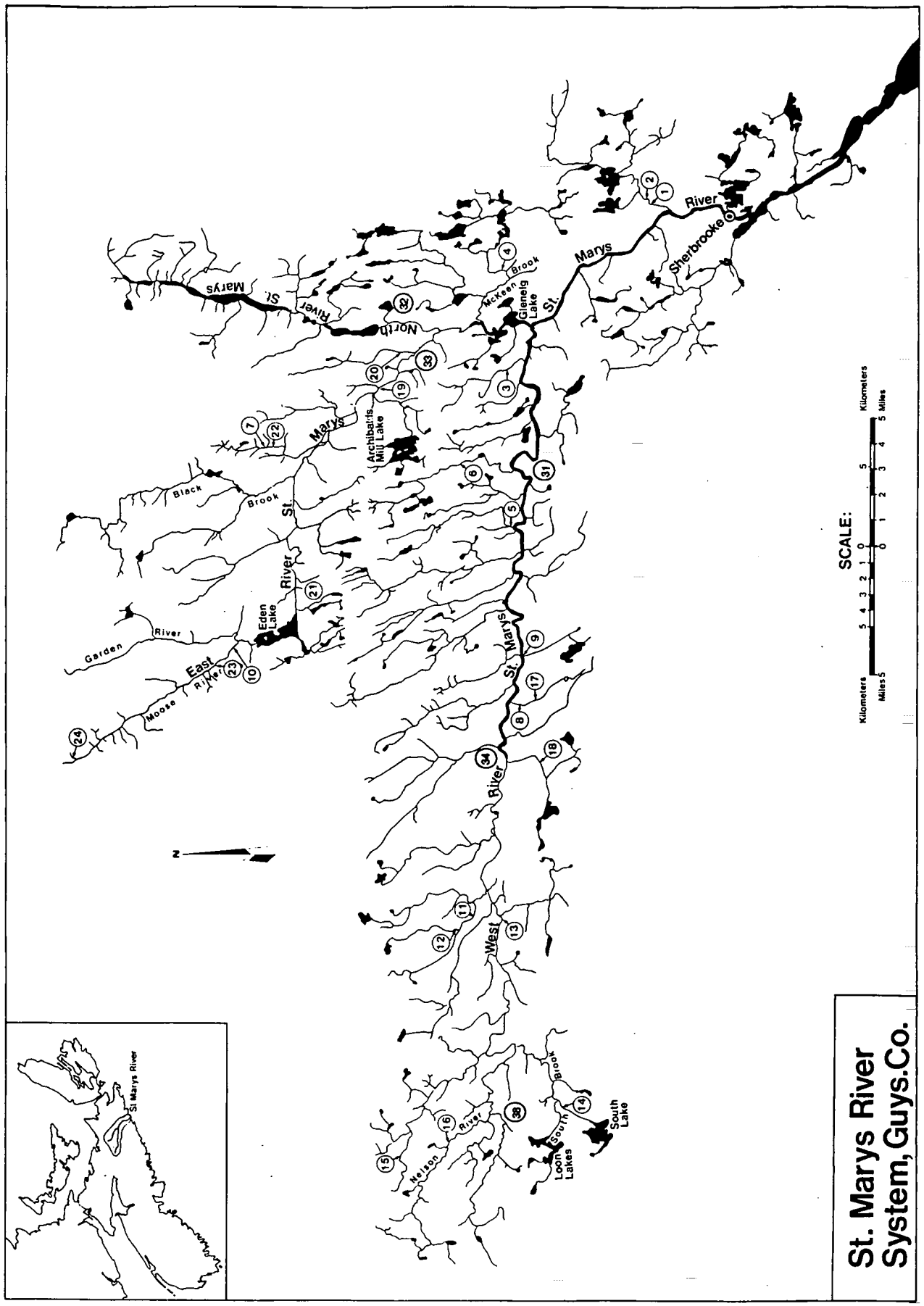


Figure 4. Electrofishing sites on the St. Mary's River (adapted from Amiro 1989 and Buckland-Nicks 1995).

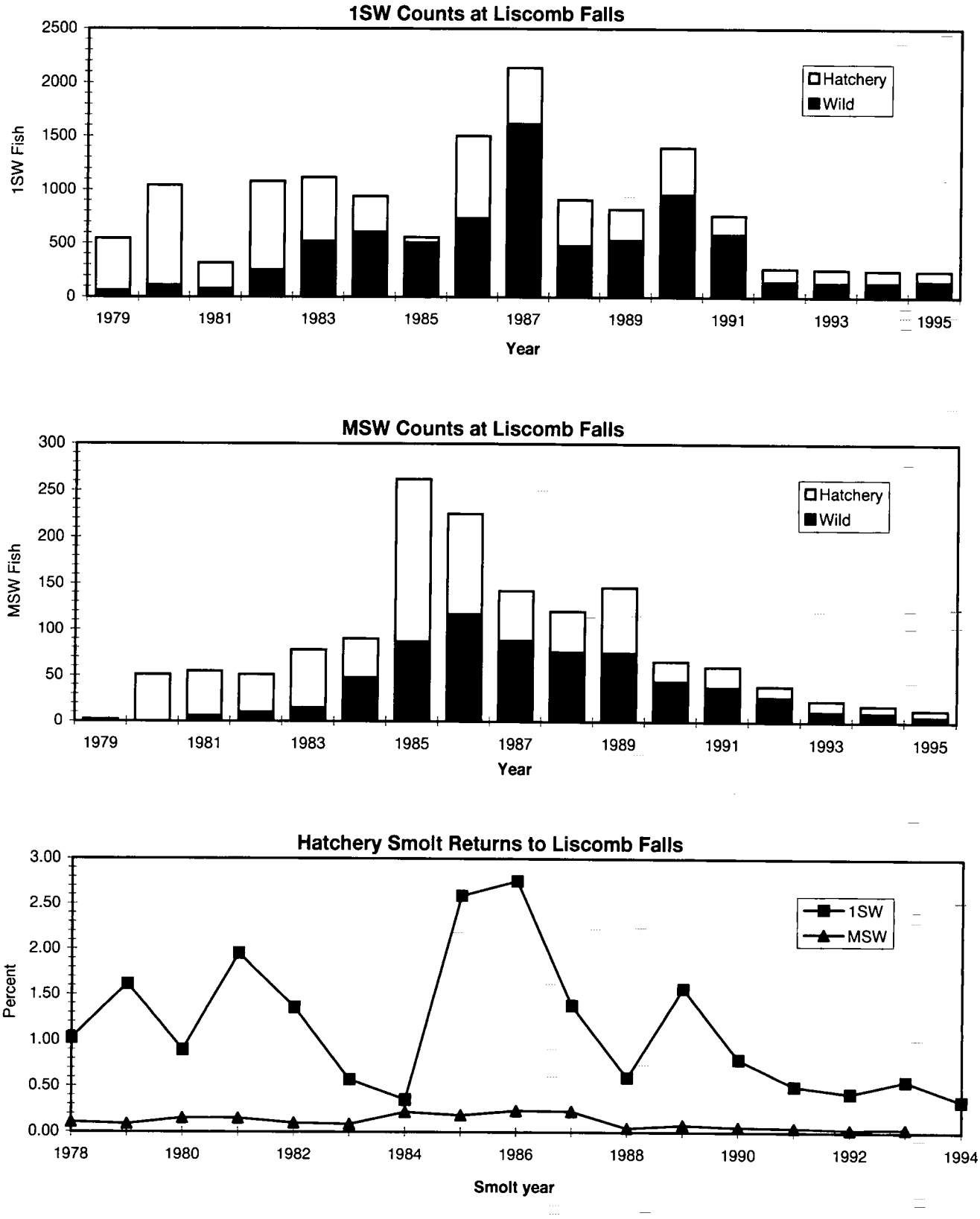
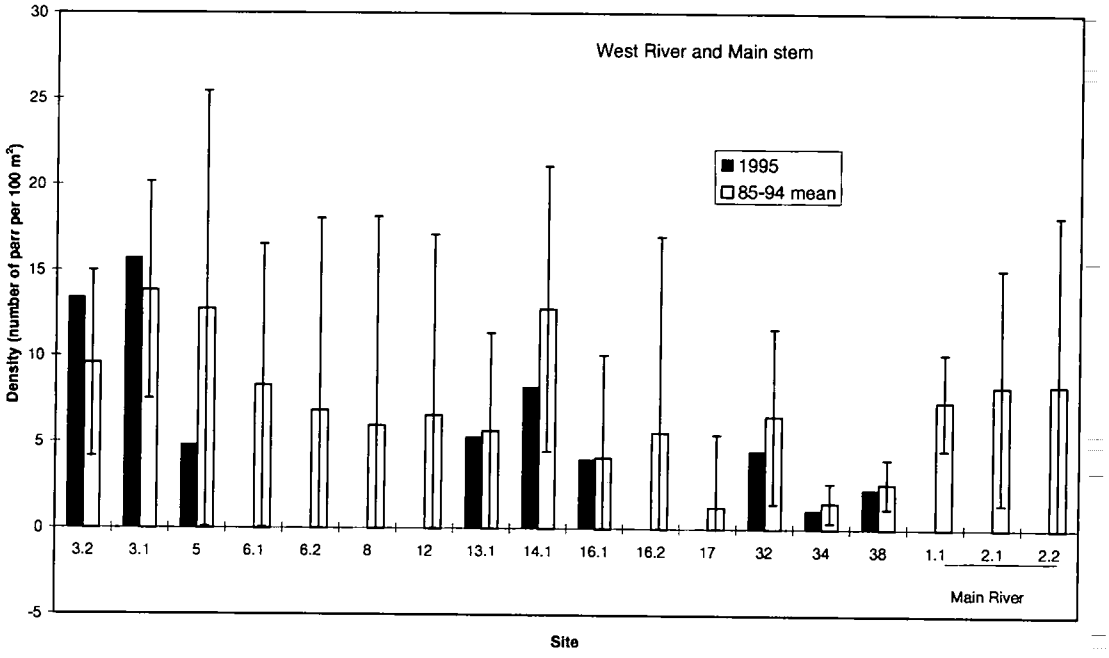


Figure 5. Counts of wild and hatchery salmon and percent return from hatchery smolts at the Liscomb Falls fish counting facility in recent years.



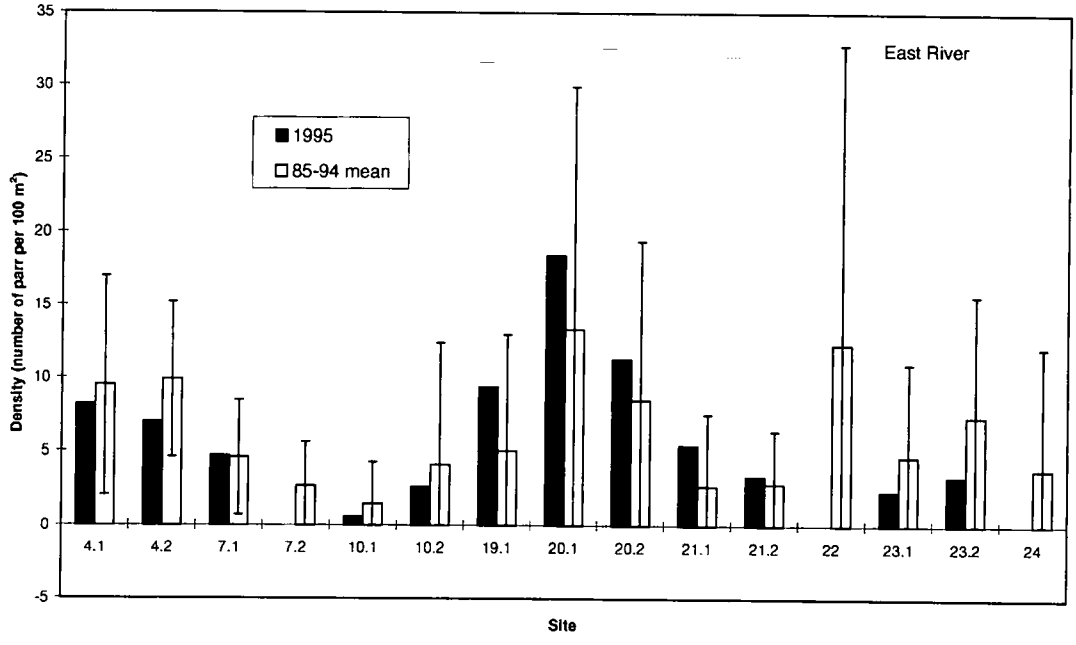


Figure 6. Total parr density by site on the Saint Mary's River for 1995 and as a mean with error bars (2* SD), 1985-1994. Site numbers are indicated on the map on Figure 4. More than one site may be fished at each location and are designated as decimal 1, 2 etc. so that 4.1 and 4.2 are two separate sites fished at location 4, Figure 4.

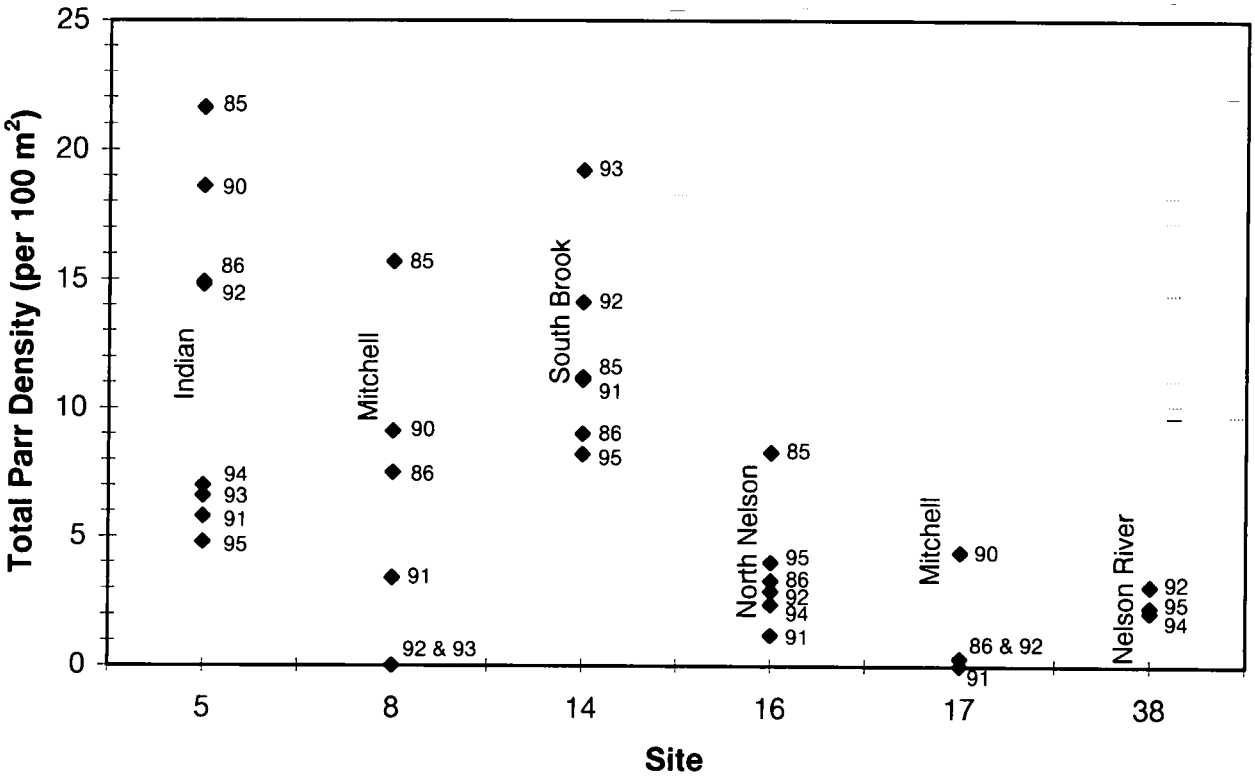


Figure 7. Total parr densities by year on tributaries to the West River St. Mary's River that are impacted by acid precipitation.

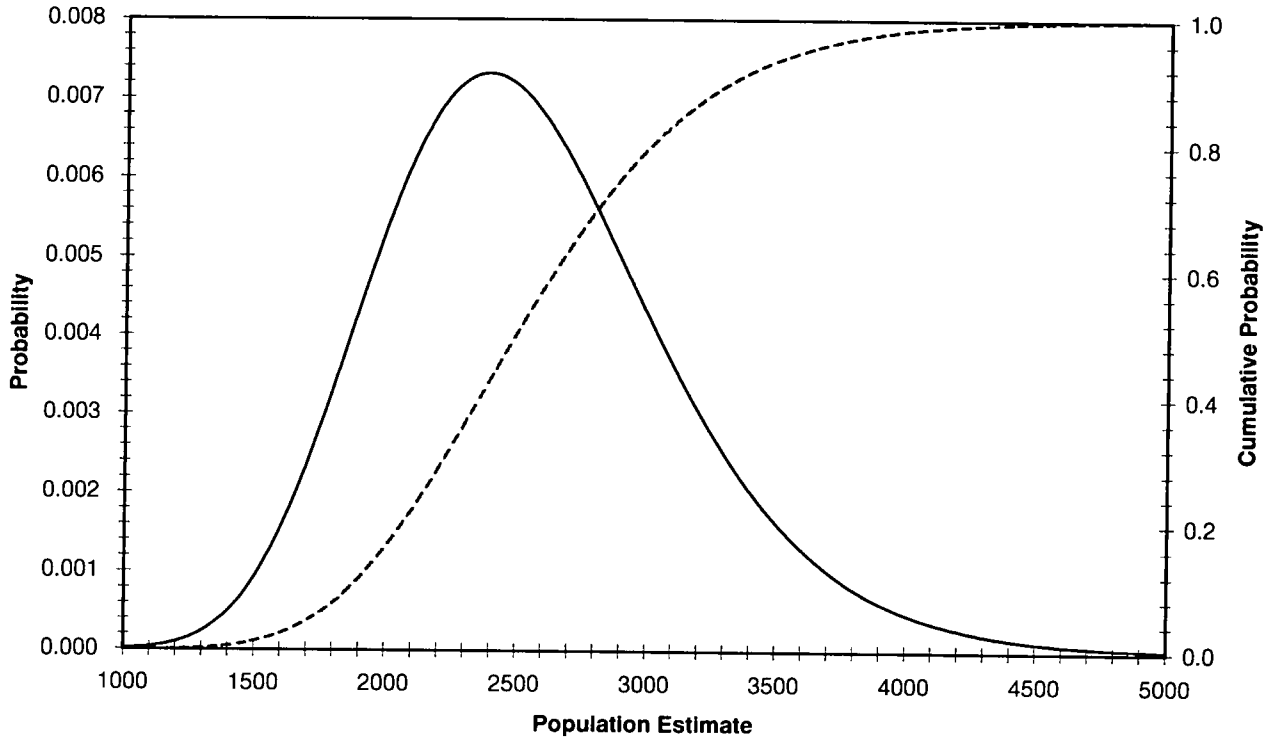


Figure 8. Probability (solid line) and cumulative probability (dashed line) distributions of total Atlantic salmon returns to the St. Mary's River in 1995 based on the LaHave River 1995 exploitation rate (see text) and the total angling catch on the St. Mary's River in 1995.

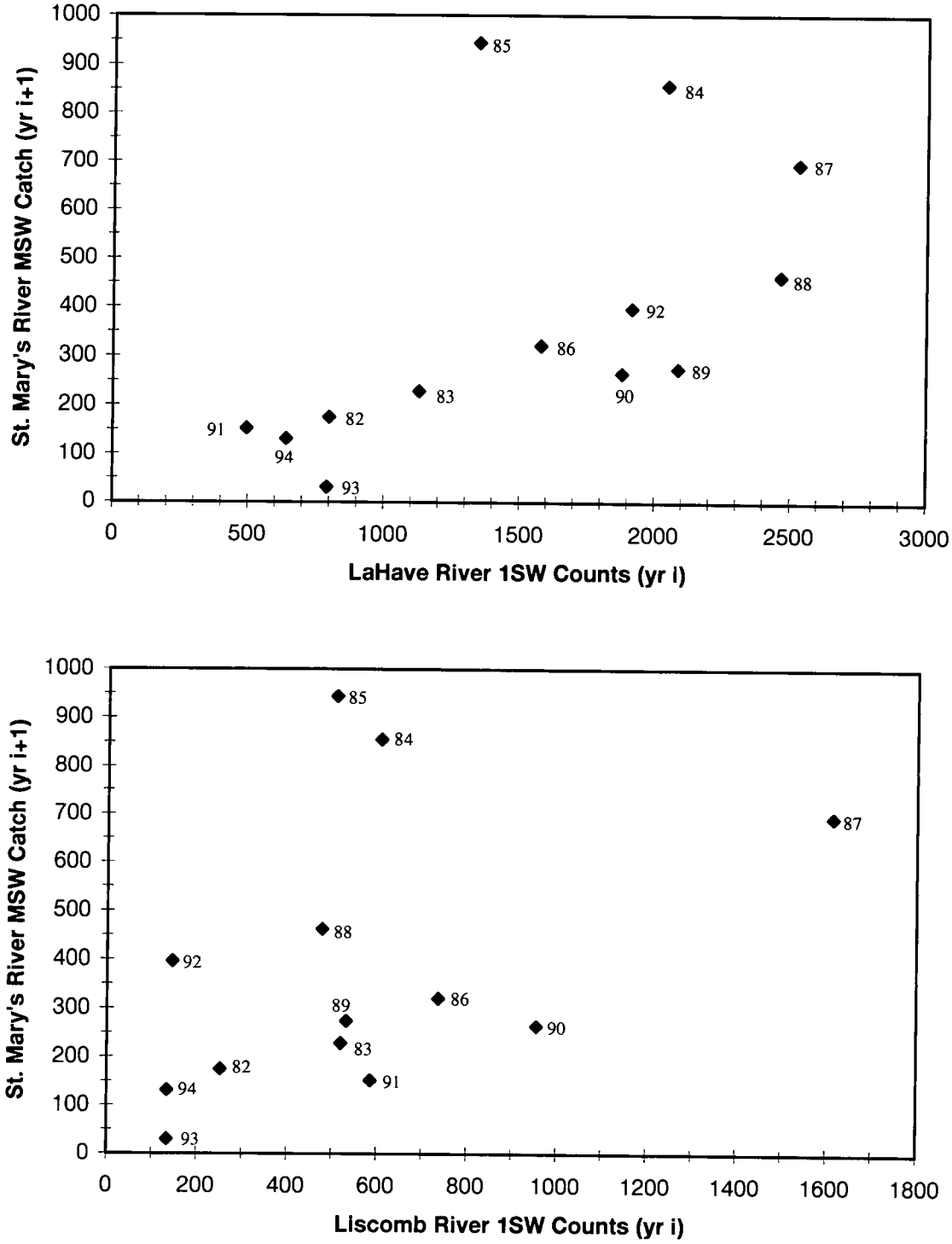


Figure 9. Scatter plots of the St. Mary's River large salmon sport catch in year i+1 plotted against both the LaHave wild grilse returns in year i (upper graph) and the Liscomb River wild grilse counts in year i (lower graph), 1982-1994. Each grilse year (year i) is indicated on the plots.

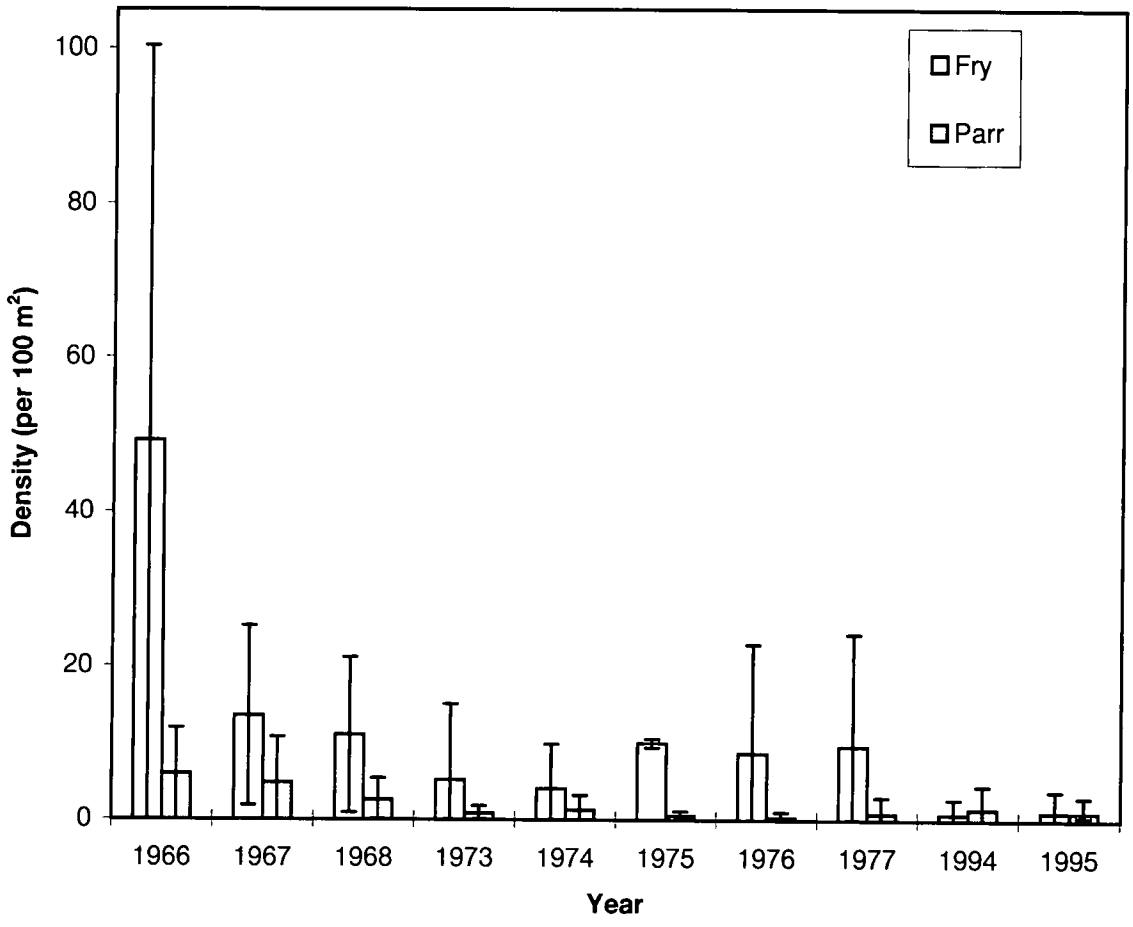


Figure 10. Juvenile Atlantic salmon densities of fry (0+ parr), total parr (1+ and 2+) and error bars (2*SD) on the West River, Sheet Harbour, for some years, 1966-1995.