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Status of Atlantic salmon in Salmon Fishing Areas 22 and 23 for 1996, with emphasis on inner Bay of Fundy stocks.

by

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Abstract

Assessment of the status of Atlantic salmon(*Salmo salar*) stocks of Salmon Fishing Area (SFA) 22, the Bay of Fundy area of Nova Scotia and those of SFA 23 east of the Saint John River, known as inner Bay of Fundy, indicated that escapements of salmon to six of seven assessed rivers were less than conservation requirements. All harvest and hook-and-release fisheries have been closed since 1991. Stewiacke River parr densities remain low at 1.16 age-0^+, 5.29 age-1^+ and 1.92 age-2^+ parr 10^{-2} m^2. Escapements to the Petitcodiac River remained low in 1996 and although age 0^+ parr were found in three of four electrofishing sites in the vacinity where adult salmon were released in 1995, no age-1^+ parr or older were observed. Observations and counts of salmon in Point Wolfe and Alma rivers were low in 1996. Escapements to the Big Salmon River were 16% of the conservation requirement in 1996. Mean density of age-0^+ parr (fry) parr of five sites electrofished in 1996 in the Big Salmon River was 49.22 fry ($m^{-2} * 100$) and 10.68 age-1^+ parr. Densities of fry and older parr were higher in Big Salmon River than other assessed rivers and higher than densities in six other inner Bay of Fundy rivers electrofished in 1996. Gaspereau River, a river containing two-sea-winter salmon atypical of inner Bay of Fundy and impacted by hydroelectric development, was 105% of the egg deposition requirement when hatchery returns were included and 27% of requirement without hatchery returns. Ineffective downstream fish passage of smolts in the Annapolis and Gaspereau rivers and episodic incidence of low marine survival for all Inner Bay of Fundy stocks are suggested as reasons for low returns in 1996 and since 1990. Prognosis and mitigation techniques were discussed and no fishery was recommended for 1997.

Résumé

L'évaluation des stocks de saumon atlantique (*Salmo salar*) de la zone de pêche du saumon (ZPS) 22, la partie néo-écossaise de la baie de Fundy, et de la ZPS 23 à l'est de la rivière Saint-Jean, connue comme le fond de la baie de Fundy, a montré que les échappées de saumons dans six des sept rivières évaluées étaient inférieures aux besoins de la conservation. Toutes les pêches, y compris celles par capture et remise à l'eau, sont interdites depuis 1991. Les densités de tacons de la rivière Stewiacke demeurent faibles à 1,16 d'âge 0+, 5,29 d'âge 1+ et 1,92 d'âge 2+ 10^{-2} . m^2. Les échappées de la rivière Petitcodiac sont demeurées faibles en 1996 et bien que des tacons d'âge 0+ aient été décelés à trois des quatre sites de pêche électrique se trouvant au voisinage de la remise à l'eau de saumons adultes en 1995, aucun tacon d'âge 1+ ou poissons plus âgé n'a été aperçu. Les résultats d'observations et de dénombrements des saumons des rivières de la pointe Wolfe et Alma ont été faibles en 1996. Pour cette année, les échappées de la rivière Big Salmon correspondaient à 16 % des besoins de la conservation. En 1996, la densité moyenne des tacons d'âge 0+ (alevins) en cinq sites de pêche électrique de la Big Salmon ont été de 49,22 (100 . m^{-2}) et de 10,68 d'âge 1+. Les densités d'alevins et de tacons plus âgés étaient supérieures dans la rivière Big Salmon, par rapport aux autres rivières examinées, et supérieures à celles notées dans six autres rivières du fond de la baie de Fundy ayant fait l'objet d'une pêche électrique en 1996. La rivière Gaspereau, où l'on retrouve des saumons dibermarins non typiques du fond de la baie de Fundy et qui subit les effets d'un projet hydroélectrique présentait une ponte correspondant à 105 % des besoins, si on y inclus les poissons de pisciculture, mais de 27 % si l'on ne tient pas compte de ces poissons. Les auteurs font état d'un passage vers l'aval inefficace des saumoneaux dans les rivières Annapolis et Gaspereau et d'épisodes de faible survie en mer pour les poissons de tous les stocks du fond de la baie de Fundy comme raisons pouvant expliquer les faibles remontées notées en 1996 et depuis 1990. Ils traitent aussi des prévisions et de techniques d'atténuation et recommandent l'absence de toute pêche en 1997.

Introduction

This document reviews the status, in 1996, of inner Bay of Fundy Atlantic salmon (*Salmo salar*). Inner Bay of Fundy salmon stocks consist of twenty-eight rivers in Nova Scotia of Salmon Fishing Area (SFA) 22 and ten rivers of SFA 23 east of the Saint John River, New Brunswick. Inner Bay of Fundy rivers and their salmon share similarities of geography, biology and probably marine distribution. With few exceptions these rivers have Atlantic salmon stock characteristics more similar to inner Bay of Fundy rivers than outer Bay of Fundy rivers such as the Saint John River (Figure 1, Table 1).

Assessments were conducted in one form or another on the Big Salmon River, Petitcodiac River, Point Wolfe River and Alma River, of SFA 23, New Brunswick and the Stewiacke, Gaspereau and Annapolis rivers in SFA 22, Nova Scotia. The Gaspereau and Annapolis rivers have non-inner Bay of Fundy stock types although they are in SFA 22. Historic electrofishing sites in six other rivers: Maccan, Portapique, Economy, Great Village, Folly and North River (Truro), all inner Bay of Fundy type stocks, were electrofished in 1996.

The inner Bay of Fundy salmon stock has been in decline since 1989 and has historically shown periods of low abundance and recovery (Huntsman 1958). Salmon of inner Bay of Fundy rivers have a high proportion of the stock that recruit back to the rivers after only one winter at sea, have few salmon that migrate to the North Atlantic Ocean, have high survival between recruit and repeat spawning. Most recruit and repeat-spawning salmon enter rivers in the fall of the year (Amiro MS 1987, Amiro and Jefferson MS 1996). Important exceptions are the Annapolis and Gaspereau rivers in N.S. which migrate greater distance, enter rivers early and have a much higher incidence of two-sea-winter recruitment. The Big Salmon River, New Brunswick, has most of the characteristics of inner Bay of Fundy stocks but with some portion of the run with July to August river-entry. Big Salmon River has had higher incidences of two-sea-winter salmon possibly as a result of hatchery introductions.

Atlantic salmon assessments for the inner Bay of Fundy stocks in 1995 were reported by Amiro and Jefferson (MS 1996). In 1996, salmon were counted through the White Rock Dam Fishway on the Gaspereau River, Kings County, Nova Scotia.

In 1989 all salmon fisheries on rivers of the inner Bay of Fundy were closed until in-season assessments indicated conservation requirements on the Big Salmon River and/or Stewiacke River were met. Not since 1989, in the Big Salmon River, have in-season forecasts indicated that conservation requirements would be met. All rivers of SFA 22, with the exception of the Annapolis and Gaspereau rivers and rivers northeast of the Saint John River in SFA 23, have remained closed to all fishing since 1991.

Assessment Methodology

Conservation of Atlantic salmon stocks is assessed by comparing estimates of the escapement of all salmon (or egg deposition) escaping past fisheries to the number of salmon (or eggs) required to produce juvenile and adult salmon at a level expected to maximize production of the largest fish within the capabilities of the different rivers and stocks (Anon. MS 1986). This escapement past fisheries is known as the conservation requirement and, in addition to maximizing production, satisfies the World Conservation Strategy produced by the United Nations Environment Program in that the ecological process, genetic diversity and fullest sustainable advantage is maintained (Anon. MS 1991). Thus in addition to the egg deposition objective, proportions of multi-sea-age salmon are sometimes also set and, therefore, numbers of grilse (one-sea-winter) and salmon (multi-sea-winter) are stated in some conservation requirements. In the absence of river or stock specific data to estimate production parameters, a value of 2.4 eggs m^{-2}, determined to maximize production and yield in several Maritime salmon streams (Anon. MS 1991), is used to derive the conservation requirement.

Biological characteristics necessary to estimate required conservation requirements for the Stewiacke and Big Salmon rivers were developed from sampling 3,290 salmon at a fence in the

Big Salmon River, 1965-1973. These data are the most complete set of biological characteristics available for an inner Bay of Fundy salmon stock. Biological characteristics for the Stewiacke River were also derived from 238 salmon sampled in the angling fishery of 1983, and 38 salmon sampled by boat electrofishing in 1983, (Amiro and McNeill MS 1986) and indicated a similar age structure. The complex repeat spawning life history of inner Bay of Fundy stocks requires long time series to define and therefore the Big Salmon River age structure data was used to derive adult salmon requirements for conservation in the Stewiacke and other inner Bay of Fundy rivers.

The Gaspereau River is impacted by hydro-electric development and conservation requirements for the accessible portion of the river have been agreed upon by stakeholders, electrical power operators and by Fisheries Management of the Department of Fisheries and Oceans for the area below Lane's Mills on the mainstem of the original river channel (Amiro and Jefferson, MS 1996).

Salmon habitat area for most streams of the inner Bay of Fundy was obtained by remote sensing techniques (Amiro 1993) and only stream areas greater than 0.12% stream-grade (map measured) were used to estimate salmon production (Table 1).

Fecundity-length relationships were established for the Stewiacke (Amiro and McNeill MS 1986) and for the Big Salmon River (Eggs=$646.16e^{(0.0299 * \text{Fork length})}$, G. Farmer, pers. comm.)[1] An egg deposition rate of 2.4 eggs m^{-2} (Elson 1957, 1975, Anon. MS 1991) was used in conjunction with the biological characteristics to derive the required number of spawners.

Stewiacke River stock was assessed by four methods: 1) Counts of adult salmon were obtained and caudal fin punches applied at a salmon trapping facility located at the head of tidal influence in 1992 to 1994 and subsequent re-capture with electrofishing boat. 2) By electrofishing boat operated above the upstream migrating adult salmon trapping facility from 1988 to 1993, 1995 and 1996. 3) Counts of seaward migrating smolts were conducted at a counting fence located 2.57 km up the Little River, a tributary 7.57 km above the approximate head of tide in the Stewiacke River from 1990 to 1996. 4) Counts and population estimates of juvenile salmon were made by electrofishing at 27 to 44 mark-and-recapture sites throughout the Stewiacke River system, 1984 to 1996.

Big Salmon River salmon stock was assessed using stream-side counts of salmon conducted by the New Brunswick Department of Natural Resources and Energy personnel (T. Pettigrew, pers. comm.)[2], and by removal electrofishing in five sites in the Big Salmon River.

The Point Wolfe and Alma (Upper Salmon) rivers, wholly or partially within Fundy National Park, New Brunswick, are assessed by Parks Canada (D. Clay)[3].

Salmon were counted in a trap in the fishway at the Petitcodiac River Causeway by the New Brunswick Wildlife Federation under the direction of Mr. Gary Griffin. Salmon may also pass undetected upstream through a notch in the stop-log structure in the gates during most high tides.

Salmon were counted in a trap located in the White Rock Fishway, 2.97 km above the head-of-tide, on the Gaspereau River by the Kings County Wildlife Association. In the absence of a stock-specific length-fecundity curve for the Gaspereau River, the LaHave River length-fecundity curve (Eggs = $446.54 * e^{(0.0362 * \text{Fork length})}$, Cutting et al. MS 1987) was used. The LaHave length-fecundity curve was used because the stock characteristics of Gaspereau River salmon (one and two-sea-winter recruits with a low incidence of repeat spawning fish) are more similar to those of the LaHave River salmon than the Stewiacke River salmon stock.

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Description of the Fisheries

First Nations and Native Peoples

No salmon were harvested from Bay of Fundy rivers by members of the Native Council of Nova Scotia in 1996.

No harvests of salmon were reported from rivers east of the Saint John by First Nation people in SFA 23 or SFA 22 in 1996.

Commercial

No licensed commercial salmon fishery operated in SFA 22 or 23 in 1996 and no commercial salmon fishing licenses remain in the area.

Angling

The salmon angling season was again closed by variation order for most inner Bay of Fundy rivers in SFA 22 and 23 in 1996.

The angling season on the Gaspereau River, an outer Bay of Fundy type stock was open for hook and release from June 15 to July 15, 1996. Extension of the season was contingent upon an in-season review utilizing counts conducted at the fishway at the White Rock Powerhouse. The angling fishery in the Gaspereau River, continued for hook and release August 1, 1996, after 138 fish (salmon and grilse) were reported passing through the fishway. The season closed August 15, 1996.

Fishery data

Data for the Gaspereau River was derived from the voluntary license stub returns as of January 21, 1996. Estimates of released salmon were adjusted down by 13% to account for voluntary license-stub bias in reporting (S. O'Neil pers. comm.[4]). This was done because successful anglers are more likely to voluntarily return their report stub.

Assessment Results

Stewiacke

Conservation Objectives

Atlantic salmon conservation requirement for Stewiacke River was estimated at 1,061 salmon of all ages (Amiro MS 1990) and includes 772 recruit-grilse (first-time one-sea-winter spawner). Because of the complexity of the repeat spawning component, Marshall et al. MS (1992) rounded the small salmon requirement to 800 and the large salmon component to 300. Management is currently based on a conservation requirement of 1,100 salmon.

Research Data

Juvenile salmon counts

Densities ($m^2 * 100$) of age-0^+, age-1^+ and age-2^+ Atlantic salmon parr were determined in 35 sites at 17 locations in the Stewiacke River in 1996 (Figure 2 , Table 2). Densities were determined by mark-and-recapture methods at standard sites and procedures reported in Amiro et al. (MS 1989) with re-surveys of five sites where stream alteration had occurred. Twenty-six of the 35 sites have been sampled for at least ten of the twelve years of record. The frequency of

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samples by stream gradient category (GRCAT), a measure of the habitat suitability, is similar throughout the data series (Figure 3).

The 1996 mean age-0^+ parr (fry) density of 1.17 $\pm$ 2.70SD is the lowest of the twelve year record (Table 3, Figure 4) and confirmed the low catch per kilometre of the electrofishing boat in 1995 (Amiro and Jefferson MS 1996).

The mean density of age-1^+ parr was 5.28 $\pm$ 4.94SD in 1996. This density was similar to 6.49 $\pm$ 6.70SD measured in 1995, but substantially lower than 12.65 age-1^+ parr measured in 1993. Analysis of covariance (ANCOVA) using Gradient and Gradient^2 terms (Amiro 1993) as covariates and Year as a categorical variable was significant ($p < 0.000001$) and indicated a significant Year effect. Post-hypothesis comparison of adjusted (for Gradient and Gradient^2) mean density of 1984-1993 of age-1^+ densities with the 1994-1996 adjusted mean density was significant ($p<0.000001$) and indicated significantly lower age-1^+ parr densities in the later period (Figure 5).

The mean density of age-2^+ parr increased to 1.93$\pm$ 1.68SD in 1996 from 1.67 $\pm$ 1.26 SD in 1995. These values are among the lower of the 1984 to 1996 record.

Smolt counts

The smolt counting fence in the Little River, tributary to the main Stewiacke River (Figure 2) was installed May 9, 1996, and was operated until July 2, 1996 (Table 4). The fence operated continuously from May 13, 1996. The count of 467 smolt was considered to be a complete count of the spring migration of smolts out of the Little River in 1996.

The Little River tributary has 147,300 m^2 of accessible fluvial habitat. The Little River fence trap is located 2.573 km above the confluence with the Stewiacke River. The confluence of Little River with the Stewiacke is 7.570 km above the 10.0 m elevation point (approximate head of tide). Little River is 4.19% of the accessible fluvial water surface area of the Stewiacke River and 8.7% of the area with map measured surface gradient >0.12% (no stillwaters or lakes are included). The area above the trap is 112,097 m^2 and smolt production has ranged from a low of 0.36 10^{-2} m^2 in 1995 to a high of 3.66 10^{-2} m^2 in 1994. Counts of smolt migrating from the Little River tributary to Stewiacke River, 1990 to 1996, and mean smolt density ($m^2 * 100$) declined to very low levels in both 1995 and 1996 (Table 5). Mean parr densities at two electrofishing sites (Location 18) above the trap from 1989 to 1995, and at 4 sites above the trap in 1996, were lowest in 1996.

Adult salmon counts

The main Stewiacke River from Upper Stewiacke to Stewiacke River Park (41.09 km) was electrofished by boat on November 7 and 19, 1996 (Table 6). Only four salmon were captured or observed on each cruise. Two were hatchery origin recruit grilse identified by their clipped adipose fin.

The 0.10 catch km^{-1} by the electrofishing boat, estimated on either date in 1996, was among the lower observed electrofishing boat catch rates of 1988 to 1995 but was a slight improvement over the two 1995 values. The 1991 catch rate (1.02 fish km^{-1}) was the last associated with age-1^+ parr densities not significantly different from habitat adjusted mean parr densities. Although escapement was undetermined in 1991, the 1993 parr densities (resultant of 1991 escapement) were not significantly different than the 1984 to 1992 habitat adjusted mean. Age-1^+ parr densities since 1993 have been significantly lower than the 1984 to 1993 mean. The 1992 - 1996 catch km^{-1} of 0.12$\pm$0.12SD is less than the 1988 - 1991 mean catch rate of 0.48$\pm$0.32SD. These lower catch rates are therefore indicative of less than required escapement in the Stewiacke River since 1991. The catch rate data also show the increased escapement in 1992 coincident with the increased age-1^+ parr density in 1994. The 1994 age-1^+ parr is less than that attainable from a conservation required escapement of 1,100 salmon. By inference, escapement in 1996 was less than 25% of the earlier period when escapements were generally considered insufficient for harvest.

The low escapement of salmon postulated in the 1995 assessment (Amiro and Jefferson MS 1996), when breaches in the fence occurred and follow-up electrofishing of adult salmon by boat was conducted, was supported by the low age-0^+ salmon parr densities observed in 1996 (Table 3). The 1996 average age-0^+ parr density is the second lowest observed since 1984. The 1996 age-0^+ parr density was not as low as 1993 when 230 salmon were estimated to have escaped to spawn in the Stewiacke River.

Salmon stocking program

While utilizing hatchery smolts for research purposes did not result in a net loss of production, enhancement of the stock is not feasible while return rates are low (Amiro and Jefferson MS 1996). A total of 7,000 hatchery spawned and reared Stewiacke River smolts were released in 1996 (Table 7). These smolts may contribute about 4,900 migrating smolts in 1996 and at the last observed return rate of 0.19 per 100 smolts migrating, about 10 hatchery grilse can be expected in 1997.

Aquaculture escapees

No aquaculture salmon were observed in the eight fish captured during two cruises with the electrofishing boat on November 7 and 19, 1996.

1997 Forecast

Counts of smolts at Little River indicated a very low migration of smolt in 1996. Densities of age-1^+ and age-2^+ parr throughout the Stewiacke River, which will contribute to the 1996 smolt migration, were about 30% of densities measured in 1984 to 1993, and indicate a low production of smolt in 1996 and 1997. If smolt production is 30% of the average and wild smolt return is in the range of 0.2 to 0.4% (Amiro and Jefferson MS 1996), then only a major increase in marine survival, in the order of a thirty fold increase, would generate enough returns to meet conservation requirements in 1997. There is neither an indication of a major increase in marine survival in 1997, nor is there historic evidence that an annual turn around in marine survival of inner Bay of Fundy salmon stocks has ever been of this magnitude.

Big Salmon River

Conservation Objectives

The Big Salmon River salmon stock is similar to that of the Stewiacke River (Amiro and McNeill MS 1986, and Amiro MS 1987). The conservation requirement totals 700 salmon comprised of 280 one-sea-winter and 420 multi-sea-winter fish of which the majority are repeat-spawning grilse (Marshall et al. MS 1992).

Research Data

Adult salmon counts

Counts of adult salmon made from shore were hindered by high water in 1996. Only two pools, the Roddy Pool and the Catt Pool, were observed. These observations together with two partial river counts of salmon suggested that salmon were about as plentiful as in 1995 when 100 - 150 salmon were estimated to have spawned. (T. Pettigrew pers. comm.[2]) This escapement is at best 20% of the requirement.

Unlike 1995, no adult salmon from the Big Salmon River smolts grown in sea cages were released into the Big Salmon or Petiticodiac rivers in 1996.

Juvenile salmon counts

Electrofishing was conducted at five removal electrofishing sites (Site numbers 2, 7, 13, and 15, Figure 6) in 1996 (Table 8).

Mean density of age-0^+ parr in these five sites increased from 21.8 $\pm$18.36 age-0^+ (m^{-2} * 100) in 1995 to 49.22 $\pm$38.63 in 1996 (Figure 7). This increase is the result of increased densities at Crow Brook (Site 11) and Anderson Brook (Site 15). These age-0^+ parr densities were likely influenced by the release of 152 female salmon weighing an estimated average 4.99 kg and 75 male salmon, of similar size, into two pools of the Big Salmon River on October 3, 4 and 5, 1995.

Mean density of age-1^+ parr of 10.68 $\pm$5.485 is similar to densities determined in 1968, 1970 to 1973, and 1989 to 1994 and much lower than that determined in 1982. The age-1^+ parr densities increased from 6.44 estimated in 1995. A total of 152, female, cage-reared grilse of Big Salmon River stock were released into the King and Bridge Pools below Crow Brook on October 4, 1994.

The mean density of age-2^+ parr of 0.52 $\pm$0.55 is less than the 1995 value of 2.04 and shows a similar temporal pattern to that of age -1^+ parr.

1997 Forecast

Age-1^+ parr densities in 1996 are similar to densities observed in most years with the exception of 1968 and 1982. The 1996 parr densities were the first pre-smolts of enhancement through aquaculture grow-out of Big Salmon River hatchery spawned smolts. Adult salmon returns resultant of age-1^+ parr densities at these levels have been inadequate to meet conservation at current marine survival values. Conservation requirement for the Big Salmon River is 700 fish of all ages. Recent returns have been less than 200 fish. If smolt production in 1997 is at recent average levels (suggested by the electrofishing data) then only a five fold increase in marine survival would yield returns adequate to meet spawning requirements.

Petitcodiac River

Conservation Objectives

A conservation requirement for the Petitcodiac River was estimated (Semple unpublished MS 1984) at 1,688 grilse and 101 salmon for 2,815,000 m^2 of habitat estimated by the Department of Natural Resources and Energy, New Brunswick, (T. Pettigrew, pers. comm.[2]) and a 2.4 eggs m^{-2} egg deposition rate. Stock composition was based on 1,211 salmon and grilse sampled in the fishway trap during 1983.

Research Data

Juvenile salmon counts

Eight sites in the Petitcodiac River system were spot checked electrofished for juvenile salmon on September 9-12, 1996. No parr of any age were found in two sites on the mainstem of the Petitcodiac where two age-1^+ hatchery parr were found in 1995. Three of the four sites fished in the Little River (Coverdale) in 1966 contained age-0^+ parr. On October 10, 1995, the Coverdale River received 24 female and 14 male salmon from the Big Salmon River cage-reared adult salmon project.

Adult salmon counts

No salmon were reported at the trap in the fishway in the Petitcodiac River causeway in 1996. No adult salmon were released into the Petitcodiac River or tributaries in 1996.

Gaspereau River

Conservation requirements

There are 115,850 m^2 of water surface area below the White Rock Dam of which 71,450 m^2 are tidal (10 m contour). The remaining 216,740 m^2 above the fishway and below Lanes Mills, not including Trout River, would require 83 salmon and 55 grilse using the 1995 age structure. A minimum target to seed the area below Lanes Mills is 138 fish.

Fishery data

The preliminary estimate of angler effort for the Gaspereau River was 131 rod-days. Nine anglers reporting by January 23, 1996, released 21 grilse and 8 salmon. The estimated released catch, accounting for un-reported stub-returns, was 28 grilse and 11 salmon. The catch-per-unit effort was 0.305 and the portion salmon in the catch was 27.6%.

Research Data

Adult salmon counts

Restoration and enhancement of salmon was re-initiated in 1992. Broodstock were collected by angler donation and seining in the White Rock headpond in 1992 and 1993 and by seining alone in 1994. No salmon were released into the river in 1994 because of a draw-down of the White Rock head pond. The adult age structure obtained from these data indicate 45.8% age 2.2 (pre-smolt winters . post-smolt winters) salmon in 1992, 63.6% age 2.2 salmon in 1993 and 60.0% age 2.2 salmon in 1994 (Amiro and Jefferson MS 1996).

The second year of hatchery returns from the 1992 collection were counted at a trap in the fishway in 1996. The first salmon were counted in the White Rock Dam Fishway Trap on May 27, 1996, and the last was counted on October 29, 1996. The last two fish counted through the fishway (October 12 and 29) appeared to the operators to be post-spawners. The median run time was July 3, when 50% of the run had passed through the trap. The fishway trap was operated a full two months longer in 1996 and indicated that there was an insignificant number (3) of late run salmon ascending the river in 1996. The 1996 fishway counts and percentages of the salmon run were:

	Count			%	%
	Salmon	Grilse	Total	Salmon	Grilse
Total	62	116	178	34.8	65.2
Hatchery	29	75	104	27.9	72.1
Wild	33	41	74	44.6	55.4
%Hatchery	46.8	64.7	58.4		
%Wild	53.2	35.3	41.6		

1996 Assessment

Totals of 62 salmon and 116 grilse were counted which included 29 clipped hatchery salmon and 75 clipped hatchery grilse. Forty-one fish retained for brood stock provided a sample of the age structure, lengths and gender of the 1996 return (Table 9). Escapement above White Rock Dam in 1996 was 49 salmon and 92 grilse. Using the biological characteristics established in 1995, this number of fish would contribute about 105% of the required egg deposition below Lanes Mills above White Rock and not including Trout River.

Hatchery Programs

A total of 20,705 age-1^+ parr and 8,972 one-year and 8,000 two-year smolts were stocked in 1995. Since 1992 all hatchery smolts have been stocked immediately below the White Rock fishway and all parr stocked above the fishway in the main Gaspereau River below the confluence of Trout River. Using a 0.7 rate to smoltification for one-year smolt and 0.9 for two-year smolts these fish contributed an estimated 13,480 smolt migrants in 1995 (Table 10). The return from these smolts numbered 41 grilse in 1996 (a 0.3% return rate). Although this is an improvement from the 1995 return rate of 0.14%, it is much lower than the 1.39% estimated for above Morgan Falls on the LaHave River in 1996. The return of 29 hatchery salmon to White Rock Fishway gave a smolt to two-sea-winter salmon survival rate of 0.14% for the 1994 smolt class. This rate is also lower than the 0.22% observed at Morgan Falls in 1996 for the 1994 smolt class.

1997 Forecast

In 1996, 18,392 age-1^+ smolts, 4,600 age-2^+ smolts and some residual hatchery smolts, stocked as parr in 1995, contributed to an estimate of 17,014 hatchery origin smolts of Gaspereau River stock. Assuming all hatchery salmon that entered the river returned to the fishway, the 1995 return rate to White Rock Dam was 0.3%. Using the 1995 return rate and the 1996 estimate of the hatchery smolt migration, 51 hatchery grilse may be expected in 1997. Using the 1996 two-sea-winter return rate of 0.14% for hatchery fish and the 13,480 smolts migrating in 1995, returns to the fishway may number 19 hatchery salmon in 1997.

There are not enough years of counts at White Rock fishway to forecast returns of wild salmon to Gaspereau River. Also reservoir draw-downs and maintenance flows within various reaches of the river have been altered within the years of parr production contributing to the 1997 returns, further impacting on the uncertainty in a forecast. Returns of wild fish in 1996 would have contributed to only 27% of the required egg deposition. These observations combined with the low return of hatchery smolt, contribute to a prognosis for low stock abundance in 1997.

Alma River (Upper Salmon River)

Conservation Objectives

Atlantic salmon habitat distribution and useage is under review by Parks Canada. A new conservation requirement is expected as a result of this study.

Research Data

Adult salmon counts

Few salmon have been seen in the Alma River since last reported in 1991 by Parks Canada staff (Amiro MS 1992). Only 10 salmon were observed on November 10, 1992; 15 in 1994 and due to high water in 1995 no estimate was possible. The observation of 16 salmon, by a "knowledgeable salmon fisher" , in one pool on the Upper Salmon River in August, 1996 was not able to be verified in a stream-side survey by Parks Canada employees at the time, nor later in October 1996 when a zero count was attained.

Juvenile salmon counts

Electrofishing of established sites was conducted in two sites in the Alma River in 1996. Densities were about 70% of 1995 values and 15% of densities measured in the late 1980s.(D. Clay pers. comm.[3])

Point Wolfe River

Conservation Objectives

Atlantic salmon habitat distribution and useage is under review by Parks Canada. A new conservation requirement is expected as a result of this study.

Research Data

Adult salmon counts

Parks Canada staff have monitored the salmon return to the Point Wolfe River using snorkel and shore counts from 1985 to 1990. Between 25 and 196 grilse and 4 to 39 salmon were observed in the river during these counts. Few salmon have been seen in the river since 1990. Counts of 7 fish were made in 1992 and 8 fish were counted in 1993. A count was not conducted in 1995 due to high water conditions. A stream-side survey for salmon by fifteen Parks Canada employees on October 1996, did not observe any salmon in the river.

Juvenile salmon counts

Four to five sites electrofished in the Point Wolfe River in 1996 indicated that populations continue to decline and are 30% of 1995 densities and about 20-30% of densities measured in 1993.(D. Clay pers. comm.)

Annapolis River

Introduction

The Annapolis River drains the industrial and agricultural area of southwestern Nova Scotia, known as the Annapolis Valley. The drainage includes two ridges known as the North Mountain and the South Mountain. Soils in the valley are sedimentary and contain extensive clay-sand composites. Water quality in the river is impacted by linear development from agriculture. The North Mountain and central Annapolis Valley portions of the drainage are not impacted by acidification. Portions of the river draining the lower South Mountain are impacted by acidification but because of historic and more recent hydroelectric barriers to migration these areas do not produce Atlantic salmon.

Three electrical power systems impact discharges and accessibility of diadromous fish in the system: 1) tidal barrage dam in the estuary; 2) hydroelectric storage and power generation on the Nictaux River, a salmon producing tributary in the vacinity of the town of Middelton; and 3) hydroelectric storage and power generation on Allains River at LeQuille, below the tidal barrage dam at Annapolis. There are numerous other tidal barrage gates and impoundments throughout the system, some of which have fish passage.

Historically the Annapolis River was known for an early run of large salmon. The Nictaux River was a noted salmon holding area and the site of a fish hatchery which no longer exists. Runs of salmon have dwindled to low levels and broodstock collection attempts have often come up short of minimum collection goals.

Conservation Objectives

The Annapolis River has 20,886 x 10^2 m^2 of rearing area with stream gradient >0.12% accessible to salmon (Table 1). At a conservation requirement of 2.4 eggs m^{-2} and assuming size, fecundity and proportion of salmon in the run similar to the LaHave River, the Annapolis has a conservation requirement of 2,769 fish.

Research Data

The only activity by DFO Science personnel on the Annapolis River in 1996 was broodstock collections. Two collection attempts were made, October 1, and October 24, 1996. The Nictaux River, at Martin Mills Dam pool, was fished using a small mesh drift net which tangles larger fish without significant injury. In the first collection, a total of nine salmon (seven hatchery and two wild) and twelve grilse were caught. All salmon and five grilse sized fish were retained for broodstock. The second collection began at Martin Mills Dam and continued downstream for two kilometers. A total of three salmon were retained for broodstock and fifteen male grilse were released. All released grilse were visually examined and classified as wild fish. No scale samples were obtained from the released fish. Two of the retained salmon were female, one of which did not mature and was not scale sampled before spawning. Broodstock were scale sampled and the ages interpreted. One of the broodstock was judged to be an escaped aquaculture fish.

Assessment

No direct assessment of the status of the salmon stock in the Annapolis River is available. However, data collected from the angling stub-returns prior to 1995 indicate little probability that escapements have been greater than the conservation requirement. The 1994 angling data (the last open angling season on the Annapolis River) indicate that three anglers fished an estimated fifteen days and caught five fish. Two conclusions can be drawn from this data: 1) there was not an abundance of salmon in the Annapolis River in 1994 that attracted anglers to fish the river; 2) at the 5^{th} percentile catch rate of 0.206 observed in the LaHave River in 1995, (Amiro and Jefferson MS 1996), the total population would be 24 salmon. This escapement would have been 0.9% of the required escapement. Assuming almost any value for error of the catch number, there is almost no probability that escapement in 1994 was greater than the conservation requirement. Angling has remained closed since 1994. Based on an average five-year recruitment pattern for two-sea-winter salmon stocks of southern Nova Scotia, only several years of increased frequencies of adult salmon observations and catch rates (during broodstock collections) would warrant re-assessment of the harvest allocation of this stock.

Electrofishing in other rivers of SFA 22

Six other rivers of SFA 22: Maccan, Portapique, Economy, Great Village, Folly and North River were electrofished in 1996 (Figure 1). Sites were re-visits of historical electrofishing sites where possible. When compared to historical data the 1996 data indicate wide spread low abundance of age-0^+ parr and a general decline in abundance of age-1^+ parr (Table 12).

Prognosis - Inner Bay of Fundy Salmon Stocks

The data for inner Bay of Fundy salmon stocks indicates acute low population abundance and systemic low survival of smolt to adult recruits. Smolt-to-recruit survival was low both for multiple-repeat-spawning stocks (Stewiacke and Big Salmon River) and for two-sea-winter stocks (Gaspereau and Annapolis). The reasons for low post-smolt survival of both the Annapolis and Gaspereau river smolts may be ineffective downstream passage. Annapolis River smolts may be affected by the tidal barrage causeway and Gaspereau River by downstream passage at White Rock. Low returns of repeat-spawning stocks of inner Bay of Fundy were independent of smolt numbers (see hatchery-return rates for Stewiacke River and Little River smolt counts and parr densities) directly implicating marine survival. Low marine survival is systemic throughout inner bay stocks (see the individual assessments and Table 12 in this document) and the recent episode has been over a long enough time period to significantly reduce production of smolts. There is little resiliency left in recruitment for these stocks and no cause for low marine survival has been detected.

Regardless of the detection of a cause for the decline in stocks, two courses of action to conserve the stocks may be taken: 1) "Wait it out", based on the observation that this is a recurrent biological fact or; 2) prescribe a treatment to guard against the loss (extinction) of a significant biological stock. The second course of action may be based on conservation and economics which involves minimizing the risks of extinction and setting-up for an accelerated recovery for the time when marine survival increases.

Concerning the first course of action, we have at least three observations in the history of these stocks when it was widely felt that the fish were gone.

P. F. Elson (1957) wrote,

"In 1874 the commercial catch from Chignecto region amounted to 150,000 pounds (Huntsman, 1931) or about 2% of the catch in the Maritimes region south of Cape Gaspe. Within a few years the Chignecto catch dwindled to less than one-tenth of this proportion. Seven years later Venning (1881) advised that salmon on the Petitcodiac system were so few that conservation measures were scarcely warranted. The next 60 years saw sporadic attempts at conservation, but the fishery never again approached its earlier magnitude. However, local inhabitants continued to get a few salmon by one means or another and in 1943 some native young salmon were found in all suitable reaches not barred by dams."

A.G. Huntsman (1958) wrote about the Shubenacadie River (Stewiacke River) salmon,

> "Shubenacadie salmon vary greatly in abundance. The landings for Colchester and Hants Counties, which include the salmon taken on north and south sides respectively of the estuary, the Bay and most of the Basin, show these highs and lows in hundreds of pounds taken in various years: 1903-1,428; 1914-62;1919-1100; 1923-54; and 1928-898. In 1951, there was a record low of only 3 hundred weight. It was the virtual disappearance of the fishery that drew our attention to it."

Commercial catches of salmon in Albert and Westmorland Counties peaked at 65,900 lb. in 1915 and declined to 1,000 lb. by 1926 (Dunfield pers. comm. and Dunfield 1986).

In all cases overfishing was the central cause attributed to the downturn in stocks. However, Huntsman (1958) attempted to attribute the loss of salmon to low water levels during spawning. In all cases salmon stocks rebounded and as recently as 1979, when over 3,200 grilse were angled in inner Bay of Fundy Rivers. In the recent era of low abundance of adult salmon in the inner Bay of Fundy rivers (1986 to the present, with the exception of 1989), juvenile populations in the Stewiacke River have been monitored and have not declined at the same rate as the adult population.

Until 1994, when the resilience in the population brought about through strong repeat-spawning components was gone, parr populations in the Stewiacke River remained relatively stable in numbers, although different in age distribution and size. Smolt migrations from the Little River remained moderate to high until 1994, and indicated that parr were migrating as viable smolts. Low survival was also demonstrated in the returns of large numbers of stocked hatchery smolts. These data indicate that the cause of low recruitment is firstly attributable to low marine survival before stock and recruitment effects and that historically, recovery has re-occurred.

The second course of action would involve some form of gene banking and/or protection. Techniques for this action range from cryo-preservation of sperm, artificial spawning and grow-out to smolts or adults, to capture of wild juvenile salmon and grow out to smolts or mature adults for release back to the river of origin. These techniques are used in various conservation, mitigation and enhancement activities throughout the range of Atlantic salmon. Each technique has different genetic, environmental and economic risks as well as benefits. A review of these techniques for inner Bay of Fundy salmon stocks would have to be conducted before any of these options can be evaluated as viable mitigation options. Grow-out to mature adults of hatchery smolts obtained by artificial breeding is currently practiced in a tri-party agreement for the Big Salmon River. Release of artificially spawned hatchery smolts has been shown to be ineffective for the Stewiacke River and discontinued as a mitigation technique (Amiro and Jefferson MS1996).

Modeling the economic component in a review of these techniques is relatively straight forward once a monetary value for a mature fish is accepted.

Ecological Considerations

Hypotheses that place the downturn in inner Bay of Fundy stocks on causes impacting other than marine survival do not withstand information provided by electrofishing, smolt production, repeat-spawner survival or hatchery stocking. Simple correlation of returns with the increase in aquaculture without a causal relationship is inconclusive and unwarranted. Hypotheses that link disease, predators or competition with the aquaculture industry require close scrutiny. Without information on marine foraging behavior of inner Bay of Fundy salmon, hypothesizing interactions is speculative. Information on distribution of, and foraging by, these stocks is required before further understanding of their marine survival is possible.

Observations of periodic downturns in salmon populations of inner Bay of Fundy rivers, together with the repeat-spawning age structure of inner Bay of Fundy salmon populations, suggest that episodes of low marine survival can result in temporary but not catastrophic low stock abundance. Populations persist because of the repeat-spawning contribution and the generally high productivity of these rivers. These same features contribute to periodic large population sizes during episodes of high marine survival.

Management Actions

The data and analysis indicate that low abundance of inner Bay of Fundy stocks is wide spread and acutely low relative to historical data. Based on the parr densities and the smolt counts observed there is little possibility for recovery, i.e., fish surplus to conservation requirements, in the next four years. Management strategies for recovery of the stocks, if returns met conservation requirement in the year 2001 (spawning for which has not yet occurred), would have to be assessed through simulation analysis before statements concerning the risks to conservation, obligation to Native Peoples harvests and economics associated with a proposed fishing plan and policy could be evaluated.

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Table 1. Accessible rearing area, target Atlantic salmon egg depositions and spawners for rivers in Nova Scotia and southwest New Brunswick.

SFA	No. on Map	River name	Rearing units 100m2	Target eggs (240/unit)	Spawner requirements(No.) 1SW	MSW	Total	Prop 2SW	2SW	References
SFA 22 (Inner-Fundy NS)										
	1	Annapolis	20,886	5,012,640	2,232	537	2,769	0.70	376	7,2-LaHave
	2	Apple	2,111	506,640	125	47	171	0.03	1	7,2-Stewiacke
	3	Bass (Colchester Co.)	696	167,040	41	15	56	0.03	0	7,2-Stewiacke
	4	Chiganois	3,369	808,560	199	74	273	0.03	2	7,2-Stewiacke
	5	Cornwallis	1,706	409,440	182	44	226	0.70	31	7,2-LaHave
	6	Debert	3,499	839,760	206	77	284	0.03	2	7,2-Stewiacke
	7	Diligent	335	80,400	20	7	27	0.03	0	7,2-Stewiacke
	8	Economy	2,386	572,640	141	53	193	0.03	2	7,2-Stewiacke
	9	Folly	2,896	695,040	171	64	235	0.03	2	7,2-Stewiacke
	10	Gaspereau (Kings Co.)	3,856	925,440	412	99	511	0.70	69	7,2-LaHave
	11	Great Village	2,587	620,880	153	57	210	0.03	2	7,2-Stewiacke
	12	Harrington	629	150,960	37	14	51	0.03	0	7,2-Stewiacke
	13	Kennetcook	3,976	954,240	235	88	322	0.03	3	7,2-Stewiacke
	14	Maccan	8,228	1,974,720	485	182	667	0.03	5	7,2-Stewiacke
	15	North (Colchester Co.)	4,485	1,076,400	265	99	364	0.03	3	7,2-Stewiacke
	16	Parrsboro	705	169,200	42	16	57	0.03	0	7,2-Stewiacke
	17	Portapique	3,309	794,160	195	73	268	0.03	2	7,2-Stewiacke
	18	River Hebert	2,282	547,680	135	50	185	0.03	2	7,2-Stewiacke
	19	Salmon (Colchester Co.)	13,468	3,232,320	795	297	1,092	0.03	9	7,2-Stewiacke
	20	Shubenacadie	10,340	2,481,600	610	228	838	0.03	7	7,2-Stewiacke
	21	St. Croix (Hants Co.)	4,283	1,027,920	253	95	347	0.03	3	7,2-Stewiacke
	22	Stewiacke	13,086	3,140,640	772	289	1,061	0.03	9	7,2-Stewiacke,15,16
	23	Tantramar	-							
		Total SFA 22	**88,232**	**21,175,680**	**5,471**	**1,969**	**7,440**	**0.03**	**531**	prop-Stewiack, LaHave
SFA 23 (Inner-Fundy NB)										
	24	Demoiselle Crk								
	25	Crooked Crk								
	26	Shepody								
	27	West (Albert Co.								
	28	Alma								
	29	Point Wolfe								
	30	Petitcodiac	28,150	6,756,000	1,688	101	1,789			17
	31	Big Salmon	9,093	2,182,320	280	420	700			7,2-Big Salmon,8,18
	32	Irish								
	33	Mosher (Saint John Co.)								
Total SFA 23 of Inner Bay of Fundy			**37,243**	**8,938,320**	**1,968**	**521**	**2,489**	**0.13**	**68**	prop-Big Salmon
Inner Bay of Fundy total			**125,475**	**30,114,000**	**7,439**	**2,490**	**9,929**		**598**	

2-Spawners based on.....; 7-Rearing units > 0.12% ortho-gradient measured on air photos (Amiro 1993); 8-Marshall et al. (MS 1992);15-Amiro and Jefferson (MS 1996); 17- Semple (MS 1984); 18- Amiro and McNeill (MS 1986).

Table 2. Site key for Stewiacke River electrofishing sites.

Number	River name	Contour interval (m)
1	Upper Stewiacke River Shepherds Junction	120-125
2	Upper Stewiacke River Roadside	70-75
3	Upper Cox Brook	150-165
4	Lower Cox Brook	50-55
5	Pembroke River above falls	95-110
6	Pembrooke River at Glenbervie (below falls)	45-50
7	Upper Pembroke River	175-185
8	Newton Brook above Bridge	90-100
9	Little Branch Cox Brook	145-160
10	Mahailas Brook	55-95
11	South Branch Stewiacke River	75-90
12	Little River (upper site)	95-105
13	Little Branch Stewiacke	145-160
14	Newton Brook above bridge	35-40
15	Newton Brook above Dean	120-125
16	Goshen Brook	40-45
17	Fulton Brook	75-90
18	Little River at bridge (lower site)	80-85
19	Chapman Brook	105-115
20	Rutherford Brook Kennedy's Farm	20-25
21	Fall Brook	130-140
22	Scrubgrass Brook	60-65
23	Stewiacke River Landsdowne Road	100-105
24	Stewiacke at De Grootes	10-15
25	Stewiacke at Corbetts Bridge	10-15
26	Sucker Brook	65-75
27	Little River at Boys Camp	10-15
28	East Brook	15-20
29	Putnum Brook	20-25
30	Rutherford Brook Sheep Hill	40-45
31	South Branch Stewiacke	20-25
32	Blackie Brook	25-30
33	Big Branch Stewiacke	95-100
34	Sutherland Brook	110-115
35	Otter Brook	20-25
36	Otter Brook	25-30
37	Little River Bud Stevens Interval	15-20
38	Little River Below Rail track in Brentwood	20-25

Table 3. Location, date, area, number of age-0+,1+ and 2+ Atlantic salmon captured, estimated density 10^{-2} m^2 by age classes and coefficient of variation of the estimate derived by mark-recapture electrofishing at 35 sites in the Stewiacke River, 1996.

Location .site	Date dd/mm	Area m^2	Age-0+ marks count	Age-1+ M	Age-1+ C	Age-1+ R	Age-1+ Mort[a]	Age-2+ M	Age-2+ C	Age-2+ R	Age-2+ Mort[a]	Parr 10^{-2} m^2 age-1+	Parr age-2+	Parr total	Parr age-0+	Coefficient of variation age-1+	Coefficient of variation age-2+
1.1	12/07	304	0	11	17	10		7	3	2		6.5	3.5	10.0	0.0	18.0	25.0
1.2	12/07	234	0	17	12	8		7	10	6		11.1	5.4	16.5	0.0	17.5	21.3
1.1+2	12/07	538	0	28	29	18		14	13	8		8.5	4.3	12.8	0.0	13.5	18.9
4.10	06/08	482	15	21	21	9		4	2	0		10.0	3.1	13.2	7.2	22.3	57.7
4.11	06/08	472	27	16	9	6		1	4	1		5.1	1.1	6.2	8.7	19.4	44.7
4.12	06/08	907	12	32	32	13		9	4	3		8.6	1.4	10.0	3.2	19.6	20.0
4.10+11+12	06/08	1,861	54	69	62	28		14	10	4		8.2	1.8	9.9	6.4	13.4	30.2
8.1	23/07	984	0	52	57	30	1	16	19	9		10.2	3.5	13.6	0.0	11.9	21.3
8.2	23/07	761	0	42	47	23	1	25	17	9		11.4	6.1	17.6	0.0	14.0	20.1
15.1	19/07	567	0	2	5	1		4	1	1		1.6	0.9	2.5	0.0	47.1	0.0
15.2	19/07	388	0	9	7	4		8	8	5		4.1	3.5	7.6	0.0	25.0	21.8
15.3	19/07	379	0	3	2	2		2	4	1		1.1	2.0	3.0	0.0	0.0	44.7
15.1+2+3	19/07	1,334	0	14	14	7		14	13	7		2.1	2.0	4.1	0.0	22.8	21.8
16.1	24/07	283	0	26	21	5		6	6	4		35.0	3.5	38.4	0.0	32.2	21.8
18.1	15/07	380	0	0	0	0		5	3	3		0.3	1.6	1.8	0.0	0.0	0.0
18.2	15/07	368	0	0	0	0		4	2	1		0.3	2.0	2.3	0.0	0.0	33.3
18.1+2	15/07	748	0	0	0	0		9	5	4		0.1	1.6	1.7	0.0	0.0	16.7
19.1	11/07	273	0	3	4	2		0	1	0		2.4	0.7	3.2	0.0	31.6	50.0
19.2	11/07	210	0	2	0	0		1	1	1		1.4	1.0	2.4	0.0	0.0	0.0
19.1+2	11/07	483	0	5	4	2		1	2	1		2.1	0.6	2.7	0.0	31.6	33.3
27.10	08/07	1,302	0	2	0	0		0	0	0		0.2	0.1	0.3	0.0	0.0	0.0
27.4	08/07	1,251	0	27	27	13		4	1	1		4.5	0.4	4.9	0.0	18.3	0.0
28.1	24/07	408	0	1	0	0		0	0	0		0.5	0.2	0.7	0.0	0.0	0.0
28.8	24/07	246	0	0	0	0		0	0	0		0.4	0.4	0.8	0.0	0.0	0.0
28.1+8	24/07	654	0	1	0	0		0	0	0		0.3	0.2	0.5	0.0	0.0	0.0
29.1	08/07	450	0	19	20	12	1	13	9	6		7.4	4.4	11.8	0.0	16.0	19.4
29.2	08/07	447	0	15	9	5	1	11	9	5		6.2	4.5	10.7	0.0	23.0	23.9
29.4	08/07	317	0	10	8	5		0	3	0		5.2	1.3	6.5	0.0	21.8	61.2
29.1+2+4	08/07	1,214	0	44	37	22	2	24	21	11		6.3	3.8	10.1	0.0	12.5	18.7
30.1	09/08	904	21	33	30	9		4	4	3		11.7	0.7	12.4	7.4	24.8	20.0
30.2	09/08	1,009	21	62	53	26		10	11	5		12.5	2.2	14.7	4.2	13.4	26.7
30.3	09/08	562	27	70	63	33		10	6	3		23.8	3.4	27.2	9.2	11.6	29.3
30.1+2+3	09/08	2,475	69	165	146	68		24	21	11		14.3	1.9	16.1	6.0	8.7	18.7
31.1	16/08	985	0	4	2	2		0	0	0		0.5	0.1	0.6	0.0	0.0	0.0
31.2	16/08	858	0	9	11	5		0	0	0		2.3	0.1	2.4	0.0	26.7	0.0
32.2	17/07	453	0	9	9	2		7	4	2		7.4	2.9	10.3	0.0	41.8	31.6
33.1	12/07	791	0	28	17	11		1	2	1		5.5	0.4	5.9	0.0	16.0	33.3
33.2	12/07	1,112	1	35	17	11		4	4	2		4.9	0.7	5.6	0.1	16.0	31.6
34.4	05/07	643	0	15	11	8		2	3	1		3.3	0.9	4.3	0.0	15.8	40.8
34.5	05/07	565	0	17	15	9		10	3	1		5.1	3.9	9.0	0.0	18.5	40.8
34.6	05/07	695	0	14	7	4		9	3	3		3.5	1.4	4.9	0.0	25.0	0.0
34.4+5+6	05/07	1,903	0	46	33	21		21	9	5		3.8	1.9	5.7	0.0	12.4	23.9
37	12/08	1086	0	6	5	2		0	0	0		1.3	0.1	1.4	0.0	35.4	0.0
38	12/08	1561	6	4	6	3		0	0	0		0.6	0.1	0.6	0.8	29.3	0.0

a Count of fish-at-age during the mark run (M)
Total count of fish-at-age during the capture run (C)
Count of recaptured (marked) fish-at-age during the capture run (R)
Number of mortalities during mark run (Mort)

Table 4. Days of operation, time of active fishing, water temperature, water elevation on trap mounted staff gauge, weather, number of Atlantic salmon smolts counted, number of smolts sampled and operators comments from the Little River smolt trap operation, 1996.

Date dy/mo/yr	Time	H2O Temp o C	Staff Guage	Weather	No. of Smolt	No. Sampled	Comments
May-09		Installed fence					
May-10	15:00			Rain			Put conduit in the fence.
May-11							High Water Removed conduit
May-12				Sun & showers			High Water & Muddy
May-13	21:00-23:00	8			0	0	
May-14	21:00-23:00	9	1.55		0	0	
May-15	21:00-23:00	10	1.55		0	0	
May-16	21:00-23:00	10	1.525	Sunny	0	0	
May-17	21:00-23:00	10	1.5	Cloudy	0	0	
May-18	22:00-24:00	10	1.6	Overcast & Drizzle	1	0	Water Muddy
May-19	21:00-23:00	10	1.5	Overcast & Drizzle	0	0	
May-20	21:00-23:00	10	1.4		0	0	
May-21	21:00-23:00	10	1.4		3	0	
May-22	21:00-23:00	12	1.4	Sunny & very warm 27C	18	1	
May-23	21:15-22:20	12	1.3	Overcast & Showers pm.	6	0	
May-24	21:00-23:00	12	1.25	Sunny & windy	5	0	
May-25	21:15-23:30	9	1.2	Overcast & Flurries	2	0	
May-26	21:30-23:30	9	1.15	Cool & sunny	0	0	
May-27	21:15-23:15	10	1.1	Overcast	11	0	
May-28	21:10-23:10	11	1	Sunny & warmer	0	0	Water Low
May-29	20:45-22:45	10	1	Rain & windy pm.	33	2	Water Muddy
May-30	21:00-23:00	9	1.2	Rain	52	3	Water raising
May-31	21:00-23:00	11	1.2	Showers & cool	28	1	Water raising
Jun-01	21:00-24:00	12	1.15	Sunny & warm	79	5	
Jun-02	21:00-23:00	15	1.075	Sunny & warm	48	3	
Jun-03	21:00-23:00	18	1.05	Sunny & warm	48	3	
Jun-04	20:00-20:30	14	2.6	Rain	0	0	Water high & muddy
Jun-05	21:00-23:00	15	1.8	Sunny & warm	28	1	
Jun-06	21:00-23:30	18	1.45	Sunny & warm	43	2	
Jun-07	21:00-22:30	18	1.3	Sunny & warm	7	0	
Jun-08	21:30-22:30	18	1.2	Sunny	5	0	
Jun-09	21:00-23:00	18	1.1	Sunny & windy	12	0	
Jun-10	21:00-22:00	18	1.05	Sunny & windy	3	0	
Jun-11	21:00-22:00	20	1	Sunny & windy	4	0	
Jun-12	21:00-22:00	18	1	Sunny	7	0	
Jun-13	21:00-22:00	20	1.25	Sunny	12	0	
Jun-14	21:00-22:00	20	1	Sunny	3	0	
Jun-15							
Jun-16	21:00-22:00	19	<0	Sunny & cool	3	0	
Jun-17	21:00-22:00	18	<0	Overcast & cool	0	0	
Jun-18	21:00-22:00	19	<0	Sunny & windy	1	0	
Jun-19	21:00-22:00	18	<0	Sunny & windy	0	0	
Jun-20	21:00-22:00	17	<0	Sunny - Overcast & cool pm.	0	0	
Jun-21				Total	462	21	Water too low to fish trap
Jun-22							Water too low to fish trap
Jun-23							Water too low to fish trap
Jun-24							Water too low to fish trap
Jun-25							Water too low to fish trap
Jun-26							Water too low to fish trap
Jun-27							Water too low to fish trap
Jun-28							Water too low to fish trap
Jun-29							Water too low to fish trap
Jun-30							Water too low to fish trap
Jul-01							Water too low to fish trap
Jul-02				Removed fence.			

Table 5. Count of smolts migrating from Little River, tributary to Stewiacke River 1990 to 1996, smolts per 100 m^2 with mean parr densities (per 100 m^2) of age-1+,age-2+ parr the year previous to migration in N sites above the fence.

Year	Count	Smolt/100m^2	Densities yr i-1			
			Age-1+	Age-2+	Total	N sites
1990	3579	3.19	25.35	19.30	44.65	2
1991	3144	2.80	72.50	6.25	78.75	2
1992	1959	1.75	44.60	8.10	52.70	2
1993	1303	1.16	44.90	2.00	46.90	2
1994	4098	3.66	59.10	5.20	64.30	2
1995	407	0.36	1.30	14.50	15.80	2
1996	462	0.41	4.35	2.50	6.90	2
1997			0.63	0.95	1.58	4

Table 6. Numbers of Atlantic salmon caught, salmon per kilometer, reach length weighted mean salmon per kilometer, length of reach fished and date of electrofishing-boat sampling on the Stewiacke River, 1988 to 1993 and 1995-1996.

Reach	Date	Length	Salmon caught	Salmon /km	Len. wtd salm/km[a]	
Reynolds-Forest Glen	01-Nov-88	31.78	23	0.72	0.72	
Reynolds-Park	31-Oct-89	35.2	19	0.54	0.54	
Reynolds-Park	01-Nov-90	35.2	4	0.11	0.11	
Reynolds-Middle	15-Nov-90	13.57	11	0.81		
Middle-Park	15-Nov-90	21.64	4	0.18	0.43	1988 - 1991 Average = 0.48 0.32 SD
Reynolds-Birch Hill	28-Aug-91	23.66	1	0.04		
Birch Hill-Forrest Glen	28-Aug-91	8.12	2	0.25		
Forrest Glen-Park	28-Aug-91	3.44	2	0.58	0.14	
Upper-Reynolds	15-Oct-91	5.88	9	1.53		
Reynolds-Middle	15-Oct-91	13.57	1	0.07		
Middle-Birch Hill	15-Oct-91	10.09	3	0.30		
Birch Hill-Park	15-Oct-91	11.55	4	0.35	0.41	
Reynolds-Middle	25-Nov-91	13.57	19	1.40		
Middle-Birch Hill	25-Nov-91	10.09	10	0.99		
Birch Hill-Park	25-Nov-91	11.55	7	0.61	1.02	
Reynolds-Middle	03-Nov-92	13.57	5	0.37	0.37	
Upper-Reynolds	16-Nov-92	5.88	2	0.34		
Reynolds-Middle	16-Nov-92	13.57	2	0.15		
Middle-Birch Hill	16-Nov-92	10.09	3	0.30	0.24	
Upper-Park	27-Oct-93	41.09	2	0.05	0.05	
Upper-Park	16-Nov-93	41.09	1	0.02	0.02	1992 - 1996 Average = 0.12 0.12 SD
Upper-Park	02-Dec-93	41.09	6	0.15	0.15	
Upper-Reynolds	21-Nov-95	5.88	3	0.51		
Reynolds-Middle	21-Nov-95	13.57	0	0.00		
Middle-Birch Hill	21-Nov-95	10.09	0	0.00		
Birch Hill-Park	21-Nov-95	11.55	0	0.00	0.07	
Upper-Park	05-Dec-95	41.09	0	0.00	0.00	
Upper-Reynolds	07-Nov-96	5.88	0	0.00		
Reynolds-Middle	07-Nov-96	13.57	4	0.29		
Middle-Park	07-Nov-96	21.64	0	0.00	0.10	
Upper-Reynolds	19-Nov-96	5.88	0	0.00		
Reynolds-Middle	19-Nov-96	13.57	3	0.22		
Middle-Birch Hill	19-Nov-96	10.09	0	0.00		
Birch Hill-Park	19-Nov-96	11.55	1	0.09	0.10	

a. Average number of salmon per kilometre of stream surveyed. Count per kilometre is multiplied by the length of the section and divided by the sum of all section lengths.

Table 7. Number of juvenile Atlantic salmon by growth stage released into the Stewiacke River, 1985-1995, estimates of smolt migrants and counts of marked and tagged adult fish at the counting fence in year i+1and i+2 with estimated return rates. (Note: All releases were adipose fin clipped.)

Year of release	Stage at release: Fry	2	3	4	Yearling	1+	2+	Smolt class	Year of migration	Returns and reports: smolt	adult yri+1	adult yri+2	Fence efficiency	River return 100^{-1} smolts: 1sw	2sw
1985						1,895 t		1,327 t	1985						
				17,061	11,156	19,219		13,453 u							
1986						2,973 t	1,687 t	3,599 t	1986						
						7,099	894	10,735 u							
1987						2,669 t	1,350 t	3,083 t	1987						
						4,363		3,054 u							
1990						5,150 a		3,605 t	1990	2					
						5,450		3,815 u				1			
1991						6,000 b		4,200 t	1991						
						13,400	7,900	16,490 u			1	2		0.02	0.02
1992						3,000 t	14,700 b	15,330 t	1992				0.33		
						7,100		4,970 u			13	0		0.42	0.00
1993						t	6,673 t	6,006 t	1993				0.63		
						19,976		13,983 u			27			0.19	
1994								0 t	1994				UK		
				20,400				0 u							
1995								0 t	1995						
						17,000		15,164 u							
1996						7,000		4,900							
Totals				37,461	11,156	122,294	33,204	123,714							

t =Tagged u=untagged
a 5,150 tagged (2,600 saline, 2,550 Vibriogen)
b 6,000 tagged (3,000 saline, 3,000 Vibriogen)

Survival rates		
	stage 4 to 1+ parr	0.40
	yearling to 1+ parr	0.50
	1+ to smolt	0.70
	2+ to smolt	0.90
	1+parr to 2yr smolt	0.40

Table 8. Results of electrofishing surveys on the Big Salmon River, 1996.

Tributary	*Site #*	*Area (m^2)*	*No. of Sweeps*	*Life Stage*	*Total Catch*	*Total Estimate*	*Density (100m^2)*
Catt's Park	2	1,554	3	Age 0+	17	31	2.0
Mast Brow	7	213	4	Age 0+	44	58	27.2
Crow Brook	11	217	3	Age 0+	73	187	86.2
Scroll's Dam	13	492	3	Age 0+	148	193	39.2
Anderson Brook	15	387	4	Age 0+	187	354	91.5
Average				Age 0+			**49.2**
Catt's Park	2	1,554	3	Age 1+	60	80	5.1
Mast Brow	7	213	4	Age 1+	33	37	17.4
Crow Brook	11	217	3	Age 1+	28	33	15.2
Scroll's Dam	13	492	3	Age 1+	39	48	9.8
Anderson Brook	15	387	4	Age 1+	13	23	5.9
Average				Age 1+			**10.7**
Catt's Park	2	1,554	3	Age 2+	0	0	0.0
Mast Brow	7	213	4	Age 2+	1	1	0.5
Crow Brook	11	217	3	Age 2+	0	0	0.0
Scroll's Dam	13	492	3	Age 2+	3	4	0.8
Anderson Brook	15	387	4	Age 2+	3	5	1.3
Average				Age 2+			**0.5**

1+ and 2+ were combined for analysis and resulting estimate was divided based on ratio found!
Surveys were conducted from September 9th - 12th using barrier nets and removal methods.

Table 9. Age and size composition of wild and hatchery origin adult Atlantic salmon sampled at the Coldbrook Fish Culture Station from broodstock collected in the Gaspereau River during 1996. Age is shown as years to smolt (fresh), post-smolt years (sea) and ages at previous spawnings (s1,s2).

	Age				Fork Length (cm)				
Origin	Fresh	Sea	s1	s2	Number	Mean	Min.	Max.	Std. dev.
Wild									
	2	1			11	53.81	50	57	1.87
	3	1			9	54.17	51	55	1.37
	2	2			6	71.08	66	74	2.74
	3	2			9	70.28	67	74	2.68
Hatchery									
	0	1			2	53	52	54	1
	1	1			2	51.5	51	52	0.5
	0	2			1	69.5			
	1	2			2	72.5	72	73	0.5

Table 10. Number of juvenile Atlantic salmon by growth stage released into the Gaspereau River, 1994-1996, estimates of smolt migrants and counts of marked adult fish at the fishway trap in year i+1and i+2 with estimated return rates. (Note: All releases were adipose fin clipped.)

Year of release	Stage at release: Fry	4	Yearling	1+	2+	Smolt class	Year of migration	Returns and reports: smolt	adult yri+1	adult yri+2	River return 100^{-1} smolts: 1sw	2sw
1994				28,959		20,271	1994		29	29	0.14	0.14
1995		20,705		8,972	8,000	13,480	1995		41		0.30	
1996				18,392	4,600	17,014	1996					
Totals		20,705	0	56,323	12,600	50,765						

Survival proportions		
	stage 4 to 1+ parr	0.40
	yearling to 1+ parr	0.50
	1+ to smolt	0.70
	2+ to smolt	0.90
	1+parr to 2yr smolt	0.40

Table 11. Lengths, classification by age at first maturity and percent distribution by age and gender of Atlantic salmon collected and retained for broodstock from the Annapolis River, 1996.

Salmon				Grilse			
Wild		Hatchery		Wild		Hatchery	
Male	Female	Male	Female	Male	Female	Male	Female
79.7	80.0	72.5	73.5	56.0	57.0 *a*	58.5	59.5
		79.0	74.0			57.0	
		75.0	77.0				
			83.4				

a Aquaculture escapee

Table 12. Location, date, area, number of age-0+,1+ and 2+ Atlantic salmon captured, estimated density 10^{-2} m^2 by age classes and coefficient of variation of the estimate derived by mark-recapture electrofishing at sites in the Maccan, Portapique, Economy, Great Villiage, Folly and North rivers ,1996, with historical electrofishing conducted in 1978 and 1979 (Gray et al. 1978, Cameron and Gray

Location .site	Date dd/mm	Area m^2	Age-0+ marks count	Age-1+ M	Age-1+ C	Age-1+ R	Age-1+ Mort[a]	Age-2+ M	Age-2+ C	Age-2+ R	Age-2+ Mort[a]	Parr 10^{-2} m^2 age-1+	Parr 10^{-2} m^2 age-2+	Parr 10^{-2} m^2 total	age-0+	Coefficient of variation age-1+	Coefficient of variation age-2+	Data collected during 1977 & 1978* Location Site	Parr 10^{-2} m total	Fry 10^{-2} m^2 age-0+
Maccan #1	28/08	1,377	2	52	47	19		1	0	0		9.2	0.1	9.4	0.4	16.7	0.0	Maccan #10	18.4	10.3
Maccan #2	28/08	1,094	0	72	67	32	1	1	1	0		13.8	0.4	14.2	0.0	12.2	50.0	Maccan #11	33.8	41.3
Maccan #3	28/08	866	0	23	17	6		0	0	0		7.1	0.1	7.2	0.0	27.6	0.0	Maccan #12	16.1	51.4
Maccan #4	28/08	752	3	23	22	9		3	1	1		7.3	0.5	7.9	1.0	22.7	0.0			
Portapique#1	29/08	786	3	80	90	49		2	2	2		18.8	0.4	19.1	0.7	9.4	0.0	Portapique#1	7.9	8.7
Economy#3	29/08	1,436		58	68	26		0	0	0		10.5	0.0	10.5	0.0	14.7	0.0	Economy#3*	2.9	4.1
GreatVillage	29/08	550	33	36	20	13		5	6	4		10.1	1.5	11.6	9.3	14.9	21.8			
Folly River	15/08	1,298	13	55	47	31		9	8	7		6.5	0.9	7.3	1.5	10.1	11.1			
North River #1	15/08	1,254	0	8	3	2		6	5	2		1.0	1.1	2.1	0.0	25.0	35.4			
North River #2	15/08	847	46	46	44	23	3	5	3	3		10.8	0.7	11.5	10.8	13.2	0.0			
												9.508	0.576		2.355					

a Count of fish-at-age during the mark run (M)
Total count of fish-at-age during the capture run (C)
Count of recaptured (marked) fish-at-age during the capture run (R)
Number of mortalities during mark run (Mort)

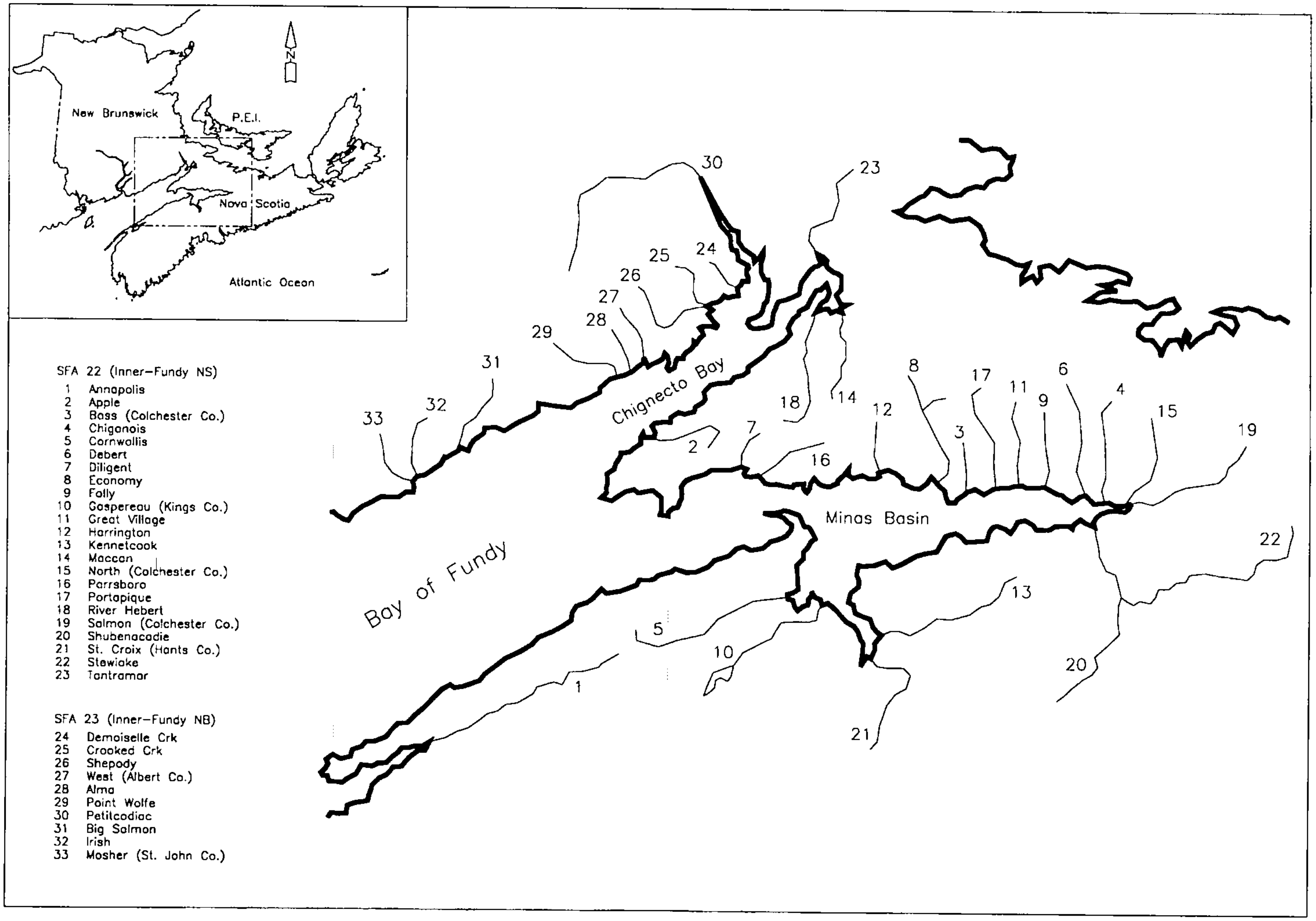

Figure 1. Map of inner Bay of Fundy showing locations and names of rivers in Salmon Fishing Areas 22 and 23.

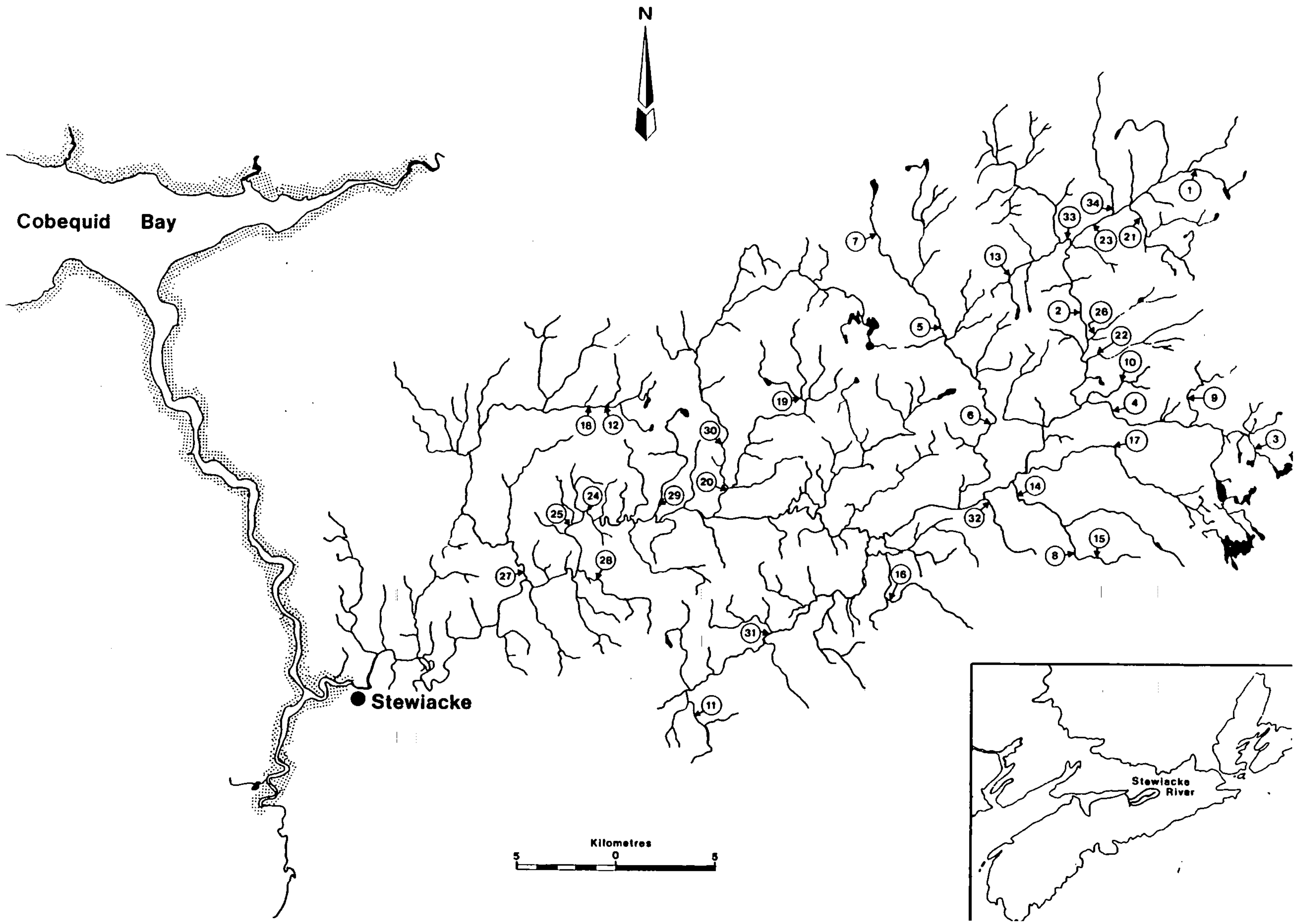

Figure 2. Map of the Stewiacke River showing the locations of electrofishing (see Table 5 for locations and sites fished in 1996), location of the Atlantic salmon trap on the mainstem of the Stewiacke River and the downstream smolt trap on the Little River.

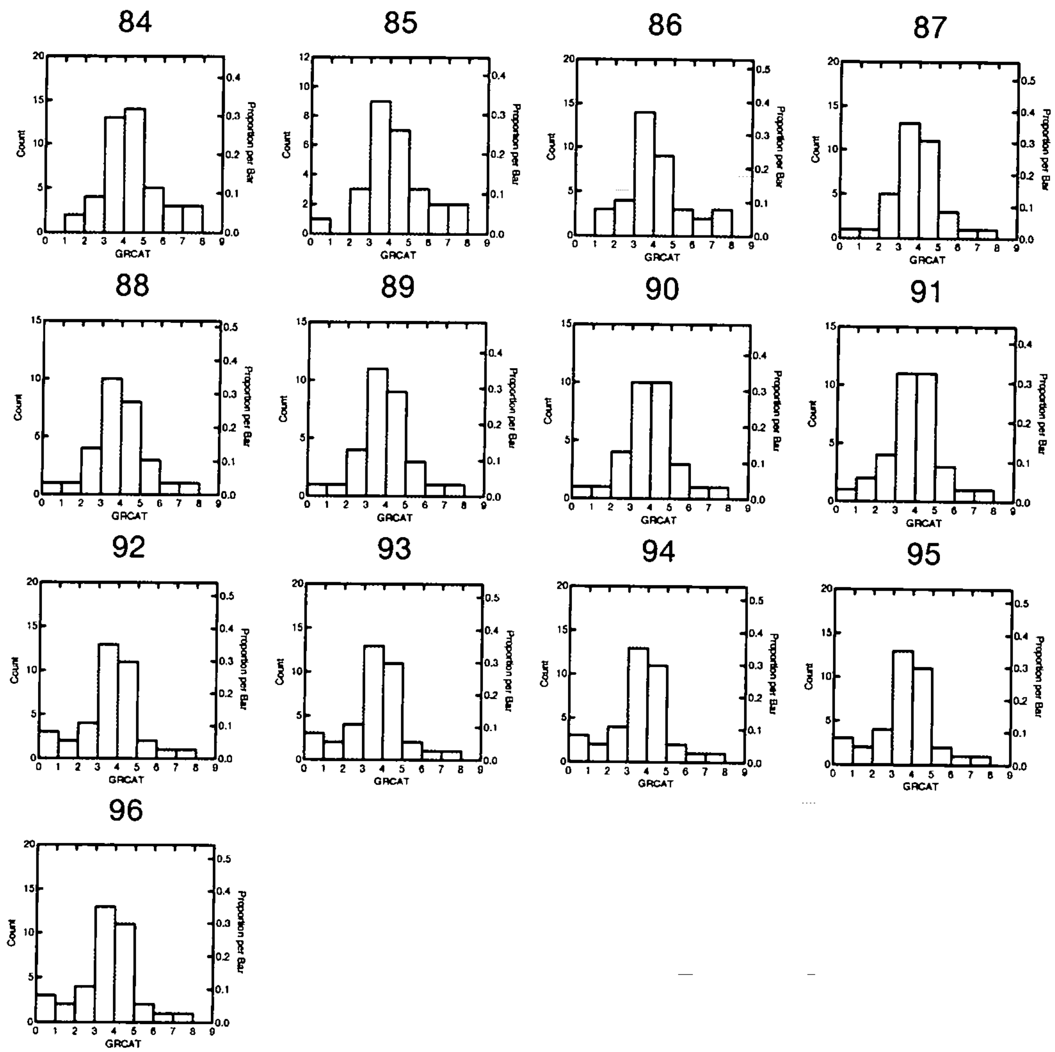

Figure 3. Frequency distributions of electrofishing sites by 11 stream gradient categories (GRCAT) from 0.0 to 5.0% stream gradient for 27 to 44 sites electrofished in the Stewiacke River, 1984 - 1996.

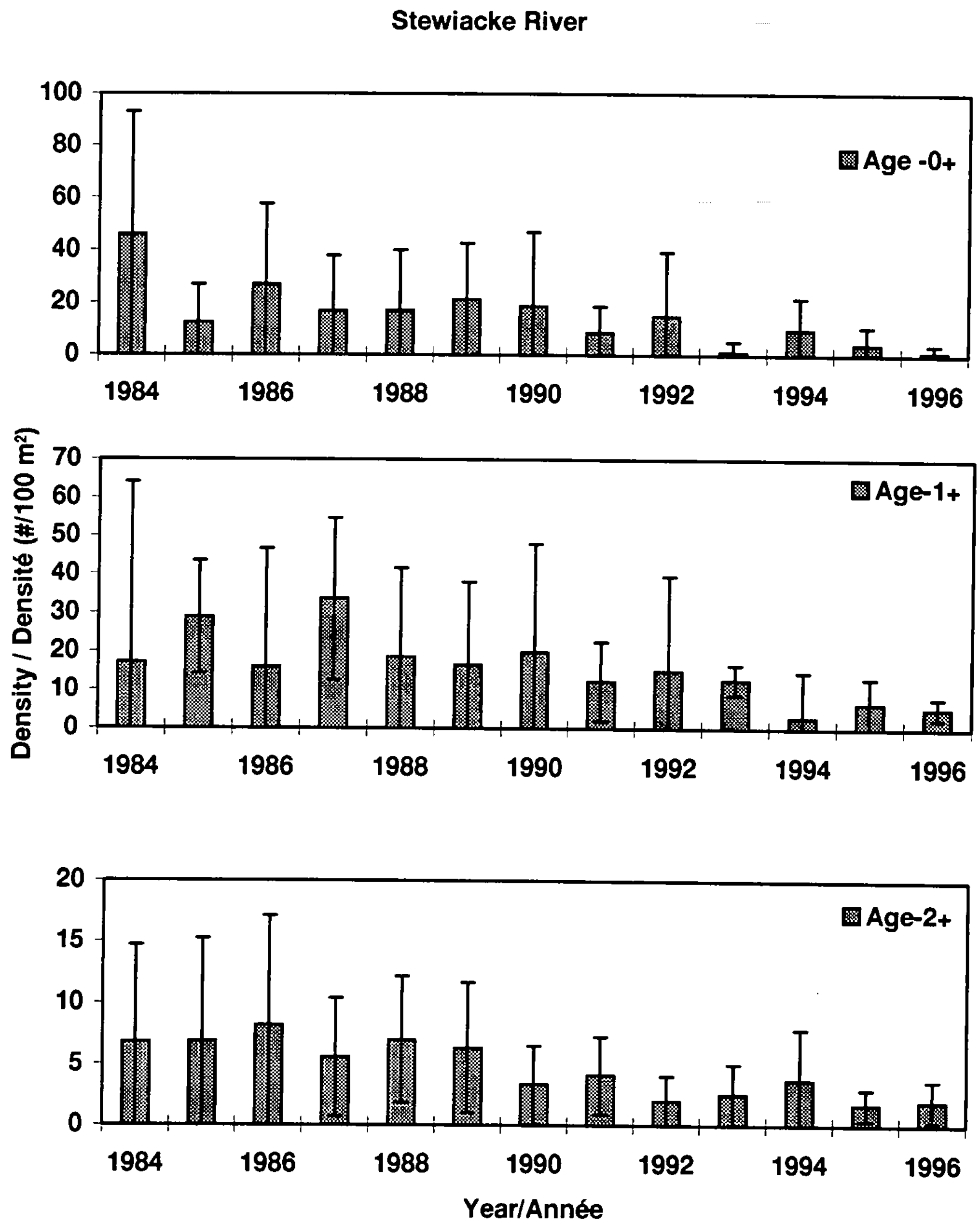

Figure 4. Densities, numbers 10^{-2} m^2, of juvenile Atlantic salmon electrofished from 44 to 27 sites in the Stewiacke River, 1984 to 1996. Bar height represents mean density while vertical lines indicate one standard deviation of the mean.

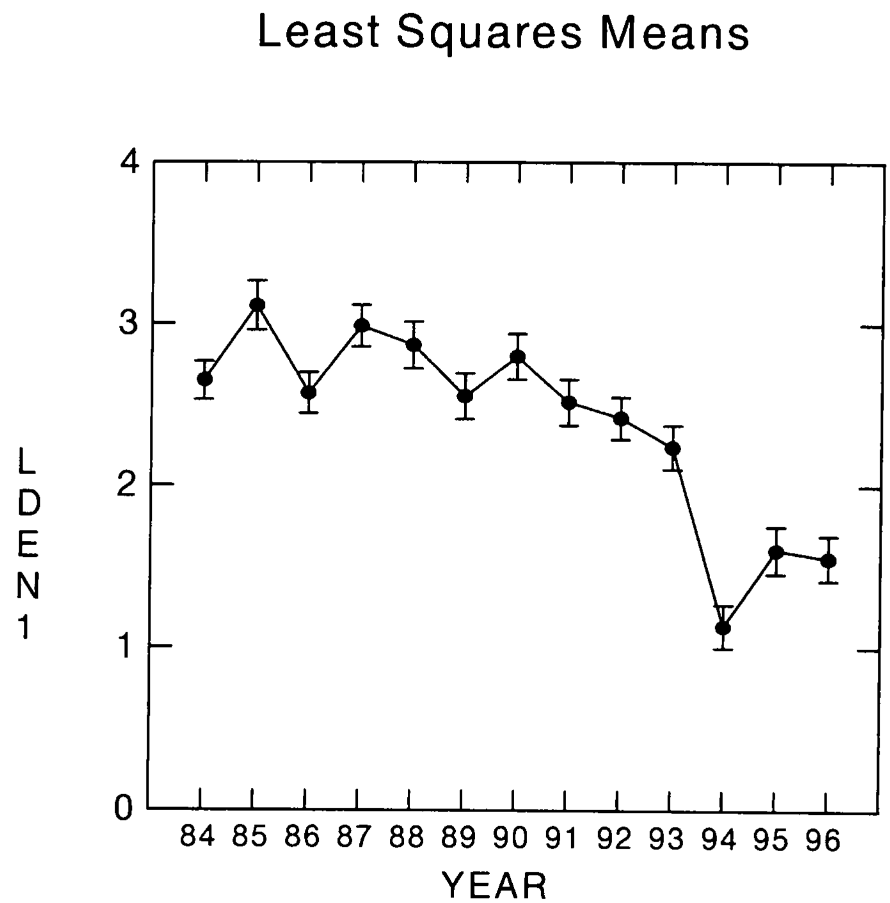

Figure 5 Gradient adjusted annual mean density of Log(age-1$^+$ parr + 1) for 27 - 44 sites in the Stewiacke River 1984 to 1996. (1994 - 1996 mean density is significantly lower than the 1984 -1993 mean density)

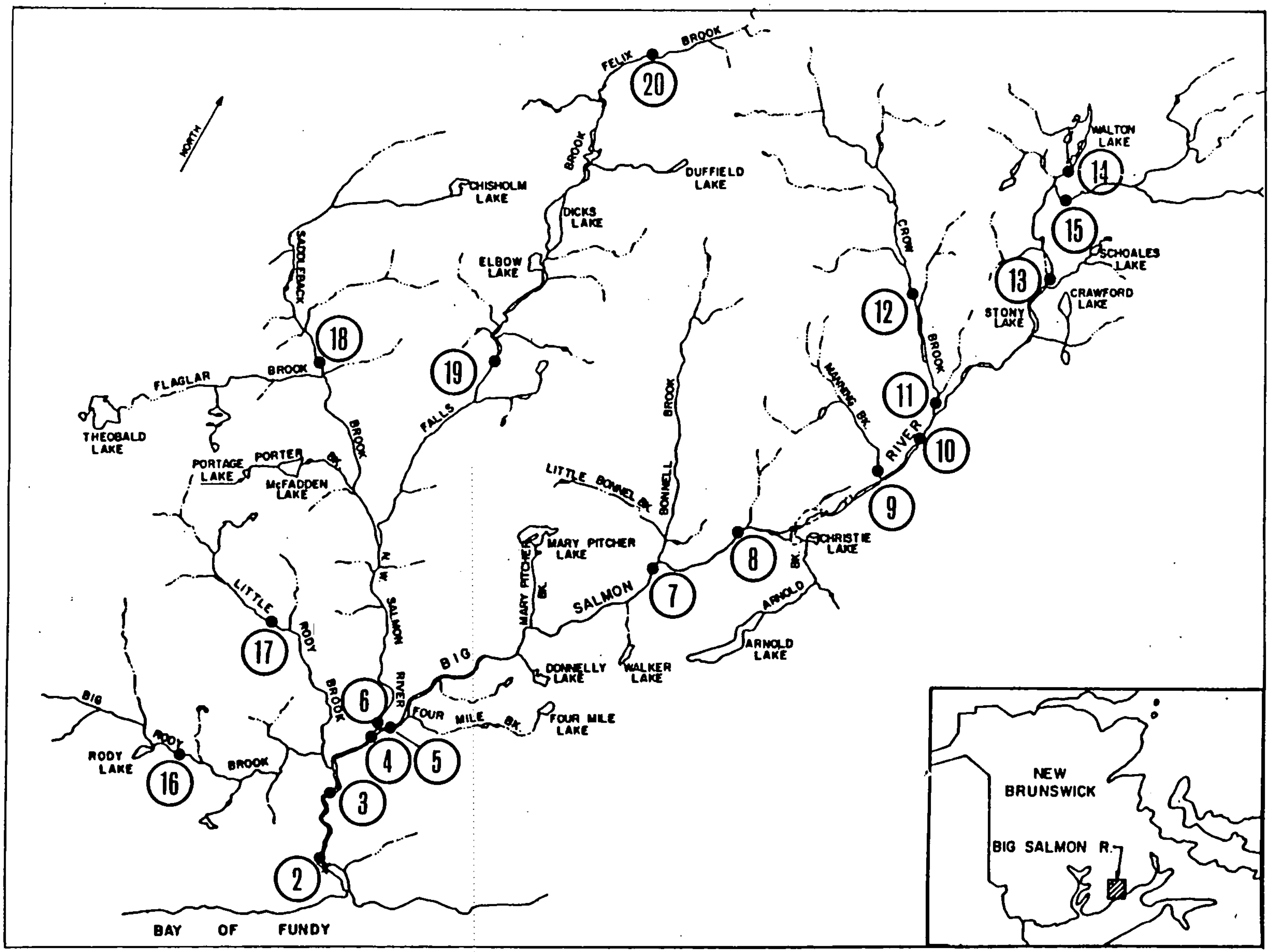

Figure 6 Map of the Big Salmon River, New Brunswick, showing the locations of electrofishing. Sites 2,7,11,13 and 15 were fished in 1996.

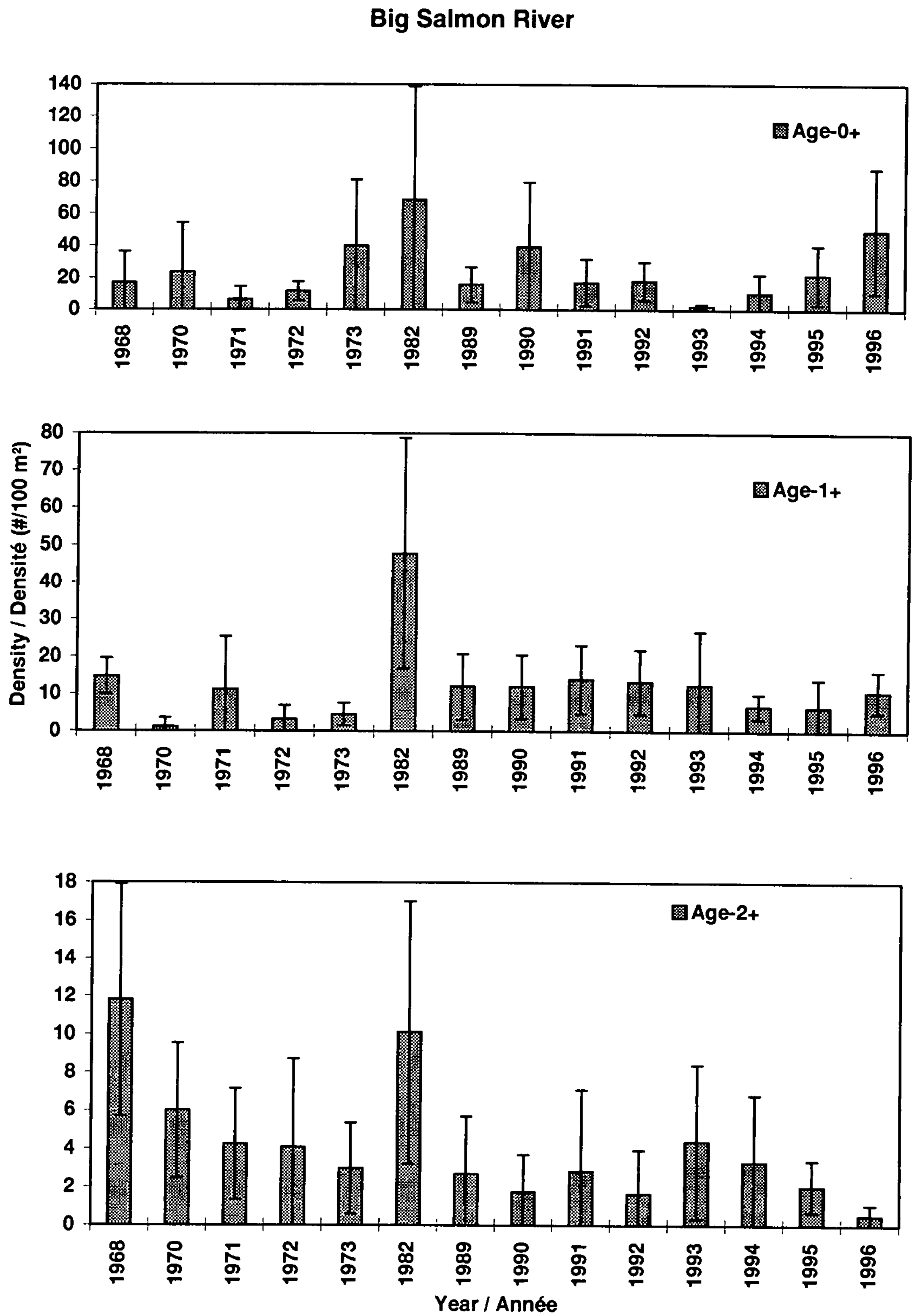

Figure 7. Densities, per 100 m^2, and standard deviation of parr at three to five standard sites (sites 2,7,11,13 and 15) in the Big Salmon River, 1968, 1970 to 1973, 1982, and 1989 to 1996. Bar heights indicate the mean densities while lines indicate one standard deviation of a mean.