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ATLANTIC SALMON STOCK STATUS FOR SAND HILL RIVER, LABRADOR, 1995

by

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ABSTRACT

The status of Atlantic salmon in 1995 was determined for Sand Hill River, Labrador which is located in Salmon Fishing Area (SFA) 2. Assessments were conducted in relation to reduced Atlantic salmon commercial fisheries in Labrador due to quota restrictions and the five-year moratorium on the commercial Atlantic salmon fishery in insular Newfoundland, which entered the fourth year in 1995. Target spawning requirements were derived using a habitat-weighted model which utilizes separate conservation target egg deposition values for fluvial and lacustrine habitats. In 1995, an aerial habitat survey was done and a new target was established. The new egg deposition target is 23.544 x 10^6 which translates into 4,211 small and 1,805 large salmon based on the average biological characteristics in 1994-95. Total returns to Sand Hill River adjusted for the lateness of installation of the counting fence were 2,781 small and 559 large salmon. In 1995, the proportion achieved of the target egg deposition requirements was 43.7%.

RÉSUMÉ

L'exposé qui suit porte sur la situation, en 1995, du saumon atlantique de la rivière Sand Hill, située dans la zone de pêche du saumon 2 du Labrador. Des évaluations ont été effectuées en relation avec la pêche commerciale réduite du saumon atlantique au Labrador suite aux restrictions imposées sur les quotas et au moratoire de cinq ans de la pêche commerciale de l'espèce dans les eaux insulaires, dans sa quatrième année en 1995. Un modèle pondéré en fonction de l'habitat, basé sur des valeurs différentes de la ponte cible aux fins de conservation pour les habitats fluviaux et lacustres, a été utilisé pour établir les besoins cibles en géniteurs. Un relevé aérien de l'habitat a été effectué en 1995, et une nouvelle ponte cible a été fixée. Celle-ci se situait à 23,544 x 10^6, ce qui se traduit, d'après les caractéristiques biologiques moyennes de 1994-1995, par 4 211 petits saumons et 1 805 gros saumons. Le nombre total de saumons amontants dans la rivière Sand Hill, ajusté en fonction du retard de l'installation de la barrière de dénombrement, se chiffrait à 2 781 petits saumons et 559 gros saumons. La ponte cible pour satisfaire aux besoins 1995 en matière de conservation a été réalisée dans une proportion de 43,7 %.

INTRODUCTION

Sand Hill River (Sandhill River) is located in southern Labrador (SFA 2) and flows into Sand Hill Cove, an inlet of Table Bay at 53^0 34'N 56^0 21'W (Anderson 1985) (Fig. 1). The main stem of the system has a drainage area of 1,474 km^2 and a total stream length (including tributaries) of 1,228 km (exclusive of Northwest Tributary).

In 1967, a temporary counting facility was located on the river and on the basis of this, a permanent facility was constructed in 1968; upstream migration of adult salmon and downstream migration of smolt were monitored from 1969 to 1973 (Murphy 1970; Peet 1971; Pratt *et al.* 1974; Murphy 1974). The main focus of this project was to study the exploitation of Labrador salmon by the west Greenland fishery and included the tagging of large numbers of smolt and enumeration of returning adults. In addition to this information, other biological, physical and chemical data were collected. Thus, Sand Hill River is one of the few Atlantic salmon rivers in Labrador from which quantitative data are available on the salmon population and its physical habitat.

In 1992, several major changes were introduced to the management of Atlantic salmon in Newfoundland and Labrador. A five-year moratorium was placed on commercial salmon fishing in the island portion of the province, for the Labrador commercial fishery the quotas first introduced in 1990 were reduced, and a voluntary retirement of commercial salmon licences was instituted for all of the province. In the angling fishery, in 1992 and 1993, a quota on the number of fish that could be retained was introduced in each Salmon Fishing Area (SFA). The quota was assigned for an entire SFA and was not administered on an individual river basis. Only hook-and-release fishing was permitted after the quota was caught. In 1994, quotas for the angling fishery were eliminated. In place of quotas, for Labrador, the season bag limit for retained salmon was lowered from eight to six fish, only two of which could be large salmon. The West Greenland commercial salmon fishery closed for the 1993 and 1994 fishing seasons. In 1995, the season bag limit for the angling fishery remained at six fish but only one large salmon could be retained. The commercial salmon quota for SFA 2 was set at 48 metric tonnes (t) and the West Greenland salmon fishery opened again with a quota of 77 t.

In 1992, the Co-operation Agreement for Salmonid Enhancement/Conservation (CASEC), aimed at promoting angling fisheries was announced. One goal of this initiative was to monitor the effects of reduced fishing effort on the abundance of Atlantic salmon and the status of the stocks. Sand Hill River, because of the availability of a historical database (1969-73), was selected to evaluate the change in the fisheries on salmon stocks on the Labrador coast beginning in 1994. In this paper, the stock status of the Sand Hill River salmon population in 1995 is examined.

METHODS

Angling and commercial fisheries data

Catch and effort data from the angling fishery in Sand Hill River were collected by Department of Fisheries and Oceans (DFO) enforcement staff in conjunction with angling reports submitted by fishing camp operators and processed by DFO Science Branch personnel. Commercial catch data were collected by DFO enforcement staff from fish plant landing slips and processed by DFO Statistics and Informatics Branch personnel. Procedures for the collection and compilation of commercial and angling fishery data are described by Ash and O'Connell (1987). Catch and effort statistics were further broken down by fishing camp in order to determine the catch above the fence (Wulff Lake Camp) and below the fence (Sand Hill River Camp). These statistics were used to determine the amount of salmon retained above and below the counting fence.

Adult salmon counts

COUNTING TECHNIQUES

Between June 16 and July 8, 1995 a counting fence was constructed approximately 0.5 km upstream from the old counting fence site (Fig. 2). Upstream migrating adult salmon were enumerated from July 8 to Sept 1. The counting fence, located approximately 6 km upstream from the mouth of the river, consisted of 43 sections (each 3 m long) which were installed according to the description in Anderson and McDonald (1978). The fence was constructed of conduit and channel iron, supported by steel poles and 5 cm x 15 cm wooden supports and is typical of other portable counting fences constructed in the Newfoundland and Labrador. To facilitate boat passage and to act as a platform for camera boxes, two wooden 1 m x 2.5 m piers were positioned 1.5 m apart in the main channel of the river. The two camera boxes were each divided into one section for fish passage and another section containing camera equipment and lights. The fence was operated with every second conduit in place except for an area on both sides of the piers.

Once the counting fence was completely installed, enumeration was done using two video camera systems. Fish passage was recorded by video cassette recorders (VCRs) and fish counted manually by reviewing tapes. Distinction between large and small salmon was made by comparison of passing fish to a known measure on the floor of the tunnels. Large salmon were defined as those salmon with a fork length equal to or greater than 63 cm and small are those less than 63 cm.

ADJUSTED COUNTS

Salmon counts for 1972, 1973, and 1994 were adjusted for operating periods based on counts

from longer operating periods in 1970 and 1971 (Reddin et al. 1995). The years 1970 and 1971 had data spanning the longest continuous time during migration periods of adults entering this system. Adjustments were made on a yearly basis by determining the number of salmon entering outwith the counting period from the average percentage of the 1970 and 1971 counts that occurred after the fence was removed for the year in question. Numbers of large and small salmon based on the percent of total fish counted were then allocated according to average daily percentages for 1970 and 1971. Salmon counts for 1969 were not used because the time period of complete counts (July 17 - August 28) was deemed to be too short and fence log books indicated several washouts and holes in fence had occurred for indeterminate periods of time. The correction procedure used to adjust the counts followed the same technique outlined in O'Connell et al. (1995b) and is as follows:

$$AC_i = C_i / (1 - AF_i)$$

where, AC_i = adjusted count in year i
C_i = fence count in year i
AF_i = adjustment fraction from year i (1970-73 & 94) determined as the portion of the count observed within 8 July to 1 September

In 1995, the counting fence at Sand Hill River operated from 8 July to 1 September. Fence staff had arrived on site June 22 but because of high water levels due to heavy rains were unable to completely install the counting fence until the 8th of July. Staff observed salmon in the river before the counting fence was operational, confirming that some fish had already entered the river. Also, counts for years 1970-73 and 1994 show that in each of these years fish had entered the river before 8 July. The text table below shows the percent of the count that occurred within the 8 July to 1 September period in 1970-73 and 1994 and potentially could be used as an adjustment to the 1995 count:

	1970	1971	1972	1973	1994
Small	94.9	93.4	96.2	88.7	86.6
Large	87.7	52.6	90.5	42.0	67.6

The adjustment fraction (AF_{94}) was chosen for several reasons. Reddin and Shearer (1987) and Narayanan et al. (1993) showed that environmental conditions affect run timing of salmon into rivers in Newfoundland and Labrador with colder water delaying river entry and warmer sea temperatures accelerating it compared to entry time when sea temperatures are average. Environmental conditions in 1994 were similar to 1995 and in particular, a lack of ice in June (Colbourne 1995). Also 1994 is closest chronologically to 1995 with all other data coming from 20 years before. Therefore, salmon for 1995 were adjusted for missing periods at the beginning

and end of the summer counting season based on the daily percentage of salmon caught in the 1994 season.

Unrecorded Mortalities

Complete understanding of all life history factors including mortalities is an important part of any stock assessment (Ricker 1975). Mortalities due to fishing, but not recorded as part of the catch statistics, have been defined as non-catch fishing mortalities by Anon. (MS 1980) and Ricker (1976). Non-catch fishing mortalities could include fish killed due to illegal and legal fishing activities. Legal fishing mortalities of salmon in Newfoundland and Labrador include catches in native food, angling, and commercial fisheries. Illegal mortalities include poaching in both freshwater and marine environments. Illegal mortalities by their very nature are extremely difficult to quantify. An indirect method of assessing illegal removals prior to arrival of fish at enumeration facilities is by observation of net marks on the fish surviving these activities. In 1994 and 1995, records were kept of salmon with visible net marks at facilities with video counters. These observations provide a minimum estimate of net-marked salmon, since due to light conditions or minor scarring, some net marks will be rendered invisible to either the camera or the naked eye. Since there is a legal commercial salmon fishery in Labrador, it is expected that some salmon would be netmarked.

Exploitation rates

Exploitation rates for the angling fishery were determined as the number of salmon reported to have been retained by the angling fishery divided by the total number of salmon entering the river adjusted for salmon caught below the enumeration facility.

Biological characteristics data

Biological characteristics data on adult Atlantic salmon were obtained by taking samples of angling catches. These data were collected at the Sand Hill River fishing lodges in 1995 with the assistance of fishing guides and under the guidance of DFO technical staff. Information on fork length, weight, sex, scales, and ovaries were collected. The ovaries were collected for relative fecundity estimates and were stored in Gilson's fluid until transferred to 10% formalin. Eggs, which for the most part were in early stages of development, were counted directly and egg diameters measured. Fecundity was calculated as the number of eggs per kg of whole weight. Egg depositions were based on percentage female and mean weight data which were used to convert target spawning requirements in eggs to spawning requirements in numbers of fish.

Smolt samples were collected by angling. They were sampled for fork length to the nearest mm, whole weight to nearest 0.1 kg, sex determined visually by examination of internal organs and scales removed from the standard location as recommended by Shearer (1992).

Total river returns, spawning escapement, and egg deposition

TOTAL RIVER RETURNS

Total river returns (TRR) were calculated separately for small and large salmon as follows:

$$TRR = RC_b + C$$

where,

RC_b = angling catch below counting fence
C = count of fish at counting fence

SPAWNING ESCAPEMENT

Spawning escapement (SE) was calculated as the difference between the number of fish released from the counting fence (FR) and the angling catch retained above the fence (RC_a).

$$SE = FR - RC_a$$

EGG DEPOSITION

Egg deposition (ED) was calculated as follows:

$$ED = SE \times PF \times RF \times MW$$

where,

SE = number of spawners
PF = proportion of females
RF = relative fecundity (No. of eggs per kg)
MW = mean weight of females

Because of low number of large salmon examined for biological characteristics from the angling fishery, samples from large salmon were combined for 1994 and 1995.

Accessible rearing habitat

Murphy (1970) calculated potential fluvial rearing habitat based on a measured stream length of 321.8 km (converted from 200 miles) of fluvial rearing habitat and an estimated stream width of 9.144 m (30 ft) taken from 1:250,000 topographical maps and survey flights.

In 1994, accessible rearing habitat was calculated from the 1:50,000 topographic maps (Surveys and Mapping Branch, Department of Energy, Mines and Resources, Ottawa) using

Spans GIS software as described in O'Connell and Dempson (MS 1991). On 1:50,000 topographic maps, 1st and 2nd order streams show up as lines and widths have to be estimated. It was also observed that many of these streams were not previously measured by Murphy (1970) since they were not visible on the 1:250,000 scale maps.

In 1995, an aerial survey was done on the Sand Hill River system by low flying helicopter. This covered most of the main stem and a portion of the 1st & 2nd order streams. The river was divided into sections and an estimate of the percentage of standing water and fluvial habitat was determined. Substrate type (boulder, rubble, cobble, etc) was determined for each section and obstructions to salmon migration were observed. First and second order streams were surveyed and estimated widths were determined for some of these streams. The areas of these observed sections were then calculated from the digitized map and accessible habitat was calculated. Approximately 95% of the main stem of the river was surveyed and about 5% of the first and second order streams were surveyed.

Target spawning requirements

The minimum egg deposition requirement (target egg deposition) for conservation in Sand Hill River (SFA 2) was derived using egg deposition rates of 240 eggs per 100 m^2 for fluvial parr rearing habitat (Elson 1957; 1975) and 105 eggs per ha for lacustrine habitat (O'Connell *et al.* MS 1991). Although these values may be habitat and river specific for river systems from which they were derived, they represent the best available data and are used as a general baseline for determining stock status of Sand Hill River. Biological characteristics used to calculate the target are averages for 1994 and 1995. Minimum spawner requirements in terms of eggs were converted to small and large salmon by the following formula:

$$\text{No. of salmon} = \frac{\text{Target no. of eggs}}{(\%\ \text{small} \times RF \times MW \times \%\ ♀) + (\%\ \text{large} \times RF \times MW \times \%\ ♀)}$$

where RF = relative fecundity (No. eggs/kg)
MW = mean weight of females

Total production

Total production of Sand Hill River salmon stocks including salmon caught in the Newfoundland and Labrador commercial fishery and at west Greenland was estimated using exploitation rates calculated from the tagging study in 1969-73 (Reddin and Dempson, pers. comm., Reddin, 1981). A base exploitation rate of 0.28 to 0.51 on small salmon and 0.83 to 0.97 on large salmon was used to convert total returns to freshwater to total salmon prior to the commercial fishery for the years 1970-73. Exploitation at Greenland on large salmon was accounted for using an exploitation rate of 0.22. Total returns to freshwater in 1994-95 were estimated by reducing exploitation rates on small and large salmon to account for changes in

effort due to the cessation of fishing at west Greenland, the licence buy-out program in Labrador, commercial quotas in Labrador, and the elimination of the commercial fishery in Newfoundland which took Sand Hill River origin salmon.

The technique used to evaluate exploitation rates (μ) devalued by the decrease in fishing effort is described in Anon. (1995). It estimates the changes in exploitation from the equation $\mu = 1\text{-}e^{-aF}$, where a = fraction of the 1991 licensed effort remaining in 1994 and 1995 and F = fishing mortality. In 1994-95, the licensed effort for all of Labrador was 37% of the 1991 level of 570 licenses. The estimate of fishing mortality in 1994 including adjustments for removal of nets from Sand Hill Cove and the closure of commercial fishing in Newfoundland is 15% to 25% for small and 30% to 40% for large salmon. In 1995, further adjustments were made to account for the new opening date for the commercial fishery in Labrador which was delayed in 1995 from June 5 to July 3. Determination of the adjustment was done from the proportion of fish at the counting fence in 1994 prior to July 5 of 4% for small and 16% for large salmon. The new estimate of fishing mortality in 1995 is 12% to 23% for small and 15% to 33% for large salmon.

Environmental data

During field operations, environmental data were collected at the fence site. Water temperatures were recorded by Hugrun thermograph set at 1 m from the surface at the fence site and at Sand Hill cove. Cloud cover, relative water levels, weather conditions and air temperatures were also recorded.

RESULTS

Angling and commercial fisheries data

In 1995, the commercial quota for SFA 2 was reduced to 48 metric tonnes (t) from 60 t for 1994. Total commercial catches of 38 t, divided into 9 t small and 30 t large were reported (Table 1). The 1 t difference between the total and the sum of small and large is due to rounding error. The landings in 1995 were a big reduction (41%) from 1994 and the multi-year mean catches presented in Table 1.

In 1995, the angling salmon fishery in Sand Hill River had a total of 426 rod days (a rod day being a day or any part thereof in which an individual fishes for salmon) for a retained catch of 289 small salmon and 28 large salmon (Table 2). There were also 340 small salmon and 14 large salmon released. Almost all effort for this system results from two fishing lodges on the main stem of the river. Some effort does occur from fishers outside these lodges but an estimate of the amount, although small, is not included in the total. The angling catch can be further broken down into catch above and below the fence based on camp angling statistics which shows that 81 small and 11 large salmon were retained above the fence and 208 small

and 17 large salmon below the fence.

Adult salmon counts

In 1995, a total of 2,228 small salmon and 366 large salmon was counted upstream through the adult fence between July 8 and Sept 1. This is an underestimate of the actual number of salmon entering Sand Hill River as a result of the later starting date caused by high water.

The adjusted counts for 1995 based on the 1994 distribution that include salmon for the period the fence was not in operation were 2,573 small salmon and 542 large salmon or 82% small and 18% large (Table 3). An alternate estimate of the counts can be made using the 1973 count distribution rather than 1994 which would result in 2,478 small and 872 large salmon. Unadjusted and adjusted counts for 1970-73, 1994 and 1995 are shown in Table 4. In 1994 and 1995, no counts were made of other species since the fence was constructed to allow fish smaller than salmon to pass and any count would only be partial.

Table 3 and Fig. 3 indicate that in 1995, a high percentage of the small salmon returning did so during standard weeks 28 and 30 or the 2nd to the 4th weeks of July with 82.0% having passed through the fence by July 31. Large salmon enter this system earlier with standard weeks 27 and 28 (the first and second weeks of July) typically having the largest counts (Fig. 3).

Angling catch statistics indicated that 208 small salmon and 17 large salmon were reported caught and retained below the fence. It is assumed that these fish would have passed through the fence and would have been included in the salmon counts at the fence if they had not been caught. Total returns to the main stem of the river therefore were 2,781 small salmon and 559 large salmon.

Net-marked salmon

The number of net-marked salmon was 39 small and 1 large. The total percentage of observed net marked salmon was 1.5%. In 1994, the number of net-marked salmon was estimated at 5%. This reduction may have been due to the reduced exploitation from the later opening date of July 3 for the commercial fishery.

Exploitation rates

The combined retained catch in the angling fishery, above and below the fence, was 289 small and 28 large salmon. In 1995, exploitation rates in the angling fishery were 10.4% for small salmon and 5.0% for large salmon. Exploitation rates (%) in the angling fishery for all years were as follows:

Year	Small	Large
1970	3.1	1.5
1971	3.1	0
1972	10.8	5.7
1973	10.9	2.6
1994	12.9	4.0
1995	10.4	5.0
Mean	10.0	3.1

Biological Sampling

In 1995, 180 adult salmon were sampled from the angling fishery. Mean fork length (FL) of the grilse was 55.8 cm (SD=2.68, n=147) and mean whole weight (WW) was 1.88 kg (SD=0.33, n=147) (Table 5). Mean fork length of two-sea winter virgin salmon was 74.7 cm (SD=3.00, n=24) and mean WW was 4.52 kg (SD=0.48, n=24). Mean WW and FL of previous spawners was 2.24 kg (SD=1.28, n=4) and 62.7 cm (SD=7.14, n=4), respectively.

Freshwater (river) age information is available from 173 salmon and is presented along with information for previous years in Table 5. It indicates that 74.6% of the adults have a river age of 4 and 5 years. It also indicates that 84.0% of the fish sampled were virgin one-sea winter fish, 13.7% virgin multi sea-winter fish, and 2.3% previous spawners.

Fifty smolt samples were collected from the lower section of the system in 1995. The mean length was 168.0 mm and mean weight was 53.5 gm (Table 5). Sex information from 19 samples indicated that 53% of smolt were female and 47% were male. River age information is presented in Table 5.

The percentage of female salmon sampled from the angling fishery in 1995 was 57% (n=131) for small salmon and 96% (n=24) for large salmon (Table 6). The mean weight for small female salmon was 1.86 kg (SD=0.28, n=75) and for large female salmon was 4.47 kg (n=23 and sd=0.49). Average percent female salmon in 1994-95 was 50% for small salmon and 79% for large salmon (Table 6). In 1994-95, the mean weights for female salmon was 1.86 kg for small and 4.55 kg for large.

Fecundity from ovaries collected from the angling fishery in 1994 indicate that the mean total egg count per salmon was 4,392 eggs (n=40). Egg counts were not separated by fish size

since only one egg count from large salmon was available at the time of this report. Total fecundity was calculated at 2,263 eggs per kg. This fecundity value was used for the 1995 assessment since the ovaries collected in 1995 had not been analyzed and no new fecundity values were available.

Accessible rearing habitat

In 1994, we calculated the total amount of potential lacustrine parr rearing habitat for Sand Hill River (not including Northwest Tributary) at 81.5 km^2 or 8,150 ha. We also calculated a total fluvial length for all 1st and 2nd order streams of 1119.5 km. The total area of the main stem of the river (not including ponds) was calculated at 11.2 km^2 (Reddin et al. 1995).

The areas calculated from 1:50,000 topographical maps in 1994 were corrected based on observations from the 1995 aerial survey. The area for the main stem (excluding ponds) was adjusted removing the portion of the area that was considered steady or bedrock substrate. This new area for fluvial habitat is 4.95 km^2 for the main stem. A number of 1st & 2nd order streams were surveyed and the estimated weighted mean width was calculated to be 4.0 m. The area of fluvial habitat for these streams was calculated to be 4.48 km^2. The total fluvial habitat for the main stem and 1st & 2nd order streams is 9.43 km^2. The area of steady water and pond was adjusted and a total of 87.3 km^2 or 8730 ha of lacustrine rearing habitat was calculated. The calculations of the numbers of rearing units for salmon in Sand Hill River is:

Potential habitat

Main stem: 4.95 km^2 = 49,500 units of rearing habitat

1st and 2nd order tributaries:

1119.5 km * 4 m width (average) = 44,780 rearing units

Total rearing units fluvial habitat = 94,280

Habitat for standing water = 8,730 ha.

Target spawning requirements

The estimated target spawning requirement for Sand Hill River in terms of eggs as well as

adult salmon were as follows:

	Fluvial	Lacustrine	Total
Accessible habitat	9,428,000 m^2	8730 ha.	-
Eggs (No. x 10^6)	22.627	0.917	23.544

Fluvial Rearing Units: 94,280 (100 m^2)
Lacustrine Rearing Area: 8,730 ha

Target Egg Deposition: Fluvial = 240 per rearing unit
Lacustrine = 105 per ha

Fecundity: 2,263 eggs/kg.

Small - % overall from total production	70.0
- % female	50.0
mean wt.	1.86
Large - % overall from total production	30.0
- % female	79.0
mean wt.	4.55

Number of spawners to obtain sufficient females using 1994-95 average biological characteristics:

Required spawners = egg requirements/eggs per spawner

$$= \frac{\text{Area} * \text{Optimal Egg Deposition}}{(\%\text{grilse}*\%\text{female}*\text{mean wt}*\text{fecundity}) + (\%\text{large}*\%\text{female}*\text{mean wt}*\text{fecundity})}$$

$$= \frac{94{,}280 * 240 + 8{,}730 * 105}{(0.70*0.50*1.86*2{,}263) + (0.30*0.79*4.55*2{,}263)}$$

$$= \frac{23{,}543{,}850}{3{,}914}$$

= 6,016 ---> consisting of 4,211 small salmon and 1,805 large salmon

Total river returns, spawning escapement, and egg deposition

In 1995, the percent of the target egg deposition achieved on Sand Hill River was 43.7% of the new target (Table 7). If alternate counts were used based on the 1973 count distribution then the percent of the target egg deposition achieved on Sand Hill River in 1995 would be 54.4%. In the period of 1970-73, percent target egg deposition achieved ranged from a low of 8.8% in 1972 to a high of 29.3% for 1973. Average values for the period of 1970-73 were 15.7%. A summary of the stock status information for Sand Hill River is in Appendix I.

Total production

On average from 1970-73, total recruits produced by the Sand Hill River salmon stock including salmon caught in the Newfoundland and Labrador commercial fishery and at west Greenland were about 6,000 small and 6,806 large salmon (Table 8). In comparison, an estimate of total production for 1994 showed 2,482 small and 1,525 large salmon when adjusted for reduced exploitation in commercial fisheries. Therefore, small and large salmon in 1994 had decreased by 59% and 78%, respectively compared to the 1970-73 means. An estimate of total production in 1995 showed 3,159 small and 924 large salmon when adjusted for the reduced exploitation in commerical fisheries. Therefore, small and large salmon in 1995 had decreased by 47% and 86%, respectively compared to the 1970-73 means. In comparison to 1994, 1995 production figures increased by 27% for small salmon and decreased by 39% for large.

The total production of small and large salmon can also be converted to the percent of the spawning target achieved with and without a commercial fishery (Table 9). In all years with the existing commercial fishery in place target spawning was never achieved. However, there were enough salmon available so that it could have been achieved in all years during 1970-73. On average in the period of 1970-73, 232% of spawning target could have been achieved if all of the total production went into spawning escapement compared with 16% with a fishery. In 1994-95, total production of Sand Hill River salmon had declined substantially from that of the 1970-73 period. In the 1994-95 period, a higher proportion of the total production was going into spawning escapement. However, even without a commercial fishery there were not enough salmon to achieve target spawning escapement, viz. 72% in 1994 and 64% in 1995 (Table 9).

Environmental data

Figure 4 indicates the mean water temperature at the fence site and Sand Hill Cove. The daily mean for the fence site was 14.2 ^{o}C (SD=3.94) and for Sand Hill Cove was 11.4 ^{o}C (SD=2.84).

DISCUSSION

O'Connell and Dempson (MS 1991) reported that there is evidence (unpublished) that atresia (the non-development and reabsorption of eggs) occurs to varying degrees in insular Newfoundland salmon. This phenomenon has also been reported in Atlantic salmon in the Soviet Union (Melnikova 1964) and in France (Prouzet *et al.* 1984). Therefore, fecundity values measured from eggs in early stages of development (green eggs) should be regarded as potential values. Since calculations of target spawning requirements and the percent of target achieved were based on green eggs, the occurrence of atresia in a given year on a particular

river would increase the number of spawners required and decrease the percent of the target achieved.

The target egg deposition attained in 1995 for the Sand Hill River salmon population has increased relative to average egg deposition in the period of 1970-73 by a factor of two. The large increase in percent of target achieved between 1970-73 and 1995 is in large part due to the increase in the large salmon component which probably resulted from the decrease in commercial fishing effort in Labrador, the salmon moratorium in Newfoundland, and reductions in bag limits for the angling fishery in Labrador. Commercial fishing effort at west Greenland was also reduced by a buy-out of commercial fishing effort which should have reduced to near zero the fishing mortality of Sand Hill River salmon (Anon. MS 1995). Although the success of management plans designed to reduce fishing mortality and increase spawning escapement are recognized, efforts should continue to reduce fishing mortality until 100% of target spawning is achieved. Once production from these higher spawning populations begin to return to Labrador then fishing mortality can be increased.

While reductions in fishing effort have resulted in increased spawning in Sand Hill River, the total production of the stock prior to the commercial fishery has declined considerably in 1994 and 1995 from earlier higher levels. It was noted that small and large salmon in 1994 had decreased by 59% and 78% and in 1995 by 47% and 86%, respectively, compared to the 1970-73 means. These decreases may have been due to reduced spawning for the spawning years that produced the returns and/or may also have been due to reduced marine survival as has been noted for other stocks in Newfoundland and Labrador (O'Connell *et al.* MS 1995a). If reduced marine survival is continued into future years, it may be that spawning populations will also decline from values observed in 1994 and 1995.

In 1995, due to high water, the counting fence at Sand Hill River was operational after some salmon had entered the system. The 1995 count for small and large salmon of 2,573 and 542, respectively was adjusted using the distribution of fish from 1994 before counting began on July 8. An alternate estimate based on the 1973 distribution would provide for counts of 2,478 and 872 small and large salmon, respectively. There are several reasons for choosing the 1994 distribution for adjustment purposes including environmental and chronological that were previously discussed.

Reddin et al. (1995) pointed out the necessity to update the habitat survey for Sand Hill River. Earlier surveys were based on 1:250,000 scale maps available at the time the surveys were completed (Murphy 1970) and did not include habitat readily discernible on the currently available 1:50,000 maps. In order to correct the habitat measurements, a habitat survey was done in 1995 to obtain width measurements, habitat typing to determine the area of the river suitable for parr rearing, and the accessible habitat. The new survey indicates 9.428×10^6 m^2 of rearing habitat and 8,730 ha in fluvial habitat are available. This results in a target egg deposition of 23.544×10^6 eggs which converts to 4,211 small and 1,805 large salmon required to adequately seed the river. Habitat surveys for other rivers in Labrador were also

based on the 1:250,000 survey maps and may underestimate the habitat available for parr rearing similar to the original survey for Sand Hill River.

In conclusion, this paper summarizes the stock status of the salmon population in Sand Hill River, Labrador the first for a Labrador river since 1973. Efforts should continue to obtain assessment information for Labrador rivers in future years.

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Table 1. Summary of Atlantic salmon commercial catch data for Salmon Fishing Area 2, 1974-1995. Weight in metric tonnes. Also shown is percentage change for 1995 in relation to 1994 and the 1984-89, 1986-91 and 1992-94 means.

SALMON FISHING AREA 2

YEAR	SMALL WEIGHT	SMALL NUMBER	LARGE WEIGHT	LARGE NUMBER	TOTAL WEIGHT	TOTAL NUMBER	QUOTA WEIGHT
1974	75	37145	456	93036	530	130181	
1975	110	57560	306	71168	415	128728	
1976	100	47468	349	77796	450	125264	
1977	81	40539	343	70158	425	110697	
1978	23	12535	230	48934	253	61469	
1979	60	28808	120	27073	180	55881	
1980	159	72485	435	87067	595	159552	
1981	179	86426	356	68581	536	155007	
1982	107	53592	249	53085	356	106677	
1983	60	30185	153	33320	213	63505	
1984	24	11695	115	25258	138	36953	
1985	46	24499	76	16789	122	41288	
1986	90	45321	174	34071	264	79392	
1987	128	64351	240	49799	367	114150	
1988	107	56381	153	32386	260	88767	
1989	69	34200	121	26836	190	61036	
1990	43	20699	85	17316	127	38015	
1991	40	20055	36	7679	76	27734	
1992	25	13336	96	19608	121	32944	180
1993	23	12037	46	9651	68	21688	90
1994	10	4535	55	11056	64	15591	60
1995*	9	3981	30	8028	38	12009	48
$\bar{X}$ 84-89	77.3	39407.8	146.5	30856.5	223.5	70264.3	
S.D.	38.7	19812.2	56.8	11107.6	92.0	29617.7	
95% LCL	36.7	18612.8	86.8	19197.9	127.0	39177.4	
95% UCL	118.0	60202.8	206.2	42515.1	320.0	101351.3	
$\bar{X}$ 86-91	79.5	40167.8	134.8	28014.5	214.0	68182.3	
S.D.	35.3	18403.4	71.2	14558.4	105.1	32433.4	
95% LCL	42.5	20851.5	60.1	12733.9	103.7	34140.1	
95% UCL	116.5	59484.1	209.6	43295.1	324.3	102224.6	
$\bar{X}$ 92-94	19.3	9969.3	65.7	13438.3	84.3	23407.7	
S.D.	8.1	4750.9	26.7	5389.1	31.8	8803.4	
95% LCL	-0.9	-1833.5	-0.5	50.1	5.3	1537.1	
95% UCL	39.6	21772.1	131.9	26826.6	163.4	45278.3	
%Change, 1995 vs:							
1994	-10	-12	-45	-27	-41	-23	
$\bar{X}$ 84-89	-88	-90	-80	-74	-83	-83	
$\bar{X}$ 86-91	-89	-90	-78	-71	-82	-82	
$\bar{X}$ 92-94	-53	-60	-54	-40	-55	-49	

Table 2. Summary of Atlantic salmon angling data, 1967 - 1995, Sand Hill River.

YEAR	EFFORT ROD DAYS	SMALL <63 CM	LARGE ≥63 CM	TOTAL CATCH	CPUE	PERCENT SMALL
1967	90	14	5	19	0.21	86
1968	100	10	26	36	0.36	35
1969	.	.	.	.	.	.
1970	115	111	2	113	0.98	.
1971	74	112	0	112	1.51	100
1972	148	219	10	229	1.55	92
1973	272	519	11	530	1.95	100
1974	219	311	10	321	1.47	98
1975	.	.	.	.	.	.
1976	66	165	7	172	2.61	.
1977	.	.	.	.	.	.
1978	127	100	29	129	1.02	.
1979	351	650	5	655	1.87	95
1980	561	691	94	785	1.40	87
1981	.	.	.	.	.	.
1982	382	370	24	394	1.03	.
1983	188	215	7	222	1.18	98
1984	240	184	14	198	0.83	94
1985	169	120	2	122	0.72	99
1986	239	425	12	437	1.83	91
1987	507	702	63	765	1.51	87
1988	340	564	30	594	1.75	96
1989	553	515	27	542	0.98	95
1990	365	372	38	410	1.12	93
1991	691	197	18	215	0.31	95
[1]1992	411	448	25	473	1.15	89
[1]1993	396	258	12	270	0.68	96
[1]1994	499	279	29	308	0.62	91
[1]1995	426	289	28	317	0.74	91
MEAN	301	314	21	335	1.18	91

IN THE ABOVE TABLE A PERIOD INDICATES NO DATA FOR THAT YEAR

[1] figures based only on retained fish

TABLE 3. DAILY COUNT OF UPSTREAM MIGRATING ATLANTIC SALMON AT SANDHILL RIVER 1995.

DATE	NO. GRILSE	NO.SALMON	CUMM TOT-G	CUMM TOT-S	CUMM TOTAL
24/06/95	0	2	0	2	2
25/06/95	0	1	0	3	3
26/06/95	0	5	0	8	8
27/06/95	12	15	12	24	35
28/06/95	8	6	19	30	49
29/06/95	5	10	24	40	64
30/06/95	10	5	35	45	80
01/07/95	6	2	41	47	88
02/07/95	13	8	54	54	108
03/07/95	17	11	71	65	136
04/07/95	27	21	97	86	184
05/07/95	55	20	153	106	259
06/07/95	56	14	209	120	329
07/07/95	50	35	259	155	414
08/07/95	26	10	285	165	450
09/07/95	71	38	356	203	559
10/07/95	39	12	395	215	610
11/07/95	75	30	470	245	715
12/07/95	86	15	556	260	816
13/07/95	62	9	618	269	887
14/07/95	142	40	760	309	1069
15/07/95	132	23	892	332	1224
16/07/95	146	32	1038	364	1402
17/07/95	113	16	1151	380	1531
18/07/95	53	2	1204	382	1586
19/07/95	91	10	1295	392	1687
20/07/95	115	14	1410	406	1816
21/07/95	111	8	1521	414	1935
22/07/95	101	6	1622	420	2042
23/07/95	85	3	1707	423	2130
24/07/95	89	12	1796	435	2231
25/07/95	98	9	1894	444	2338
26/07/95	66	6	1960	450	2410
27/07/95	48	6	2008	456	2464
28/07/95	18	6	2026	462	2488
29/07/95	9	0	2035	462	2497
30/07/95	26	1	2061	463	2524
31/07/95	75	4	2136	467	2603
01/08/95	32	0	2168	467	2635
02/08/95	33	1	2201	468	2669
03/08/95	29	1	2230	469	2699
04/08/95	15	1	2245	470	2715
05/08/95	42	6	2287	476	2763
06/08/95	16	6	2303	482	2785
07/08/95	22	6	2325	488	2813
08/08/95	24	1	2349	489	2838
09/08/95	9	2	2358	491	2849
10/08/95	8	2	2366	493	2859
11/08/95	8	0	2374	493	2867
12/08/95	1	1	2375	494	2869
13/08/95	1	0	2376	494	2870
14/08/95	4	1	2380	495	2875
15/08/95	1	1	2381	496	2877
16/08/95	0	0	2381	496	2877
17/08/95	2	2	2383	498	2881
18/08/95	3	1	2386	499	2885
19/08/95	0	0	2386	499	2885
20/08/95	3	1	2389	500	2889

Table 3 (continued)

DATE	NO. GRILSE	NO.SALMON	CUMM TOT-G	CUMM TOT-S	CUMM TOTAL
21/08/95	4	2	2393	502	2895
22/08/95	1	2	2394	504	2898
23/08/95	6	0	2400	504	2904
24/08/95	7	1	2407	505	2912
25/08/95	1	0	2408	505	2913
26/08/95	6	0	2414	505	2919
27/08/95	3	2	2417	507	2924
28/08/95	32	6	2449	513	2962
29/08/95	25	3	2474	516	2990
30/08/95	4	3	2478	519	2997
31/08/95	8	2	2486	521	3007
01/09/95	1	0	2487	521	3008
02/09/95	10	2	2497	523	3021
03/09/95	13	3	2510	526	3037
04/09/95	5	4	2515	531	3046
05/09/95	5	1	2520	532	3052
06/09/95	3	1	2523	532	3055
07/09/95	5	4	2528	536	3065
08/09/95	3	1	2531	537	3068
09/09/95	3	1	2533	538	3071
10/09/95	8	1	2541	539	3080
11/09/95	3	0	2543	539	3083
12/09/95	3	0	2546	539	3085
13/09/95	1	0	2547	539	3086
14/09/95	3	0	2550	539	3089
15/09/95	3	1	2552	540	3092
16/09/95	3	0	2555	540	3095
17/09/95	3	0	2558	540	3097
18/09/95	3	0	2560	540	3100
19/09/95	1	0	2561	540	3101
20/09/95	0	0	2561	540	3101
21/09/95	0	1	2561	541	3102
22/09/95	0	1	2561	542	3103
23/09/95	0	1	2561	542	3104
24/09/95	0	0	2561	542	3104
25/09/95	0	0	2561	542	3104
26/09/95	0	0	2561	542	3104
27/09/95	0	0	2561	542	3104
28/09/95	0	0	2561	542	3104
29/09/95	1	0	2563	542	3105
30/09/95	0	0	2563	542	3105
01/10/95	1	0	2564	542	3106
02/10/95	1	0	2565	542	3108
03/10/95	3	0	2568	542	3110
04/10/95	0	0	2568	542	3110
05/10/95	0	0	2568	542	3110
06/10/95	0	0	2568	542	3110
07/10/95	3	0	2570	542	3113
08/10/95	0	0	2570	542	3113
09/10/95	0	0	2570	542	3113
10/10/95	0	0	2570	542	3113
11/10/95	0	0	2570	542	3113
12/10/95	0	0	2570	542	3113
13/10/95	0	0	2570	542	3113
14/10/95	0	0	2570	542	3113
15/10/95	0	0	2570	542	3113
16/10/95	3	0	2573	542	3115

Table 4. Summary of Atlantic salmon fence counts at Sand Hill River, 1970-95.

	UNADJUSTED FENCE COUNTS			ADJUSTED FENCE COUNTS			
Year	Number Small	Number Large	Total	Number Small	Number Large	TOTAL	% Small
1970	3,600	138	3,738	3,600	138	3,738	96
1971	3,484	266	3,750	3,484	266	3,750	93
1972	1,879	164	2,040	1,901	168	2,069	92
1973	4,550	487	5,037	4,584	491	5,075	90
1994	1,935	683	2,618	2,006	715	2,721	74
1995	2,228	366	2,594	2,573	542	3,115	82
MEAN	2,346	351	3,293	3,025	387	3,411	89

Table 5. Size and age composition, Atlantic salmon population, Sand Hill River, 1969-95.

1969-73	Number	Mean Length (cm)	Mean Weight (gms)	YEARS IN FRESHWATER (%)					
LIFE STAGE				2	3	4	5	6	7
Smolt	1214	16.0	380	0.2	6.6	52.2	35.3	5.4	0.3
Grilse	2262	53.9	1698	0.0	7.6	58.6	30.2	3.6	0.0
Virgin 2-Sea Year	573	73.4	4177	0.1	8.0	56.2	31.6	4.0	0.1
Successive Spawners[1]	6	63.4	2690	16.7	16.7	50.0	16.7	0.0	0.0
Alternate Spawners[2]	58	77.9	5320	0.0	5.5	56.5	37.1	1.0	0.0
Virgin 3-Sea Year	3	79.2	5550	0.0	66.7	0.0	33.3	0.0	0.0

1994	Number	Mean Length (cm)	Mean Weight (gms)	YEARS IN FRESHWATER (%)					
LIFE STAGE				2	3	4	5	6	7
Smolt	35	16.9	650	-	-	-	-	-	-
*Grilse	156	55.6	1900	0.0	4.5	35.3	50.0	9.0	0.0
Virgin 2-Sea Year	18	76.5	4990	0.0	5.6	44.4	50.0	0.0	0.1
*Successive Spawners[1]	4	69.1	3815	0.0	0.0	0.0	50.0	25.0	0.0
Alternate Spawners[2]	1	86.5	8500	0.0	0.0	0.0	100	0.0	0.0
SIZE									
*Small	162	55.6	1217	0.0	4.3	34.0	48.8	9.3	
*Large	21	75.6	5294	0.0	4.8	42.9	47.6	0.0	

[1] Fish which return each year to spawn.

[2] Fish which spend 1 full year at sea before returning to spawn.

* Includes fish with no river age.

Table 5. Continued

1995 LIFE STAGE	Number	Mean Length (cm)	Mean Weight (gms)	YEARS IN FRESHWATER (%)					
				2	3	4	5	6	7
Smolt	50	16.8	535	0.0	4.0	22.0	50.0	20.0	2.0
*Grilse	147	55.8	1880	0.0	1.4	36.6	34.5	27.6	0.0
Virgin 2-Sea Year	24	74.7	4520	0.0	0.0	25.0	70.8	4.2	0.0
Successive Spawners[1]	4	62.7	2240	0.0	0.0	25.0	50.0	25.0	0.0
SIZE									
*Small	154	55.8	1860	0.0	1.4	36.1	34.7	27.9	0.0
Large	26	74.5	4490	0.0	0.0	26.9	69.2	3.8	0.0

Note: 5 adult salmon have no age information.

[1] Fish which return each year to respawn.

* Includes fish with no River age.

Table 6. Sex ratios from Atlantic salmon sampled at the Sand Hill River counting fence and from combined samples in the Sand Hill Cove commercial and Sand Hill River sports fisheries, 1969-1995.

YEAR	Smolt Samples (fence and angling)		Small Salmon Samples			Large Salmon Samples		
	Sample size	% Female	Sample size	% Female	Mean WW	Sample size	% Female	Mean WW
1969	159	66	22	9		5	100	
1970	212	67	68	10		72	65	
1971	225	52	112	11		31	81	
1972	149	63	184	12		60	77	
1973	465	60	61	20		319	76	
Mean 69-73		61		12	1.7[1]		75	4.3[1]
1994	35	60	155	44	1.87	19	58	4.73
1995	19	53	131	57	1.86	24	96	4.47
1994-1995	54	57	286	50	1.86	43	79	4.55

[1] mean weight for males and females (only available data)

Table 7. Summary of total returns, spawning escapements, egg depositions and percent of target achieved for Sand Hill River salmon stocks in 1970-73 ,1994 and 1995.

YEAR	Total Returns (Number)		Spawning Escapement (Number)		Egg Deposition (No. x 10^6)		% of 1995 Target
	Small	Large	Small	Large	Small	Large	Total
1970	3,600	138	3,489	136	1.342	0.860	9.4
1971	3,596	266	3,484	266	1.474	2.097	15.2
1972	2,038	175	1,819	164	0.840	1.263	8.8
1973	4,761	504	4,242	491	3.264	3.761	29.3
1994	2,159	730	1,880	701	3.501	5,702	39.1
1995	2,781	559	2,492	531	5.979	4.319	43.7

Table 8. Estimated total production of Atlantic salmon from Sand Hill River, Labrador. Commercial exploitation rates were 0.83 to 0.97 for large salmon and 0.28 to 0.51 for small salmon in Nfld and Labrador, Greenland exploitation at 0.22, 1970-73. Exploitation rates were adjusted for decreased licensed effort in 94 & 95, for closure of Newfoundland fishery and for season change in 1995 . Mid-points are in table.

	Total returns to freshwater		Total production prior to commercial fishing		Entrants to freshwater with no commercial change	
Year	Small	Large	Small	Large	Small	Large
70	3600	138	6173	3469	3600	138
71	3596	266	6167	6687	3596	266
72	2038	175	3495	4399	2038	175
73	4761	504	8164	12670	4761	504
94	2159	730	2482	1525	1447	61
95	2781	559	3159	924	1842	37
AVG 70-73	3499	271	6000	6806	3499	271
SD 70-73	1118	165	1916	4136	1340	165
CL-95%	2235	329	3833	8272	2680	329

Table 9. Percent of spawning target achieved for Sand Hill River, Labrador with and without a fishery.

	Total production prior to commercial fishing		% of spawning target achieved with and without commercial fishing	
Year	Small	Large	With a fishery	Without a fishery
70	6173	3469	9.4	103
71	6167	6687	15.2	235
72	3495	4399	8.8	151
73	8164	12670	29.3	439
94	2482	1525	39.1	72
95	3159	924	43.7	64
AVG 70-73	6000	6806	16	232
SD 70-73	1916	4136	10	148
CL-95%	3833	8272	19	297

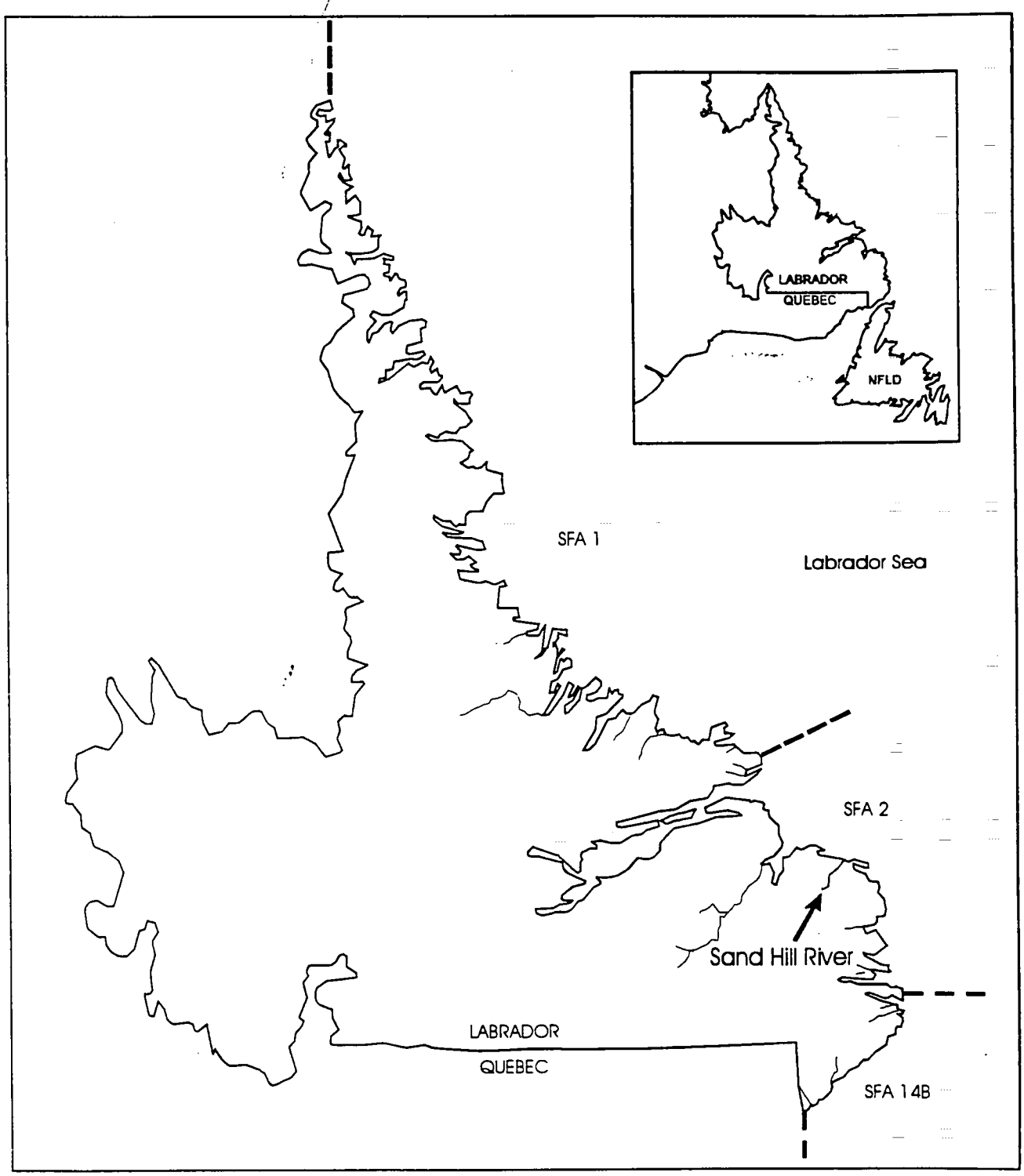


Fig 1. Map of Labrador showing the location of Sand Hill River.

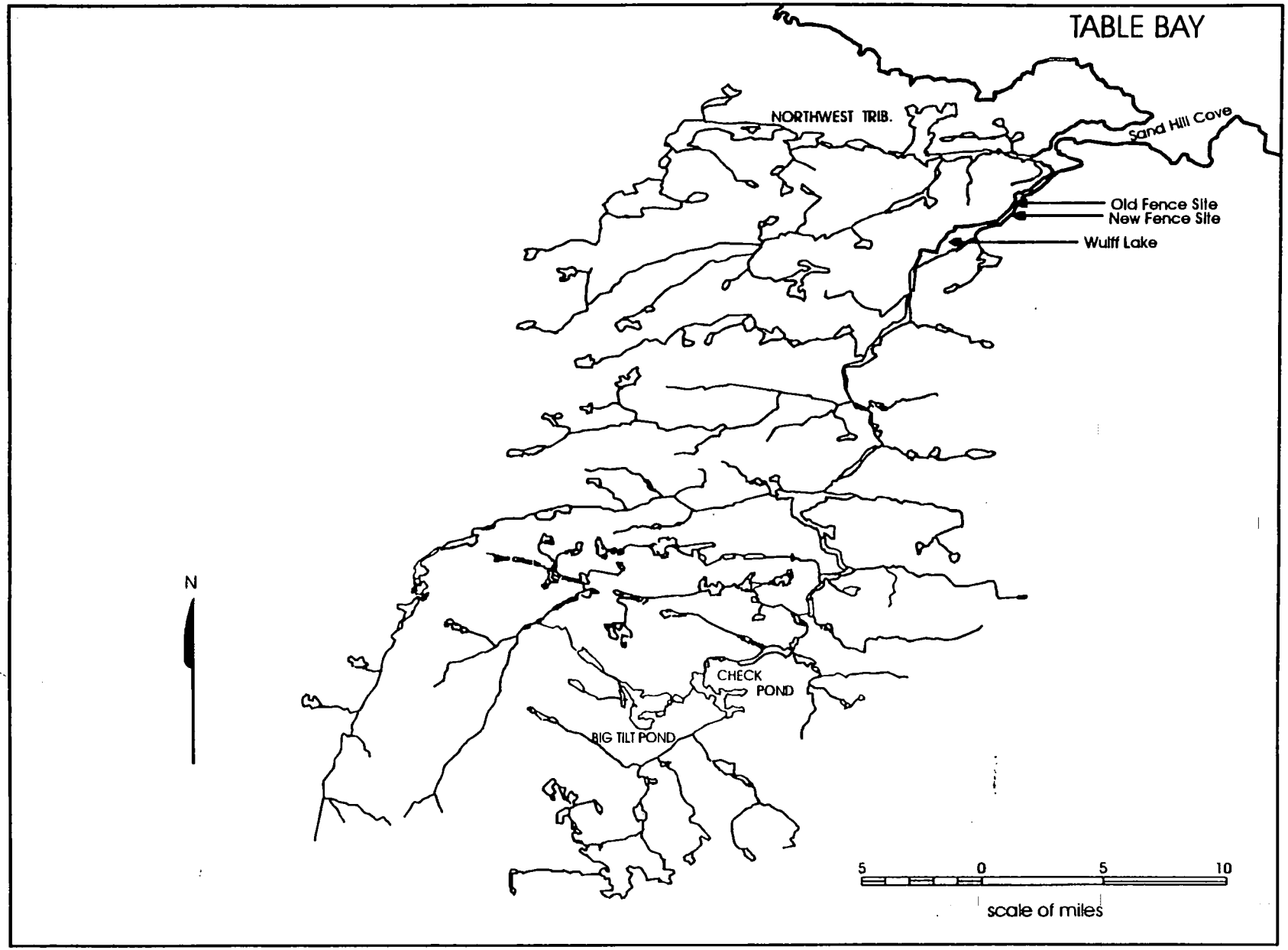
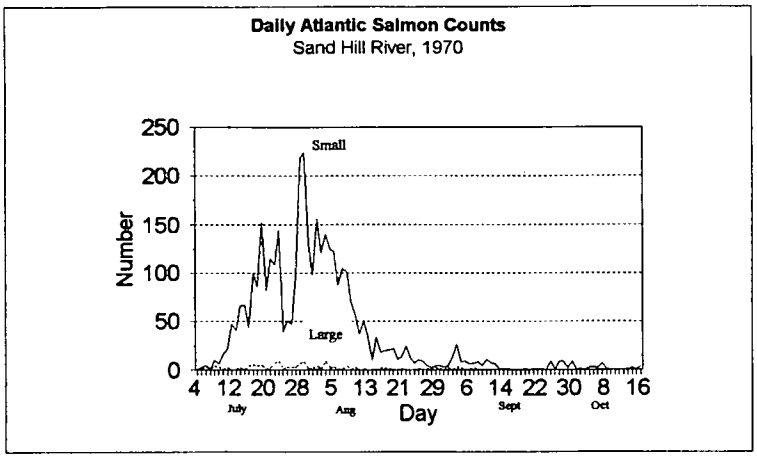
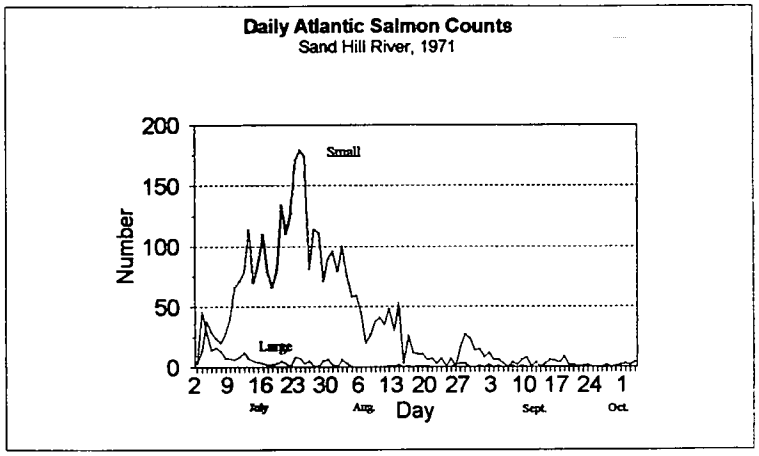
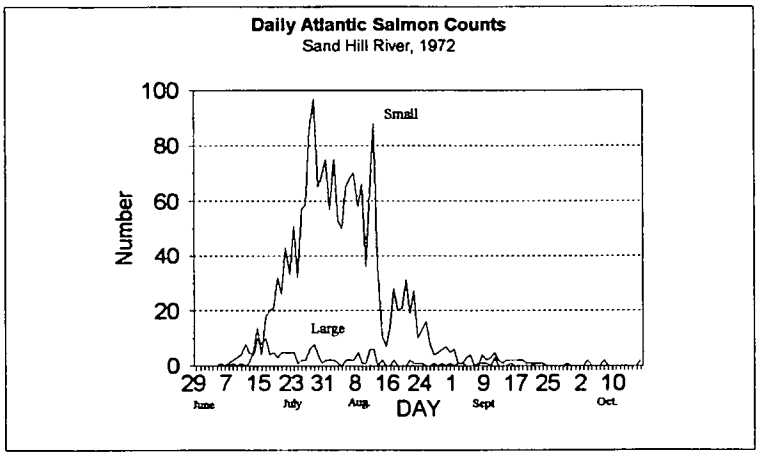
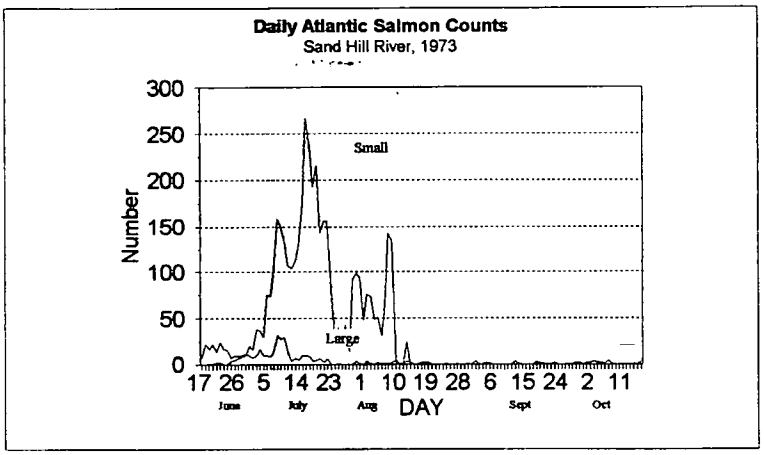


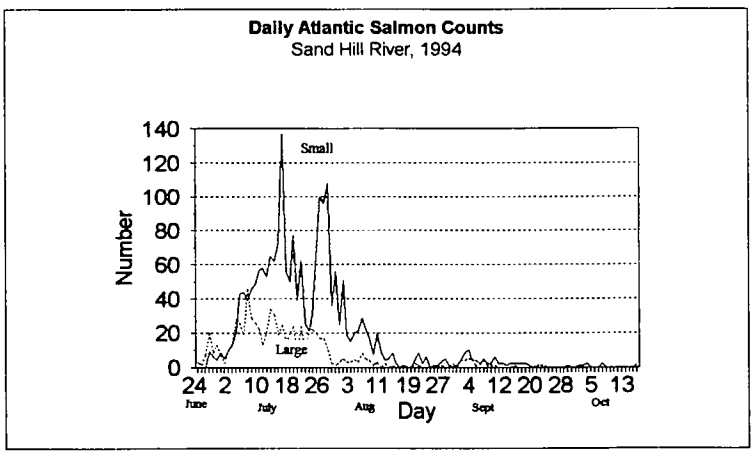
Fig. 2. Map of Sand Hill River watershed and site of counting fences in 1969-73 and 1994.











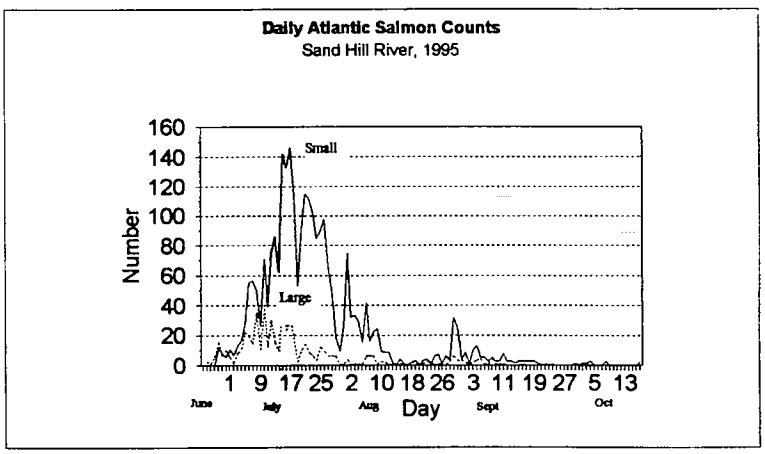
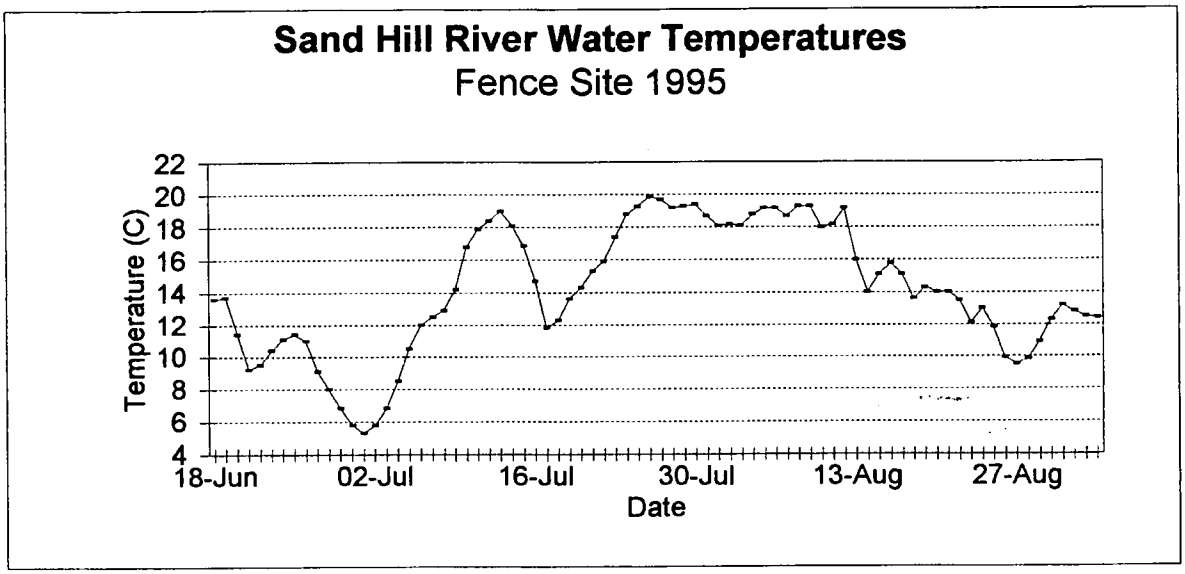
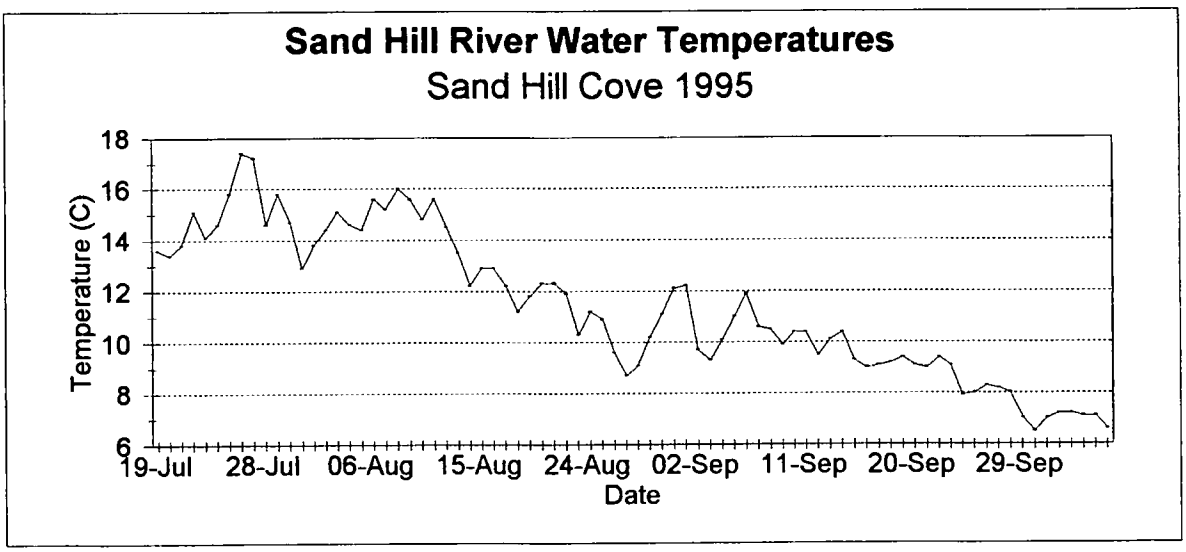


Fig 3. Daily small and large salmon counts from counting fence on Sand Hill River, Labrador, 1970-73, 1994 and 1995.

Figure 4. Water Temperatures at Sand Hill River & Sand Hill Cove,1995.





APPENDIX I

STOCK: Sand Hill River, SFA 2
TARGET: 23.544 million eggs

Year	1989	1990	1991	1992	1993	1994	1995	MIN[1]	MAX[1]	Mean[1]
Recreational catch										
Small	515	372	197	448	258	279	289	100	702	372
Large	27	38	18	25	12	29	28	2	94	25
Smolt counts										
Adult counts										
Small						2159	2781	2038	4761	
Large						730	559	138	730	
% Target eggs met (small +large)						**39.1**	**43.7**			

[1]**Recreational catch is for the period 1974 to 1991. Catches for 1992 - 1993 are retained catches to the time the SFA quota was caught and do not include hook-and-release fish. Catches prior to 1992 and for 1994 are for retained fish for the entire angling season. Counts are for the period 1970-74 ,1994&1995.**

Recreational catches: Catches have ranged from 122 to 785 during the period 1974-95. The number of small salmon retained in 1995 was 289 and 340 were released. The number of large salmon retained was 28 and 14 were released.

Data and assessment: Complete counts of smolt and adult salmon migrations were obtained from portable fish counting fences in 1970-73 and a complete count of adults was done in 1994 & 1995.

State of the stock: Egg deposition in 1995 was 10.3 million eggs which was below target requirements.

Accessible habitat: A new calculation of of available habitat was done to include data collected durning an aerial survey of the system.

Target : Fluvial = 9.428 million m^2; Lacustrine = 8730 ha