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ASSESSMENT OF THE ATLANTIC SALMON POPULATION SAND HILL RIVER, LABRADOR, 1995

by

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ABSTRACT

The status of Atlantic salmon in 1994 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 third year in 1994. Target spawning requirements were derived using a habitat weighted model which utilizes separate conservation target egg deposition values for fluvial and lacustrine habitats. Because of uncertainty in the habitat available for salmon in Sand Hill River two targets were derived. Egg deposition was calculated as 3.50×10^6 for small salmon and 4.35×10^6 for large salmon. The proportion of egg deposition requirements met for the lower and upper targets were 54% and 78%, respectively.

RÉSUMÉ

On a déterminé l'état du stock de saumon de l'Atlantique de la rivière Sand Hill, située au Labrador dans la zone de pêche du saumon (ZPS) 2, en 1994. Les évaluations étaient reliées à la diminution de la pêche commerciale du saumon de l'Atlantique au Labrador, occasionnée par la baisse des quotas et par le moratoire de cinq ans sur la pêche commerciale du saumon dans l'île de Terre-Neuve, qui en était à sa troisième année en 1994. On a établi les besoins-cibles de reproducteurs au moyen d'un modèle pondéré selon l'habitat, qui fait appel à des pontes-cibles de conservation distinctes pour les habitats fluviaux et pour les habitats lacustres. En raison de l'incertitude quant à l'habitat qu'offre au saumon la rivière Sand Hill, deux cibles ont été établies, soit $3{,}50 \times 10^6$ pour le petit saumon et $4{,}35 \times 10^6$ pour le gros saumon. Les besoins ont été comblés à 54 % et 78 % respectivement par rapport à la cible inférieure et à la cible supérieure.

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.

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 smolts 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 smolts and enumeration of returning adults. In addition to this information, other biological, physical and chemical data were collected and as a result 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, a major change was 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, quotas first introduced in 1990, were reduced for Labrador, 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 1992, the Co-operation Agreement for Salmonid Enhancement/Conservation (CASEC), aimed at promoting commercial and recreational angling fisheries was announced. One aspect of this initiative is monitoring 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, was selected to evaluate the change in the fisheries on salmon stocks on the Labrador coast. In this paper, the stock status of the Sand Hill River salmon population in 1994 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 (MS 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

Between June 15 and June 22, 1994 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 June 24 to August 31. 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 installation was complete 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 equal to or greater than 63 cm and small are those less than 63 cm. Salmon were counted manually (without camera equipment) for a four day period in August after a severe wind storm caused excessive siltation that obscured the viewing chamber.

Adult salmon counts for 1972, 1973, and 1994 were adjusted for operating periods based on counts from longer operating periods in 1970 and 1971. The years of 1970 and 1971 reflect the longest time periods of continuous adult counts for this system. Adjustments were made on a yearly basis by determining the number of salmon entering outside of the counting period from the average percentage of the 1970 and 1971 counts that occurred after the fence

was removed for the year. 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-Aug 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.

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 enumeration facilities is by observation of net marks on the fish surviving these activities. In 1994, 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. These observations do not by themselves quantify illegal removals but only indicate that illegal activities might have been taking place.

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 1994 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.

Ovaries collected for relative fecundity estimates 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/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 and parr samples were collected by angling. They were sampled for fork length to the nearest cm, whole weight to nearest 0.1 kg, sex determined visually 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:

(1) $$TRR = RC_b + C$$

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).

(2) $$SE = FR - RC_a$$

EGG DEPOSITION

Egg deposition (ED) was calculated as follows:

(3) $$ED = SE \times PF \times RF \times MW$$

where,

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

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 redone taking measurements from the 1:50,000 topographic maps (Surveys and Mapping Branch, Department of Energy, Mines and Resources, Ottawa) and 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. Due to the lack of an extensive river survey of this system, the amount of classic parr rearing habitat (Elson 1975) has yet to be determined.

Target spawning requirements and potential smolt production

The target or minimum egg deposition requirement for conservation in Sand Hill River (SFA 2) was derived using egg deposition rates of 240 eggs/ 100 m^2 for fluvial parr rearing habitat (Elson 1957; 1975) and 105 eggs/ 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. Minimum spawner requirements in terms of eggs were converted to small and large salmon by the following formula:

$$(4)\quad \text{No. of salmon} = \frac{\text{Target no. of eggs}}{(\%\ \text{small} \times RF \times MW \times \%\ ♀) + (\%\ \text{large} \times RF \times MW \times \%\ ♀)}$$

Total production

Total production by Sand Hill River 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 MS 1981). An average exploitation rate of 0.36 on small salmon and 0.92 on large salmon was used to convert total returns to freshwater to total salmon prior to the commercial fishery for the years 1970-73. Total production was derived by increasing the number of large salmon by 25% to include those potential large salmon caught at Greenland devalued by natural mortality. Total returns to freshwater in 1994 were estimated by reducing exploitation rates on small and large salmon by 75% 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 about 40% of Sand Hill River origin salmon (Reddin and Dempson, unpublished data).

Environmental data

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

RESULTS

Angling and commercial fisheries data

In 1994, the commercial quota for SFA 2 was reduced to 60 metric tonnes (t) from 90 t for 1993. Total commercial catches of 64 t, divided into 9 t small and 54 t large were reported (Table 1). This is a reduction from 1993 and 1984-91 mean catches, but it is unclear if the reductions are due to the reduced quota or the unavailability of salmon. During public meetings salmon fishers reported that large salmon were very abundant but not small salmon and that catches suddenly ended shortly before the quotas closed.

In 1994, the angling salmon fishery in Sand Hill River had a total of 499 rod days (a rod day being a day or any part thereof in which an individual fishes for salmon) for a retained catch of 279 small salmon and 29 large salmon (Table 2). This effort also resulted in 326 small salmon and 7 large salmon released. Almost all effort for this system occurs at 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 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. These statistics show that 124 small and 14 large salmon were retained above the fence and 155 small and 15 large salmon below the fence.

Adult salmon counts

In 1994, a total of 1,935 small salmon and 683 large salmon was counted upstream through the adult fence between June 24 and August 31 (Table 3). Table 3 also includes a correction for salmon after August 31 when the fence was removed. These are adjusted counts for the period the fence was not in operation. The total adjusted count was 2,006 small salmon and 715 large salmon or 73.7% small and 26.3% large. Unadjusted and adjusted counts for 1970-73 and 1994 are shown in Table 4. In 1994, 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. 2 indicate that in 1994, a high percentage of the small salmon returning did so during standard weeks 29 and 30 or the 3rd and 4th weeks of July with 82.4% 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. 2).

Daily angling catch statistics indicated that 155 small salmon and 15 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 returns if they had not been caught. Total returns to the main stem of the river therefore were 2,159 small salmon and 730 large salmon.

Net-marked salmon

Estimates of the numbers of net-marked salmon were made by fence personnel as they viewed the tapes of salmon moving upstream. The number of net-marked salmon was estimated to be ~ 5% of the total count.

Exploitation rates

The combined retained catch in the angling fishery, above and below the fence, was 279 small and 29 large salmon. In 1994, exploitation rates in the angling fishery were 12.9% for small salmon and 4.0% 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
Mean	8.2	2.8

Biological Sampling

In 1994, 183 adult salmon were sampled from the angling fishery. Mean fork length (FL) of the grilse was 55.6 cm (SD=0.30, n=156) and mean whole weight (WW) was 1.90 kg (SD=0.38, n=156) (Table 5). Mean fork length of two-sea winter virgin salmon was 76.5 cm (SD=0.73, n=18) and mean WW was 4.99 kg (SD=1.11, n=18). Mean WW and FL of previous spawners was 4.75 kg (SD=2.68, n=5) and 72.6 cm (SD=1.40, n=5), respectively.

Freshwater (river) age information is available from 179 salmon and is presented along with information for previous years in Table 5. It indicates that 83.6% of the adults have a river age of 4 and 5 years. It also indicates that 87.2% of the fish sampled were virgin one-sea winter fish, 10.0% virgin multi sea-winter fish, and 2.8% previous spawners.

Thirty smolt samples were collected from the lower section of the system in 1994. The mean length was 169.4 mm and mean weight was 65.0 gm (Table 5). Sex information indicated that 60% of smolts were female and 40% were male. Age information was not available at the time of this report.

The percentage of female salmon sampled from the angling fishery in 1994 was 44% (n=155) for small salmon and 58% (n=19) for large salmon (Table 6). The mean weight for small female salmon was 1.87 kg (sd=0.372, n=69) and for large female salmon was 4.73 kg (n=11 and SD=0.599).

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/kg.

Accessible rearing habitat

Murphy (1970) and Pratt *et al.* (1974) calculated a potential fluvial rearing habitat of 2,943,167 sq. meters or 29,432 units (100 m^2) based on a preliminary length of 321.8 km. and a estimated width of 9.144 m.

We calculated the total amount of potential lacustrine parr rearing habitat for Sand Hill River (not including Northwest Tributary) at 8,150 ha. We also calculated a total fluvial length of 1,227.5 km which includes all 1st and 2nd order streams. We know that the habitat from 1st and 2nd order streams was not included in the original calculations as these size of streams are not visible on the 1:250,000 maps used in the original survey (Murphy, 1970). The length of 1st and 2nd order streams not originally included is calculated as our total stream length minus the original stream length. Since the width of the 1st and 2nd order streams was not known, two calculations for the amount of accessible habitat were done based on assumed stream widths of 1 m and 3 m. The following calculations are for the two amounts of potential habitat:

Potential habitat 1 (used to calculate target 1)

200 mi * 30' = 321.8 km * 9.144 m = 29,426 units of rearing habitat

plus an estimate for the 1st and 2nd order tributaries:

1,227.5 (our estimate for total fluvial length) - 321.8 = 905.7

905.7 km * 1 m width (assumed) = 9,057 rearing units

Total rearing units fluvial habitat = 38,483

Habitat for standing water = 8,150 ha

Potential habitat 2 (used to calculate target 2)

200 mi * 30' = 321.8 km * 9.144 m = 29,426 units of rearing habitat

plus an estimate for the 1st and 2nd order tributaries:

1,227.5 (our estimate for total fluvial length) - 321.8 = 905.7

905.7 km * 3 m width (assumed) = 27,171 rearing units

Total rearing units fluvial habitat = 56,597

Habitat for standing water = 8,150 ha

Target spawning requirements and potential smolt production

The estimated target spawning requirement for Sand Hill River in terms of eggs as well as adult salmon were estimated as follows:

Target 1

	Fluvial	Lacustrine	Total
Accessible habitat	3,843,000 m^2	8150 ha.	-
Eggs (No.x 10^6)	9.236	0.856	10.079

Fluvial Rearing Units	38,430 (100 sq.m)
Lacustrine Rearing Area	8,150 ha

Optimal Egg Deposition	Fluvial	240 per rearing unit
	Lacustrine	105 per ha
Fecundity		2,263 eggs/kg.
Small - % overall		74.0
- % female		44.0
mean wt.		1.87
Large - % overall		26.0
- % female		58.0
mean wt.		4.73

Number of spawners to obtain sufficient females:

Required spawners = egg requirements/eggs per spawner

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

$$= \frac{38{,}430 * 240+8{,}150 * 105}{(0.74*0.44*1.87*2{,}263) + (0.26*0.58*4.73*2{,}263)}$$

$$= \frac{10{,}079{,}430}{2{,}992}$$

= 3,369 ---> consisting of 2,493 small salmon and 876 large salmon

Target 2

	Fluvial	Lacustrine	Total
Accessible habitat	5,659,639 m^2	8150 ha.	-
Eggs (No.x 10^6)	13.583	0.856	14.439

Fluvial Rearing Units		56,596 (100 sq.m)
Lacustrine Rearing Area		8,150 ha.
Optimal Egg Deposition	Fluvial	240 per rearing unit
	Lacustrine	105 per ha
Fecundity		2,263 eggs/kg.
Small - % overall		74.0
- % female		44.0
mean wt.		1.87
Large - % overall		26.0

- % female	58.0
mean wt.	4.73

Number of spawners to obtain sufficient females:

Required spawners = egg requirements/eggs per spawner

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

$$= \frac{56{,}596 * 240+8{,}150 * 105}{(0.74*0.44*1.87*2{,}263) + (0.26*0.58*4.73*2{,}263)}$$

$$= \frac{14{,}438{,}790}{2{,}992}$$

= 4,826 ---> consisting of 3,571 small salmon and 1,255 large salmon

Total river returns, spawning escapement, and egg deposition

In 1994, the percent of the egg deposition achieved on Sand Hill River was 77.9% of target 1 and 54.4% of target 2 (Table 7). In the period of 1970-73, percent target egg deposition achieved ranged from a low of 14.3% for target 2 in 1972 to a high of 68.4% for target 1 in 1973. Average values for the period of 1970-73 were 36.5% for target 1 and 25.5% for target 2. 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 Newfoundland and Labrador commercial fishery and at west Greenland were about 5,500 small and 3,200 large (Table 8). In comparison, an estimate of total recruitment for 1994 showed 2,200 small and 1,000 large when adjusted for reduced exploitation in commercial fisheries. Therefore, small and large salmon in 1994 had decreased by 59% and 71%, respectively compared to the 1970-73 means.

Environmental data

Figure 4 indicates the mean water temperature at the fence site and Wulff Lake. The daily mean for the fence site was 15.2 ^{0}C (sd=2.6) and for Wulff Lake was 14.9 ^{0}C (sd=2.4).

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 should be regarded as potential values. Since calculations of target spawning requirements were based on eggs in early stages of development, the occurrence of atresia in a given year on a particular river would increase the number of spawners required.

The target egg deposition attained in 1994 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 for both targets 1 and 2. The large increase in percent of target achieved between 1970-73 and 1994 is in large part due to the increase in the large salmon component which may have 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 1994). Efforts should continue to reduce fishing mortality until 100% of target spawning is achieved.

While reductions in fishing effort have resulted in increased spawning in Sand Hill River, the total production of that stock has declined considerably in 1994 from earlier higher levels. It was noted that small and large salmon in 1994 had decreased by 59% and 71%, 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 1994). If reduced marine survival is continued into future years it may be that spawning populations will also decline from values observed in 1994.

The necessity for two spawning targets was due to the lack of an updated 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 do not include habitat readily discernible on the currently available 1:50,000 maps. To correct this a habitat survey is required to obtain width measurements for this 'new' habitat. Habitat surveys for other rivers in Labrador were also based on the 1:250,000 survey maps and have the same problems as that 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 other Labrador rivers and for Sand Hill River in future years.

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REFERENCES

Anon. MS 1980. Report of the Working Group on North Atlantic Salmon. ICES C.M. 1980/M:10, 52 p.

Anon. MS 1994. Report of the North Atlantic Salmon Working Group. ICES C.M. 1994/M:16, 182 p.

Anderson, T. C. 1985. The Rivers of Labrador. Can. Spec. Publ. Fish. Aquat. Sci. 81: 389p.

Anderson, T. C. and B. P. McDonald. 1978. A portable weir for counting migrating fishes in rivers. Fish. Mar. Serv. Tech. Rep. 733: 13 p.

Ash, E. G. M., and M. F. O'Connell. 1987. Atlantic salmon fishery in Newfoundland and Labrador, commercial and recreational, 1985. Can. Data Rep. Fish. Aquat. Sci. 672: v + 284 p.

Elson, P. F. 1957. Using hatchery reared Atlantic salmon to best advantage. Can. Fish. Cult. 21: 7-17.

Elson, P. F. 1975. Atlantic salmon rivers, smolt production and optimal spawning: an overview of natural production. Int. Atl. Salmon Found. Spec. Publ. Ser. 6: 96-119.

Melnikova, M. N. 1964. The fecundity of Atlantic salmon (***Salmo salar*** **L.**) from the Varguza River. Vopr. Ikhtiol. 4: 469-476.

Murphy, H. P. 1970. A Report of Biological Operations Sand Hill River, Labrador, 1969. In Progress Report No. 89. A Report of Biological Operations Sand Hill River, Labrador 1969, 1970, & 1971.

Murphy, H. P. 1974. Biological operations Sand Hill River, Labrador 1972 and 1973. Internal Report Series No. NEW/1-74-6. 125p.

O'Connell, M. F. and J. B. Dempson. MS 1991. Atlantic salmon (***Salmo salar* L.**) target spawning requirements for rivers in Notre Dame Bay (SFA 4), St. Mary's Bay (SFA 9), and Placentia Bay (SFA 10), Newfoundland. CAFSAC Res. Doc. 91/18, 14 p.

O'Connell, M. F. , J. B. Dempson, and R. J. Gibson. MS 1991. Atlantic salmon (***Salmo salar* L.**) smolt production parameter values for fluvial and lacustrine habitats in insular Newfoundland. CAFSAC Res. Doc. 91/19, 11 p.

O'Connell, M. F. , J. B. Dempson, D. G. Reddin, E. G. M. Ash, and N. M. Cochrane. MS 1994. Status of Atlantic Salmon (***Salmo salar L.***) stocks of SFAs 1-11. Newfoundland Region, 1993. DFO Atlantic Fisheries Res. Doc. 94/49, 78 p.

Peet, R. F. 1971. A report on the counting trap and recommaissance surveys conducted in central coastal Labrador during 1967. Resource Development Branch, Internal Report Series Progress Report No. 68. 283p.

Pratt, J. D., G. M. Hare, and G. M. Murphy. 1974. Investigations of production and harvest of an Atlantic salmon population, Sand Hill River, Labrador. Fish. Mar. Serv. Res. Dev. Branch Tech. Rep. Ser. No. NEW/T-74-1: iii+ 27p.

Prouzet, P., Y. LeBail, and M. Heydorff. 1984. Sex ratio and potential fecundity of Atlantic salmon (***Salmo salar* L.**) caught by anglers on the Elorn River (Northern Brittany, France) during 1979 and 1980. Fish. Mgmt. 15: 123-130.

Reddin, D. G. MS 1981. Estimation of fishing mortality for Atlantic salmon (*Salmo salar L.*) in Newfoundland and Labrador commercial fisheries. ICES C.M. 1981/M:24, 11 p.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Fish. Marine Serv. Bull. 191, 382 p.

Ricker, W. E. 1976. Review of the rate of growth and mortality of Pacific salmon in salt water and non-catch mortality caused by fishing. J. Fish. Res. Bd Canada 33:1483-1524.

Shearer, W. M. (ed.). 1992. Atlantic salmon scale reading guidelines. ICES Cooperative Research Report No. 188, 46 p.

Table 1. Summary of Atlantic salmon commercial data for Salmon Fishing Area 2, 1974 -1994. Weight in metric tonnes. Also shown is percentage change for 1994 in relation to 1993 and 1984 - 89 and 1986 - 91 means.

SALMON FISHING AREA 2

YEAR	SMALL WEIGHT	SMALL NUMBER	LARGE WEIGHT	LARGE NUMBER	TOTAL WEIGHT	TOTAL NUMBER
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
1993	23	12037	45	9651	68	21688
1994*	9	4492	54	11013	64	15505
$\bar{X}$ 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
%Change, 1994 vs:						
1993	-61	-63	20	14	-6	-29
$\bar{X}$ 84-89	-88	-89	-63	-64	-71	-78
$\bar{X}$ 86-91	-89	-89	-60	-61	-70	-77

* Preliminary data.

Table 2. Summary of Atlantic salmon angling data, 1967 - 1994, 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
MEAN	254	270	18	287	1.13	94

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 in Sand Hill River, 1994.

DATE	NO. GRILSE	NO.SALMON	CUMM TOT-G	CUMM TOT-S	CUMM TOTAL
24 06 94	0	3	0	3	3
25 06 94	0	1	0	4	4
26 06 94	0	7	0	11	11
27 06 94	9	20	9	31	40
28 06 94	6	8	15	39	54
29 06 94	4	13	19	52	71
30 06 94	8	7	27	59	86
01 07 94	5	2	32	61	93
02 07 94	10	10	42	71	113
03 07 94	13	14	55	85	140
04 07 94	21	28	76	113	189
05 07 94	43	26	119	139	258
06 07 94	44	19	163	158	321
07 07 94	39	46	202	204	406
08 07 94	46	29	248	233	481
09 07 94	49	26	297	259	556
10 07 94	57	22	354	281	635
11 07 94	58	13	412	294	706
12 07 94	53	20	465	314	779
13 07 94	65	34	530	348	878
14 07 94	62	31	592	379	971
15 07 94	73	19	665	398	1063
16 07 94	137	25	802	423	1225
17 07 94	56	14	858	437	1295
18 07 94	50	20	908	457	1365
19 07 94	77	24	985	481	1466
20 07 94	39	9	1024	490	1514
21 07 94	63	24	1087	514	1601
22 07 94	26	7	1113	521	1634
23 07 94	21	22	1134	543	1677
24 07 94	31	22	1165	565	1730
25 07 94	65	20	1230	585	1815
26 07 94	100	17	1330	602	1932
27 07 94	96	17	1426	619	2045
28 07 94	108	10	1534	629	2163
29 07 94	36	2	1570	631	2201
30 07 94	56	1	1626	632	2258

Cont'd

DATE	NO. GRILSE	NO.SALMON	CUMM TOT-G	CUMM TOT-S	CUMM TOTAL
31 07 94	25	3	1651	635	2286
01 08 94	51	5	1702	640	2342
02 08 94	19	3	1721	643	2364
03 08 94	15	3	1736	646	2382
04 08 94	20	4	1756	650	2406
05 08 94	21	3	1777	653	2430
06 08 94	29	8	1806	661	2467
07 08 94	23	5	1829	666	2495
08 08 94	17	4	1846	670	2516
09 08 94	7	1	1853	671	2524
10 08 94	20	3	1873	674	2547
11 08 94	9	0	1882	674	2556
12 08 94	4	2	1886	676	2562
13 08 94	5	0	1891	676	2567
14 08 94	8	1	1899	677	2576
15 08 94	2	0	1901	677	2578
16 08 94	0	0	1901	677	2578
17 08 94	1	0	1902	677	2579
18 08 94	0	0	1902	677	2579
19 08 94	0	0	1902	677	2579
20 08 94	5	2	1907	679	2586
21 08 94	8	1	1915	680	2595
22 08 94	2	0	1917	680	2597
23 08 94	6	0	1923	680	2603
24 08 94	0	0	1923	680	2603
25 08 94	1	0	1924	680	2604
26 08 94	1	0	1925	680	2605
27 08 94	3	1	1928	681	2609
28 08 94	5	0	1933	681	2614
29 08 94	1	0	1934	681	2615
30 08 94	0	2	1934	683	2617
31 08 94	1	0	1935	683	2618
		Adjusted			
01 09 94	4	4	1939	687	2626
02 09 94	8	4	1947	691	2638
03 09 94	10	5	1957	696	2653
04 09 94	4	5	1961	701	2662
05 09 94	4	1	1965	702	2667
06 09 94	2	1	1967	703	2670
07 09 94	4	5	1971	708	2679

Cont'd

DATE	NO. GRILSE	NO.SALMON	CUMM TOT-G	CUMM TOT-S	CUMM TOTAL
08 09 94	2	1	1973	709	2682
09 09 94	2	1	1975	710	2685
10 09 94	6	1	1981	711	2692
11 09 94	2	0	1983	711	2694
12 09 94	2	0	1985	711	2696
13 09 94	1	0	1986	711	2697
14 09 94	2	0	1988	711	2699
15 09 94	2	1	1990	712	2702
16 09 94	2	0	1992	712	2704
17 09 94	2	0	1994	712	2706
18 09 94	2	0	1996	712	2708
19 09 94	1	0	1997	712	2709
20 09 94	0	0	1997	712	2709
21 09 94	0	1	1997	713	2710
22 09 94	0	1	1997	714	2711
23 09 94	0	1	1997	715	2712
24 09 94	0	0	1997	715	2712
25 09 94	0	0	1997	715	2712
26 09 94	0	0	1997	715	2712
27 09 94	0	0	1997	715	2712
28 09 94	0	0	1997	715	2712
29 09 94	1	0	1998	715	2713
30 09 94	0	0	1998	715	2713
31 09 94	0	0	1998	715	2713
01 10 94	1	0	1999	715	2714
02 10 94	1	0	2000	715	2715
03 10 94	2	0	2002	715	2717
04 10 94	0	0	2002	715	2717
05 10 94	0	0	2002	715	2717
06 10 94	0	0	2002	715	2717
07 10 94	2	0	2004	715	2719
08 10 94	0	0	2004	715	2719
09 10 94	0	0	2004	715	2719
10 10 94	0	0	2004	715	2719
11 10 94	0	0	2004	715	2719
12 10 94	0	0	2004	715	2719
13 10 94	0	0	2004	715	2719
14 10 94	0	0	2004	715	2719
15 10 94	0	0	2004	715	2719
16 10 94	2	0	2006	715	2721

Table 4. Summary of Atlantic salmon fence counts at Sand Hill River, 1970-94.

	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
MEAN	3,090	348	3,438	3,115	356	3,471	90

Table 5. Size and age composition, Atlantic salmon population, Sand Hill River, 1969-94.

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	-	7.6	58.6	30.2	3.6	-
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	-	-
Alternate Spawners[2]	58	77.9	5320	-	5.5	56.5	37.1	1.0	-
Virgin 3-Sea Year	3	79.2	5550	-	66.7	-	33.3	-	-

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	7.80	5294	0.0	4.8	42.9	47.6	0.0	

[1] Fish which return each year to respawn

[2] Fish which spend 1 full year at sea before returning 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, 1969-1994.

YEAR	Smolt Samples (fence and angling)		Small Salmon Samples			Large Salmon Samples		
	Number	% Female	Number	% Female	Mean WW	Number	% 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

[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 and 1994.

YEAR	Total Returns (Number)		Spawning Escapement (Number)		Egg Deposition (No. x 10^6)		% of Target 1	% of Target 2
	Small	Large	Small	Large	Small	Large	Total	Total
1970	3,600	138	3,489	136	1.342	0.860	21.8	15.3
1971	3,596	266	3,484	266	1.474	2.097	35.4	24.7
1972	2,038	175	1,819	164	0.840	1.263	20.5	14.3
1973	4,761	504	4,242	491	3.264	3.761	68.4	47.8
1994	2,159	730	1,880	701	3.501	4.352	77.9	54.4

Table 8. Estimated total production of Atlantic salmon from Sand Hill River, Labrador. Exploitation rate in 1969-71 was small 0.36 and large 0.92 (Reddin, 1981). Greenland exploitation was accounted for at 20%. 94 exploitation at 0.1-small & 0.25-large due to 75% reduction in effort and quota.

		Total returns to freshwater		Total production	
Year	Smolts	Small	Large	Small	Large
70	50494	3600	138	5625	1656
71	55000	3596	266	5619	3192
72	37007	2038	175	3184	2100
73	47724	4761	504	7439	6048
94	NA	2159	730	2399	973
Avg 70-73		3499	271	5467	3249
SD 70-73		1118	165	1746	1974
CL-95%		2235	329	3492	3949

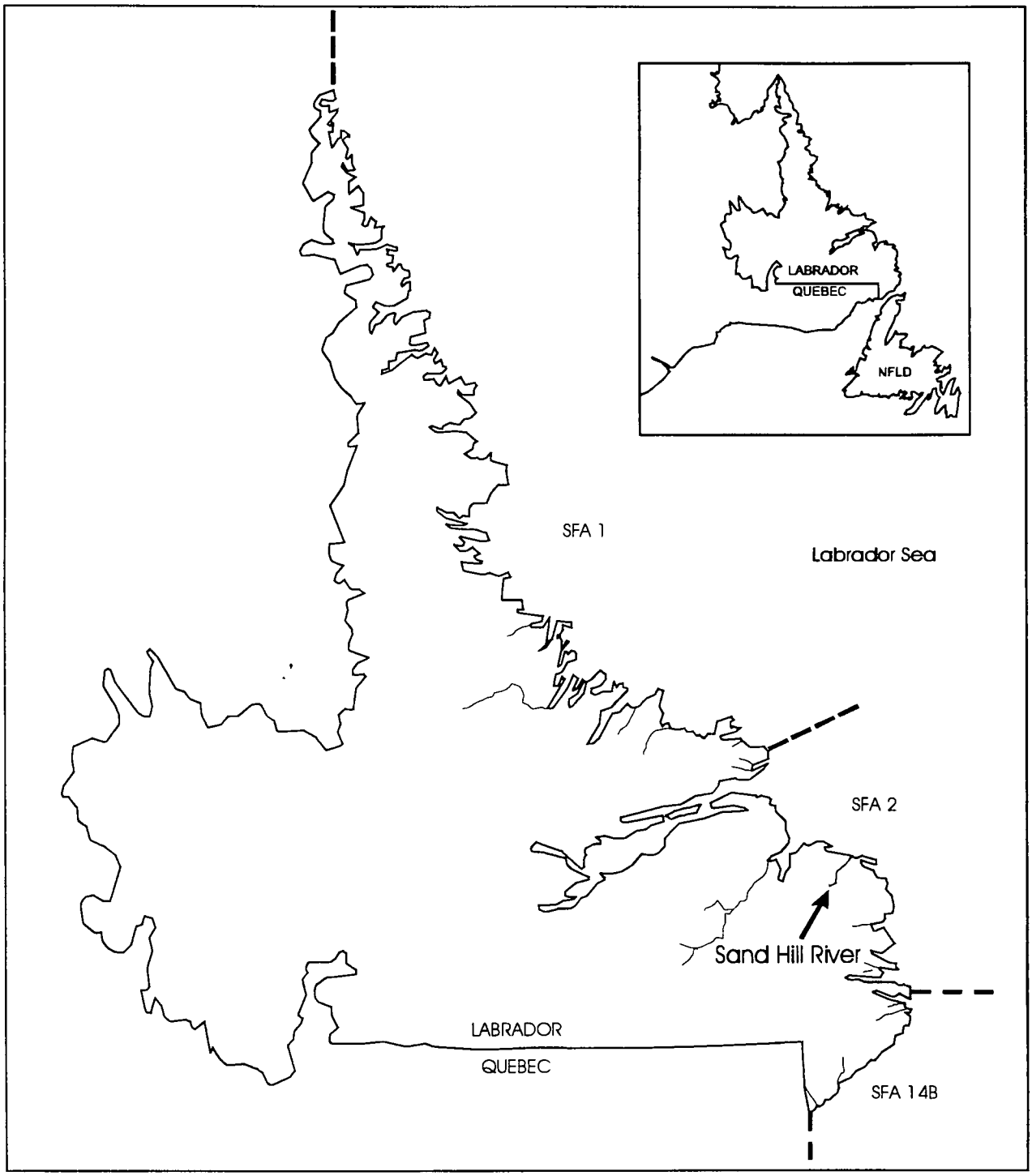


Fig 1. Map of Labrador showing the location of Sand Hill River.

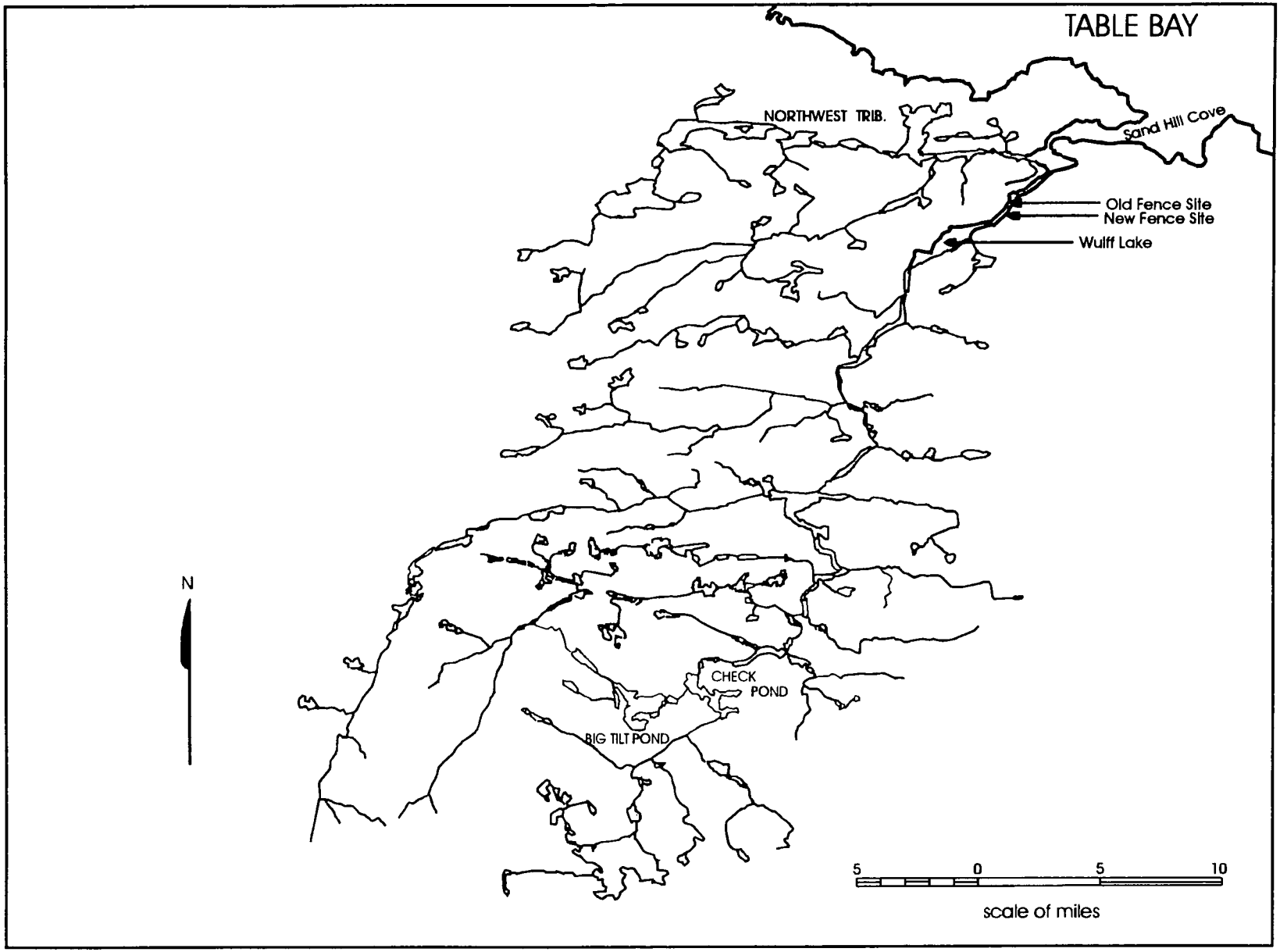


Fig. 2. Map of Sand Hill River watershed and site of counting fences in 1969-73 and 1994.

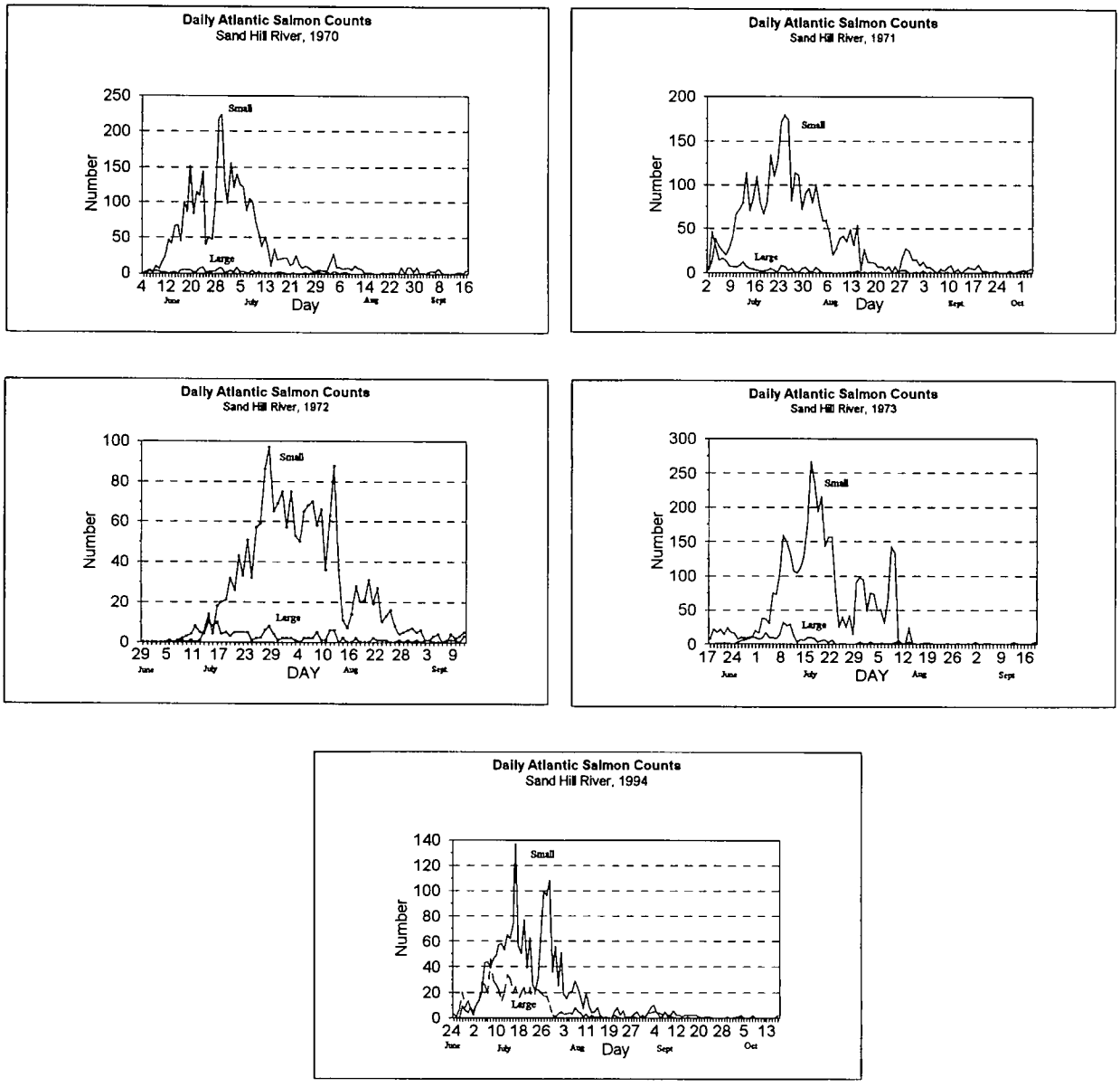
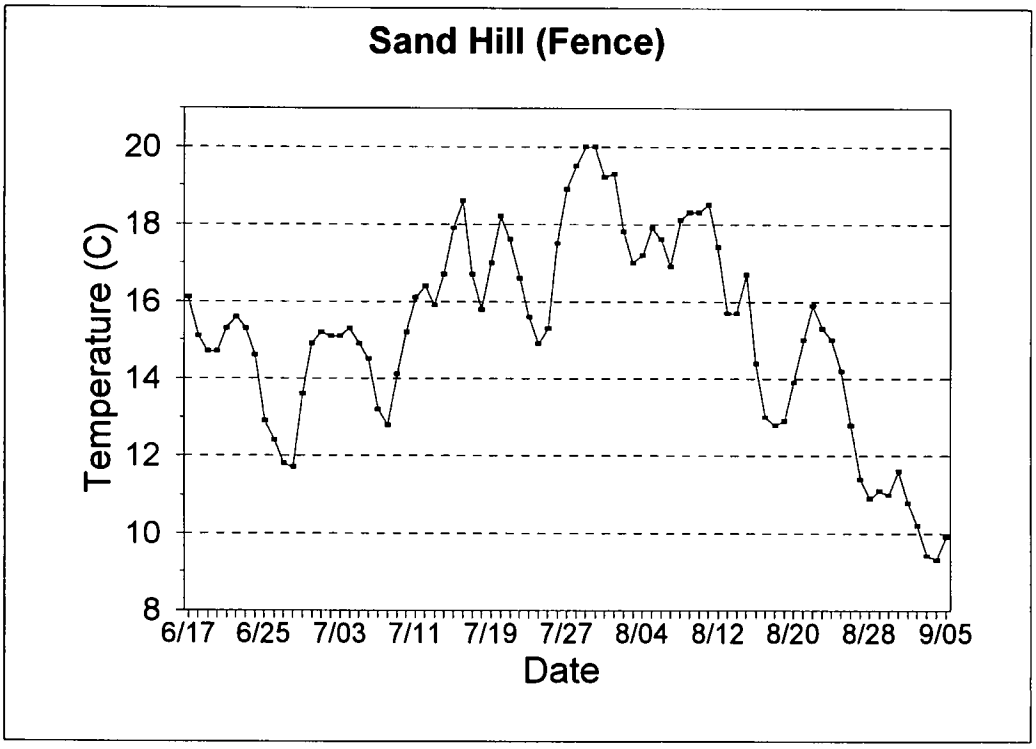


Fig 3. Daily small and large salmon counts from counting fence on Sand Hill River, Labrador, 1970-73 and 1994.



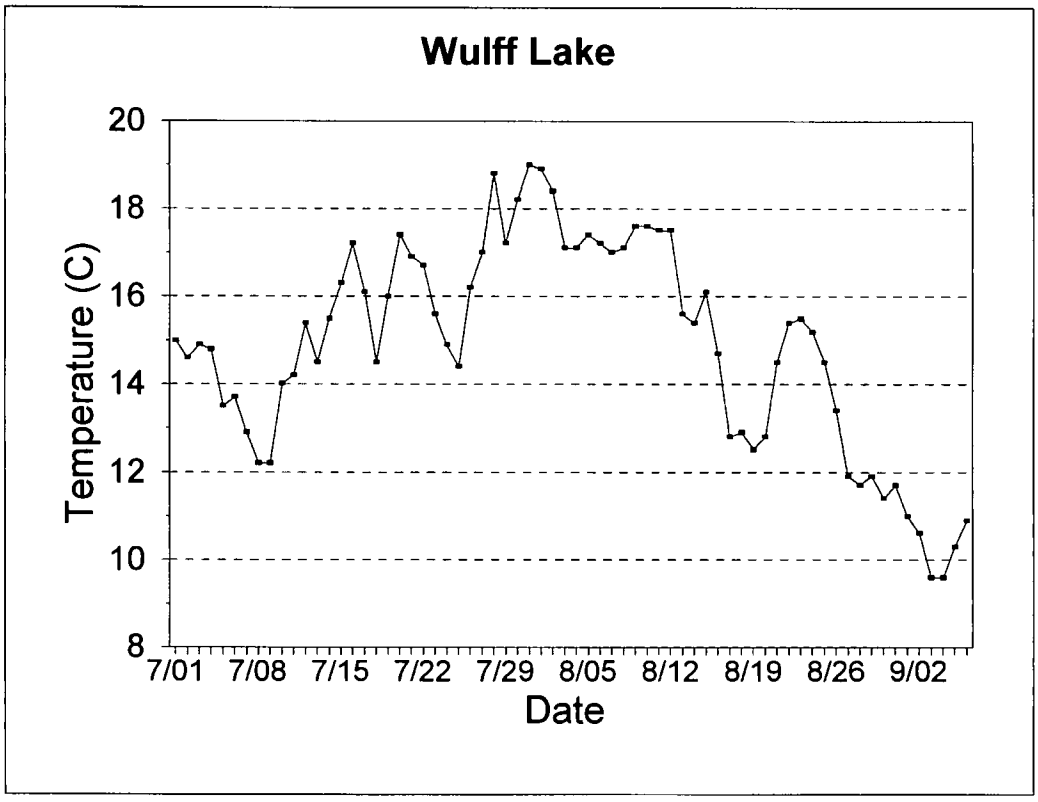


Fig. 4 Mean water temperatures at Sand Hill River fence site and Wulff Lake, 1994.

APPENDIX I

STOCK: Sand Hill River, SFA 2
TARGET: No. 1 - 10.079 million eggs, No. 2 - 14.439 million eggs.

Year	1989	1990	1991	1992	1993	1994	MIN[1]	MAX[1]	Mean[1]
Recreational catch									
Small	515	372	197	448	258	279	100	702	372
Large	27	38	18	25	12	29	2	94	25
Smolt counts									
Adult counts									
Small						2159	2038	4761	
Large						730	175	730	
% Target 1 eggs met (small +large)						77.9			
% Target 2 eggs met (small+large)						54.4			

[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.

Recreational catches: Catches have ranged from 122 to 765 during the period 1974-94. The number of small salmon retained in 1994 was 279 and 326 were released. The number of large salmon retained was 29 and 7 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.

State of the stock: Egg deposition in 1994 was 7.85 million eggs which was below target requirements.

Accessible habitat: Because of the unavailability of information on some of the physical parameters of this system, two different amounts of accessible habitat were calculated.

Target 1: Fluvial = 3.843 million m^2; Lacustrine = 8150 ha

Target 2: Fluvial = 5.660 million m^2; Lacustrine = 8150 ha