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Assessment of the Atlantic salmon population of Conne River, Newfoundland, in 1990

by

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Abstract

Results obtained from a fish counting fence provided the basis for the assessment of the Atlantic salmon population of Conne River, Newfoundland, SFA 11, in 1990. Returns to home waters (river and estuary) were 5,383 salmon < 63 cm in length and 361 salmon ≥ 63 cm in size. This represented an increase of 8% for small salmon over 1989 but was more than 20% less than expected. Large salmon were up 13% over 1989. Estimated egg deposition from small and large salmon in 1990 was 7.07 and 1.17 million eggs, respectively; 106% of the target requirement of 7.8 million eggs. The recreational catch of 767 small salmon was 26% less than the previous year with estimated effort (rod-days) down 38%. This decrease was largely due to a partial closure of the recreational fishery from July 1-26 to allow additional spawners to enter the river. The native food fishery reported a catch of 966 salmon, the highest catch to date. Sea survival was comparable to that estimated for 1988-89, but still low relative to 1987-88. A mark-recapture study indicated a smolt run in 1990 of 60,885 fish (56,042-65,728); 20% lower than 1989. Unless sea survival is considerably higher than values previously recorded at Conne River, then total returns in 1991 will be less than that observed during 1986-88. If sea survival is similar to that estimated for the past two years, then returns will be lower than that observed during the past two years with little surplus available for harvest.

Résumé

Les résultats obtenus à un barrage de dénombrement du poisson sont à la base de l'évaluation de la population de saumons de l'Atlantique de la rivière Conne (T.-N.), ZPS 11, en 1990. Quelque 5 383 saumons < 63 cm et 361 saumons ≥ 63 cm ont remonté dans les eaux d'origine (rivière et estuaire). En ce qui concerne le petit saumon, ces remontées étaient supérieures de 8 % à celles de 1989 et dépassaient de 20 % la prévision. Dans le cas du gros saumon, les remontées étaient supérieures de 13 % à celles de 1989. Le nombre estimé d'oeufs déposés par les petits et gros saumons en 1990 était respectivement de 7,07 et 1,17 millions, soit 106 % du nombre-cible (7,8 millions d'oeufs). Les prises sportives étaient de 767 petits saumons, c'est-à-dire 26 % de moins que celles de l'année précédente, tandis que l'effort estimé (jour de pêche)avait diminué de 38 %, en raison principalement d'une fermeture partielle de la pêche sportive, du 1er au 26 juillet, pour permettre à un plus grand nombre de géniteurs de remonter la rivière. Dans la pêche de subsistance des autochtones, les prises déclarées s'établissent à 966 saumons, soit les plus hautes jusqu'ici. Les résultats relatifs à la survie en mer étaient comparables aux estimations établies pour 1988-1989, quoique encore bas par rapport à ceux de 1987-1988. Une expérience de marquage-recapture a révélé que la remontée de saumoneaux se chiffrait à 60 885 poissons (56 042-65 728), c'est-à-dire 20 % de moins qu'en 1989. À moins que la survie en mer ne soit beaucoup plus élevée qu'auparavant dans la rivière Conne, les remontées totales de 1991 seront inférieures à celles que l'on a connues en 1986-1988. En revanche, si la survie en mer reste comparable à ses estimations des deux dernières années, les remontées seront plus basses que celles de 1989 et 1990 et il restera peu de surplus pour la récolte.

Introduction

Conne River, SFA 11 (Fig. 1), is one of the most important salmon rivers in Newfoundland. Over the combined period 1983-89 Conne River had the second highest recreational catch in the Newfoundland Region behind that of Gander River. Since 1986, a fish counting fence has been operated to enumerate the upstream migrating population of Atlantic salmon. Mark-recapture studies were initiated in 1987 to survey the number of outward migrating smolts. Both of these operations continued in 1990. The objective of this paper is to present an assessment of the Atlantic salmon population of the Conne River for 1990. Catch data from various fisheries are reviewed, biological characteristic data of the stock updated, salmon returns and spawning escapements are estimated and compared with earlier years and previous forecasts, and a forecast of adult returns in 1991 is provided.

Background

As in past years, Atlantic salmon stocks of the Conne River potentially could contribute to commercial, recreational, and native food fisheries during 1990. The opening and closing dates for these fisheries are summarized in Table 1. Restrictions for the native food fishery were similar to past years and were as follows: 1) a total quota of 1200 salmon; 2) fishing was restricted to the Conne River estuary and the use of two trap nets or a combination of one trap net and two gillnets; 3) mesh size of gillnets was restricted to 127 mm or larger; 4) maximum weekly harvest levels were 200 fish form June 4-10, 400 fish from June 11-17, 400 fish from June 18-24, with the remainder of the quota during other weeks of the fishery. The food fishery was allowed to open May 30 this past year. Both recreational and food fisheries were prohibited from retaining salmon $\geq$ 63 cm, although salmon of this size found dead in the food fishery gear could be retained and counted against the quota.

A major management incentive this past year included the introduction of zonal quotas in the commercial fishery. A mid-season review was also carried out to determine if additional management restrictions were necessary. The quota for SFA 11 was set at 25 tonnes, about 50% less than the 1984-89 commercial catch in this area. A mid-season evaluation of the Conne River indicated that target spawning escapements were likely not going to be met and as a result it became the first river in the Newfoundland Region to have the recreational fishery closed in mid-season because of low escapements. The native food fishery was also temporarily halted to try and allow additional spawners to enter the river.

Methods

1. Landings in 1990

Data on landings in the recreational fishery were collected by Department of Fisheries and Oceans (DFO) Fisheries Officers and guardians and processed by DFO Science Branch personnel. Estimates of the recreational catch below the fish counting fence (first allowed in 1989) were obtained from Science Branch personnel operating the fish counting fence. Landings in the native food fishery were obtained from the Conne River Native Band Council. Commercial landings for Statistical Section 36 of SFA 11 were obtained from Fisheries Statistics and Systems Branch of DFO.

2. Biological characteristics

Biological characteristic information on adult salmon, including fork length, whole weight, age and sex, was obtained from sampling salmon caught in the recreational fishery. Age and length data were also obtained from fish sampled at the fish counting trap following the closure of the recreational fishery. Biological data from Atlantic salmon smolts were obtained from specimens sampled at the downstream counting trap. Comparisons of the river age distribution of smolts among years, and of smolts in year i with grilse in year i+1 were carried out using likelihood ratios statistics (G^2 - test). Analyses of smolt condition factor, whole weight, and fork length were performed on rank transformed data (Conover 1980; Conover and Iman 1981).

3. Estimated returns and spawning escapement

Adult Atlantic salmon migrants were enumerated at a fish counting fence, located about 1 km upstream from the mouth of the Conne River (Fig. 1), which operated from May 23 to August 6, 1990 (Table 2). Total returns were estimated from:

Total returns = count of fish at the counting fence + known mortalities below the fence + recreational catch below the fence + an estimate of the number of Conne River origin salmon caught in the native food fishery.

Similar to past years (Dempson 1988, 1989), the estimated proportion of Conne River origin salmon in the food fishery was an average value calculated during 1986 and 1987 and was 0.833.

Number of spawners were estimated from:

Spawners = salmon released at the counting fence - known mortalities above the fence - unrecorded mortalities - angling catch above the fence.

Unrecorded mortalities, which include natural mortality in the river prior to spawning and illegal removals, were assumed to be 5% of the number released upstream at the counting fence as in past years (Porter et al. 1986; Dempson et al. 1987; Dempson 1988, 1989).

Egg deposition was calculated separately for salmon < 63 cm and salmon $\geq$ 63 cm and then totaled.

Egg deposition = spawners x % female x fecundity at mean length.

An estimate of fecundity was obtained from the relationship derived in 1987 (October 27-30) from ripe salmon (Dempson et al. 1987):

$$\textbf{Fecundity} = 0.198\ (\text{fork length, cm})^{2.3943}$$
$$(r^2 = 0.48,\ P < 0.001)$$

where length is the mean length of female salmon < 63 cm in size sampled in 1990.

An estimate of the egg deposition from salmon ≥ 63 cm in size was obtained using the same length-fecundity relationship for salmon < 63 cm in size, with the same data for mean length (67.8 cm) as used in the 1989 assessment (Dempson 1989) as no new data were available. Similarly, the estimate of percent females for the large salmon component was also taken from the 1989 assessment (71%).

The target spawning requirements were the same as in previous years at **7.8 million eggs** or approximately **4000 salmon < 63 cm**. Egg deposition from salmon ≥ 63 cm has been considered as a buffer in relation to the management target of 4000 salmon < 63 cm.

4. Forecast of 1991 returns

A mark-recapture study was carried out to estimate the smolt production in 1990. The study was similar to those carried out during the past three years which used two partial counting fences, located about 10 km apart to catch migrating smolts. Smolts were tagged with individually numbered Floy streamer tags. As in past years, smolts were not anesthetized.

In previous years a maximum likelihood estimate derived by Darroch (1961) for a two-sample stratified population was applied to estimate the smolt population (Dempson and Stansbury 1991). In each year, a variety of time intervals (between 4 and 8) were used to stratify the data resulting in a similar number of population estimates. The subsequent estimates were usually close differing by less than 6% from the highest to the lowest value, but gave rise to the question of which time-interval stratification was 'best'. Generally, the smolt estimate with the lowest variance was chosen.

Continued interest in this problem led to the development of a new estimator which has been applied to the 1990 data as well as to update previous information from 1987-89. The new estimator (details will be found in Schwarz and Dempson 1991) includes parameters to describe the mean time for smolt to migrate between the two locations and to describe the probability of capture on a particular date. It can also incorporate the influence of environmental factors (temperature, discharge) into the estimate. The new estimator allows for unequal recapture probabilities on each day of recapture and, therefore, can derive daily estimates of the run of smolts.

A forecast scenario of adult returns in 1991 was derived by applying observed survival estimates from smolts to returning adults from the previous three years to the estimated smolt output in 1990.

Results

1. Landings in 1990

Table 3 summarizes the commercial landings of small and large salmon from Statistical Section 36, SFA 11, from 1974-90. Preliminary landings in 1990 of 3.3 t of small salmon and 5.8 t of large salmon were below 1989 values, possibly in relation to the zone quota of 25 t, and 65% and 45% respectively below the previous 5-year means (1985-89, small = 9.5 t, large = 10.5 t).

Landings in the recreational fishery are summarized in Table 4 and Figure 2. Native food fishery catches are also provided in Table 4. The recreational catch of 767 fish was 26% lower than in 1989 and 57% below the previous 5-year mean of 1793 fish. A total of 213 fish were angled in the lower section of the river below the fish counting fence. The reported number of rod-days fished also decreased by 38%. Much of this decline can be attributed to the closure of the sport fishery from July 1 to July 26. Approximately 23% (N = 174) of the recreational catch occurred following the reopening of the fishery on July 27. The native food fishery reported a catch of 966 small salmon; up considerably from 1989 and 59% greater than the previous highest catch of 609 fish in 1988. An additional 50 salmon were reported to have been found dead and partially destroyed in the food fishery traps.

Estimates of angling exploitation rate over the entire season have varied from 16.5 to 27.5% for the period 1986-90 (Table 5). In 1990, the exploitation rate up until the time that the sport fishery was closed (July 1) was 28.5%.

2. Biological characteristics

Biological characteristic information was obtained from 271 smolts and 174 grilse sampled during 1990 (Table 6). Smolts averaged 148 mm in fork length with an average river age of 3.29 years. Seventy-four percent of the out going smolts were female.

There were significant differences in smolt condition factor (P = 0.0001), whole weight (P = 0.0001), and fork length (P = 0.0001) among years with contrasts indicating that condition and whole weight of smolts in 1990 were both significantly less in comparison with earlier years. Grilse averaged 508 mm in fork length with a mean river age of 3.27 years. Eighty-one percent of the grilse were female. River age distribution of smolts in 1989 was similar to that of the returning grilse in 1990 ($G^2 = 2.25$, $P = 0.523$). No additional data were obtained for large salmon.

3. Estimated returns and spawning escapement

There were 4321 salmon < 63 cm and 361 salmon ≥ 63 cm counted at the fish counting fence on Conne River in 1990 (Table 7). This represents a decrease of 3% in the number of small salmon and an increase of 13% in the number of large salmon counted in comparison with 1989. Both values, however, fall well short of the highest counts observed in 1987. Peak run of small salmon was in standard week 26 (June 25 - July 1) with the single largest daily run occurring on July 5 (Fig. 3). Mean timing of the run (in standard weeks) for both small and large salmon for the past five years is as follows:

	Small salmon	Large salmon
1986	25.93	24.86
1987	25.68	24.56
1988	26.31	25.47
1989	25.28	24.66
1990	26.56	25.92

The run of both small and large salmon was somewhat later during 1990 in comparison with other years (Figs. 4). Cooler water temperatures prevailed during the spring at Conne River (Table 8, Fig. 5) and at Station 27 (Fig. 6) which may have influenced the run timing in 1990.

Total returns of adult salmon to Conne River (and estuary) in 1990 are summarized in Table 9. The estimate of small salmon returns was 8% greater than that of 1989 while large salmon returns were 13% higher. Predicted return for 1990 was expected to have been greater than that of 1989 at 6824-7896 small salmon. This was based on assuming an average sea survival over two years of 9.4% (Dempson 1989). While the forecast was in the right direction, the magnitude was incorrect since the actual return of small salmon was 21% below the predicted lower limit. Table 10 summarizes the previous forecasts relative to actual returns for Conne River. Results for 1990 suggest that sea survival was 7.0% (Table 11).

Last year it was observed that there was a differential survival between age 3+ and 4+ smolts. While this was not apparent in 1990, it is interesting to note that an identical pattern was also observed for Northeast Brook Trepassey (SFA 9) (Table 12).

Spawning escapement in 1990 was estimated to be 3549 salmon <63 cm and 343 salmon ≥ 63 cm (Table 9). These values are 5% and 13% higher than those of 1989. Increased spawning escapement of small salmon was largely related to the decreased recreational catch resulting from the mid-season closure of the fishery.

Mean length of female salmon in 1990 was 51.2 cm, which results in a mean number of eggs per fish of 2459. The percentage of females in the run was 81%.

Estimated total number of eggs deposited were:

salmon $<$ 63 cm = 7.07×10^6 eggs

salmon $\geq$ 63 cm = 1.17×10^6 eggs

for a **total egg deposition** of 8.24×10^6 eggs. With angling exploitation rate approaching 30% early in the season, the target would not have been achieved without the closure of the sport fishery.

4. Estimated smolt run of 1990 and forecast of 1991 returns

In 1990, 3,719 smolts were tagged and released at the upstream partial fence site (Fig. 1). At the downstream recapture site 13,863 smolts were caught, including 943 tagged smolts. Figure 7 illustrates the number of migrating smolts caught by day at the downstream recapture site in relation to mean daily water temperature and discharge. Colder temperatures during the spring of 1990 (Fig. 5) appear to have delayed the run of smolts relative to previous years (Fig. 4).

The estimated number of smolts in 1990 was 60,885 (95% Confidence limit = 56,042 - 65,728) (Table 13). Smolt numbers for the other years in the table reflect values derived from the new estimator. The percentage of smolts at each river age and the estimated number of smolts in each age group are summarized in Tables 13 and 14 respectively.

A forecast of the number of adults expected to return in 1991 is summarized in the following matrix where the minimum, mean, and maximum smolt to adult survival rates observed at Conne River (based on only 3 years of data) are applied to the 95% confidence limits of the 1990 smolt estimate:

% Survival	Lower limit	Upper limit
7.0	3,923	4,601
8.1	4,539	5,324
10.2	5,716	6,704

In general, unless sea survival is considerably higher than estimates previously recorded at Conne River, then total returns in 1991 will be less than that observed during 1986-88. If survival is similar to that estimated for 1988-89 and 1989-90, then returns in 1991 will be lower than that observed in 1989 and 1990 with little available harvest if a target of 4,000 small salmon is to be achieved.

Discussion

Returns to Conne River have ranged from a high of over 10,000 small salmon in 1987 to under 5,000 in 1989. Similar to Pacific salmon populations, there is a large degree of interannual variation in the number of adults returning to spawn (Noakes et al. 1990). Noakes et al. (1990) stated that it is common for the number of adults in a stock to vary by more than an order of magnitude between years and at the same time show no clear temporal regularity in adult stock size.

With respect to Conne River, adult returns were forecasted to be higher in 1990 relative to that of 1989. This forecast was based on an estimated smolt to adult survival from only two years of data. While the direction of the prediction was correct, inability to 'predict' the rate of sea survival resulted in the magnitude of the forecast being wrong. Clearly reliable point estimate forecasts cannot be made with limited data of this nature. The data from Conne River again suggested that sea survival was low in 1990 and consistent with that recorded for the previous year. This has also been observed in Northeast Brook Trepassey (SFA 9) where smolt to adult survival for the past four years has been as follows: 1986-87, 8.1%; 1987-88, 6.9%; 1988-89, 3.7%; 1989-90, 4.2% (M. O'Connell, personal communication). In view of the quota restrictions place on the commercial fishery in 1990, no apparent increase in survival back to these rivers was apparent.

Marine environmental conditions are believed to influence both distribution (Christensen and Lear 1980; Reddin and Shearer 1987; Ritter 1989) and survival of Atlantic salmon at sea (Scarnecchia 1984; Ritter 1989). With the exception, perhaps, of monitoring estuarine temperatures with the intent of predicting the impact on smolt survival, our present ability to 'predict' general marine conditions and subsequent effects on sea survival salmon is relegated to a retrospective analysis. Since we cannot predict what marine survival will be, it would be better, perhaps, to provide a realistic range of cases from which forecast generalities can be made. Thus the above approach for 1991 returns.

The 1990 smolt estimate was lower than expected given the estimated egg deposition in 1986 (assuming it was correct) of 10.6 million eggs which would have produced the 3+ smolts this year. A number of factors could have been responsible including the widespread drought conditions in 1987. Temperatures in the Conne River during July and early August of 1987 were frequently over 25°C with a temperature of 28°C recorded on one day (Fig. 8). As water abstraction also occurred, many places on the river were left with only isolated pools where fry were observed (occasionally dead) and where temperatures could have been greater than that recorded at the counting fence. According to Fry (1947), at an acclimation temperature of 20°C, 50% mortality of salmon fingerlings can occur within six to seven hours at 28°C.

Assuming the drought had a severe impact on a particular year class, we may have expected to observe this in the subsequent river age distribution of smolts. However, no change in the river age distribution of smolts was noted in 1990 relative to other years ($G^2 = 2.53$, $P = 0.47$). This suggests that: 1) either there was no impact from the drought; 2) there was and impact and but all year classes (in this case the 1986 and 1987 year classes as 1+ and 0+ parr respectively in 1987) were equally affected; 3) there was an impact and one year class was differentially affected but because of compensatory mechanisms no change in age distributions resulted.

Alternatively, the number of smolts may be lower than expected in 1990 as a result of greater mortality of pre-smolts during the spring of 1990 or because the 'window' to migrate (review by Bley 1987) was to narrow to accommodate the entire smolt run. Temperature has been cited as a major factor initiating and regulating smolt migrations (Jessop 1975; McCleave 1978; Ruggles 1980; Chadwick 1981; Bley 1987; Nettles and Gloss 1987). As shown in Fig. 5, water temperatures in 1990 tended to be lower during the month of May when smolts were migrating. Condition of smolts in 1990 was also low in comparison with the average of other years while cumulative frequency of the 1990 smolt run was later in comparison with other years (Fig. 4). Cooler temperatures may have also affected other species in the Conne River. The timing of the anadromous smelt spawning run was later (Fig. 4) and the number of anadromous smelt counted in 1990 (N = 7,797) was much lower (48% lower) than the average number for the previous three years (N = 15,025). Other rivers have shown similar declines, for example on Black River, New Brunswick (SFA 15) smelts were 72% lower than the 1983-89 mean (Gulf Region, unpublished data).

Target spawning requirements were essentially met in Conne River in 1990 due to the mid-season evaluation and subsequent temporary closure of the recreational and food fisheries. The prognosis for 1991 is not good and in the absence of an unusually high sea survival this current year, additional mid-season adjustments may be required in order to achieve target requirements.

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Table 1. Opening and closing dates for 1990 Atlantic salmon recreational, commercial (SFA 11), and native food fisheries potentially harvesting salmon of Conne River origin.

Fishery	Season
Recreational[1]	June 16 - September 3
Commercial[2]	June 5 - July 10
Native Food[3]	May 30 - July 31

[1]River closed because of low salmon escapement from July 1-26, inclusive.

[2]Commercial fishery closed because of quota restriction on June 21, 1990.

[3]Food fishery closed from July 1-7, inclusive due to low escapement of salmon.

Table 2. Summary of dates of operation for downstream smolt mark-recapture studies, and upstream adult fence counts at Conne River, Newfoundland.

Year	Smolt mark-recapture studies		Adult counting fence	
	Start	Finish	Start	Finish
1986			May 12	Sept 10
1987	April 26	June 16	May 18	Sept 8
1988	May 9	June 14	May 21	Aug 29
1989	May 9	June 15	May 20	Aug 28
1990	May 3	June 20	May 23	Aug 6

Table 3. Commercial landings (t) of Atlantic salmon in Statistical Section 36, SFA 11, 1974-90.

Year	Small	Large	Total	Proportion small
1974	14.2	37.5	51.7	0.28
1975	22.5	24.3	46.8	0.48
1976	20.1	51.8	71.9	0.28
1977	3.3	13.0	16.3	0.20
1978	1.3	3.9	5.2	0.25
1979	3.6	8.7	12.4	0.29
1980	13.2	8.0	21.3	0.62
1981	2.9	8.7	11.7	0.25
1982	9.1	12.4	21.5	0.42
1983	5.5	7.2	12.7	0.43
1984	4.8	6.7	11.5	0.42
1985	14.8	23.9	38.7	0.38
1986	17.6	11.4	29.0	0.61
1987	7.7	8.5	16.3	0.47
1988	1.7	2.5	4.2	0.40
1989	5.5	6.1	11.7	0.47
1990[1]	3.3	5.8	9.1	0.36
Mean				
1980-89	8.3	9.5	17.9	0.45
1985-89	9.5	10.5	20.0	0.47

[1]Preliminary information only for 1990.

Table 4. Atlantic salmon landings (in numbers of fish) in the sport fishery 1953-90, and in the native food fishery, 1986-90, for the Conne River.

	Sport fishery				Native food fishery			
	Effort	Salmon				Salmon		
Year	rod days	<63 cm	≥63 cm	Total	Quota	<63 cm	≥63 cm	Total
1953	445	138	26	164				
1954	134	120	23	143				
1955	99	303	37	340				
1956	308	476	36	512				
1957	413	369	23	392				
1958	610	480	55	535				
1959	555	393	18	411				
1960	89	387	0	387				
1961	644	491	0	491				
1962	769	873	11	884				
1963	855	1007	10	1017				
1964	1073	1296	25	1321				
1965	1242	983	39	1022				
1966	1436	879	43	922				
1967	1629	570	3	573				
1968	2379	1724	49	1773				
1969	2909	1751	38	1789				
1970	2909	1673	66	1739				
1971	3483	1707	33	1740				
1972	3194	2509	42	2551				
1973	3427	2139	10	2149				
1974	4033	1988	17	2005				
1975	3800	1903	17	1920				
1976	3894	1931	27	1958				
1977	3375	1665	5	1670				
1978	3122	1735	7	1742				
1979	2147	1010	0	1010				
1980	3512	2238	14	2252				
1981	5029	2691	2	2693				
1982	5268	3302	24	3326				
1983	6972	2192	21	2213				
1984	6709	2343	0	2343				
1985	5202	2729	0	2729				
1986	6038	2060	0	2060	1200	519	3[a]	522
1987	4979	1598	0	1598	1200	18	0	18
1988	5504	1544	0	1544	1200	607	2	609
1989	4414	1036	0	1036	1200	381	1	382
1990	2740	767	0	767	1200	966[1]	0	966
Mean								
1985-89	5227	1793						
1980-89	5362	2173						

[a]Dead in trap.
[1]Food fishery values preliminary. Does not include approximately 50 fish found dead and partially destroyed in traps.

Table 5. Estimates of angling exploitation rates on small salmon in Conne River, Newfoundland, 1986-90. Confidence limits were calculated according to Cochrane (1977).

Year	Small salmon released upstream[1]	Angling catch	Exploitation rate
1986	7488	2060	0.275
1987[2]	9666	1598	0.165
1988	7111	1544	0.217
1989	4645[3]	1036	0.223
1990	4532[4]	767	0.169
Mean			0.210
95% C.L.			0.154-0.266

[1]Mortalities above fence have been subtracted from numbers released at the fence.

[2]Exploitation rate = 0.181 if upstream releases only during the period opened to recreational fishing (river closed July 13) in 1987 (N=8853) are used.

[3]Includes 180 fish angled below fence (i.e. fence count (4469) + angled below (180) - mortalities above (4).

[4]Includes 213 angled below fence (i.e. fence count (4321) + angled below (213) - mortalities above (1). Exploitation rate = 0.285 if upstream releases only during the initial period opened to recreational fishing are used (N=593).

Table 6. Summary of biological characteristic information for Atlantic salmon samples from Conne River, Newfoundland, 1986-90.

			Length (mm)			Weight (g)			River Age (y)			Sex ratio	
Class	Year	N	Mean	SD	Min-max	Mean	SD	Min-max	Mean	SD	Min-max	N	% female
smolt	1986	145	153	12.0	125-210				3.25	0.48	2-5		
	1987	271	144	16.5	106-198	29.1	9.8	11.5-73.8	3.32	0.54	2-5	270	77
	1988	328	147	15.7	102-201	32.2	10.4	12.4-78.8	3.38	0.51	3-5	327	73
	1989	288	152	21.3	98-265	35.0	14.0	9.8-123.2	3.24	0.53	2-5	288	79
	1990	271	148	21.2	100-253	30.5	13.1	10.3-122.8	3.29	0.47	2-5	271	74
1 SW	1986	357	506	23.0	440-570	1451	220.4	900-2900	3.38	0.57	2-5	356	76
	1987	372	509	23.4	430-580	1493	245.9	600-2600	3.19	0.46	2-5	326	78
	1988	267	506	26.1	440-600	1352	226.5	1000-2200	3.14	0.42	2-4	261	80
	1989	140	512	23.3	460-580	1411	201.7	1000-2000	3.18	0.50	2-5	135	79
	1990	174	508	23.4	449-575	1454	184.4	1100-2000	3.27	0.52	2-5	141	81
2 SW	1986	1	630			2600			3.00			1	100
	1989	2	665	21.2	650-680	2700			3.50	0.71	3-4	1	100
PS	1986	2	580	28.2	560-600	2100	424.3	1800-2400	3.00			2	100
	1987	5	536	23.2	520-576	1680	277.5	1400-2100	3.00	0.71	2-4	4	100
	1988	5	556	24.1	530-590	1640	260.8	1500-2100	2.80	0.84	2-4	5	40
	1989	19	649	55.4	550-710	2163	763.3	1500-3500	3.05	0.23	2-4	8	63
	1990	3	564	51.4	505-601	-	-	-	3.33	0.58	3-4	-	-

Table 7. Weekly summary of numbers of Atlantic salmon enumerated at the counting fence on Conne River, Newfoundland, 1986-1990.

		Number of Fish									
		Small					Large				
Date	Week	1986	1987	1988	1989	1990	1986	1987	1988	1989	1990
May 14-20	20	0	0	0	0		2	0	0	0	
May 21-27	21	0	0	0	0	0	4	0	0	0	0
May 28-Jun 3	22	6	2	0	3	0	14	0	0	10	0
Jun 4-10	23	108	17	11	38	1	42	15	7	2	0
Jun 11-17	24	870	1905	652	946	82	87	294	123	85	37
Jun 18-24	25	2690	3713	1939	2119	569	160	116	119	154	110
Jun 25-Jul 1	26	1899	1514	2256	856	1706	67	38	114	31	127
Jul 2-8	27	612	515	730	216	115	7	7	16	3	44
Jul 9-15	28	848	1374	769	248	588	13	17	5	9	21
Jul 16-22	29	263	32	344	3	172	4	0	17	0	20
Jul 23-29	30	114	126	91	15	88	0	4	3	0	2
Jul 30-Aug 5	31	54	3	268	4	0	2	0	11	0	0
Aug 6-12	32	7	25	1	21	0	0	1	2	0	0
Aug 13-19	33	2	0	0	0	-	0	0	0	0	-
Aug 20-26	34	11	6	57	0	-	0	0	1	0	-
Aug 27-Sep 2	35	31	38	0	0	-	1	0	0	0	-
Sep 3-9	36	0	417[1]	-	-	-	0	0	-	-	-
Total		7515	9687	7118	4469	4321	397	498	418	319	361

[1]Includes estimate of 400 fish in lower part of the river at the time the counting fence was removed.

Table 8. Summary of mean weekly water temperatures (°C) and water levels (cm) at the counting fence on Conne River, Newfoundland, 1986-1990.

		Mean water temperature					Mean water level				
Date	Week	1986	1987	1988	1989	1990	1986	1987	1988	1989	1990
May 7-13	19	7.5	-	-	12.9	6.6	32.0	-	-	-	65.3
May 14-20	20	12.3	8.3	-	11.0	9.6	26.0	44.6	-	27.5	47.5
May 21-27	21	11.1	11.4	15.6	14.5	7.5	36.5	28.2	18.6	22.0	52.7
May 28-Jun 3	22	11.3	13.1	12.0	14.6	12.5	39.9	15.5	25.2	46.8	26.2
Jun 4-10	23	12.2	14.1	10.3	16.4	13.6	61.1	13.0	68.1	34.4	21.9
Jun 11-17	24	13.4	14.5	15.1	14.3	16.4	35.2	32.5	49.8	16.7	11.9
Jun 18-24	25	15.8	16.1	15.9	17.9	13.8	24.0	22.3	42.3	14.0	10.8
Jun 25-Jul 1	26	15.3	16.7	15.1	19.0	17.6	22.7	17.1	51.9	12.9	27.2
Jul 2-8	27	15.3	18.8	16.7	17.2	17.5	33.3	11.3	67.0	5.6	19.1
Jul 9-15	28	16.0	22.1	17.8	18.4	16.9	33.4	3.1	30.4	15.8	12.3
Jul 16-22	29	17.7	20.8	18.8	18.5	18.8	30.5	-1.0	16.7	34.1	9.1
Jul 23-29	30	19.3	20.5	19.3	18.9	20.5	20.4	-1.6	9.4	20.7	23.6
Jul 30-Aug 5	31	16.8	20.4	20.2	19.6	19.0	20.0	-3.0	16.6	20.1	14.1
Aug 6-12	32	20.1	20.1	20.8	20.4	21.4	13.4	-7.4	9.3	31.6	10.0
Aug 13-19	33	19.4	17.2	17.8	20.3	-	9.2	-8.9	3.8	30.4	-
Aug 20-26	34	18.9	18.3	15.6	18.3	-	3.0	-1.6	18.7	15.9	-
Aug 27-Sep 2	35	15.5	16.8	17.6	14.0	-	9.6	-0.5	14.0	15.0	-
Sep 3-9	36	14.8	14.8	-	-	-	10.3	-4.3	-	-	-
Average		16.0	17.8	17.1	17.0	14.7	26.0	8.5	30.2	22.7	27.8

Table 9. Total estimated returns of Atlantic salmon to Conne River, Newfoundland, with a summary of mortalities and removals, and estimated spawning escapement, 1986-1990.

	Salmon <63 cm					Salmon ≥63 cm				
	1986	1987	1988	1989	1990	1986	1987	1988	1989	1990
Returns to Conne R.										
*Food fishery (estuary)	766	451	506	317	846	14	18	2	1	0
Angling below fence				180	213					
Mortalities below fence	21	17	3	2	3	1	0	0	0	0
Fence count	7515	9287	7118	4469	4321	397	498	418	319	361
Estimated count		400								
Total	8302	10155	7627	4968	5383	412	516	420	320	361
(1) Released at fence	7515	9687	7118	4469	4321	397	498	418	319	361
Removals and mortalities										
Mortalities above fence	27	21	7	4	2	1	0	0	0	0
Unrecorded mortalities-5% of (1)	376	484	356	223	216	20	25	21	16	18
Angling above fence	2060	1598	1594	856	554	0	0	0	0	0
Brood stock	0	245	0	0	0	0	10	0	0	0
(2) Total	2463	2348	1907	1083	772	21	35	21	16	18
Spawning escapement										
(1) - (2)	5052	7339	5211	3386	3549	376	463	397	303	343
Egg deposition										
in millions	9.20	13.75	9.97	6.52	7.07	1.41	1.96	1.68	1.04	1.17
% of 7.8 million target met	118	176	128	84	91	18	25	22	13	15

*Food fishery includes fish caught in estuary for tagging studies in 1986 and 1987. Proportions of Conne River origin fish in 1986 and 1987 were 0.792 (N=967) and 0.914 (N=493) respectively. For remaining years, weighted mean (0.833) was used.

Table 10. Comparison of 1 SW salmon forecasts in year i-1 with actual returns in year i for Conne River, Newfoundland.

	Return year			
	1988	1989	1990	1991
Forecast	7900-8800	6180-6798	6824-7896	4539-5324
Actual return	7627	4968	5383	
Return/forecast	86.7-96.5	73.1-80.4	68.2-78.9	

Table 11. Smolt to adult survival for Conne River Atlantic salmon.

	Number of smolts year i	Number of grilse year i-1	% survival
1987	74585	7627	10.2
1988	68938	4968	7.2
1989	76424	5383	7.0

Table 12. Estimates of smolt to adult survival by age class for Conne River and Northeast Brook, Trepassey, Newfoundland.

		Conne River			Northeast Brook		
Smolt class	Age class	Smolt year i	Grilse year i + 1	% survival	Smolt year i	Grilse Year i + 1	% survival
1987	3	49226	6113	12.4	368	45	12.2
1987	4	22375	1285	5.7	713	44	6.2
1988	3	43431	3691	8.5	547	33	6.0
1988	4	24818	1029	4.1	927	29	3.1
1989	3	54261	3651	6.7			
1989	4	18342	1547	8.4			

Table 13. Estimated size of the Conne River, Newfoundland, Atlantic salmon smolt population, 1987-90, as determined from mark-recapture studies. Mean river age, percentage of smolts at each river age and sample size are also presented.

Year	N tagged	Population estimate	95% confidence interval	Coefficient variation	Mean river age (y)	Percent in each age group				N
						2	3	4	5	
1987	4975	74585	67597-81573	5.1	3.3	2	66	30	2	271
1988	3235	68938	62976-74900	4.6	3.4	0	63	36	1	328
1989	2699	76424	69123-83733	5.1	3.1	3	71	24	2	288
1990	3719	60885	56042-65728	4.3	3.3	1	70	28	1	271

Previous smolt estimates based on Danoch's model were:

1987 72752
1988 60360
1989 78588

Table 14. Estimated total number of smolts in each age group, for Conne River, Newfoundland, 1987-90.

Year	River age (y)				Total
	2	3	4	5	
1987	1492	49226	22375	1492	74585
1988	0	43431	24818	689	68938
1989	2293	54261	18342	1528	76424
1990	609	42619	17048	609	60885

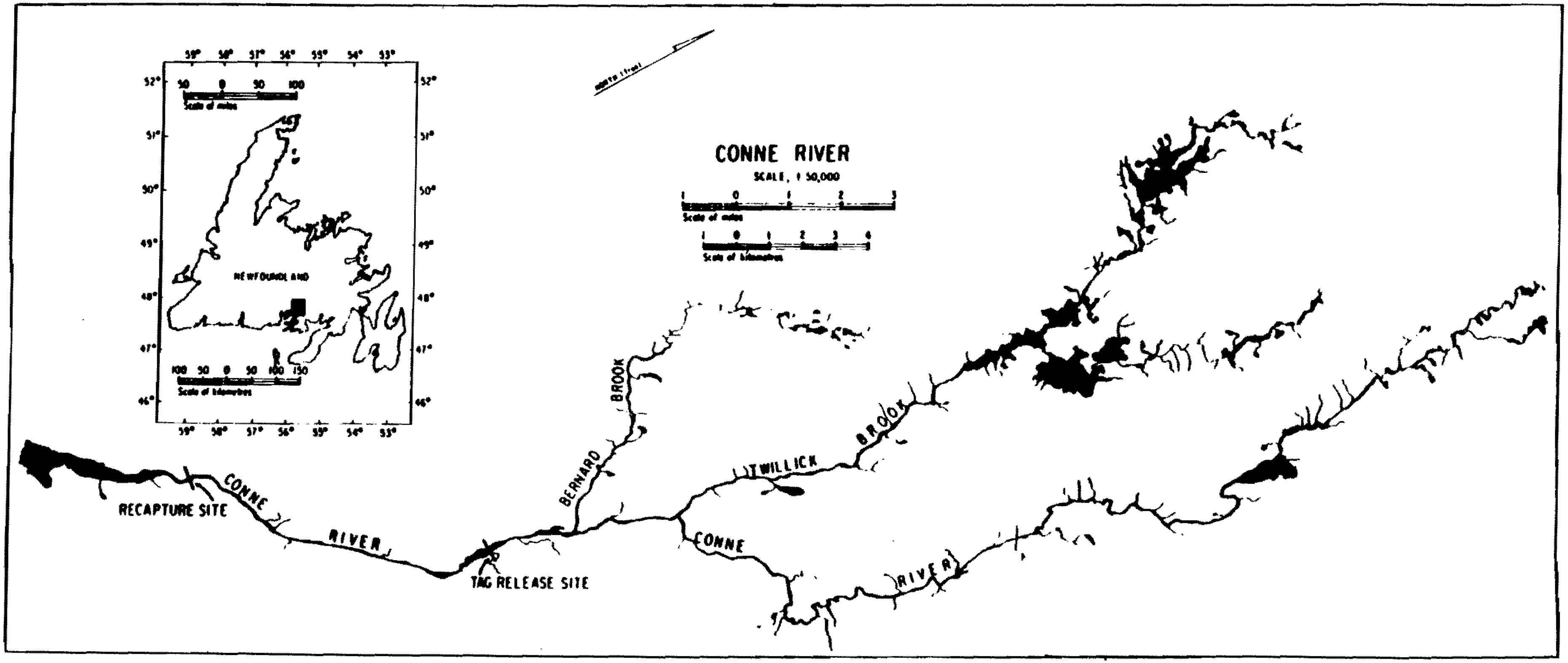

Fig. 1. Conne River, Newfoundland, SFA 11, illustrating the location of fish counting fences used for the mark-recapture survey. Recapture site is also the location of the upstream adult counting fence.

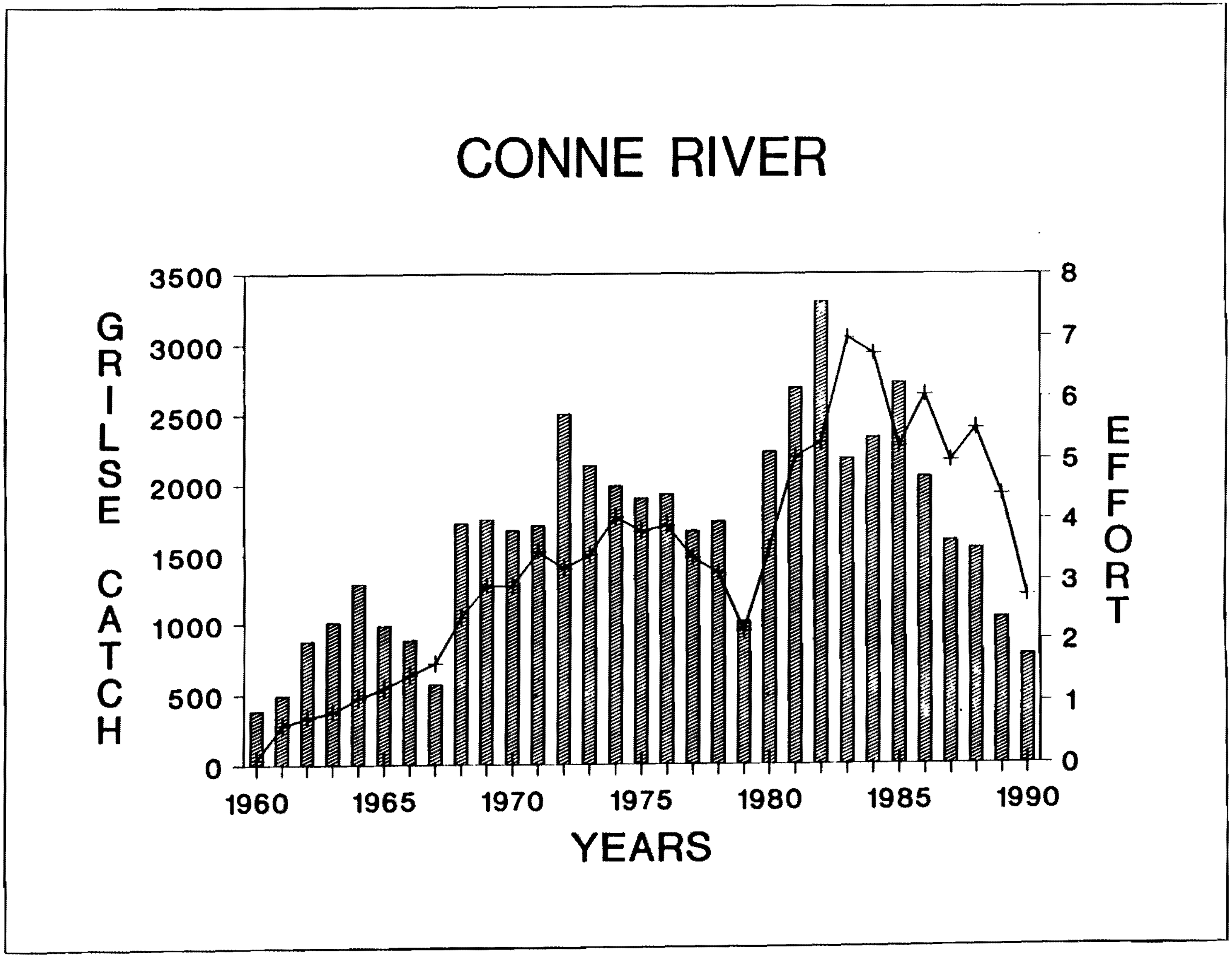

Fig. 2. Summary of the small salmon recreational catch (bars) and effort (rod-days in thousands) (line) for Conne River, Newfoundland, SFA 11, 1960-90.

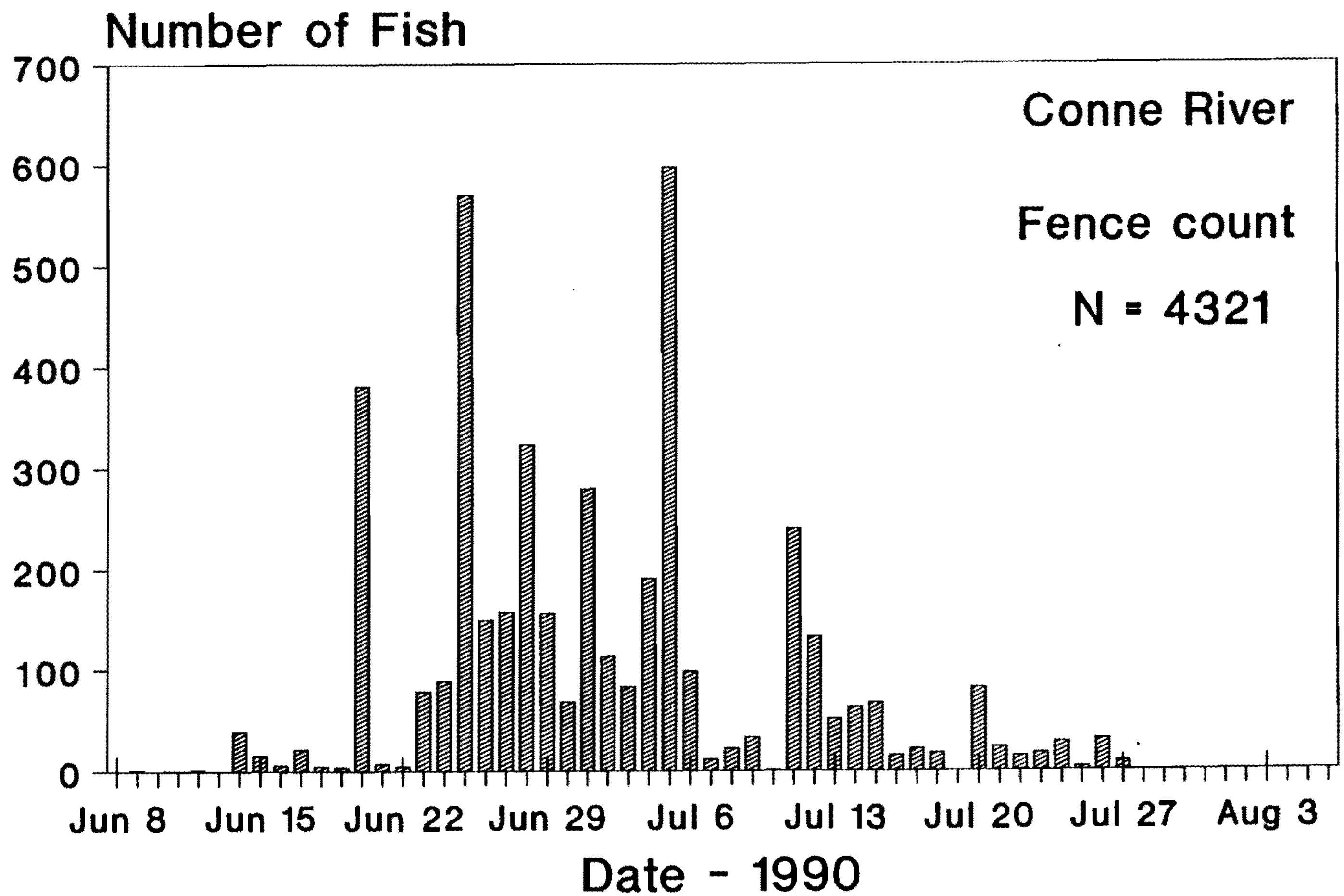

Fig. 3. Daily counts of small salmon at the Conne River fish counting fence, 1990.

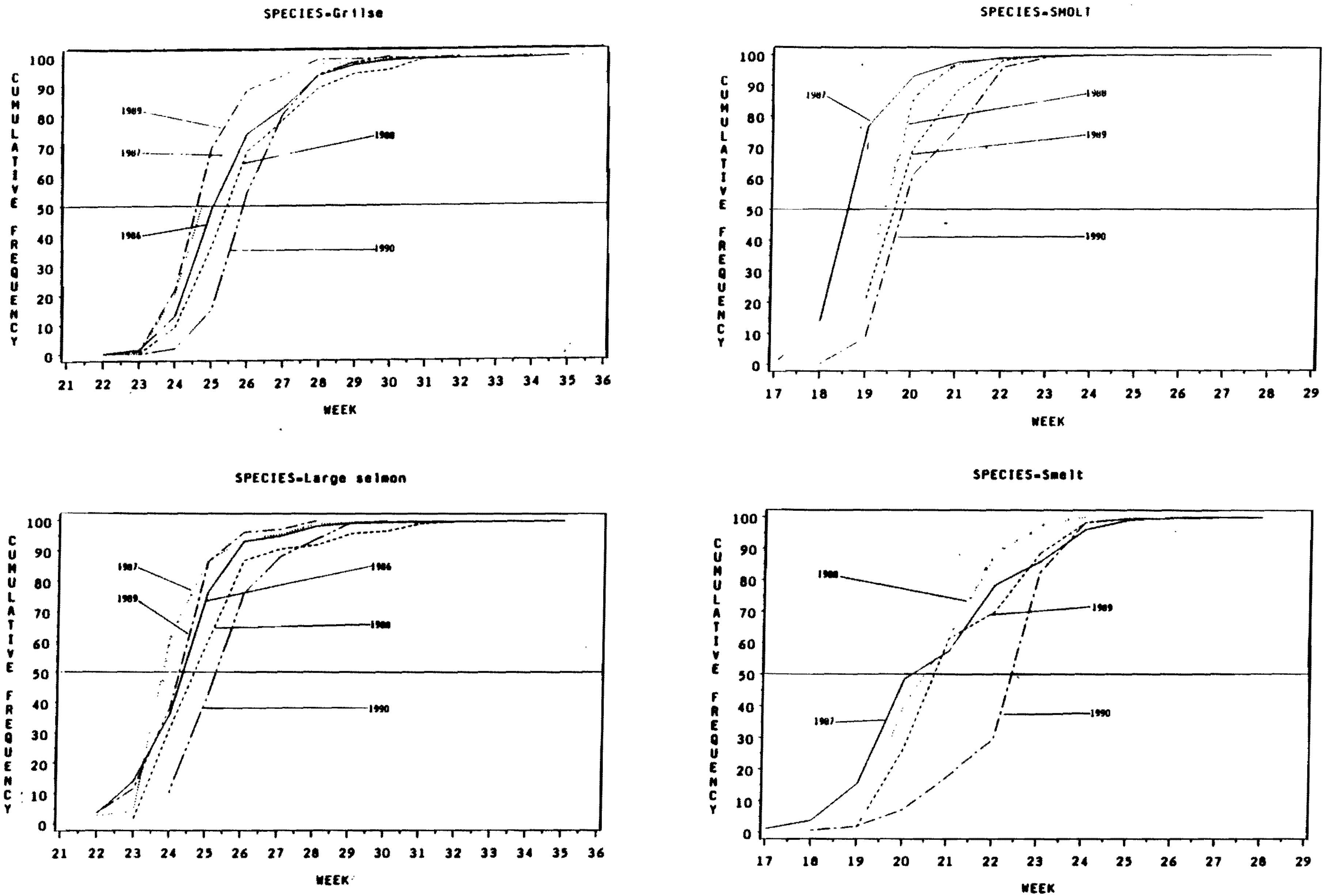

Fig. 4. Cumulative frequencies (%) of upstream migrating grilse and large salmon (1986-90) and downstream migrating Atlantic salmon smolt and American smelt (1987-90) at Conne River.

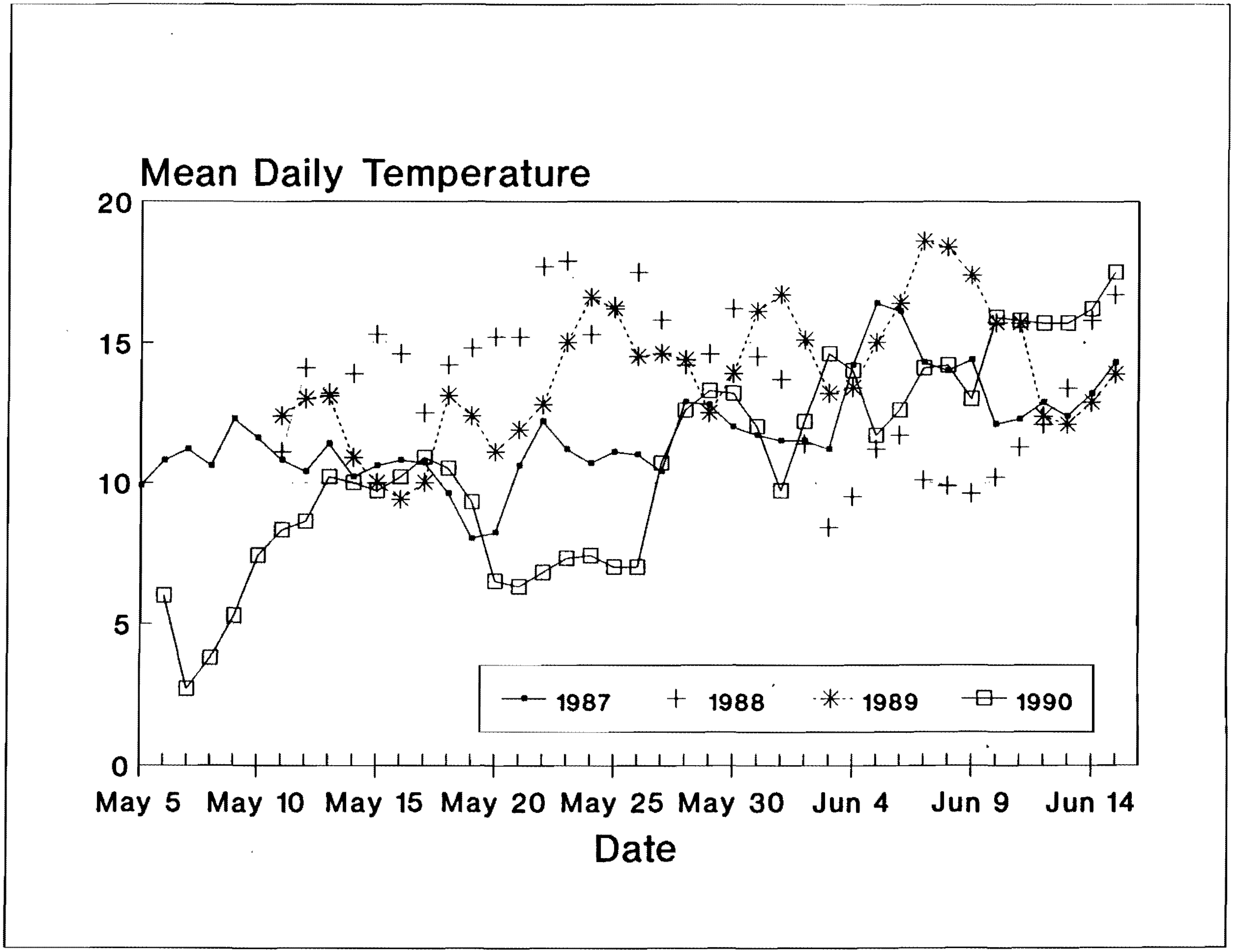

Fig. 5. Mean daily water temperatures (^{o}C) at Conne River, Newfoundland, May 5 - June 15, 1987-90.

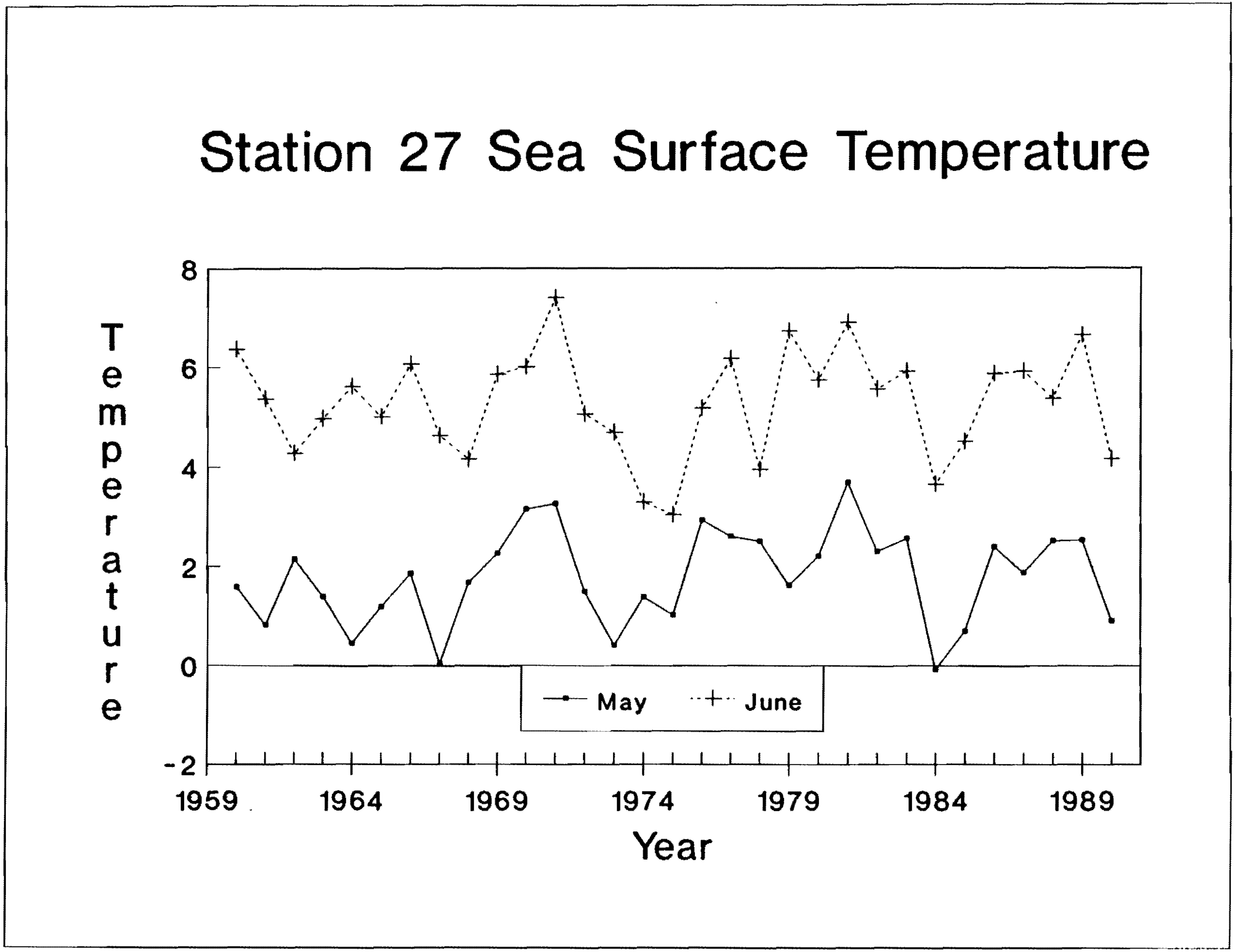

Fig. 6. Mean sea surface temperature (^{o}C) at Station 27, Newfoundland, for May and June, 1960-90.

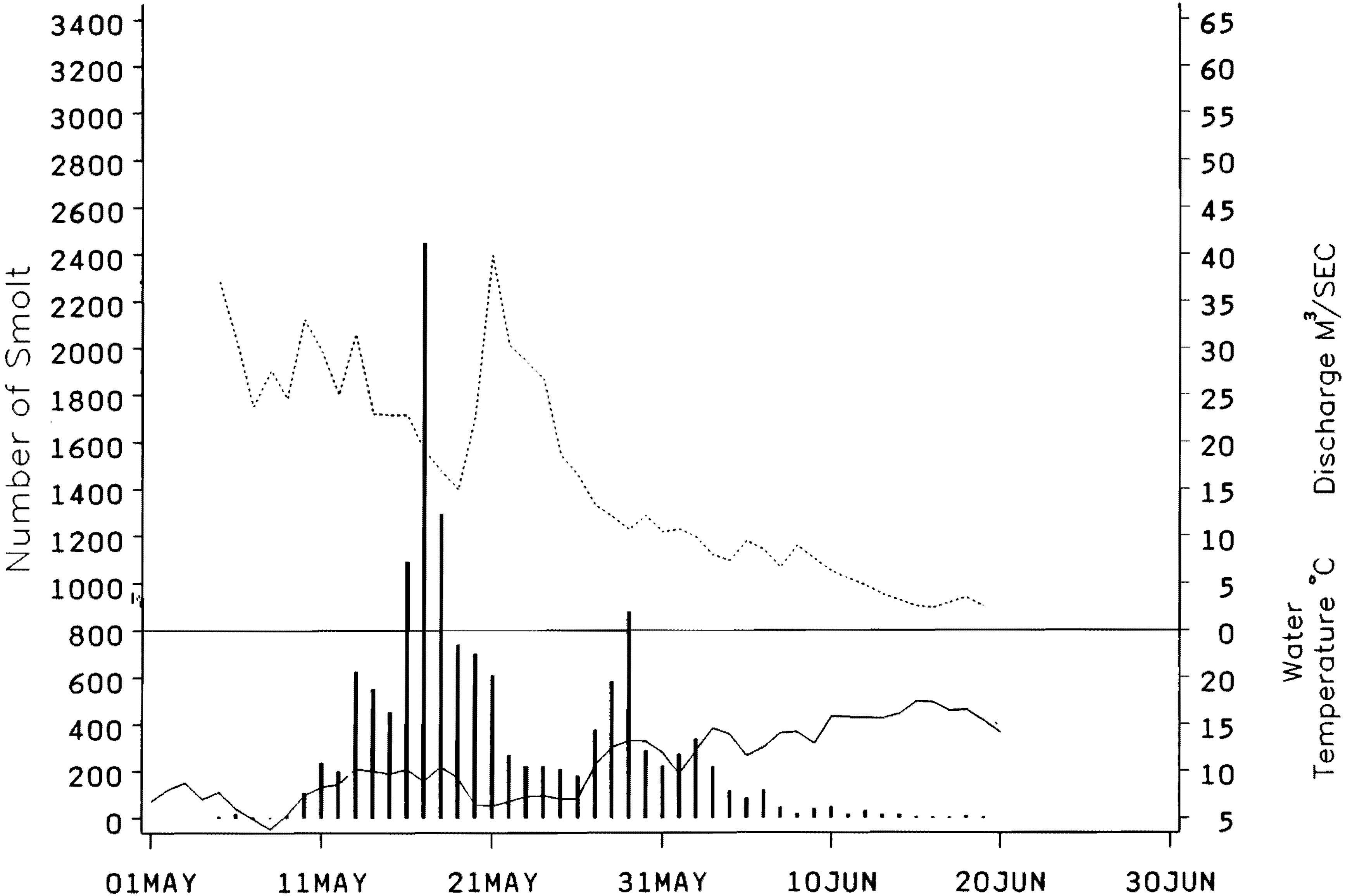

Fig. 7. Number of migrating Atlantic salmon smolts (bars) caught at the downstream recapture site along with mean daily water temperature (solid line) and discharge (dashed line), 1990.

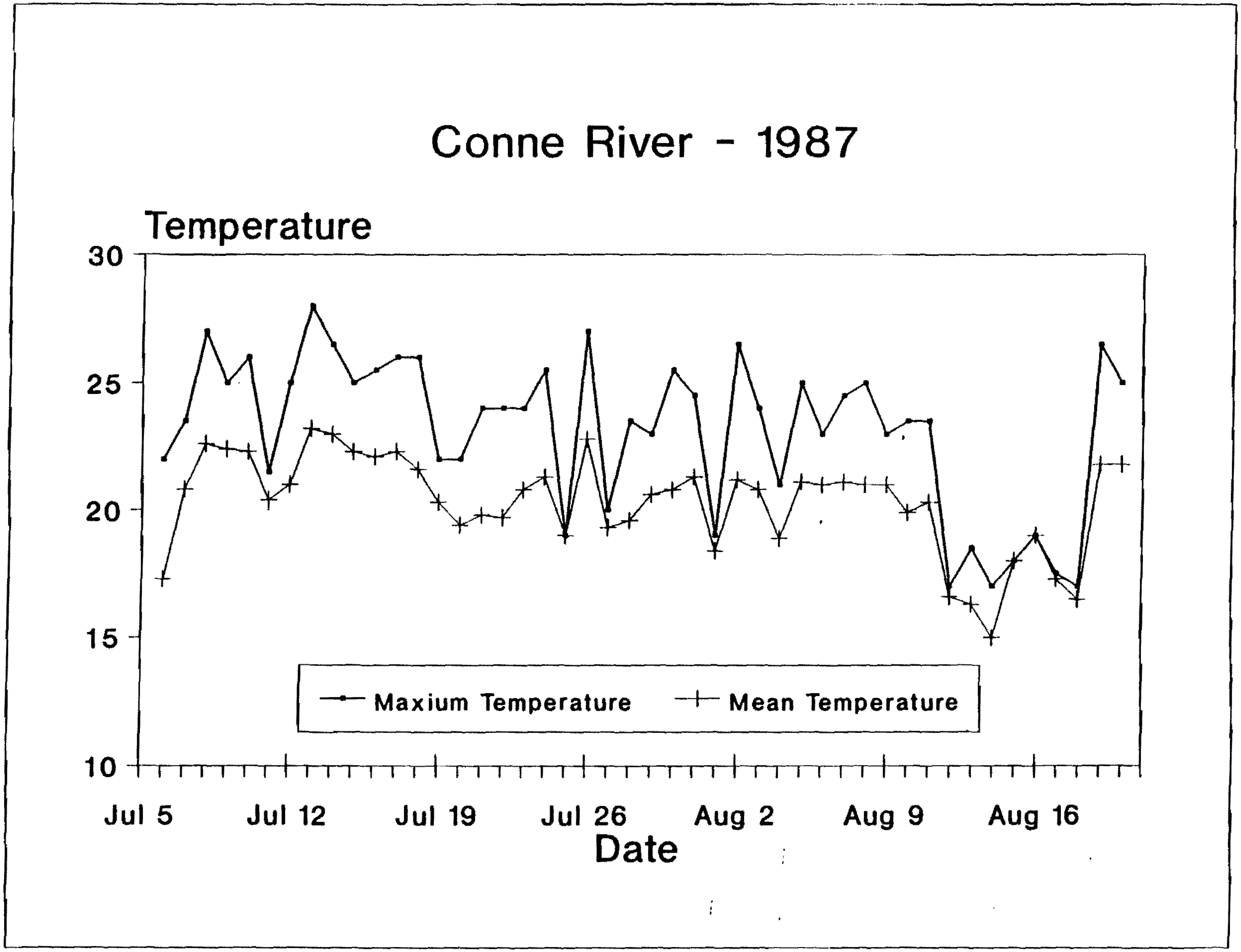

Fig. 8. Mean daily and amximum water temperatures (^{o}C) at Conne River, Newfoundland, July 6 - August 20, 1987.