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Status of the Atlantic salmon population of Conne River, SFA 11, Newfoundland, in 1993

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Abstract

Results obtained from a fish counting fence provided the basis for the assessment of the Conne River Atlantic salmon stock in 1993. Returns to home waters (river and estuary) were 2703 salmon < 63 cm in length and 100 salmon ≥ 63 cm in size. This represented an increase of 7% for small salmon but a 37% decline for large salmon from 1992. Sea survival was estimated to be only 4.0% (3.6-4.4%), higher than in the previous year but still among the lower values recorded. Estimated egg deposition from small salmon was 4.428 x 10^6 eggs; 57% of the target requirement. The contribution from large salmon was 0.332 x 10^6 eggs and thus 61% of the required target egg deposition was achieved. Higher sea survival may be associated with years in which smolt condition values were greater. A mark-recapture study suggested a smolt run in 1993 of 55765 (51666-59864). Assuming a sea survival that approximates the average recorded during the past three years (4%), then no more than 2400 fish would be expected to return in 1994. A sea survival of about 7% will be needed in order for total returns to homewaters to meet or exceed 4000 adult salmon. It is also cautioned that low spawning escapements from 1991-93 may result in lower smolt production in 1995-97. This, should it occur, could then result in low adult salmon returns, probably below target levels, in 1996-98.

Résumé

L'évaluation de la population de saumon de l'Atlantique dans la rivière Conne (T.-N.) en 1993 est fondée sur les résultats obtenus à un barrage de dénombrement du poisson. Quelque 2 703 saumons < 63cm et 100 saumons ≥ 63 cm sont revenus dans leurs eaux d'origine (rivière et estuaire), ce qui représentait un accroissement de 7 % pour le petit saumon et un recul de 37 % pour le grand saumon par rapport à 1992. Le taux estimé de survie en mer n'était que de 4 % (3,6-4,4 %), soit un taux supérieur à celui de l'année antérieure, mais néanmoins parmi les plus bas enregistrés jusqu'ici. La ponte des petits saumons était estimée à 4,428 x 10^6 oeufs, soit 57 % de la cible. Celle des grands saumons s'établissait à 0,332 x 10^6 oeufs, soit 61 % de la cible. Le taux plus élevé de survie en mer peut être associé aux années où les coefficients de condition des saumoneaux sont plus grands. D'après une expérience de marquage-recapture, 55 765 saumoneaux (51 666-59 864) auraient remonté la rivière en 1993. En tablant sur un taux de survie correspondant approximativement à la moyenne des trois dernières années (4 %), les remontées devraient être de 2 400 saumons au maximum en 1994. Il faudra parvenir à un taux de survie en mer d'environ 7 % pour que les remontées totales de saumon adulte dans les eaux d'origine soient égales ou supérieures à 4 000. Il est également à craindre que les faibles échappées de reproducteurs connues de 1991 à 1993 ne se traduisent pas une baisse de la production de saumoneaux de 1995 à 1997, phénomène qui, s'il se confirme, pourrait aboutir à de faibles remontées de saumon adulte, probablement inférieures à la cible, en 1996-1998.

Introduction

Conne River, SFA 11 (Fig. 1) flows into Bay D'Espoir on the south coast of insular Newfoundland. It is a sixth-order river with a drainage area of 602 km^2 and a total length of 193 km. 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 migrating smolts. Both of these operations continued in 1993. Previous estimates of the total return of small salmon have ranged from a low of 2411 in 1991 to 10155 in 1987; lower returns have occurred in more recent years. Target spawning requirements were met or exceeded from 1986-90, but only 50% of the target was achieved in 1991 and 1992 (Dempson 1993). Smolt production has varied from about 57000 to 75000 fish but for the most part has been relatively stable (coefficient of variation 10.1%).

This paper summarizes returns of adult salmon to Conne River in 1993 and provides a forecast of one-sea-winter (1SW) returns for 1994. Biological characteristic data are updated and summary information on rainbow trout occurring in Conne River are provided for the first time.

Noteworthy events or changes in 1993

The following summarizes noteworthy changes to fishery regulations and other observations/events occurring in 1993:

- recreational fishery closed for the entire season;
- food fishery quota reduced from 1200 to 500 fish;
- river age 1+ salmon sampled from food fishery catch; first indication suggestive of an escaped hatchery origin Atlantic salmon;
- evidence of rainbow trout feeding on salmon parr in Conne River;
- continued evidence for an association between smolt condition and subsequent sea survival;
- video camera system used for the first time at Conne River to enumerate upstream migrating salmon;
- estimated egg deposition increased by 20% from 1992 with 61% of the current target spawning requirement met;
- three (3) dynamite blasting caps found along a short stretch of the Bernard Brook tributary; no legitimate reasons were identified to account for the presence of these caps.

Background

A major change in the management of the Conne River Atlantic salmon stock for 1993 was the complete closure of the recreational fishery and an initial quota of only 500 fish for the Conne River Indian Band Council's food fishery. A forecast of low returns in 1993 prompted the closure of the sport fishery and the reduction in the food fishery quota which had been 1200 fish in previous years. The food fishery season was from May 31 - July 31, 1993, with other proposed regulations as follows: 1) fishing was restricted to the Conne River estuary and the use of two trap nets; 2) if gillnets were used, mesh size was restricted to 127 mm or larger; 3) maximum weekly harvest levels were 200 fish from May 31-June 6 and June 7-13, and 100 fish from June 14-20. As in past years, it was prohibited to retain salmon ≥ 63 cm, although salmon of this size found dead in the food fishery gear could be retained and counted against the quota.

Methods

1. Landings in 1993

Data on landings from the native food fishery were obtained from the Conne River Native Band Council.

2. Biological characteristics

Biological characteristic information on adult salmon, including fork length, whole weight, age and sex, was obtained from limited sampling of salmon caught at the fish counting fence (N = 48). The Conne River Indian Band Council provided length, weight, and sex data along with representative scale samples from 255 adult salmon caught in the food fishery. Biological data from Atlantic salmon smolts (N = 246) were obtained from specimens sampled at the downstream counting fence trap.

Rainbow trout, which stray into the Conne River as a result of incidental escapements from local fish farming activities in Bay d' Espoir, were also sampled (N = 9). The Conne River Indian Band also provided biological characteristic information along with stomachs from five rainbow trout captured in the native food fishery traps.

3. Physical measurements

Normally, water temperature information is obtained from continuous recording Hugrun thermographs. In addition, air and water temperatures are also recorded periodically throughout the day at each fish trap check. Water level is determined from a bench-mark pin established in 1986. Information on air temperature, precipitation, and discharge can also be obtained from the Environment Canada, Atmospheric and Environment Service monitoring facility located on the main stem of Conne River, below Conne Pond. Generally, over the course of season, the bench mark water level readings (summarized in Table 6) provide an accurate index of river discharge (Fig. 2).

4. 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 28 to July 31, 1993 (Table 1).

During 1993, adult salmon were counted either as they: 1) passed through monitored openings in the fish counting fence; 2) entered the trap directly; or 3) passed through the video camera tunnel. The video camera system utilized a positive image horizontally directed camera (Panasonic model WV-BD400) housed in a 1.2 x 1.8 m wooden box. The fish passage tunnel was approximately 0.5 m square and was incorporated within the above box. The video system was generally operated each day from early evening until about 0900 hours from June 16 - July 29. A Panasonic Time Lapse Video Recorder (Model AG 6040) was used to record the video signal from the camera and could also superimpose the time and date thus providing a summary of actual fish passage times.

Total returns (TR) of adult salmon were estimated from:

$$TR = Fc + Mb + Cn$$

where, Fc is the count of fish at the counting fence
Mb is the known mortalities below the counting fence, and
Cn is the estimated number of Conne River origin salmon caught in the native food fishery.

Spawning escapement (SE) was estimated as:

$$SE = Fr - Ma$$

where, Fr is the number of fish released at the counting fence
Ma is the known number of mortalities above the fence

Consistent with the practise established in 1991, estimated egg deposition refers to the '<u>potential</u>' deposition relative to the current target. That is, no additional adjustments have been made to account for any unknown or assumed mortality of fish up to the time of spawning and thus the potential egg deposition probably overestimates the actual egg deposition.

As in past years, egg deposition was calculated separately for salmon < 63 cm and salmon ≥ 63 cm and then totaled.

$$\text{Egg deposition} = \begin{matrix}\text{number of}\\ \text{spawners}\end{matrix} \times \text{\% female} \times \begin{matrix}\text{fecundity}\\ \text{at size.}\end{matrix}$$

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

$$\text{Fecundity} = 0.1988(\text{fork length, cm})^{2.3942} \qquad (r^2 = 0.48,\ P < 0.001)$$

where for this year, because of small sample sizes, fork length was the mean length of female salmon < 63 cm in size sampled over all years ($N = 1013$, $\bar{x} = 508$ mm).

An estimate of the egg deposition from salmon ≥ 63 cm in size was obtained using the same length-fecundity relationship for salmon < 63 cm, with the same data for mean length (67.8 cm) and percent females (71%) as used in past years (Dempson 1989, 1990).

The target spawning requirements were the same as in past years at 7.8 million eggs, equivalent to about 4000 salmon < 63 cm in size.

5. Forecast of 1994 returns

A mark-recapture study was carried out to estimate the smolt production in 1993. The study was similar to those carried out in 1987-92, the design of which is summarized in Dempson and Stansbury (1991) and uses the estimator described in Schwarz and Dempson (1994).

During 1993, 2456 smolts were tagged and released at the upstream partial counting fence site (Fig. 1). At the downstream recapture site, 15992 smolts were caught including 735 tagged smolts. In past years, a simulation approach was used to derive an estimate of returning numbers of adult salmon. The method incorporated into the forecast the uncertainty in the number of smolts migrating in a given year (i.e. mark-recapture estimate) and the variation in smolt to adult survival rates as derived during all of the previous years. Sea survival, however, has declined over time (Fig. 8) and cannot as yet be predicted. Thus, for 1994, the pre-season forecast used the rounded average sea survival recorded during the past three years only. This value was 4%.

Results and Discussion

1. Landings in 1993

Landings in the recreational fishery are summarized in Table 2 and Figure 3. As indicated above, no recreational fishing was allowed in 1993. In past years, angling exploitation rates, adjusted in some years for the period that the fishery was open, were estimated and yielded the following:

Year	Exploitation rate
1986	0.275
1987	0.181
1988	0.217
1989	0.223
1990	0.285
1991	0.245
1992	0.268

In general, these results indicate that, on average, about one of every four fish that had returned to the river during the period of time the recreational fishery was open was removed by the sport fishery.

Native food fishery catches are also summarized in Table 2. A total of 417 small salmon (83% of the reduced quota) and 3 large salmon were reportedly caught in the 1993 fishery before it closed on July 9 (67% females, N = 255). Of the small salmon caught, 347 (83.3%) were estimated to be of Conne River origin. The food fishery removed 12.8% of the estimated total number of small salmon returns to home waters in 1993.

2. Biological characteristics

Biological characteristic information was obtained from 246 smolts and 39 1SW fish during 1993. Additional samples of 'large' salmon were also obtained from the counting fence trap (N = 9). Small salmon caught in the food fishery in 1993 (N = 253) averaged 504 mm in fork length and 1347 g in weight.

Tables 3 and 4 summarize annual biological characteristic data for salmon sampled from the river (1986-93) or for the past two years from the native food fishery (1992-93), respectively. Repeat spawning fish are characterized as consecutive or alternate year spawners. Consecutive spawners sampled from the river are typically less than 63 cm in fork length ($\bar{x}$ = 544 mm, N = 61 and 1438 g, N = 44) while alternate spawners average 680 mm (N = 30) and 3033 g (N = 3) (Table 3) (Fig. 4). Not all size classes of fish can be sampled representatively in that any large salmon angled had to have been released. However, with respect to fish less than 63 cm in size, only 59 (3.9%) fish out of 1525 samples were either consecutive (N = 58) or alternate spawners (N = 1). Clearly at Conne River, few salmon appear to survive to return and spawn repeatedly.

One freshwater (river) age 1+ fish was sampled from the native food fishery catch in 1993. This is the first incidence of river age 1+ fish from this area and is believed to have been an escaped salmon from the local fish farming operations. However, it is noted that this fish could also have escaped from farming operations in other regions.

Figure 5 illustrates the run timing of smolt and adult small salmon at Conne River. Variability in run timing is apparent for both groups with up to a 15 day difference in the 25th percentile of the run of either life stage. Median dates are typically later during the past three years (1991-93) in comparison with the pre-1990 period.

An analysis of the condition of Conne River smolts (Dempson et al. 1994) indicated significant differences in smolt condition among years (Fig. 6). Years in which smolts had a higher condition were those that were typically associated with warmer spring temperatures (Fig. 6). In addition, there is also a suggestion that smolt condition may be subsequently related to sea survival as higher survival of smolts occurred in years where condition was greater (Fig. 6). Last year it was noted (Dempson 1993) that the condition of smolts migrating in 1992 was low and that this could result in lower than expected returns for 1993. This appears to have occurred. Condition of smolts in 1993 was higher than that estimated for 1990-92, and similar to 1987; the year in which sea survival was the highest.

2.1 Rainbow trout

Records have been kept on the numbers of rainbow trout that have been encountered at Conne River during the course of field activities (Table 5). This was because of the increased production of rainbow trout at sea farming sites in the Bay d'Espoir area, and the potential impact this could have on wild Atlantic salmon stocks in the vicinity. During the past four years (1990-93), various size classes of trout have been observed. Only small fish were captured in 1993, primarily during the downstream migration of salmon smolts (Table 5).

Twenty-five (25) rainbow trout stomachs have been examined for gross feeding characteristics; 16 (2 empty) from the river and 9 (3 empty) from fish captured in the estuary. A qualitative summary follows:

River		Estuary	
Aquatic insects: (larval form)	Ephemeroptera Plecoptera Trichoptera	**Terrestrial & Aerial insects:**	Hymenoptera Coleoptera Odonata Araneida
Fish:	Threespine sticklebacks Atlantic salmon parr	**Fish:**	Capelin Winter flounder Sticklebacks
		Mollusks:	Bivalvia (Mytilidae)

To date, only one salmon parr was positively identified in a rainbow trout stomach sampled from a fish caught in the river. No salmon were found in the nine rainbow trout samples obtained from the estuary.

3. Physical measurements

Average water temperatures and water levels are summarized in Table 6 for the years 1989-93. Temperatures for 1993 were obtained from readings taken during various trap checks as the Hugrun thermograph was rendered inoperable following a flood that resulted from a storm, on July 31-August 1. This storm also resulted in a fence washout on August 1. Sixty-five (65) mm of rain fell and increased the discharge, measured at the outlet of Conne Pond on the main river stem of the river (above the Bernard and Twillick Brook tributaries), from a monthly July average of 1.99 $m^3 \cdot s^{-1}$ to a peak of 46.9 $m^3 \cdot s^{-1}$ on August 1. The fence was scheduled to have been removed on August 2. Only five salmon in total were counted on the last three days of fence operation, while during the previous 5 days (July 27 - July 31) counts of salmon were averaging 7 fish per day (range 1 - 15).

4. Estimated returns and spawning escapement

There were 2355 salmon < 63 cm and 98 salmon ≥ 63 cm counted at the fish counting fence on Conne River in 1993 (Table 7) up to and including July 31. This represents an increase of 19% in the number of small salmon but a decrease of 36% in the number of large salmon in comparison with 1992. Peak run of salmon was in standard week 26 (June 25-July 1) although the single largest daily run occurred on June 23 (192 fish; Fig. 7). Partitioning the count of salmon among the various ways fish were enumerated is as follows:

	Small Salmon		Large Salmon	
	N	%	N	%
Fence opening	322	14	21	21
Counting fence trap	926	39	46	47
Video camera chamber	1007	47	31	32
Total	2355	100	98	100

With respect to the video camera system, salmon generally passed through the chamber all night long. The period from 2230 to 0229 hours accounted for almost 50% of the total. This pattern of movement is generally consistent with that observed at Biscay Bay River, SFA 9 (M. F. O'Connell, personal communication). A total of 577 fish were associated with time of fish passage as follows:

Time (hours)	Number of fish	%
2030 - 2229	116	20.1
2230 - 0029	139	24.1
0030 - 0229	145	25.1
0230 - 0429	113	19.6
0430 - 0900	64	11.1

<u>Total returns</u> of adult salmon to Conne River (and estuary) in 1993 are summarized in Tables 8 and 9. The forecast of returns to Conne River in 1993 was higher than in 1992. However, this forecast did not consider the low condition of 1992 smolts and the observed, but preliminary relationship between condition and survival.

Total returns of small salmon (2703) were 7% higher than in 1992 while large salmon returns (100) declined by 37%. For small salmon, this was consistent with the 1992 forecast in terms of direction, that is 1993 returns showing an improvement over the previous year. However, the magnitude of the increase was wrong and relates to another year of low sea survival. Sea survival of smolts increased from 3.4% (2.9-4.1%) in the previous year (1992) to 4.0% in 1993 (3.6-4.4%) (Table 10). A comparison of sea survival of smolts at Northeast Brook, Trepassey, SFA 9, with Conne River is illustrated in Fig. 8 (Northeast Brook data from M. O'Connell, personnel communication). On a broad scale, similar patterns are observed; survival declined from 1986-87 (smolt migration year) to 1988-89, followed by the lowest value in 1991 with a small increase in 1992.

Low sea water temperature has been cited as a factor influencing survival of Atlantic salmon. Sigholt and Finstad (1990) found that in cultured Norwegian salmon, low temperature contributed to osmoregulatory failure and poor survival of smolts transferred from freshwater to sea water. Mortality was most pronounced at temperatures below 6° C. Lega et al. (1992) also found that low sea temperature affects water balance in salmon resulting in a decrease in body moisture content and an increase in plasma osmolarity. The most dramatic changes occurred at temperatures below 4° C (Lega et al. 1992). Other studies have established that low temperature or rapid change in salinity alone may not impact on survival; however, when interacting together, decreased survival in Atlantic salmon and rainbow trout occurs (Byrne et al. 1972; Finstad et al. 1988).

Potential spawning escapement in 1993 was estimated to be 2353 small salmon and 97 large salmon (Tables 8 and 9). Mean number of eggs per female is 2357 (based on overall mean size of female salmon). With 82% of the run made up of female salmon, the number of eggs per fish is 1933. Estimated total number of eggs deposited was:

small salmon = 4.429 million eggs

large salmon = 0.332 million eggs

for a total egg deposition of 4.760 million, 61% of the current target egg requirement and about a 20% increase in egg deposition from 1992.

The finding of three dynamite blasting caps along a short stretch of the Bernard Brook tributary is of concern. A check with both Federal and Provincial agencies responsible for authorizing permits for blasting indicated that permits had not been issued, nor had there been any specific work in the area to warrant blasting. Thus no legitimate reasons were identified to account for the presence of these caps. It is also noted, however, that no other evidence was found to suggest illegal poaching of salmon by this means had occurred.

Relationships between estimated egg deposition and subsequent smolt output, and estimated smolt output with adult returns are based on limited data and as such, are not conclusive (Fig. 9). At best, higher egg depositions produced more smolt but smolt output from low egg depositions will not be apparent for several more years. Moderate to high numbers of returning adults corresponded with moderate to higher numbers of migrating smolts in the previous year (Fig. 9). Low returns of adults were obtained over the entire range of smolt migrants. We caution, however, that it is premature to draw any conclusions from these limited data.

Estimates of egg-to-smolt survival are now available for three year-classes (1986 to 1988; the 1988 year-class complete only to age 4 smolts in 1993). These values, by year-class, are:

1986 - 0.50; 1987 - 0.46; 1988 - 0.52. Estimates differ slightly from those recorded in O'Connell et al. (1992) owing to updated smolt estimates by age class.

5. Forecast of 1994 returns

The estimated number of smolts in 1993 was 55765 (95% confidence limit = 51666-59864) (Table 11); about 18% lower than the previous year. The percentage of smolts at each river age and the estimated number of smolts in each age group are summarized in Tables 11 and 12, respectively. Part of the decline in the 1993 smolt run could be associated with an egg deposition in 1989 that was 40% lower than the previous three-year average (1986-88).

At 4% survival, the approximate average recorded during the past three years, no more than 2400 fish would be expected to return to home waters in 1994. A sea survival of 7% would be required in order for total returns to meet or exceed the target of 4000 fish. Sea survivals of 7-10% have been recorded at Conne River in past years but it is again stressed that sea survival cannot be predicted. Assuming that the association between condition of smolts and higher survival holds, then returns in 1994 could be greater than that indicated above since the 1993 condition index was similar to that in 1987 when a high survival was recorded.

The need to carry out in-season evaluations cannot be emphasized enough in order to ensure conservation targets are achieved. It is also cautioned that low spawning escapements from 1991-93 may result in lower smolt production in 1995-97. This, should it occur, could then result in low adult salmon returns, probably below target levels, in 1996-98.

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Table 1. 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
1991	May 3	June 16	May 26	Aug 18
1992	May 10	June 15	May 26	Aug 10
1993	May 9	June 14	May 28	July 31

Table 2. Atlantic salmon landings (in numbers of fish) in the sport fishery 1953-92, and in the native food fishery, 1986-93, 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	948[1]	11	959
1991	679	108	0	108	1200	281	3	284
1992	1499	329	0	329	1200	483	5	488
1993	0	0	0	0	500[2]	417	3	420
Mean								
1988-92	2967	757						
1983-92	4474	1471						

[a]Dead in trap.
[1]Total for 1990 does not include approximately 50 fish found dead and partially destroyed in traps.
[2]500 fish initially allocated.

Table 3. Summary of biological characteristic information for Atlantic salmon samples from Conne River, Newfoundland, 1986-93. Length = fork length, weight = whole weight.

			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
	1991	246	153	19.9	104-244	33.5	13.6	12.6-112.5	3.19	0.44	2-5	245	66
	1992	169	149	15.6	116-189	30.1	8.9	14.9- 59.2	3.28	0.51	2-5	169	71
	1993	246	149	16.5	114-198	31.6	10.3	15.7- 71.7	3.26	0.45	3-5	246	67
TOTAL		1964	149	18.2	98-265	31.8	11.8	9.8-123.2	3.29	0.50	2-5	1816	73
1 SW	1986	357	506	23.0	440-570	1451	220.4	900-2900	3.38	0.57	2-5	356	76
	1987	373	509	23.3	430-580	1493	247.9	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
	1991	39	514	22.8	455-552	1364	174.7	1000-1700	3.18	0.39	3-4	33	70
	1992	77	505	22.4	453-580	1353	278.0	900-2000	3.18	0.53	2-5	43	79
	1993	39	513	30.8	475-620				3.05	0.32	2-4		
TOTAL		1466	508	24.0	430-620	1434	230.3	600-2900	3.23	0.50	2-5	1297	78
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
	1992	1	650			2700			3.00				
TOTAL		4	653	20.6	630-680	2667	57.7	2600-2700	3.25	0.50	3-4		

Table 3 (Cont'd.) Summary of biological characteristic information for Atlantic salmon samples from Conne River, Newfoundland, 1986-93. Length = fork length, weight = whole weight.

			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
Consecutive Spawning Grilse													
	1986	1	560			1800			3.00			1	100
	1987	31	511	24.5	460-576	1331	232.3	1020-2100	3.61	0.62	2-5	30	100
	1988	5	556	24.1	530-590	1640	260.8	1500-2100	2.80	0.84	2-4	5	40
	1989	6	575	23.5	550-610	1767	233.8	1500-2000	3.00	0.00	3-3	6	50
	1990	3	564	51.4	505-601				3.33	0.58	3-4		
	1991	4	586	49.9	548-659				3.50	0.58	3-4	1	100
	1992	8	581	43.6	530-660				3.50	0.53	3-4		
	1993	3	617	56.9	570-680				2.67	1.15	2-4		
TOTAL		61	544	46.6	460-680	1483	285.5	1020-2100	3.39	0.67	2-5	43	86
Alternate Spawning Grilse													
	1986	1	600			2400			3.00			1	100
	1989	13	683	18.9	660-710	3350	212.1	3200-3500	3.08	0.28	3-4	2	100
	1991	2	700	29.0	679-720				3.50	0.71	3-4		
	1992	8	682	44.4	630-770				2.88	0.35	2-3	1	100
	1993	6	675	35.1	640-710				3.33	0.52	3-4		
TOTAL		30	680	33.5	600-770	3033	568.6	2400-3500	3.10	0.40	2-4	4	100

Table 4. Summary of biological characteristic information for Atlantic salmon samples from the Conne River aboriginal food fishery, 1992-93. Length = fork length. Weight = whole weight.

			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
1 SW	1992	208	516	20.3	470-580	1389	176.6	1000-2000	3.07	0.44	2-5	206	67
	1993	253	504	24.3	430-640	1347	214.1	900-2400	3.08	0.39	1-4	253	67
Total		461	509	23.3	430-640	1366	199.1	900-2400	3.07	0.41	1-5	459	67
2 SW	1992	1	690			2200			3.00			1	100
Alternate spawning grilse													
	1992	2	665	7.1	660-670	3650	353.6	3400-3900	3.50	0.71	3-4	2	100
	1993	2	685	7.1	680-690	3550	212.1	3400-3700	3.00			2	100
Total		4	675	12.9	660-690	3600	244.9	3400-3900	3.25	0.50	3-4	4	100

Table 5. Summary of rainbow trout occurrences and captures at Conne River, 1990-93, with corresponding length and weight data where available.

Year	Date	Location	Lth (mm)	Weight (g)
1990	May 25	Downstream trap	345	400
	June 12	Upstream Trap	370	700
	July 22	Beach mortality	216	100
1991	June 5	Upstream Trap	470	1400
	June 10	In pool above fence	532	2200
	June 15	8 fish reported caught at Dashwoods:	4 - (18-20 cm)	
			2 - (1.5-2 kg)	
			2 - (0.5-0.7 kg)	
	June 15	Angled above fence		~700
	June 16	3 angled above fence	494	1600
			540	2600
			538	2200
	June 17	Angled at Dashwoods		>2000
	June 25	2 caught below fence		
	June 25	Upstream trap	395	710
	June 26	1 caught below fence		
	June 27	5 trout observed passing downstream through fence		
	June 27	Angled above fence	354	300
	June 27	Angled above fence	547	2000
	June 27	1 trout observed moving upstream through fence		
	July 13	11 trout observed while diving in pool above counting fence		
	Aug 18	9 trout observed while diving in pool above counting fence		
1992	May 21	Downstream fence	~170	
	May 28	Downstream fence	~300	
	May 28	Upstream trap	600	
1993	May 11	Downstream fence	162	63
	May 16	Downstream fence	169	60
	May 30	Downstream fence	171	68
	May 31	Downstream fence	157	56
	June 1	Downstream fence	185	96
	June 2	Downstream fence	200	99
	June 7	Downstream fence	175	73
	June 16	Downstream fence	165	60
	July 4	Upstream camera system		
	July 5	Upstream camera system		
	July 18	Upstream adult trap	195	92

Table 6. Summary of mean weekly water temperatures (°C) and water levels (cm) at the counting fence on Conne River, Newfoundland, 1989-93.

		Mean water temperature					Mean water level				
Date	Week	1989	1990	1991	1992	1993	1989	1990	1991	1992	1993
May 7-13	19	12.9	6.6	8.4	5.5	-	65.3				
May 14-20	20	11.0	9.6	7.1	8.5		27.5	47.5			
May 21-27	21	14.5	7.5	8.2	11.3		22.0	41.8	49.8	38.5	
Ma 28-Jn 3	22	14.6	12.5	9.4	13.1	9.4	46.8	26.2	40.8	53.6	48.1
Jun 4-10	23	16.4	13.6	10.8	12.6	11.6	34.4	21.9	22.3	67.5	36.0
Jun 11-17	24	14.3	16.4	12.8	14.0	12.5	16.7	11.9	21.8	75.4	27.9
Jun 18-24	25	17.9	13.8	14.9	16.6	14.5	14.0	59.9	16.2	57.1	40.3
Jn 25-Jl 1	26	19.0	17.6	17.5	13.9	15.8	12.9	42.1	8.6	35.2	62.9
Jul 2-8	27	17.2	17.5	15.1	12.5	15.6	5.6	19.1	6.9	38.0	52.4
Jul 9-15	28	18.4	16.9	16.9	15.8	17.7	15.8	12.3	6.1	48.7	33.4
Jul 16-22	29	18.5	18.8	19.6	17.4	15.1	34.1	9.1	4.9	35.4	49.4
Jul 23-29	30	18.9	20.5	19.5	18.5	16.5	20.7	23.6	9.4	27.3	58.6
Jl 30-Ag 5	31	19.6	19.0	18.3	17.1	17.9	20.1	14.1	2.1	52.4	46.0
Aug 6-12	32	20.4	21.4	15.3	18.6		31.6	10.0	21.4	45.4	
Aug 13-19	33	20.3		19.4				13.6			
Aug 20-26	34	18.3									
Aug 27-Sep 2	35	14.0									
Sep 3-9	36										
Average		17.0	14.7	14.2	12.7	14.8	22.7	27.8	15.2	48.8	45.4

Table 7. Weekly summary of numbers of Atlantic salmon enumerated at the counting fence on Conne River, Newfoundland, 1987-1993.

		Number of Fish													
		SMALL							LARGE						
Date	Week	1987	1988	1989	1990	1991	1992	1993	1987	1988	1989	1990	1991	1992	1993
May 14-20	20	0	0	0					0	0	0				
May 21-27	21	0	0	0	0				0	0	0	0			
May 28-Jun 3	22	2	0	3	0				0	0	10	0		1	2
Jun 4-10	23	17	11	38	1		5	4	15	7	2	0	2	3	0
Jun 11-17	24	1905	652	946	82	44	67	71	294	123	85	37	9	8	1
Jun 18-24	25	3713	1939	2119	569	137	513	546	116	119	154	110	16	53	29
Jun 25-Jul 1	26	1514	2256	856	1706	234	408	575	38	114	31	127	16	42	18
Jul 2-8	27	515	730	216	115	739	547	376	7	16	3	44	18	17	18
Jul 9-15	28	1374	769	248	588	584	259	361	17	5	9	21	7	20	15
Jul 16-22	29	32	344	3	172	178	66	294	0	17	0	20	9	5	0
Jul 23-29	30	126	91	15	88	83	37	126	4	3	0	2	5	1	
Jul 30-Aug 5	31	3	268	4	0	14	67	2	0	11	0	0	1	4	1
Aug 6-12	32	25	1	21	0	65	14		1	2	0	0	4		
Aug 13-19	33	0	0	0	-	27[2]			0	0	0	-			
Aug 20-26	34	6	57	0	-				0	1	0	-			
Aug 27-Sep 2	35	38	0	0	-				0	0	0	-			
Sep 3-9	36	417[1]	-	-	-				0	-	-	-			
Total		9687	7118	4469	4321	2105	1983[3]	2355	498	418	319	361	87	154	98

[1]Includes estimate of 400 fish in lower part of the river at the time the counting fence was removed in 1987.
[2]Includes estimate of 19 fish in lower part of the river at the time the counting fence was removed in 1991.
[3]Includes estimate of 10 fish in lower part of the river at the time the counting fence was removed in 1992.

Table 8. Total estimated returns of small salmon to Conne River, Newfoundland, with a summary of mortalities and removals, and estimated spawning escapement, 1986-93.

	Year							
	1986	1987	1988	1989	1990	1991	1992	1993
<u>Returns to Conne R.</u>								
*Food Fishery (estuary)	766	451	506	317	831	234	403	347
Angling below fence				180	213	70	137	0
Mortalities below fence	21	17	3	2	3	2	0	1
Fence count	7515	9287	7118	4469	4321	2086	1973	2355
Estimated count		400				19	10	
Total	8302	10155	7627	4968	5368	2411	2523	2703
1) Released at Fence	7515	9687	7118	4469	4321	2105	1983	2355
<u>Removals and mortalities</u>								
Mortalities above fence	27	21	7	4	2	5	8	2
Angling above fence	2060	1598	1544	856	554	38	192	0
Brood stock removal		245						
2) Total	2087	1864	1551	860	556	43	200	2
<u>Spawning escapement</u>								
(1) - (2)	5428	7823	5567	3609	3765	2062	1783	2353
<u>Egg deposition</u>								
x 10^6	9.86	14.66	10.65	6.95	7.50	3.79	3.45	4.43
% of target met	126	188	137	89	96	49	44	57

* Food fishery includes fish caught in the 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, the weighted mean (0.833) was used.

Table 9. Total estimated returns of large salmon to Conne River, Newfoundland, with a summary of mortalities and removals, and estimated spawning escapement, 1986-93.

	Year							
	1986	1987	1988	1989	1990	1991	1992	1993
<u>Returns to Conne R.</u>								
*Food Fishery (estuary)	14	18	2	1	11	2	4	2
Angling below fence	0	0	0	0	0	0	0	0
Mortalities below fence	1	0	0	0	0	0	1	0
Fence count	397	498	418	319	361	87	154	98
Estimated count								
Total	412	516	420	320	372	89	159	100
1) Released at Fence	397	498	418	319	361	87	154	98
<u>Removals and mortalities</u>								
Mortalities above fence	1	0	0	0	0	0	1	1
Angling above fence	0	0	0	0	0	0	0	0
Brood stock removal		10						
2) Total	1	10	0	0	0	0	1	1
<u>Spawning escapement</u>								
(1) - (2)	396	488	418	319	361	87	153	97
<u>Egg deposition</u>								
x 10^6	1.48	2.07	1.77	1.09	1.23	0.30	0.52	0.33
% of target met	19	27	23	14	16	4	7	4

* Food fishery includes fish caught in the 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, the weighted mean (0.833) was used.

Table 10. Smolt to adult survival for Conne River Atlantic salmon.

	Number of smolts year i	Number of small salmon year i+1	% survival	Confidence limit
1987	74585	7627	10.2	9.3-11.3
1988	65692	4968	7.6	6.9-8.3
1989	73724	5368	7.3	6.7-8.1
1990	56943	2411	4.2	3.9-4.6
1991	74645	2523	3.4	2.9-4.1
1992	68208	2703	4.0	3.6-4.4

Table 11. Estimated size of the Conne River, Newfoundland, Atlantic salmon smolt population, 1987-93, 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 of 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	65692	59862-71522	4.8	3.4	0	63	36	1	328
1989	2699	73724	66598-80850	5.1	3.2	3	71	24	2	288
1990	3719	56943	52315-61571	4.4	3.3	1	70	28	1	271
1991	2753	74645	62033-87527	9.0	3.2	1	80	18	1	246
1992	3758	68208	61334-75052	5.4	3.3	1	73	24	2	169
1993	2456	55765	51666-59864	3.9	3.3	0	74	26	0	246

Table 12. Estimated total number of smolts in each age group, for Conne River, Newfoundland, 1987-93.

Year	River age (y)				Total
	2	3	4	5	
1987	1492	49226	22375	1492	74585
1988	0	41386	23649	657	65692
1989	2212	52344	17694	1474	73724
1990	569	39861	15944	569	56943
1991	747	59716	13436	746	74645
1992	682	49792	16370	1364	68208
1993	0	41266	14499	0	55765

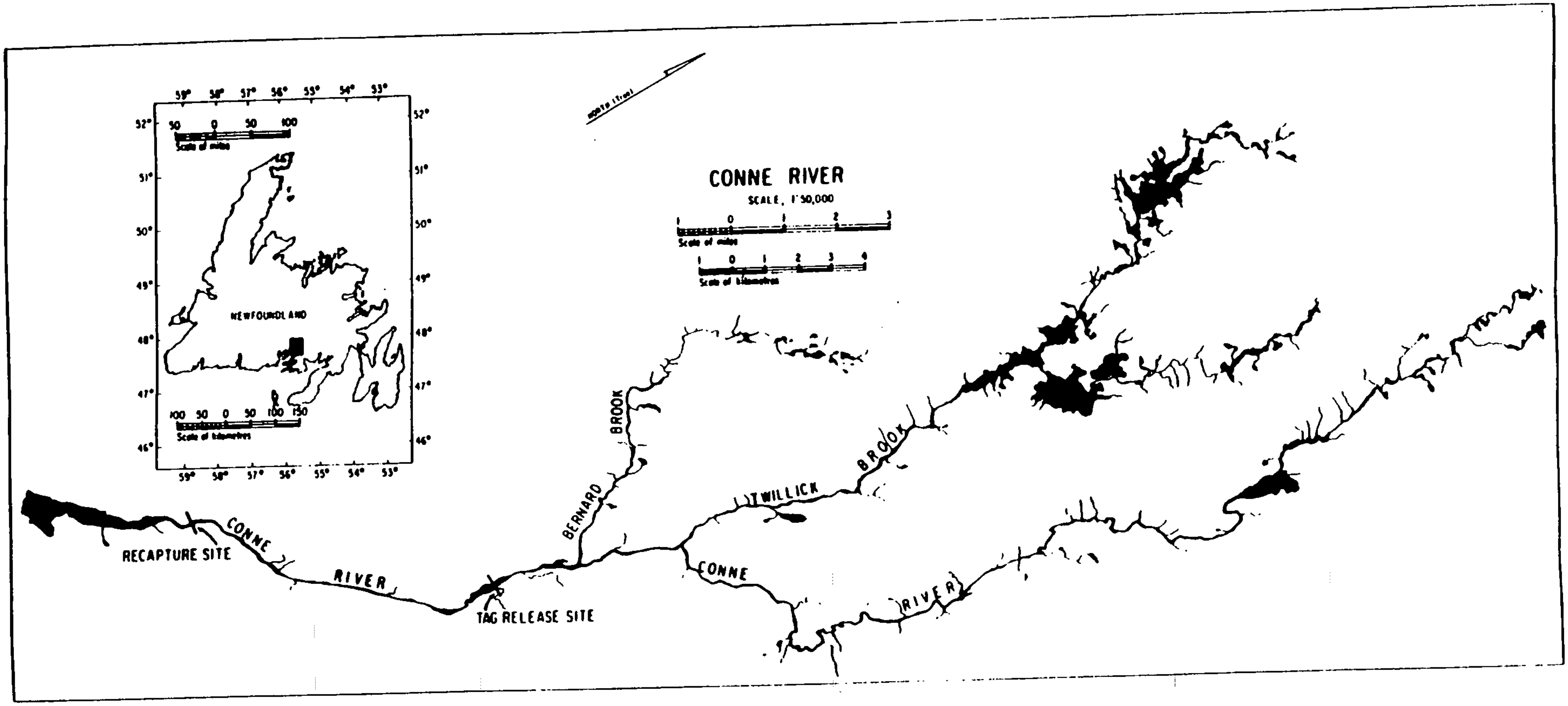


Figure 1. Conne River, Newfoundland, SFA 11, illustrating the location of the fish counting fences used for the mark-recapture survey. Recapture site is also the location of the upstream adult counting facility.

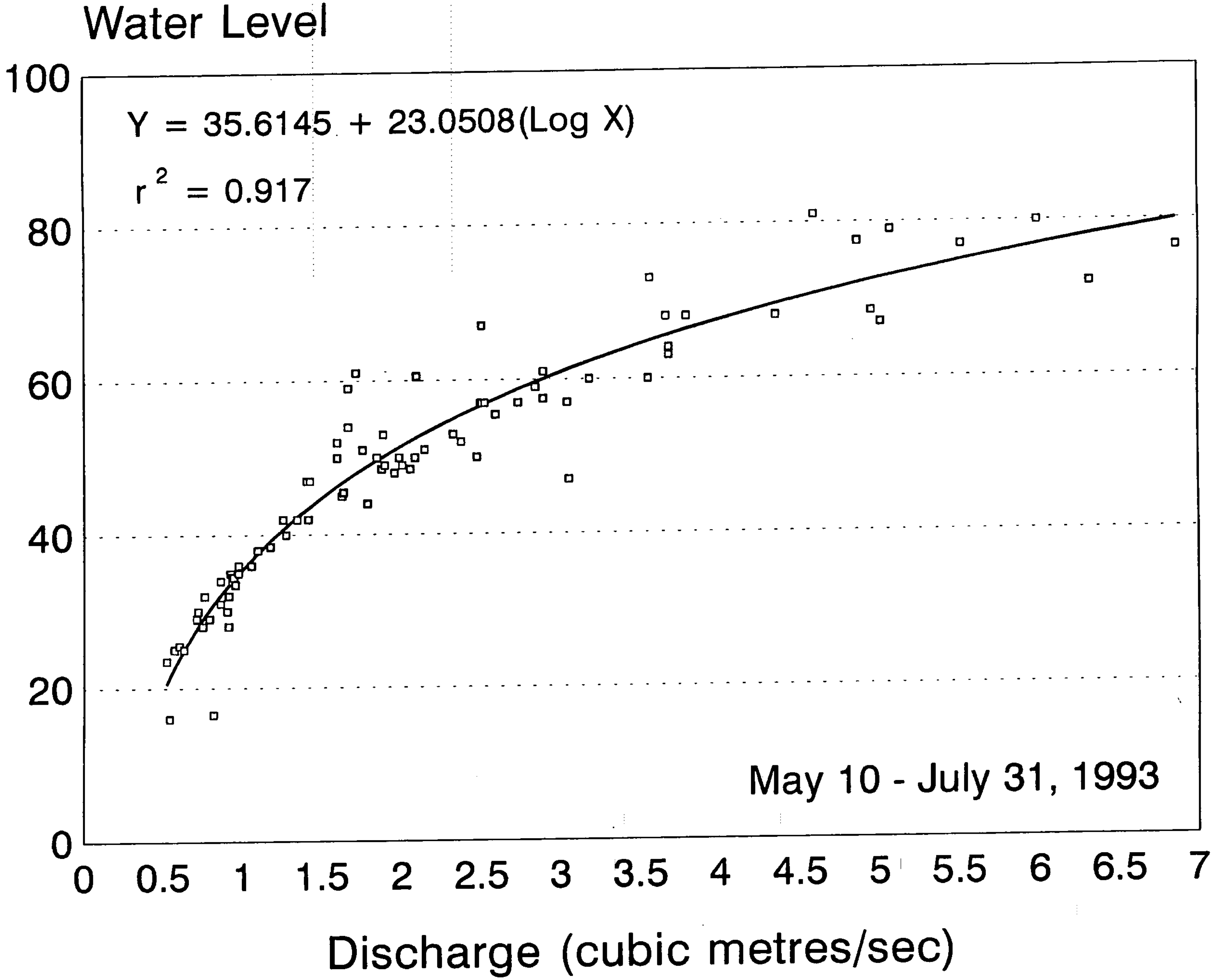
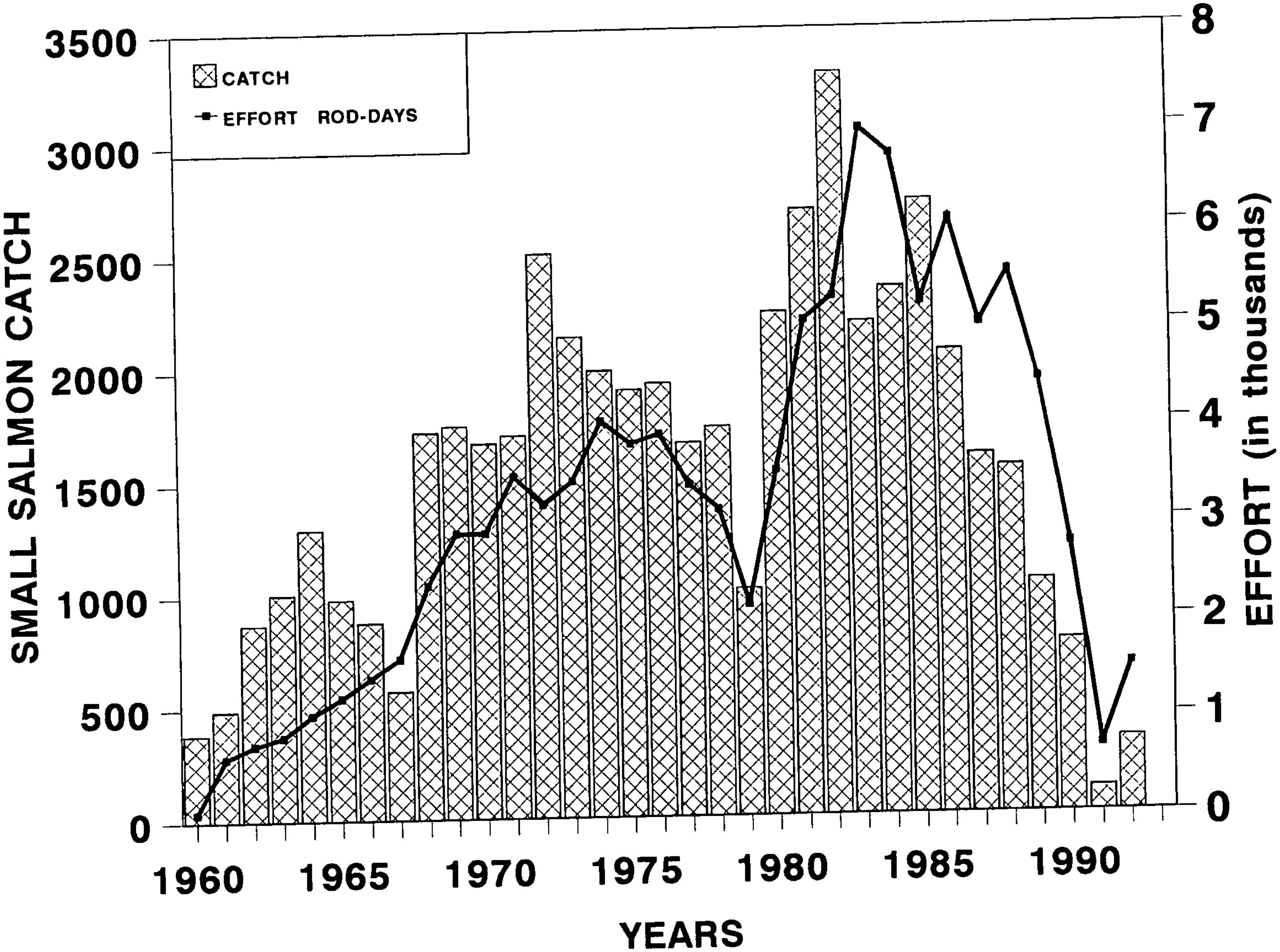


Figure 2. Relationship between relative water level in the lower section of Conne River, as measured at a stationary bench-mark pin, and the Environment Canada monitoring facility discharge records, May 10 - July 31, 1993. The Environment Canada facility is located immediately below Conne Pond, above the Bernard Brook and Twillick Brook tributaries.



Fishery closed for 1 month in 1990
Quota of 100 fish in 1991
Quota of 330 fish in 1992

Figure 3. Summary of the small salmon recreational catch (bars) and effort (rod-days fished, in thousands, solid line) for Conne River, Newfoundland, SFA 11, 1960-92. Recreational fishery was closed in 1993.

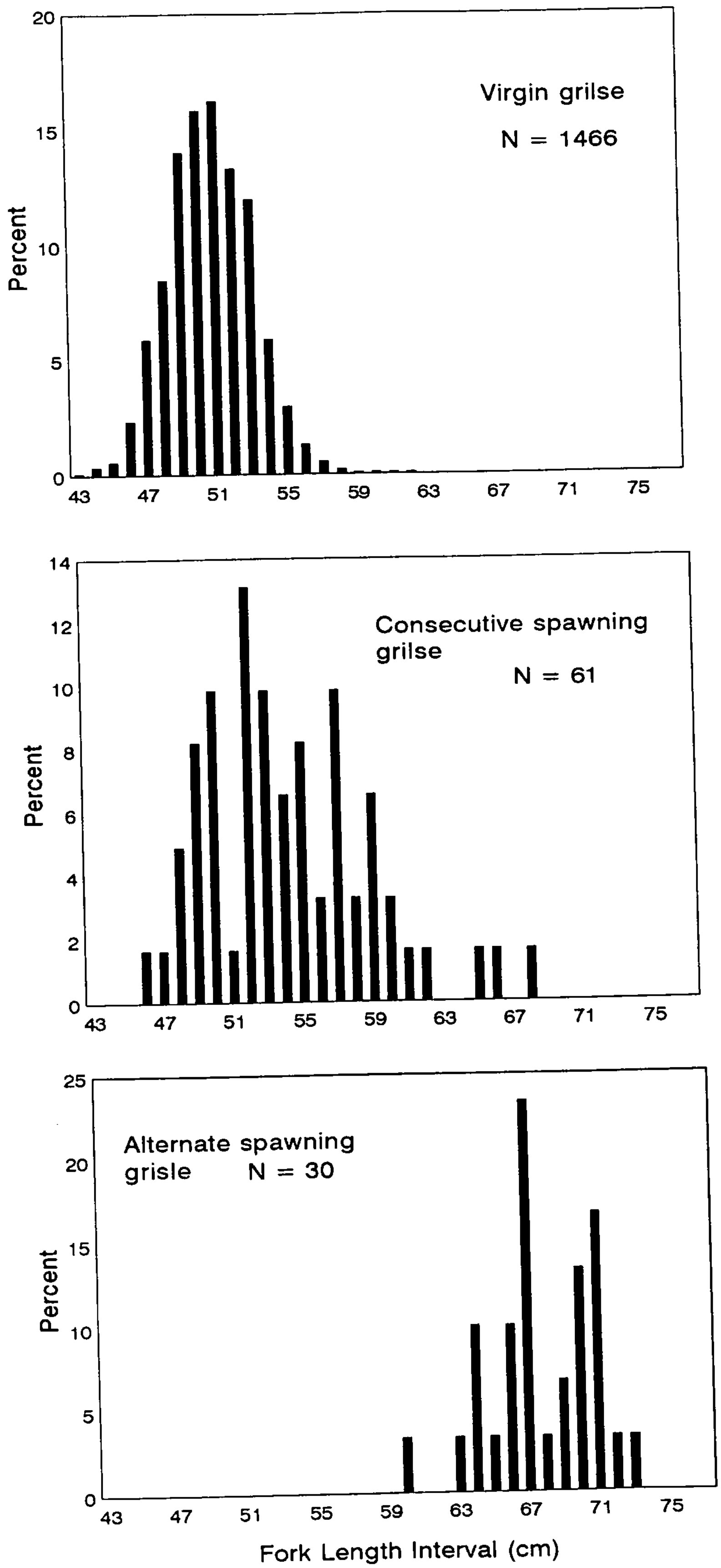
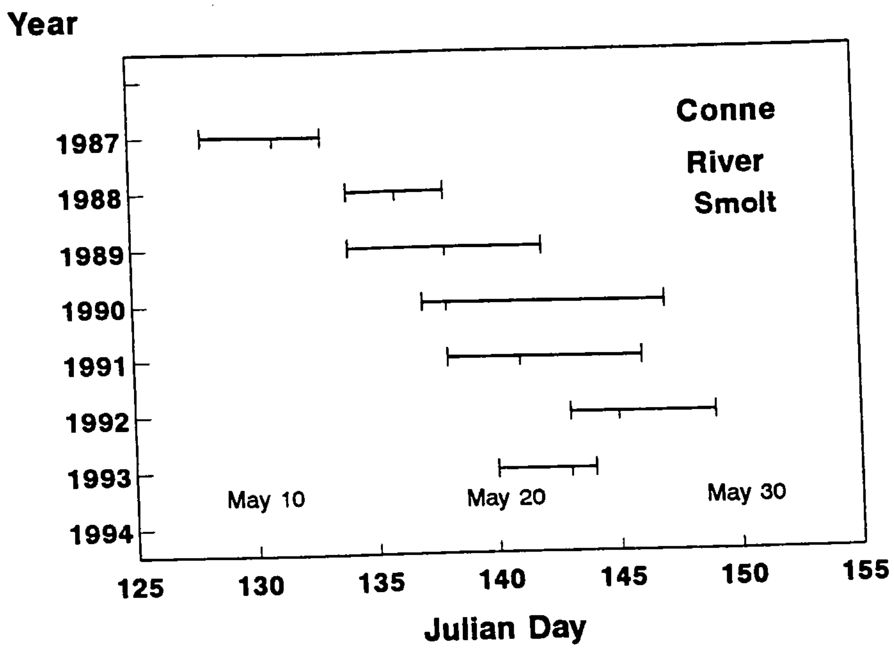


Figure 4. Length-frequency distribution of adult Atlantic salmon sampled at Conne River, 1986-93.



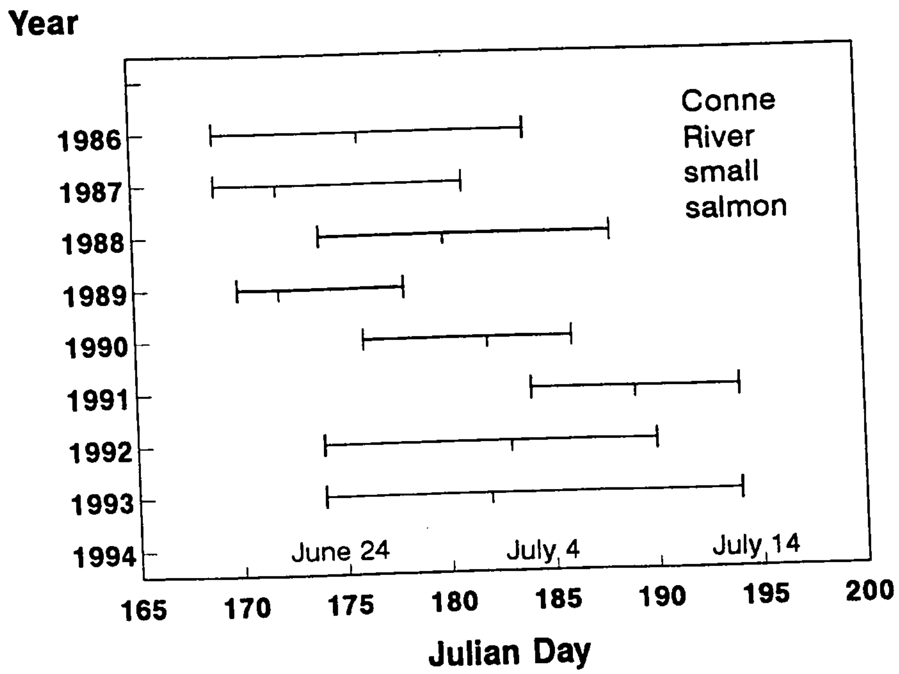


Figure 5. Run timing of smolt and adult small salmon at Conne River, Newfoundland. The median point, along with the 25th and 75th percentiles are illustrated.

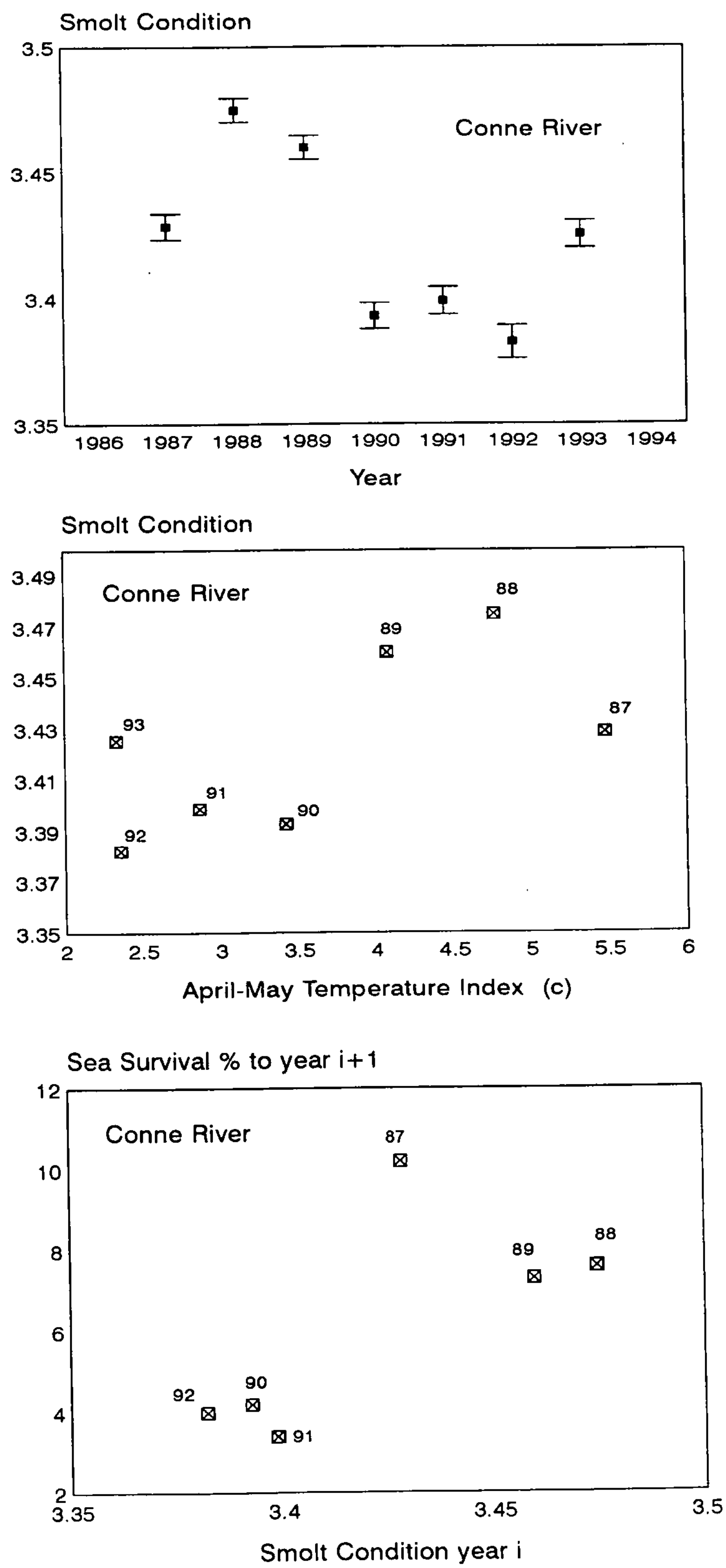


Figure 6. Index of Conne River smolt condition: varying over years (upper); in relation to the April-May air temperature index (middle); and as it relates to estimated sea survival of adult salmon returning in the following year. Vertical bars in upper graph represent ± one standard error.

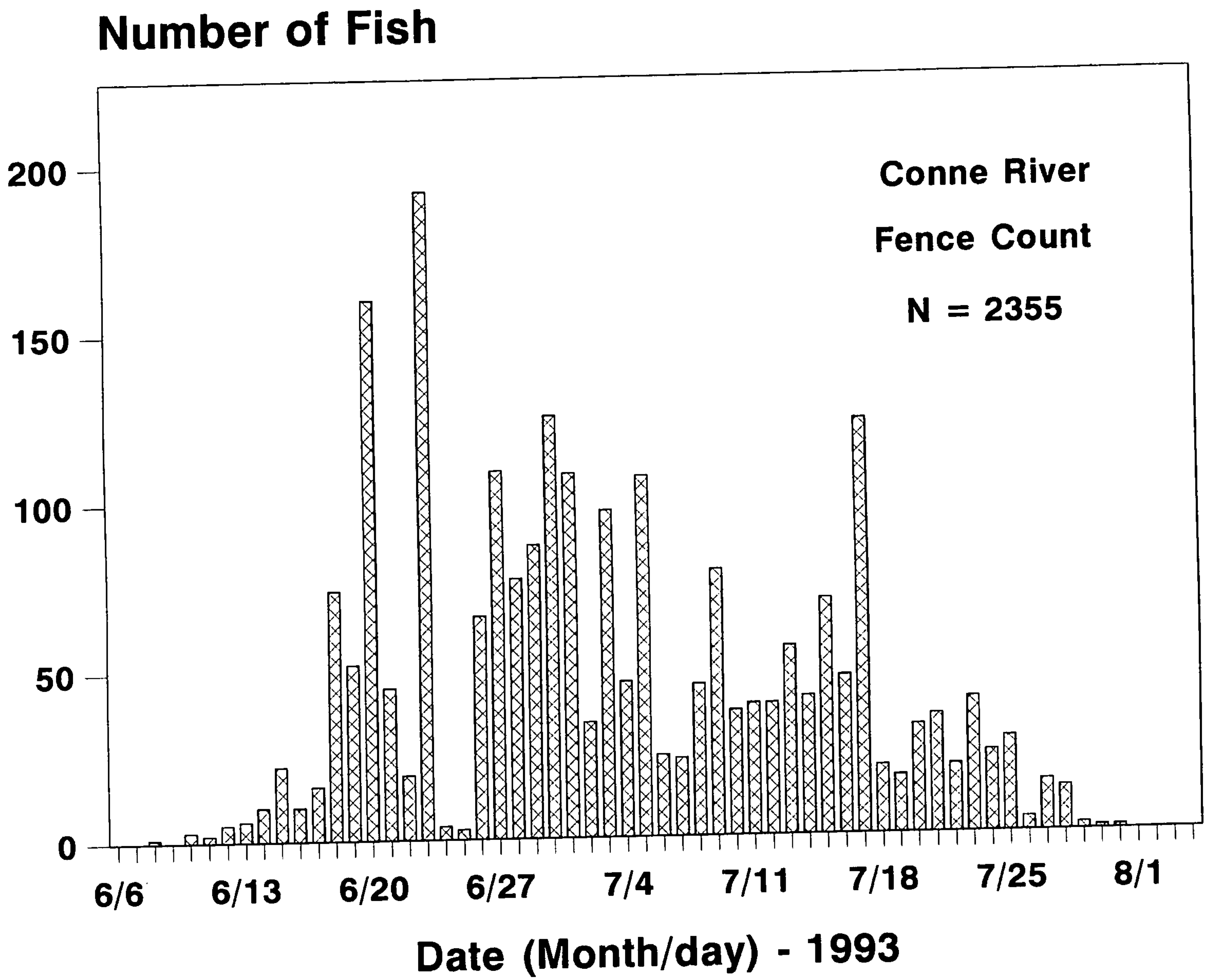


Figure 7. Daily counts of small salmon returns to the fish counting fence on Conne River, 1993.

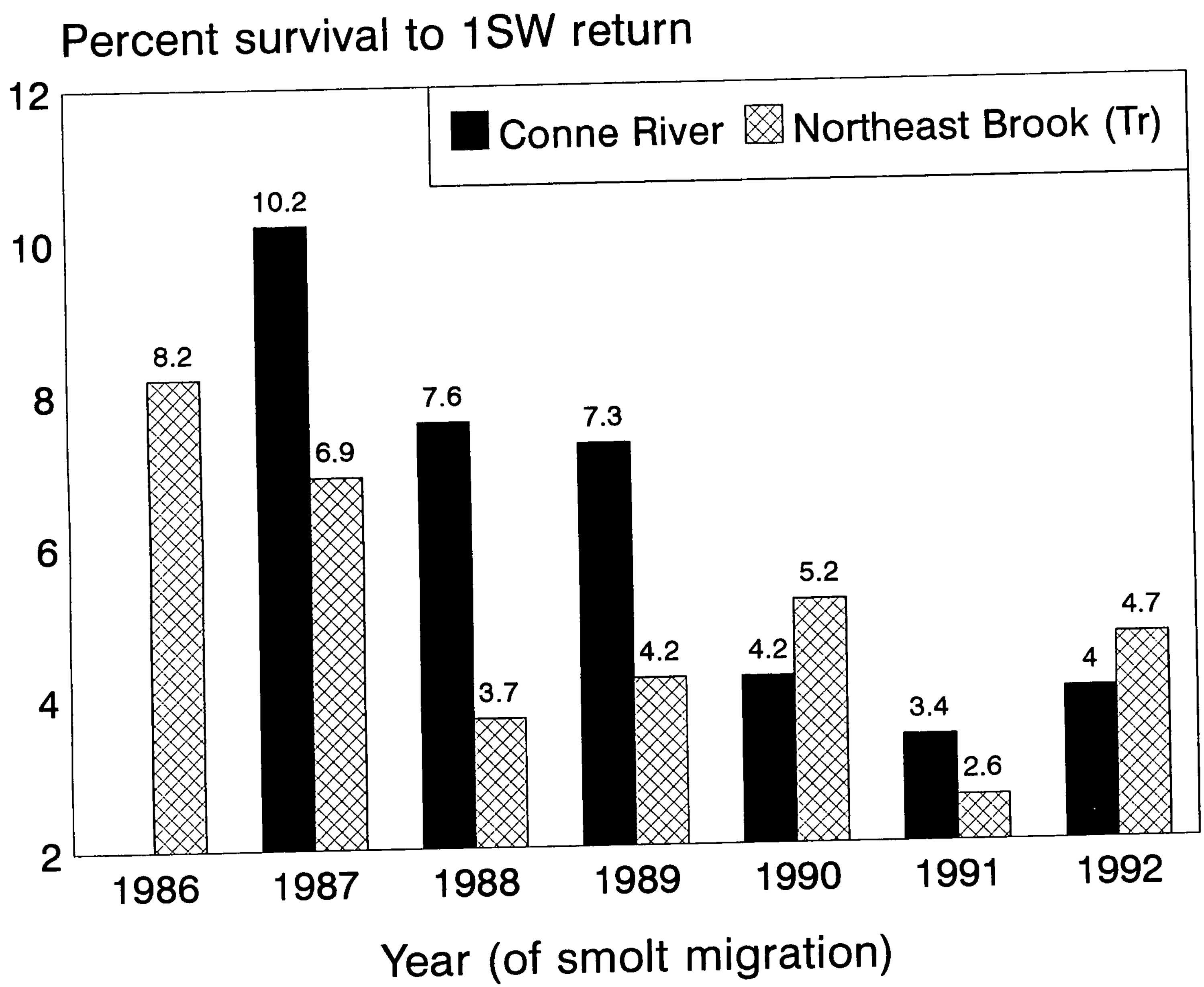
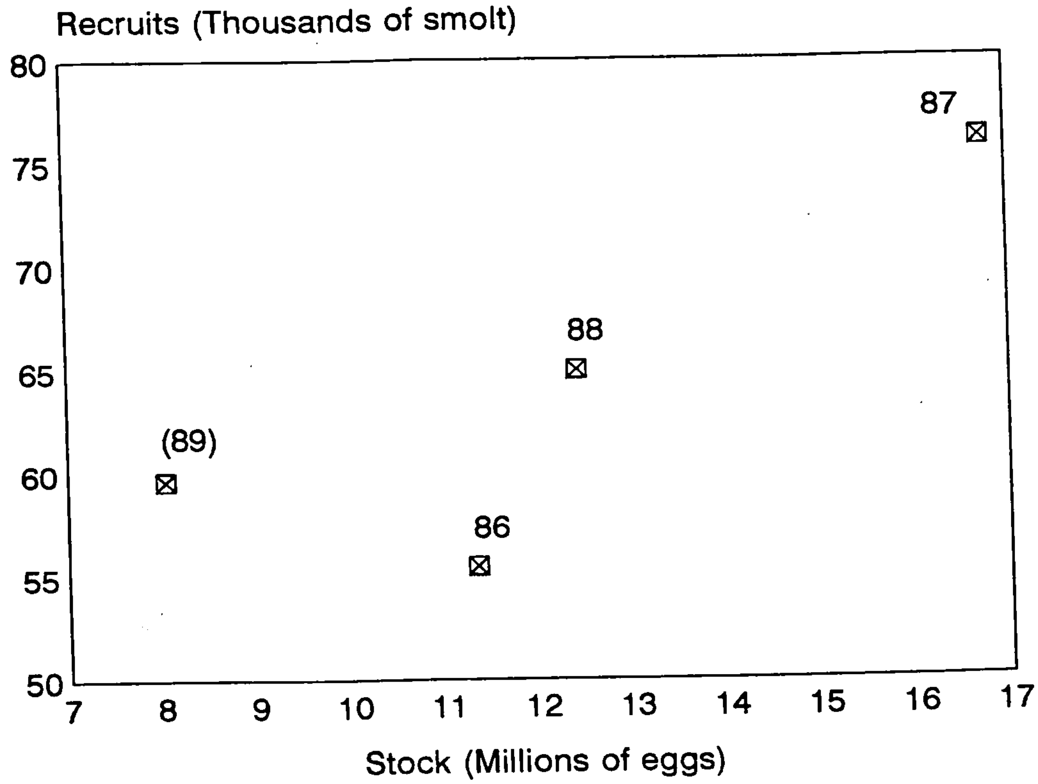


Figure 8. Estimates of sea survival from smolt to returning 1SW salmon at Conne River, SFA 11, and Northeast Brook, Trepassey, SFA 9, Newfoundland



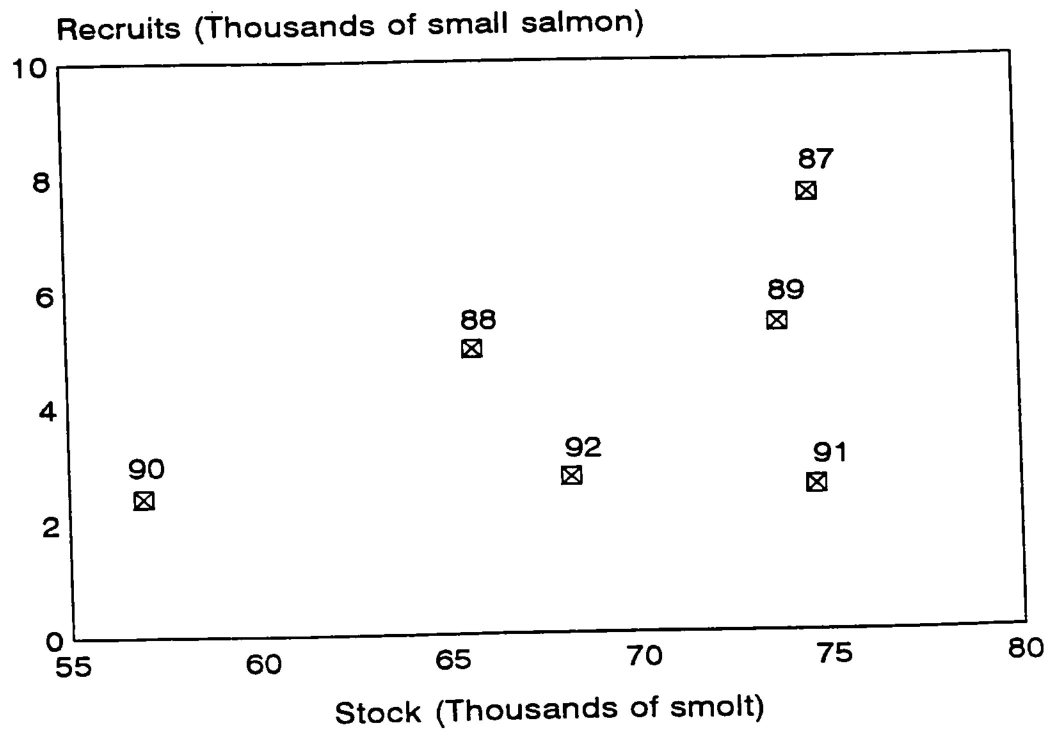


Figure 9. Relationships between estimated egg deposition and subsequent smolt production, by year class (year of egg deposition) (upper), and smolt production (year of smolt run) (by smolt class) and return of adult salmon (lower). Brackets around the 1989 year class in the upper diagram indicate incomplete information on numbers of age 4 smolt which will migrate in 1994. Therefore, an average of numbers of age 4 smolt (1987-1993) has been used.