Evaluation of Atlantic salmon stock status: Conne River, SFA 11, Newfoundland, 1994

by

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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 1994. Returns to home waters (river and estuary) were 1533 salmon < 63 cm in length and 100 salmon ≥ 63 cm in size. This represented a decrease of 43% for small salmon while large salmon returns were similar to 1993. Sea survival was estimated to be only 2.7% (2.6-3.0%), the lowest value recorded in seven years. Estimated egg deposition from small salmon was 2.778 x 10^6 eggs; 36% of the target requirement. The contribution from large salmon was 0.339 x 10^6 eggs and thus only 40% of the required target egg deposition was achieved. An enhancement project was initiated at Conne River in 1994. The egg deposition equivalency from this project could increase the overall egg deposition to 58% of the current target requirement. A mark-recapture study suggested a smolt run in 1994 of 60762 (53759-67765). Assuming a sea survival that approximates the average recorded during the period 1991-93 (4%), then no more than 2400 fish would be expected to return in 1995. A sea survival of about 7% will be needed in order for total returns to homewaters to meet or exceed 4000 adult salmon. An alternate forecast based on the number of recruits produced per spawner also suggests low returns in 1995 (1300-1730 small salmon). It is cautioned that low spawning escapements from 1991-94 may result in low smolt production in 1995-98. This, should it occur, could result in prolonged low adult salmon returns.

Résumé

L'évaluation du stock de saumon de l'Atlantique de la rivière Conne en 1994 est fondée sur les résultats obtenus à un barrage de dénombrement du poisson. Quelque 1 533 saumons < 63cm et 100 saumons ≥ 63 cm sont revenus dans leurs eaux d'origine (rivière et estuaire), ce qui représentait une baisse de 43 % pour le petit saumon et un résultat comparable à celui de 1993 pour le grand saumon. Le taux estimé de survie en mer n'était que de 2,7 % (2,6-3,0 %), soit le plus bas en sept ans. La ponte des petits saumons était estimée à 2,778 x 10^6 oeufs, soit 36 % de la cible. Celle des grands saumons s'établissait à 0,339 x 10^6 oeufs, soit seulement 40 % de la cible. Un programme d'empoissonnement a été mis en oeuvre dans la rivière Conne en 1994. La ponte découlant de ce programme pourrait porter la ponte totale à 58 % de la cible actuelle. D'après une expérience de marquage-recapture, 60 762 saumoneaux (53 759-67 765) auraient remonté la rivière en 1994. En tablant sur un taux de survie en mer correspondant approximativement à la moyenne de 1991-1993 (4 %), les remontées devraient être de 2 400 saumons au maximum en 1995. Il faudra atteindre un taux de survie en mer d'environ 7 % pour que les remontées totales de saumons adultes dans les eaux d'origine soient égales ou supérieures à 4 000. Une autre prévision fondée sur le nombre de recrues par frayeur aboutit aussi à de faibles remontées pour 1995 (de 1300 à 1730 petits saumons). Il est à craindre que les faibles échappées de reproducteurs connues de 1991 à 1994 ne se traduisent par une baisse de la production de saumoneaux de 1995 à 1998, phénomène qui, s'il se confirme, pourrait aboutir à de faibles remontées de saumons adultes.

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. These operations continued in 1994. Previous estimates of the total return of small salmon have ranged from a low of 2411 in 1991 to 10155 in 1987. Target spawning requirements were met or exceeded from 1986-90, but only 50% of the target was achieved in 1991 and 1992 (Dempson 1993). In 1993, 61% of the target requirement was estimated to have been achieved (Dempson et al. 1994a). Smolt production has varied from about 56000 to 75000.

A major change in the management of the Conne River Atlantic salmon stock for 1993 was the complete closure of the recreational fishery. In light of the forecast of low salmon returns in 1994, this closure was continued and extended to the Indian Band Council's food fishery.

This paper summarizes returns of adult salmon to Conne River in 1994 and provides an outlook of potential returns of one-sea-winter (1SW) salmon for 1995. Biological characteristic data are updated along with data on rainbow trout and farmed Atlantic salmon occurrences in Conne River. Information on parr and smelt (Osmerus mordax) runs that occur along with the smolt migration is also summarized.

Noteworthy events or changes in 1994

The following summarizes noteworthy changes to fishery regulations and other observations/events occurring in 1994:

- recreational and native food fisheries closed for the entire season;
- Atlantic salmon smolts and adults of farmed (hatchery) origin documented to occur in Conne River;
- decline in sea survival to the lowest value recorded;
- estimated egg deposition decreased by 35% from 1993 with only 40% of the current target spawning requirement met;
- net-marked salmon continue to show up at Conne River;
- enhancement program initiated at Conne River with the first fry stocking to occur in 1995.

Methods

1. Landings

In past years, information on recreational catch statistics were collected by Department of Fisheries and Oceans (DFO) Fisheries Officers and guardians and processed by DFO Science Branch personnel. 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 in 1994 largely from salmon captured at the fish counting fence and subsequently retained for brood stock use (N = 92). The brood stock fish, however, were all captured from July 13 onwards in contrast with most other years when samples were obtained in June and early July. Biological data from Atlantic salmon smolts were again obtained from specimens sampled at the downstream counting fence trap.

Analyses of smolt 'condition' were updated following the general methods outlined in Dempson et al. (1994b). A general linear model was used to examine the response of fish weight, standardized to a common length as:

$$Y_{ij} = \mu + \alpha_i + b \bullet z_{ij} + \epsilon_{ij}$$

where,

Y_{ij} is the response variable, smolt weight,
α_i is a class variable, year,
z_{ij} is the covariate fork length, and
ϵ_{ij} is the error term associated with individual observations.

The model was used to calculate adjusted mean smolt weights by year standardized to the covariate. Additional details regarding the common slope (b) model used are in Dempson et al. (1994b). Weight and length variables were transformed to natural logarithms.

Rainbow trout, which stray into the Conne River as a result of incidental escapements from local fish farming activities in Bay d' Espoir, were again sampled in 1994 (N = 12). Analyses of biological characteristic information from the native food fishery in 1988 (N = 539) were completed and added to the existing information from recent years.

3. Physical measurements

Water temperature information was obtained from a continuous recording Hugrun thermograph in the lower Conne River (April 28 - September 26). Relative water level is determined from a bench-mark pin established in 1986. Information on air temperature, precipitation, and discharge were obtained from the Environment Canada, Atmospheric and Environment Service monitoring facility located on the main stem of Conne River, below Conne Pond. Temperature and salinity data were also obtained from CTD sets conducted at various sites throughout Bay d'Espoir, May 18-21. The May sampling coincided with the dates when approximately 44% of the Conne River smolt run had occurred (to May 21).

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 June 1 to September 26, 1994 (Table 1).

During 1994, 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) generally housed in a 1.2 x 1.8 m wooden box. The opening of the fish passage tunnel was approximately 0.5 m square and was incorporated within the above box. On occasion the camera was also operated directly within the conventional adult fish trap with the back gate open, as well as placed adjacent to openings in the fish counting fence itself. 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. The video system was operated each day from early evening until about 0900 hours from June 16 - July 12. Beginning July 13, all upstream migrating salmon were processed through the conventional fish counting fence trap. These fish were then transferred to holding cages located about 50 m upstream and maintained as brood stock for artificial propagation.

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 (0 in 1994).

Spawning escapement (SE) was estimated as:

$$SE = Fr - Ma - Br$$

where, Fr is the number of fish released at the counting fence
Ma is the known number of mortalities above the fence
Br is the number of salmon removed for brood stock use.

Consistent with the practise established in 1991, estimated egg deposition refers to the 'potential' 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.

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

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 fork length was the mean length of female salmon < 63 cm in size sampled in 1994 ($\bar{x}$ = 51.4 cm, N = 64) but the percentage female used (78%) was the value for all years combined. This was because there was a statistically significant difference in the sex ratio of small salmon from early in the season versus those, as in 1994, that were sampled later in the run ($G^2 = 7.12$, $P = 0.008$). There was no difference in the length of females between early and late run fish ($F = 0.01$, $P = 0.928$).

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. Net-marked salmon

Periodic surveys of net-marked salmon returning to Conne River were carried out at different times in 1994. This was approached in two ways.

a- Beginning June 17 and continuing until July 14, underwater snorkling observations were made at 3 to 4 day intervals by one individual. The area covered extended approximately 200 m downstream from the pool immediately below the fish counting fence. Double counting undoubtedly occurs even though intervals were spaced 3-4 days apart. This is because some fish observed during one interval may not have moved through the fence by the subsequent survey. Numbers of fish counted are not exact. Water level and clarity could influence counts as well as the random movement of fish within a given pool as the observer drifts through.

b- From June 17-21 and from June 22-25, the number of net-scarred salmon directly observed in the fish counting fence were enumerated. The resulting counts were derived by several individuals in contrast with the diving observations that were carried out by a single individual. Note that not all salmon pass through the counting fence trap, but of those that do, not all fish are observed clearly enough for any scarring to be recorded.

Estimates of the potential number of fish caught and retained (R_c) in various gear were obtained from:

$$R_c = 1/(1-R_t) - 1,$$

where R_t is the retention rate of salmon that encounters a net.

6. Smolt production and forecast of 1995 returns

A mark-recapture study was carried out to estimate the smolt production in 1994. The study was similar to those carried out in 1987-93, the design of which is summarized in Dempson and Stansbury (1991) and uses the estimator described in Schwarz and Dempson (1994). Exceptionally high water rendered the smolt monitoring traps inoperable from May 7 - 13. Over 90 mm of rain fell over a five day period at the Environment Canada Conne Pond site while 125 mm was recorded at the lower fence site approximately 30 km downstream. Only 9 smolts had been tagged and released at the upstream site up until the morning of May 6, and only 5 smolts caught (no tag recoveries) at the lower recapture site. Tagging resumed on May 14 (N tagged that day = 46) but 582 smolts (including 3 tag recoveries) were caught at the lower fence site on May 15, the first full day of operation following the high water period. Mean water temperatures varied from 4.4 to 6.6 °C from May 7 - 10, but averaged 8.4 to 10.0 °C May 11 - 14. While relatively few smolts may have been migrating during the first four

days when the fences were inoperable (May 7 - 10), larger numbers could have been moving on May 13 and 14. Thus, the number of smolts migrating in 1994 represents a minimum estimate in view of the May 7 - 13 washout.

During 1994, 2366 smolts were tagged and released at the upstream partial counting fence site (Fig. 1). At the downstream recapture site, 11875 smolts were caught including 479 tagged smolts. Sea survival, however, has declined over time (Fig. 10) and cannot be predicted. Thus, similar to 1994, the pre-season forecast of 1995 returns used the rounded average sea survival recorded during the years 1991-93. This value was approximately 4%.

Number of recruits and spawners, 1974-94, and anticipated returns in 1995

O'Connell et al. (1995) described a technique used for the Gander River salmon stock whereby in selected rivers with counting facilities it was possible to construct retrospectively total population size of small salmon (or total number of small salmon recruits) prior to any exploitation, and to use the number of salmon recruits per spawner to estimate anticipated returns one year in advance. The same technique is used herein to derive recruits and spawners for the Conne River salmon stock with the exception that total numbers of small salmon recruits are derived using an exploitation rate in the commercial fishery of 0.30 (Anon. 1991).

Analysis to detect recruitment overfishing

Details on analyses to detect recruitment overfishing are provided by O'Connell et al. (1995) and Anon. (1994).

Results and Discussion

1. Landings

Landings in the recreational fishery are summarized in Table 2 and Figure 2. As indicated above, no recreational fishing was allowed in 1993 or 1994. In past years, angling exploitation rates varied from 0.181 to 0.285 (Dempson et al. 1994a).

Native food fishery catches are also summarized in Table 2. No fishery occurred in 1994 while in past years, the food fishery was estimated to have harvested from 5 to 16% of the total number of small salmon returning to Conne River.

2. Biological characteristics

Tables 3 and 4 summarize annual biological characteristic data for salmon sampled from the river (1986-94) or from the native food fishery (1988, 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 ($\bar{x}$ = 548 mm, N = 76 and 1504 g, N = 58) while alternate spawners average 682 mm (N = 33) and 3033 g (N = 3) (Table 3). 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 73 (4.6%) fish out of 1591 samples were either consecutive (N = 72) or alternate spawners (N = 1). As acknowledged last year, at Conne River, few salmon survive to return and spawn repeatedly.

Two adult salmon with a freshwater (river) age of 1+ were sampled from the river in 1994. This is the first incidence of river age 1+ adult salmon from the river although last year (1993) a river age 1+ salmon was sampled from the native food fishery catch. These salmon are believed to be escaped salmon from local fish farming operations. In addition, about 12 smolts with a characteristic green coloured sheen were readily observed and removed from the partial fish counting fence during the smolt mark-recapture investigations. This colouration was consistent with that observed on smolts obtained directly from local sea cage fish farming operations. A comparison of scale circuli characteristics between the two samples of fish suggested that the 12 smolts obtained from the river were also of hatchery origin.

Figure 3 illustrates the run timing of smolts 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 of the smolt and adult run are typically later during the past four years (1991-93) in comparison with the pre-1990 period.

Atlantic salmon parr are also captured during the smolt mark-recapture study. The numbers vary annually and, for the most part, parr tend to migrate after the smolts (Fig. 4). Similarly, anadromous rainbow smelt (Osmerus mordax) are also frequently captured during the smolt investigations. Smelt numbers vary widely from year-to-year and also tend to lag behind the smolt run (Fig. 5).

The analysis of smolt condition indicated significant differences among years (F = 39.15, P = 0.0) (Fig. 6). Lowest condition was in 1992 followed by 1994, 1990, and 1991. Years in which smolts had a higher condition were those that were generally associated with warmer spring temperatures (Fig. 6). Last year there was a suggestion that smolt condition was associated with subsequent sea survival, as higher survival of smolts occurred in years where condition was greater (Fig. 6). Given the intermediate

value of condition for the out migrating smolts in 1993, survival was expected to have been approximately 6% rather than that which was realized (2.7%). It is noted that smolt condition in 1994 was the second lowest recorded.

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. 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. Summaries of known occurrences during the four years 1990-93 were reported last year (Dempson et al. 1994a). Information from 1994 for which size data was obtained is updated in Table 5. Additional rainbow trout were observed during the course of periodic snorkling observations in the lower river. In addition, electrofishing or diving observations also confirmed the presence of rainbow trout in three other streams that flow into upper Bay d'Espoir.

3. Physical measurements

Average water temperatures and water levels are summarized in Table 6 for the years 1990-94. Daily counts of smolts in relation to water temperatures are illustrated in Fig. 7 for the years 1987 to 1994. During the week of May 14-20, smolts were migrating out of a river where maximum daily temperatures were 9.2 to 12.4 °C (minimums of 6.3 to 8.7 °C; averages 7.7-10.2 °C). In contrast, Bay d'Espoir temperatures were much cooler (Fig. 8).

Near the mouth of Conne River, defined here as the general location where Conne River empties through the proposed 'causeway' site by the communities of Conne River and Morrisville, surface temperatures (1 m depth) were 2-3 °C while bottom (7 m) temperatures were 1.4 °C (site 6, Fig. 8). In the upper mid-bay area (sites 4 and 5) surface temperatures were 1.5-2.5 °C with bottom temperatures (17-45 m) of 1.4 °C. In the Gaultois Passage (sites 8-16, Fig. 8) surface temperatures of 1.7-3.5 were recorded but at most sites, temperatures were less than 2.5 °C. The warmest water was found at the mouth of, and cage site at Roti Bay (sites 1-3, Fig. 8). Here, surface temperatures of 4-4.5 °C were recorded with bottom temperatures less than 1 °C.

Figure 9 illustrates the daily counts of adult small salmon through the fish counting fence in relation to water temperature 1986-94. From 1986 to 1990, salmon runs generally occurred during periods of increasing river water temperatures. During the past four years (1991-94), water temperatures and daily counts of salmon have both been somewhat irregular.

4. Estimated returns and spawning escapement

There were 1533 salmon < 63 cm and 100 salmon ≥ 63 cm counted at the fish counting fence on Conne River in 1994 (Table 7 and 8). This represents a decrease of 35% in the number of small salmon in comparison with 1993. Large salmon numbers were similar to the previous year. The single largest daily run occurred on July 11 (247 fish; Fig. 9). In past years, daily counts of over 1000 salmon have occurred (Fig. 9).

Partitioning the count of salmon among the various ways fish were enumerated in 1994 is as follows:

	Small Salmon		Large Salmon	
	N	%	N	%
Fence opening	34	2		
Counting fence trap	966	63	72	72
Video camera chamber	533	35	28	28
Total	1533	100	100	100

Note that some of the fish under 'counting fence trap' were actually monitored with the video camera system. This was during a interval when the camera was placed directly in the fish trap and the doors remained open. These fish, however, were committed to have entered the counting fence trap.

With respect to the video camera system, salmon generally migrated all night long. The period from 2230 to 0229 hours accounted for 53% of the total. This pattern of movement was consistent with that observed at Conne River in 1993. A total of 660 fish were associated with time of fish passage as follows:

Time (hours)	Number of fish	%
2030 - 2229	122	18.5
2230 - 0029	194	29.4
0030 - 0229	156	23.6
0230 - 0429	145	22.0
0430 - 0900	43	6.5

Total returns of adult salmon to Conne River in 1994 are summarized in Tables 7 and 8 for small and large salmon,

respectively. Returns of salmon to Conne River in 1994 were forecast to be low, but higher than that which did occur. The association between smolt condition and sea survival did not match for 1994. In the absence of the recreational and native fisheries in 1994, counts recorded at the fish counting facility represented the total returns to home waters.

Total returns of small salmon (1533) were 43% lower than in 1993 while large salmon returns (100) were the same. Sea survival of smolts decreased from 4.0% (3.6-4.4%) in the previous year (1993) to only 2.7% in 1994 (2.6-3.0%) (Table 9). This is the lowest value recorded over the seven year period that data are available. A comparison of sea survival of smolts at Northeast Brook, Trepassey, SFA 9, with Conne River is illustrated in Fig. 10 (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 low values in 1991 with a small increase in 1992. While smolt survival at Conne River continued to decline in 1993 (smolt migration year) Northeast Brook increased. Based on the association between smolt condition and sea survival (Dempson et al. 1994b) the survival at Conne River should have been over 6% while at Northeast Brook, the difference between the observed (5.4%) and the predicted (5.25%) survival was about 3%.

Potential spawning escapement in 1994 was estimated to be 1435 small salmon and 99 large salmon (Tables 7 and 8). Mean number of eggs per female is 2482 using size data from 1994. With 78% of the run estimated to have been female salmon, the number of eggs per fish is 1936. Estimated total number of eggs deposited was:

small salmon = 2.778 million eggs

large salmon = 0.339 million eggs

for a total natural egg deposition of 3.117 million, only 40% of the current target egg requirement and about a 34% decrease in egg deposition from 1993.

Salmon retained for brood stock produced about 160 thousand eggs that were incubated at the Southwest Brook incubation facility by the community of Conne River. A number of these eggs were subsequently removed. Estimated number of fry produced to May 30, 1995 was 138,332. Egg-to-fry survival from an incubator is commonly about 85% while wild survival is 10% (V. Pepper, DFO St. John's, personal communication). An 'equivalency' in terms of the number of wild eggs that would have had to have been spawned can be estimated given the numbers of fry that were produced. In doing this, the estimated egg deposition at Conne River in 1994 would approximate 58% of the target.

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. 11). 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. 11). 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 four year-classes (1986 to 1989; the 1989 year-class complete only to age 4 smolts in 1994). These values, by year-class, are:

Year-class	survival (%)
1986	0.50
1987	0.46
1988	0.52
1989	0.68

The latter value, 0.68, is associated with the lowest egg deposition in the current series.

5. Net-marked salmon

The following summarizes underwater snorkling observations of net marked fish at Conne River during 1994.

Date	Approximate number of fish observed	Number scarred	Percent Scarred
June 17	200	8	4.0
June 20	200	20	10.0
June 24	75	11	14.7
June 28	250	24	9.6
July 2	225	15	6.7
July 6	275	23	8.4
July 10	235	8	3.4
July 14	90	14	15.6
Total	1550	123	7.9

Numbers of net marked salmon varied on each occasion with no apparent increasing or decreasing trend.

Direct observations of net marked fish in the fish counting fence trap at Conne River during 1994 were as follows:

Date	Number of fish observed	Number scarred	Percent scarred
June 17-21	91	14	15.4
June 22-26	162	33	20.4
Total	253	47	18.6

The percentage of net-marked salmon from the direct observations is higher than that from snorkling observations. A number of reasons could account for the differences in the two methods used. These include, but are not limited to the following:

- water clarity could influence the numbers of fish that are observed either with or without net marks;
- net-marked fish could have a tendency to enter the trap more readily than pass through the video camera tunnel system;
- different individuals involved with the trap observations may interpret net scarring in different ways;
- clarity of fish and scars observed on salmon in the fish trap may differ from the clarity of observations done by diving surveys.

Regardless of the discrepancies in the two methods of observation, the fact remains that there appears to be a substantive number of Conne River salmon that are encountering nets while at sea. This is occurring during a period of time when there is a moratorium on commercial salmon fishing in Newfoundland, although it is acknowledged that salmon could be encountering fishing gear that has been legally set for other species (eg. herring, capelin). The net scars occurred from the snout to the gill area of the salmon, but most were in the former location. This would be suggestive of salmon encountering a smaller mesh gear (< 114 mm). Hansen (1988) reported on the frequency of net-scarred salmon in a number of Norwegian rivers. While the frequency varied among rivers and years, often in excess of 40% of the returning fish were scarred. In some rivers net-scarring was observed on over 70% of the fish. The high frequency of scarring was associated with high commercial exploitation rates.

Not all salmon returning to Conne River could be examined for net-scarring. However, by considering a range in possible retention rates (i.e. the proportion of salmon that encounter a net and are retained) an idea of the potential impact on the stock can be presented on a per-fish basis. With a retention rate varying from 0.30 to 0.80, for every net-scarred salmon that is observed returning to the river, from 0.43 to 4.00 additional fish may be

caught and retained elsewhere with a corresponding loss in potential egg deposition. During periods of high salmon stock abundance the overall impact of these losses may have been minimal. However, when stock abundance is low, the loss in potential numbers of spawners can be rather significant.

In 1994, approximately 50 new capelin licences were issued for the Pool's Cove (Fortune Bay) to Hermitage area. There were no mesh size restrictions for these nets and a substantive by-catch of salmon was noted by local fisheries officers (L. Ryan, DFO, Grand Bank, NF.).

6. Smolt production and forecast of 1995 returns

The estimated number of smolts in 1994 was 60762 (95% confidence limit = 53759-67765) (Table 9, Fig. 10); about 9% higher than the previous year. As noted earlier (Section 6 - Methods) this estimate is a minimum value due to a week long disruption in the smolt enumeration study. The estimated number of smolts in each age group is summarized in Table 10.

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 stressed that sea survival cannot be predicted. It is noted again that the condition of the 1994 smolts at Conne River was low.

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).

In light of the above, we could only speculate on the direct, or indirect, impact of the cold water throughout Bay d'Espoir on the 1994 smolt run. Comparable sea temperature data from other years is not available. At best we can conclude that smolts would have experienced cold (< 3 °C) water throughout much of their migration out of Bay d'Espoir in 1994.

Number of recruits and spawners, 1974-94, and anticipated returns in 1995

The outcome of calculations of total salmon recruits, numbers of spawners, and numbers of recruits per spawner are shown in Fig. 12 and Table 11. For the Conne River salmon stock, there has been considerable variability in recruitment from a given spawning escapement with some discernible trends over time (Fig. 12, Panel A). Since 1974, there has been a significant decline ($r^2 = 0.79$, df = 13, $P < 0.01$) in the number of small salmon recruits produced per spawner for the Conne River salmon stock (Panel B). There was no identifiable trend in the numbers of small spawners, although spawners have declined from 1987 to 1994 with the lowest value occurring in 1994 (Panel C). Overall, declines are evident in number of the salmon recruits with the lowest annual recruitment for the entire time series occurring during the period 1991-94 ($r^2 = 0.37$, df = 19, $P < 0.01$) (Panel D). In fact, 1994 was the lowest to date. Expressing target spawning requirements in terms of small salmon adults (horizontal line in Fig. 12, Panel C), it is evident that target spawners were achieved only in the years prior to 1989. Egg deposition targets, however, were achieved through 1990 by the added contribution from large salmon.

The number of small salmon recruits anticipated for 1995, based on the average number of small salmon produced per spawner for each river age grouping, is approximately 1,470 small and 40 large salmon (high = 1,683 and low = 1,254) (Table 11). Assuming no removals for native and recreational harvests, spawning escapement in 1995 is anticipated to be well below target.

Analysis to detect recruitment overfishing

During the commercial fishery moratorium years of 1992-94, numbers of spawners in Conne River were well below the replacement (diagonal) line and well below target spawners (horizontal line) (Fig. 13). Also, in the three years immediately preceding the moratorium, 1989-91, numbers of spawners were well below the replacement line and the desired spawning level. Of the total number of 15 data points, 9 were below the replacement line. In a stock with a healthy spawning population it is suggested that points should fall above and below the line in an approximately 50:50 distribution and that there be no declining trends in recent years. Also, the points should fall above target spawning requirements which in the case of Conne River, none of the recent years do. We conclude from this that the Conne River salmon stock is in danger of falling lower especially in light of the low spawning stocks that will be producing returns over the next few years. This, should it occur, could then result in a prolonged period of low adult salmon returns.

Acknowledgements

Appreciation is extended to Ross Hinks and other members of the Conne River Indian Band who ensured that representative biological characteristic data were obtained from Atlantic salmon captured during the native food fishery. Robin Anderson kindly provided the Bay d'Espoir temperature data.

References

Anon. 1991. Report of the Working Group on North Atlantic Salmon. ICES C.M. 1991/Assess:12. Copenhagen, 14-21 March, 1991. 157 p.

Anon. 1994. Report of the meeting of the Working Group on North Atlantic Salmon (Copenhagen). ICES C.M 1994/Assess: 16. 182 p.

Byrne, J. M., F. W. H. Beamish, and R. L. Saunders. 1972. Influence of salinity, temperature, and exercise on plasma osmolality and ionic concentration in Atlantic salmon. J. Fish. Res. Board Can. 29: 1217-1220.

Dempson, J. B. 1989. Assessment of the Atlantic salmon population of Conne River, Newfoundland, in 1989. CAFSAC Res. Doc. 89/76. 26 p.

Dempson, J. B. 1990. Assessment of the Atlantic salmon population of Conne River, Newfoundland, in 1990. CAFSAC Res. Doc. 90/83. 33 p.

Dempson, J. B. 1993. Evaluation of the status of the Atlantic salmon population of Conne River, Newfoundland, in 1992. DFO Atlantic Fisheries Res. Doc. 93/3. 31 p.

Dempson, J. B., G. Furey, and C. Pennell. 1994a. Status of the Atlantic salmon population of Conne River, SFA 11, Newfoundland, in 1993. DFO Atlantic Fisheries Res. Doc. 94/12. 35 p.

Dempson, J. B., M. F. O'Connell, and D. E. Stansbury. 1994b. Analysis of Atlantic salmon (Salmo salar) smolt condition and marine survival; information from two south coast Newfoundland rivers. DFO Atlantic Fisheries Res. Doc. 94/14. 23 p.

Dempson, J. B., T. R. Porter, and G. Furey. 1987. Assessment of the Atlantic salmon population of Conne River, Newfoundland, 1987. CAFSAC Res. Doc. 87/104. 14 p.

Dempson, J. B., and D. E. Stansbury. 1991. Using partial counting fences and a two-sample stratified design for mark-recapture estimation of an Atlantic salmon smolt population. N. Amer. J. Fish. Manag. 11: 27-37.

Finstad, B., M. Staurnes, and O. B. Reite. 1988. Effect of low temperature on sea-water tolerance in rainbow trout, Salmo gairdneri. Aquaculture 72: 319-328.

Hansen, L. P. 1988. Status of exploitation of Atlantic salmon in Norway. pp. 143-161. In, Mills, D., D. Piggins [eds.]. Atlantic salmon: planning for the future. Proceedings of the third international Atlantic salmon symposium, Biarritz, France, October 1986. Croom Helm, London, Timber Press, Portland, Oregon.

Lega, Yu. V., A. G. Chernitsky, and N. M. Belkovsky. 1992. Effect of low sea water temperature on water balance in the Atlantic salmon, (Salmo salar L.). Fish Physiol. and Biochem. 10: 145-148.

O'Connell, M. F., J. B. Dempson, and R. J. Gibson. 1992. Atlantic salmon (Salmo salar L.) egg-to-smolt survival in Newfoundland. CAFSAC Res. Doc. 92/122. 8 p.

O'Connell, M. F., D. G. Reddin, and E. G. M. Ash. 1995. Status of Atlantic salmon (Salmo salar L.) in Gander River, Notre Dame Bay (SFA 4), Newfoundland, 1994. DFO Atlantic Fisheries Res. Doc. In preparation.

Schwarz, C., and J. B. Dempson. 1994. Mark-recapture estimation of a salmon smolt population. Biometrics 50: 98-108.

Sigholt, T., and B. Finstad. 1990. Effect of low temperature on seawater tolerance in Atlantic salmon (Salmo salar) smolts. Aquaculture 84: 167-172.

Table 1. Summary of dates of operation for downstream smolt mark-recapture studies, and upstream adult salmon counts at Conne River, Newfoundland.

Year	Smolt mark-recapture studies		Adult salmon counts	
	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
1994	April 28	June 18	June 1	Sept 25

Table 2. Atlantic salmon landings (in numbers of fish) in the recreational fishery, 1974-1992, and in the native food fishery, 1986-1993, at Conne River, Newfoundland.

	Recreational Fishery				Native Food Fishery			
		Salmon catch				Salmon catch		
Year	Effort rod-days	Small	Large	Total	Quota	Small	Large	Total
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	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*	11	11
1991	679	108	0	108	1200	281	3	284
1992	1499	329	0	329	1200	483	5	488
1993	0	0	0	0	500	417	3	420
1994	0	0	0	0	0	0	0	0

* Total for 1990 does not include approximately 50 fish found dead and partially destroyed in traps.

Recreational fishery closed in 1993 and 1994. Quotas of 100 and 330 small salmon were in effect in 1991 and 1992, respectively.

Native food fishery closed in 1994

Table 3. Summary of biological characteristic information for Atlantic salmon samples from Conne River, Newfoundland, 1986-94. Length = fork length, weight = whole weight.

Class	Year	N	Length (mm)			Weight (g)			River Age (y)			Sex ratio	
			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
	1994	208	148	15.1	116-190	29.6	8.3	16.0- 59.2	3.20	0.41	2-4	208	74
TOTAL		2172	149	17.9	98-265	31.6	11.5	9.8-123.2	3.28	0.49	2-5	2024	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		
	1994	73	510	25.8	405-580	1272	193.9	800-1800	3.12	0.44	1-4	71	75
TOTAL		1539	508	24.1	405-620	1426	231.2	600-2900	3.22	0.50	1-5	1367	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				
	1994	1	700						4.00				
TOTAL		5	662	27.7	630-700	2667	57.7	2600-2700	3.40	0.55	3-4	2	100

Table 3 (Cont'd.) Summary of biological characteristic information for Atlantic salmon samples from Conne River, Newfoundland, 1986-94. Length = fork length, weight = whole weight.

Class	Year	N	Length (mm) Mean	SD	Min-max	Weight (g) Mean	SD	Min-max	River Age (y) Mean	SD	Min-max	Sex ratio 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		
	1994	15	564	36.1	510-640	1714	455.5	1200-2900	3.20	0.56	2-4	15	73
TOTAL		76	548	45.2	460-680	1504	350.8	1020-2900	3.36	0.65	2-5	58	83
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		
	1994	3	703	45.1	660-750				3.00	0.00			
TOTAL		33	682	34.5	600-770	3033	568.6	2400-3500	3.09	0.38	2-4	4	100

Table 4. Summary of biological characteristic information for Atlantic salmon samples from the Conne River aboriginal food fishery, 1988, 1992-93. Length = fork length. Weight = whole weight.

Class	Year	N	Length (mm) Mean	SD	Min-Max	Weight (g) Mean	SD	Min-Max	River age (y) Mean	SD	Min-Max	Sex Ratio N	% Female
1 SW	1988	527	503	25.0	406-585	1397	219.0	600-2100	3.17	0.40	2-5	516	78
	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		988	506	24.4	406-640	1382	210.1	600-2400	3.13	0.41	1-5	975	73
2 SW	1988	1	670			3300			4.00			1	100
	1992	1	690			2200			3.00			1	100
Total		2	680	14.1	670-690	2750	777.8	2200-3300	3.50	0.71	3-4	2	100
Consecutive spawning grilse													
	1988	11	591	58.6	518-733	2278	767.8	1300-3900	3.45	0.52	3-4	11	91
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, 1994, with corresponding length and weight data where available. Information complements that reported in Dempson et al. (1994a) for 1990-1993.

Year	Date	Location/gear	Lth (mm)	Weight (g)
1994	July 4	Upstream trap	160	44
	July 20	Upstream trap	185	55
	July 20	Upstream trap	170	45
	Sept 19	Upstream trap	350	-
	Sept 26	Upstream trap	450	1850
	May 22	Downstream trap	170	47
	May 24	Downstream trap	168	45
	June 7	Downstream trap	138	30
	June 7	Downstream trap	158	41
	June 15	Downstream trap	132	25
	July 5	Electrofished	147	30
	July 7	Electrofished	166	40

Table 6. Summary of mean weekly water temperatures (°C) and water levels (cm) at the counting fence on Conne River, Newfoundland, 1990-94.

Date	Week	Mean water temperature					Mean water level				
		1990	1991	1992	1993	1994	1990	1991	1992	1993	1994
May 7-13	19	6.6	8.4	5.5	-	6.8					124.1
May 14-20	20	9.6	7.1	8.5		9.4	47.5				59.4
May 21-27	21	7.5	8.2	11.3		10.6	41.8	49.8	38.5		37.7
Ma 28-Jn 3	22	12.5	9.4	13.1	9.4	12.0	26.2	40.8	53.6	48.1	39.0
Jun 4-10	23	13.6	10.8	12.6	11.6	10.8	21.9	22.3	67.5	36.0	65.1
Jun 11-17	24	16.4	12.8	14.0	12.5	15.0	11.9	21.8	75.4	27.9	47.6
Jun 18-24	25	13.8	14.9	16.6	14.5	17.1	59.9	16.2	57.1	40.3	40.8
Jn 25-Jy 1	26	17.6	17.5	13.9	15.8	17.4	42.1	8.6	35.2	62.9	36.6
Jul 2-8	27	17.5	15.1	12.5	15.6	17.7	19.1	6.9	38.0	52.4	29.2
Jul 9-15	28	16.9	16.9	15.8	17.7	18.7	12.3	6.1	48.7	33.4	24.4
Jul 16-22	29	18.8	19.6	17.4	15.1	18.6	9.1	4.9	35.4	49.4	31.1
Jul 23-29	30	20.5	19.5	18.5	16.5	19.2	23.6	9.4	27.3	58.6	31.7
Jl 30-Ag 5	31	19.0	18.3	17.1	17.9	21.4	14.1	2.1	52.4	46.0	23.9
Aug 6-12	32	21.4	15.3	18.6		20.0	10.0	21.4	45.4		42.0
Aug 13-19	33		19.4			18.8	13.6				24.6
Aug 20-26	34					18.0					16.3
Aug 27-Sep 2	35					18.3					20.8
Sep 3-9	36					14.8					25.6
Average		14.7	14.2	12.7	14.8	15.8	27.8	15.2	48.8	45.4	42.5

Table 7. Total estimated returns of small salmon to Conne RIver, Newfoundland, with a summary o mortalities and removals and estimated spawning escapement, 1986-94.

	Year								
	1986	1987	1988	1989	1990	1991	1992	1993	1994
Returns									
* Food Fishery (estuary)	766	451	506	317	831	234	403	347	0
Angling below fence				180	213	70	137	0	0
Mortalities below fence	21	17	3	2	3	2	0	1	0
Count at fence	7515	9287	7118	4469	4321	2086	1973	2355	1533
Estimated count		400				19	10		
Total Returns	8302	10155	7627	4968	5368	2411	2523	2703	1533
1 - Released at fence	7515	9687	7118	4469	4321	2105	1983	2355	1533
Removals and mortalities									
Mortalities above fence	27	21	7	4	2	5	8	2	5
Angling above fence	2060	1598	1544	856	554	38	192	0	0
Brood stock removal		245							93
2 - Total	2087	1864	1551	860	556	43	200	2	98
Spawning escapement									
(1) - (2)	5428	7823	5567	3609	3765	2062	1783	2353	1435
Egg deposition									
in millions of eggs	9.86	14.66	10.65	6.95	7.50	3.68	3.45	4.43	2.78
% of Target met	126	188	137	89	96	47	44	57	36

* Food fishery includes fish caught in the estuary during tagging studies in 1986 and 1987. Proportio salmon in 1986 and 1987 were 0.792 (N = 967) and 0.914 (N = 493), respectively. For remaing year was used.

Table 8. Total estimated returns of large salmon to Conne River, Newfoundland, with a summary of mortalities and removals and estimated spawning escapement, 1986-94. Total estimated egg deposition from small and large salmon are also indicated along with the combined estimate of the percentage of the target spawning requirement met.

	Year								
	1986	1987	1988	1989	1990	1991	1992	1993	1994
Returns									
* Food Fishery (estuary)	14	18	2	1	11	2	4	2	0
Angling below fence	0	0	0	0	0	0	0	0	0
Mortalities below fence	1	0	0	0	0	0	1	0	0
Count at fence	397	498	418	319	361	87	154	98	100
Estimated count									
Total Returns	412	516	420	320	372	89	159	100	100
1 - Released at fence	397	498	418	319	361	87	154	98	100
Removals and mortalities									
Mortalities above fence	1	0	0	0	0	0	1	1	0
Angling above fence	0	0	0	0	0	0	0	0	0
Brood stock removal		10							1
2 - Total	1	10	0	0	0	0	1	1	1
Spawning escapement									
(1) - (2)	396	488	418	319	361	87	153	97	99
Egg deposition									
in millions of eggs	1.48	2.07	1.77	1.09	1.23	0.30	0.52	0.33	0.34
% of Target met	19	27	23	14	16	4	7	4	4
Total egg deposition - small and large salmon	11.34	16.73	12.42	8.04	8.73	3.98	3.97	4.76	3.12
Total % Target met	145	214	159	103	112	51	51	61	40

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

Table 9. Estimates of Atlantic salmon smolts from Conne River, 1987 - 1994, along with subsequent survival to small salmon.

Year	Number of smolts: Upper site Tagged & released	Number of smolts: Lower site Total number Captured	Number of smolts: Lower site Tag Recoveries	Population estimate: N	Population estimate: Confidence interval	Population estimate: Coeffiicient of variation %	Survival: % survival to small salmon	Survival: Survival range
1987	4975	14314	990	74585	67597-81573	5.1	10.2	9.3-11.3
1988	3235	19515	1054	65962	59862-71522	4.8	7.6	6.9-8.3
1989	2699	16928	604	73724	66598-80850	5.1	7.3	6.7-8.1
1990	3719	13881	945	56943	52315-61571	4.4	4.2	3.9-4.6
1991	3753	9581	398	74645	62033-87527	9.0	3.4	2.9-4.1
1992	3758	10229	529	68208	61334-75052	5.4	4.0	3.6-4.4
1993	2456	15992	735	55765	51666-59864	3.9	2.7	2.6-3.0
1994	2366	11875	479	60762	53759-67765	6.2		

Table 10. Estimated total number of smolts in each age group, Conne River, Newfoundland, 1987-94. Lower chart indicates the percentage of smolts at each river age.

Year	River age (y) 2	3	4	5	Total
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
1994	0	48002	12760	0	60762

Year	Percent in each age group 2	3	4	5	Number of samples
1987	2	66	30	2	271
1988	0	63	36	1	328
1989	3	71	24	2	288
1990	1	70	28	1	271
1991	1	80	18	1	246
1992	1	73	24	2	169
1993	0	74	26	0	246
1994	0	79	21	0	208

Table 11. Data for Conne River used to estimate total stock size and anticipated returns in 1994.
Target spawning escapement =4000.

Spawn Year	Recruit years		Total river escapement	Total recruits	Spawning escapement	Recruits 3+	Recruits 4+	Total 3+4	No. of recruits/spawner 3+	No. of recruits/spawner 4+	No. of recruits/spawner Total	Total recruit
i	i+5	i+	i	i	i	i+5	i+6		i+5	i+6		
					16000							
74	79	80	8353	11933	6365	4426	3627	8053	0.6953	0.5698	1.2652	2.1792
75			7996	11423	6093	9806	3642	13448	1.6094	0.5977	2.2071	2.1905
76	81	82	8113	11590	6182	9847	4469	14316	1.5928	0.7229	2.3157	2.9894
77			6996	9994	5331	12083	2967	15049	2.2665	0.5565	2.8229	2.0003
78	83	84	7290	10414	5555	8021	3171	11192	1.4439	0.5708	2.0147	3.2218
79			4244	6063	3234	8573	3693	12267	2.6510	1.1420	3.7930	2.5356
80	85	86	9403	13433	7165	9985	3202	13188	1.3936	0.4469	1.8406	1.7294
81			9442	13489	6751	8658	3917	12575	1.2824	0.5802	1.8626	1.8586
82	87	88	11586	16551	8284	10590	3378	13968	1.2784	0.4077	1.6861	1.7749
83			7691	10987	5499	7518	2555	10073	1.3672	0.4646	1.8318	1.2374
84	89	90	8221	11744	5878	4542	1917	6459	0.7727	0.3262	1.0989	1.1663
85			9575	13679	6846	5751	999	6750	0.8401	0.1459	0.9860	0.5964
86	91	92	8302	11860	5428	2445	454	2900	0.4505	0.0837	0.5342	0.3481
87			10155	14507	7823	2069	676	2745	0.2645	0.0864	0.3508	0.4505
88	93	94	7627	10896	5567	2027	399	2426	0.3642	0.0716	0.4358	0.3859
89			4968	7097	3609	1134			0.3143			
90	95	96	5368	7669	3765							
			2411	3444	2062							
92	97	98	2523	2523	1783							
			2703	2703	2353							
94	99	00	1533	1533	1435							
					0							
96	01	02										
98	03	04										

NB - the average ratios used for anticipated returns are for low return years, 1992-94.

Smolt distn Yr	3+	4+
80	0.73	0.27
81	0.73	0.27
82	0.73	0.27
83	0.73	0.27
84	0.73	0.27
85	0.73	0.27
86	0.73	0.27
87	0.73	0.27
88	0.69	0.31
89	0.64	0.36
90	0.75	0.25
91	0.71	0.29
92	0.82	0.18
93	0.75	0.25
94	0.74	0.26

Anticipated returns in 95

		R/S ratios 3+	R/S ratios 4+	No. of small 3+	No. of small 4+	Total	Total *(avg92-94)=	1.06
Mean	92-9	0.3143	0.0805	1183	291	1474	1518	
	Hi	0.3642	0.0864	1371	312	1683	1733	
	Low	0.2645	0.0716	996	258	1254	1292	

Comparison of observed & expected in 92-94

Year	R/S ratios 3+	R/S ratios 4+	Est. no. of small 3+	Est. no. of small 4+	Total	Difference (Obs-exp)	% Diff.
92	0.3143	0.0805	2459	437	2896	-373	-15
93	0.3143	0.0805	1750	630	2380	323	12
94	0.3143	0.0805	1134	448	1583	-50	-3
						Mean	-2

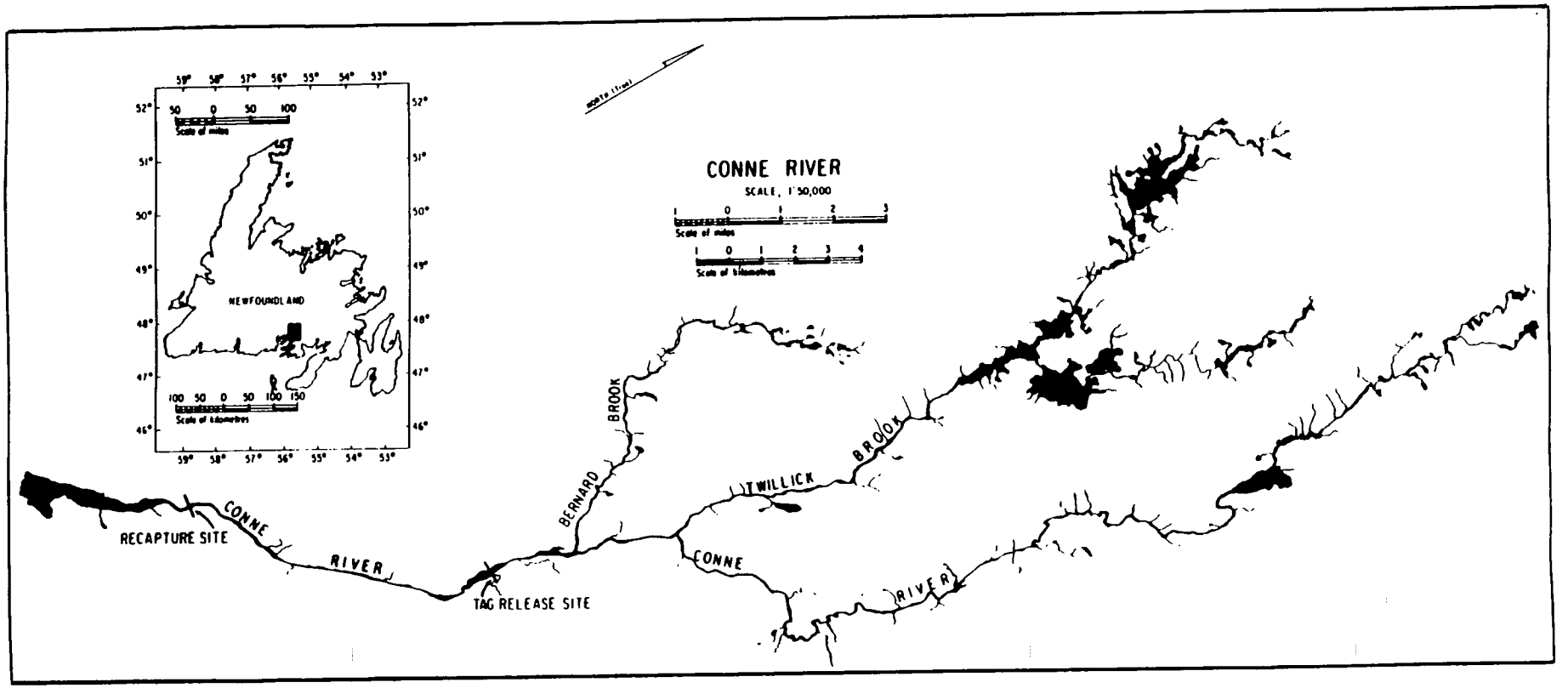
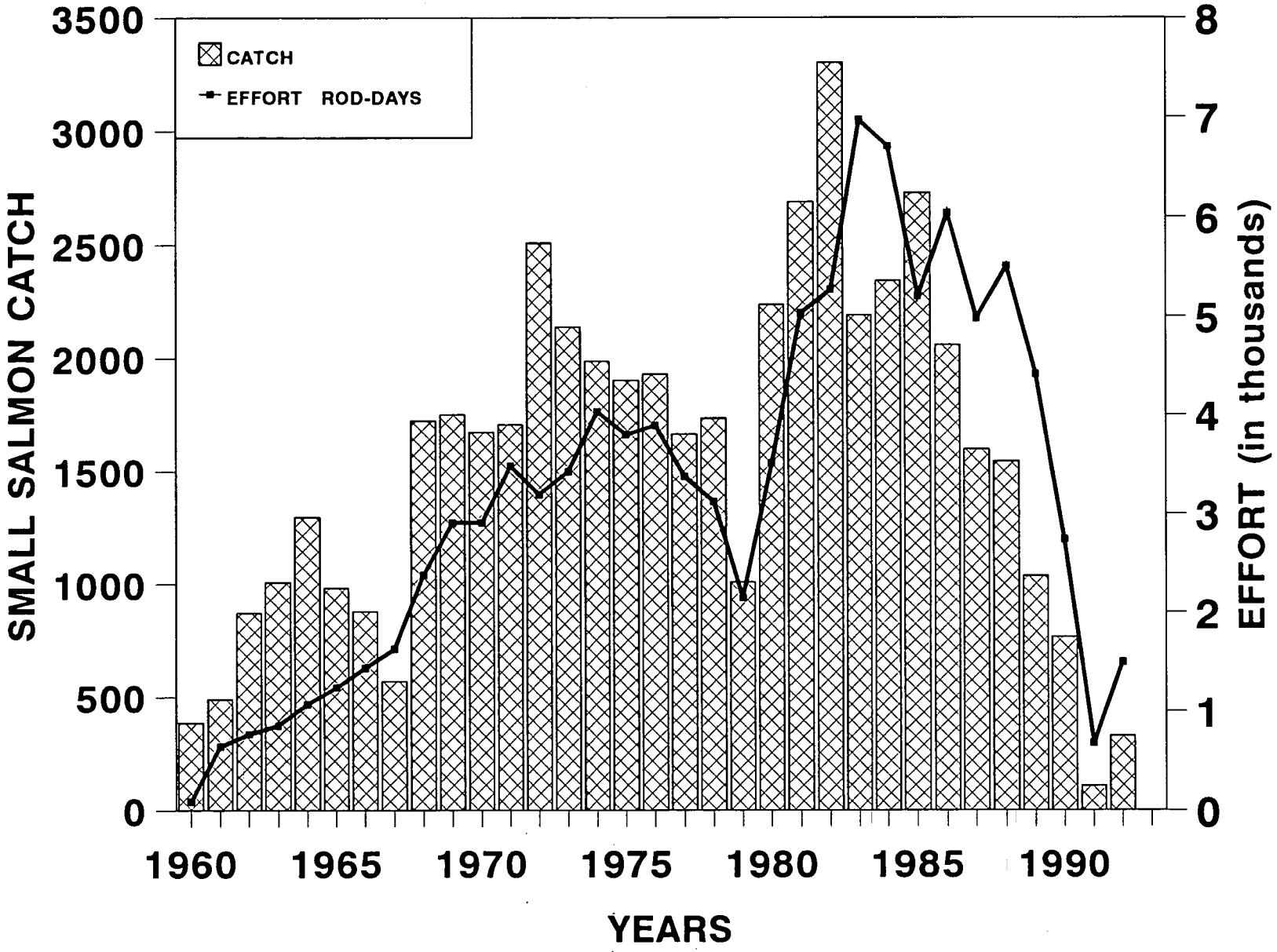
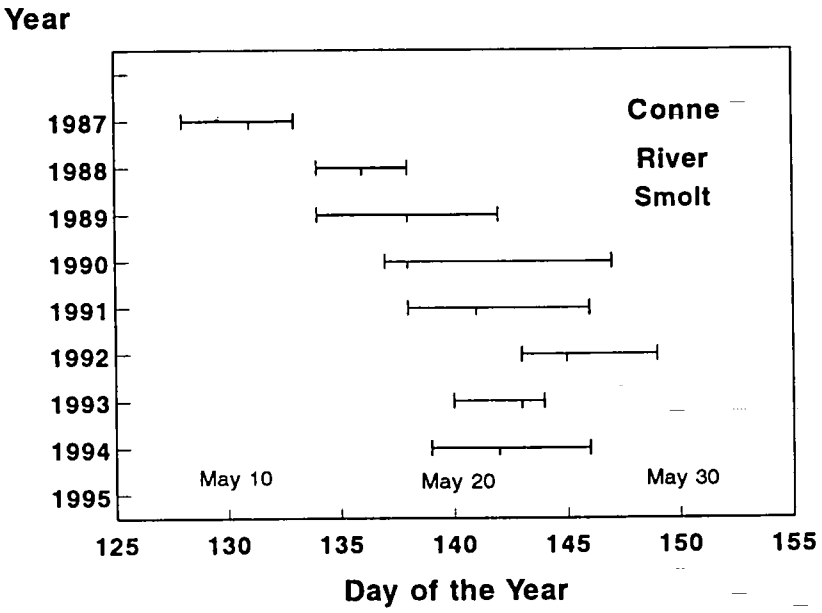


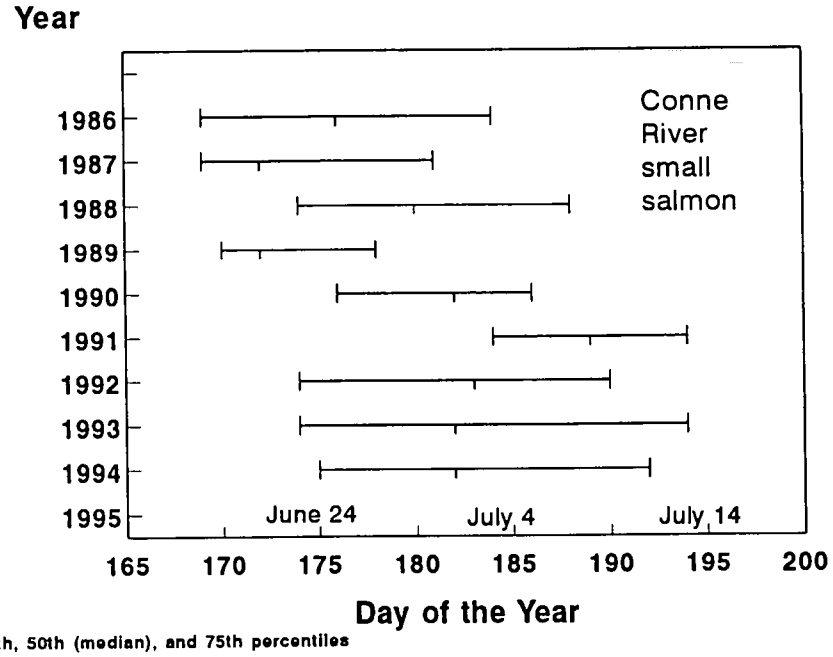
Fig. 1. Conne River, Newfoundland, SFA 11, illustrating the location of the fish counting fences used for the mark-recapture survey. The recapture site is also the location of the upstream adult salmon counting facility.



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

Fig. 2. 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 and 1994.





25th, 50th (median), and 75th percentiles

Fig. 3. Run timing of smolt and adult small salmon at Conne River, Newfoundland. The median point, along with tge 25th and 75th percentiles are illustrated.

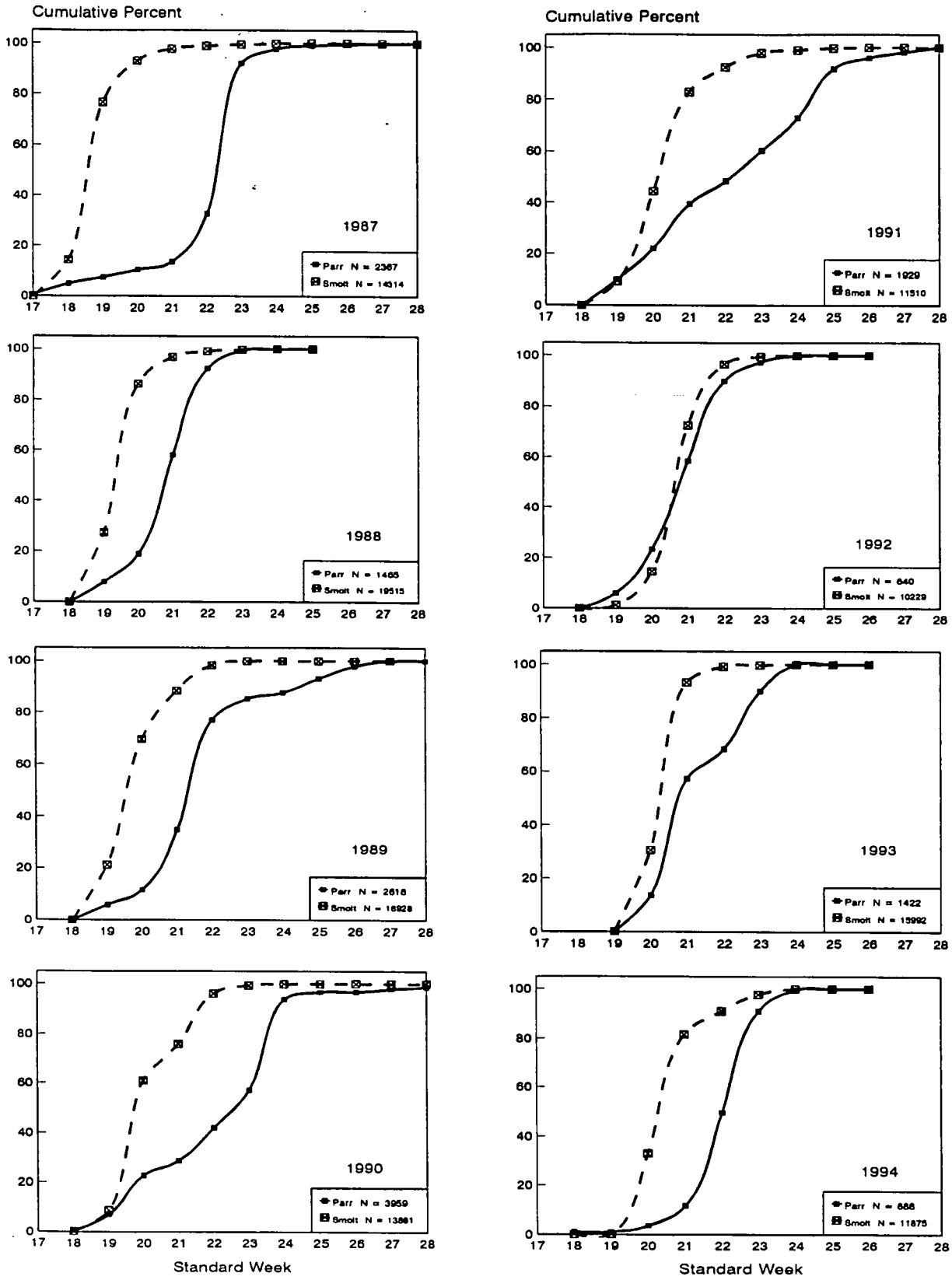


Fig. 4. Cummulative distribution (%) over standard weeks of Atlantic salmon smolts and downstream migrant parr at Conne River, 1987-94.

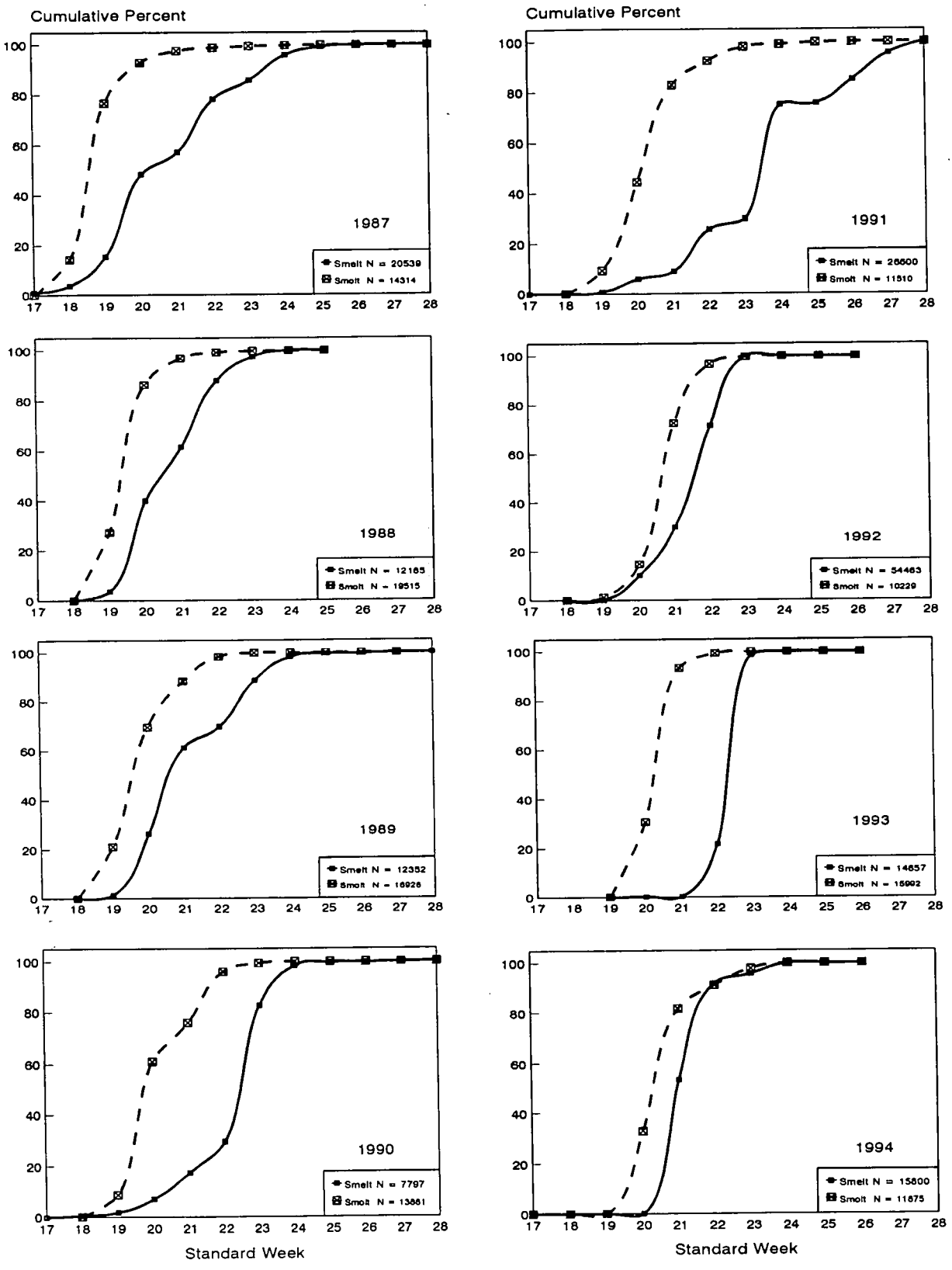


Fig. 5. Cummulative distribution (%) over standard weeks of Atlantic salmon smolts in relation to smelt at Conne River, 1987-94.

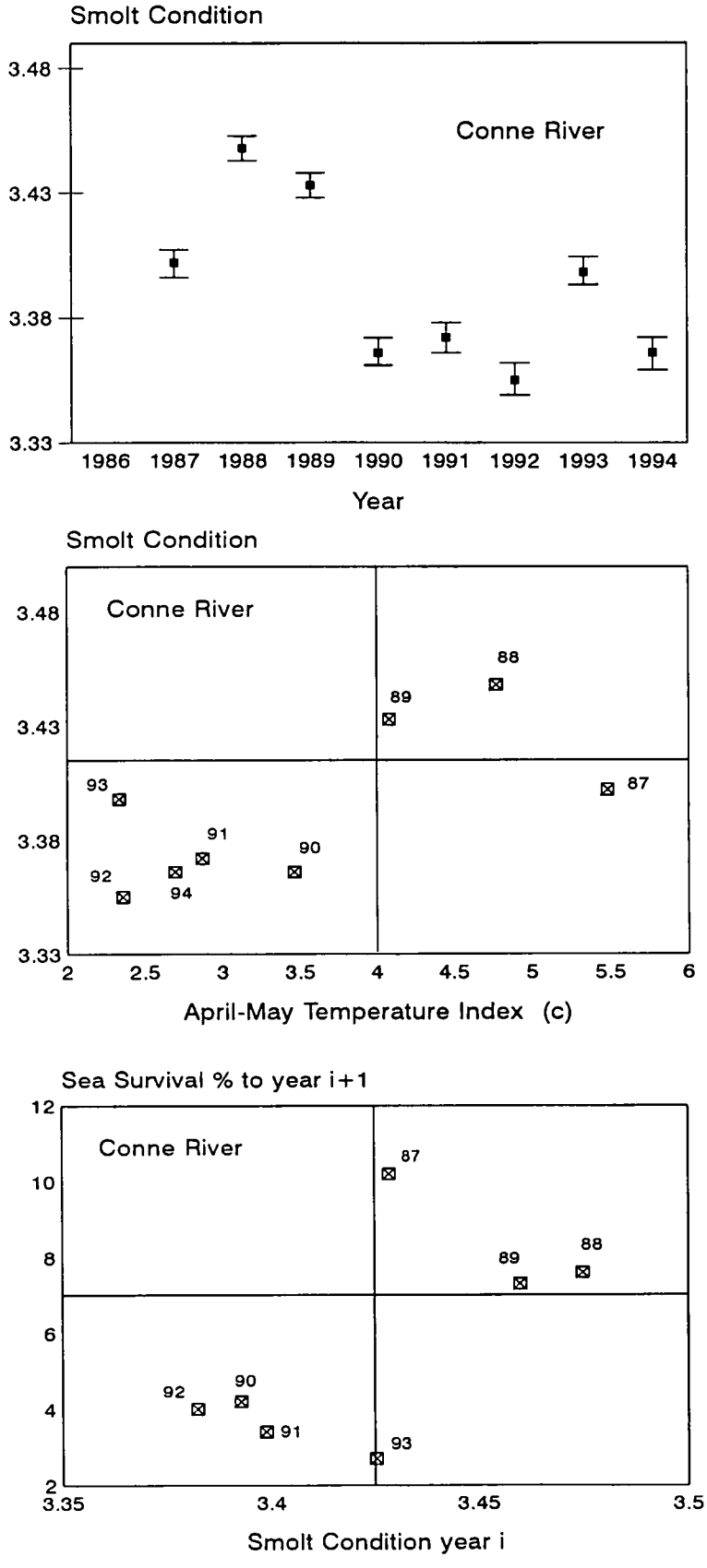


Fig. 6. Index of Conne River smolt condition: varying over years (upper); in relation to the April-May air temperature index (middle); and as it relates to estimated sea survival of adult salmon returning in the following year (lower). Vertical lines in the upper panel represent ± one standard error.

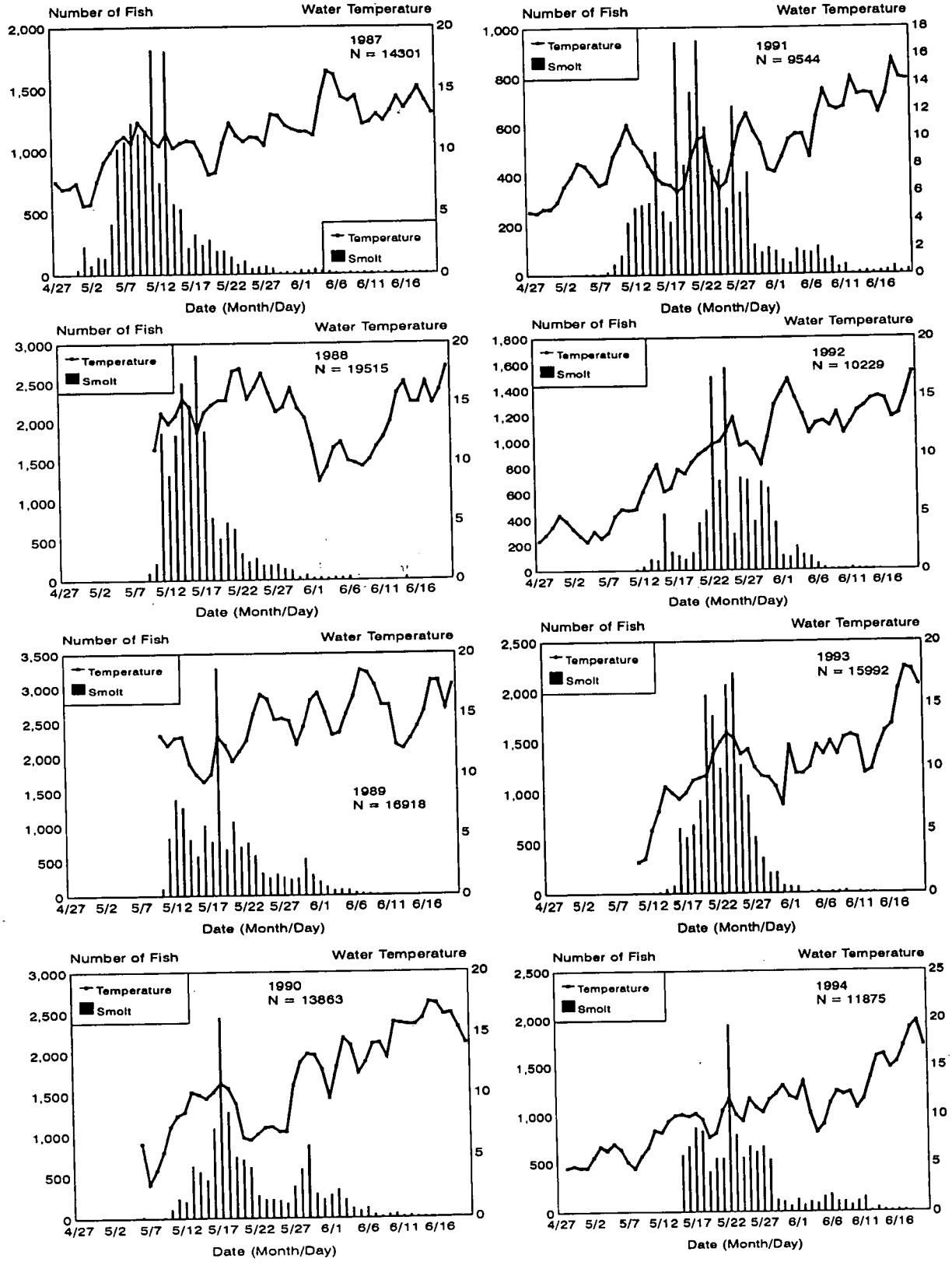


Fig. 7. Daily counts of Atlantic salmon smolts at the lower partial fish counting fence trap in relation to river water temperatures at Conne River, 1987-94. Numbers refer to the total catch of smolts in the partial trap, not the estimated values of the entire smolt run for the year.

Temperature Sampling Sites in Bay D' Espoir
May 18 - 21, 1994

STATION	LOCATION	DEPTH	TEMP (1m)	BOTTOM TEMP
1	ROTI BAY MOUTH	39	4.5	0.8
2	ROTI BAY	42		
3	CAGE SITE	37	4	0.9
4	TICKLEHEAD (3RD)	17	2	1.4
4	TICKLEHEAD (2ND)	29	2	1.2
4	TICKLEHEAD	21	2.5	1.4
5	LOU COVE (3RD)	45	1.5	1.2
5	LOU COVE	45	2.5	1.3
6	MOUTH OF CONNE	7	3	1.4
6	MOUTH OF CONNE	7	2.2	1.4
7	DAY POINT	103	1.7	1.7
8		32	1.7	0.7
9		65	2	0.3
10	MARIA CORE Pt.	60	2.8	1.3
10		62	2	0.3
11	STRICKLAND'S COVE	27	2.7	0.2
11	STRICTLAND COVE	26	2.1	0.3
12	L of ISLAND	60	2.2	0
13	R of ISLAND	45	2.2	0.1
14		204	2.4	0
16	ENTRANCE GAULTAIS	102	2.5	0.2

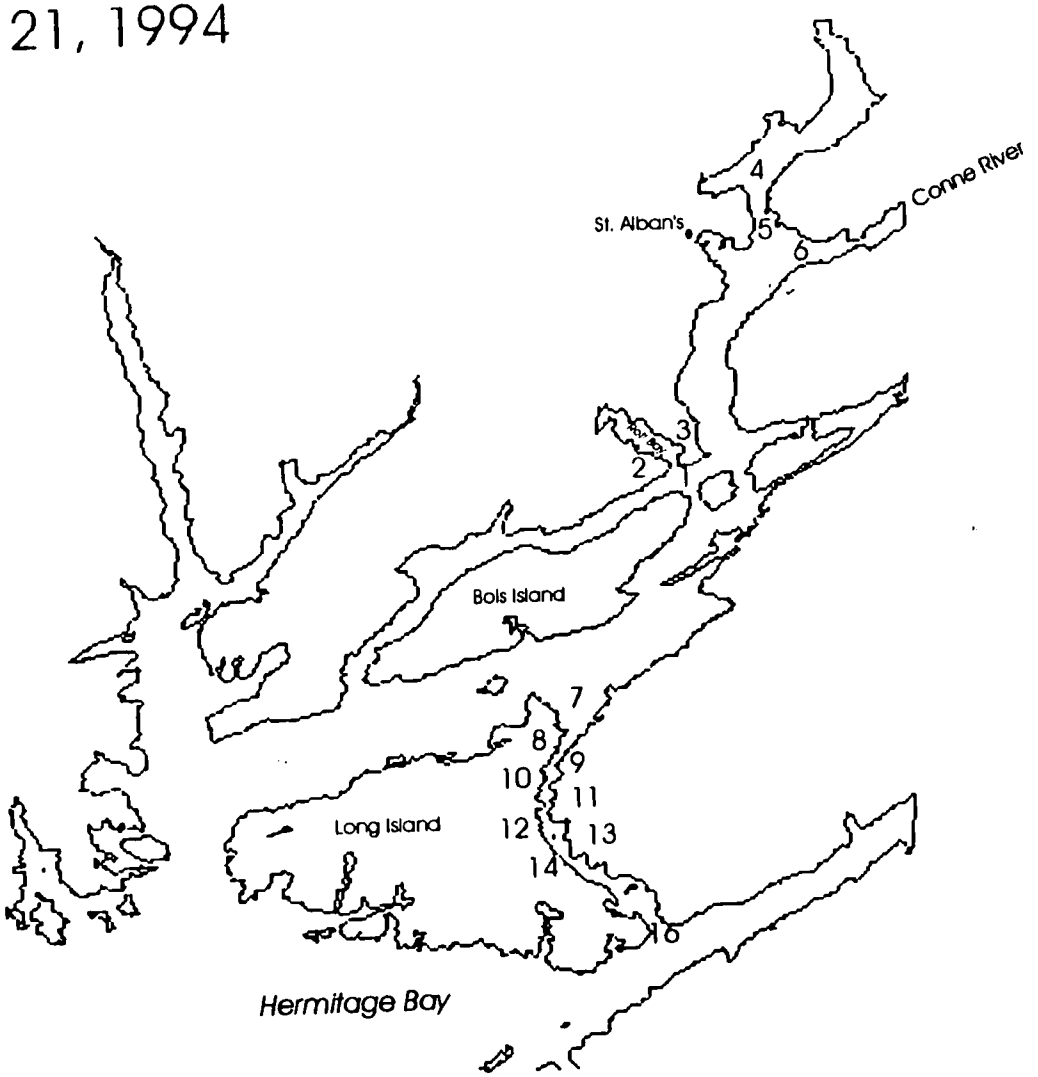


Fig. 8. Location of CTD sites throughout Bay d'Espoir from sampling conducted May 18-21, 1994. Corresponding surface (1 m depth) and bottom water temperatures are indicated on the inset chart.

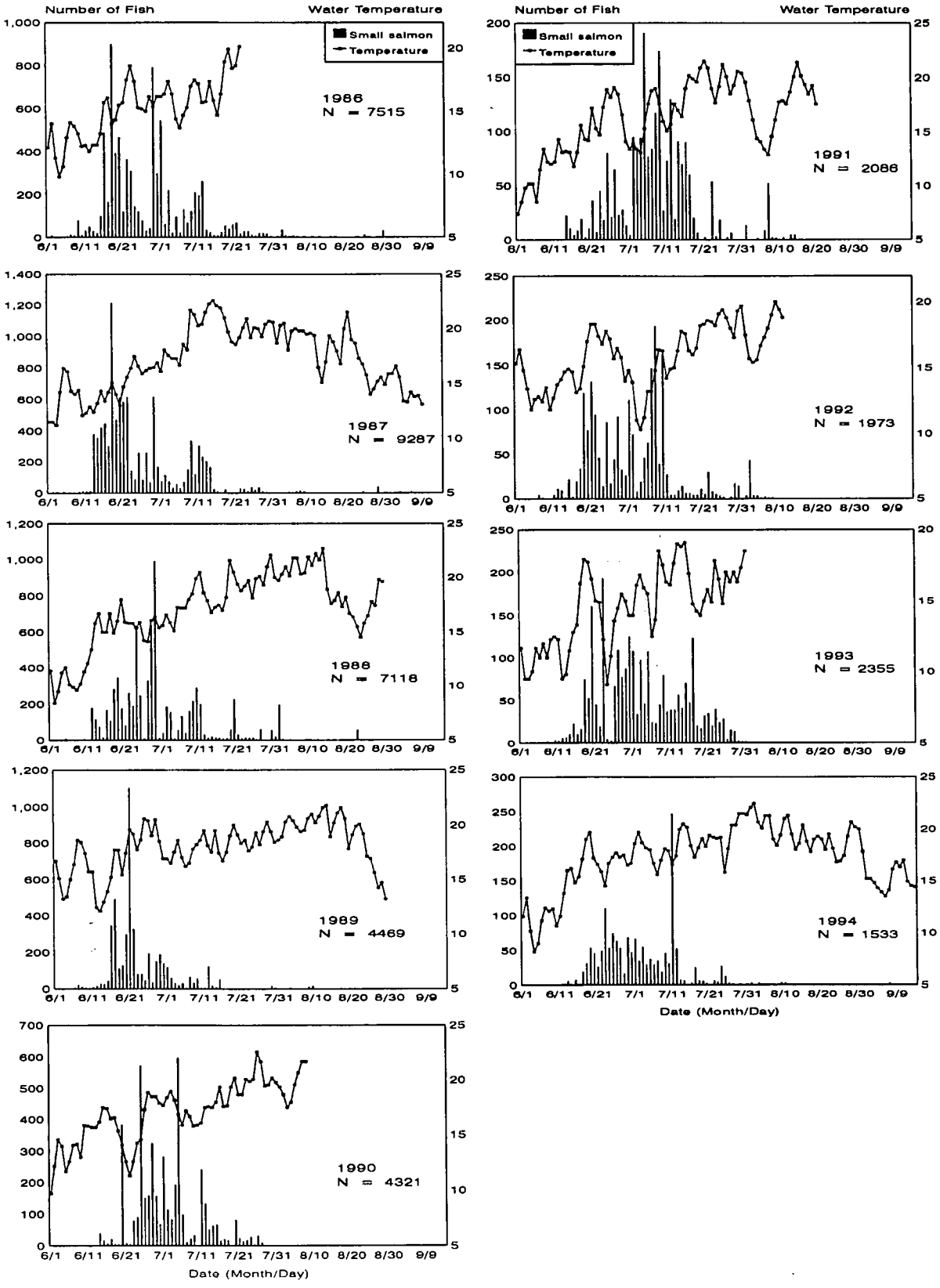
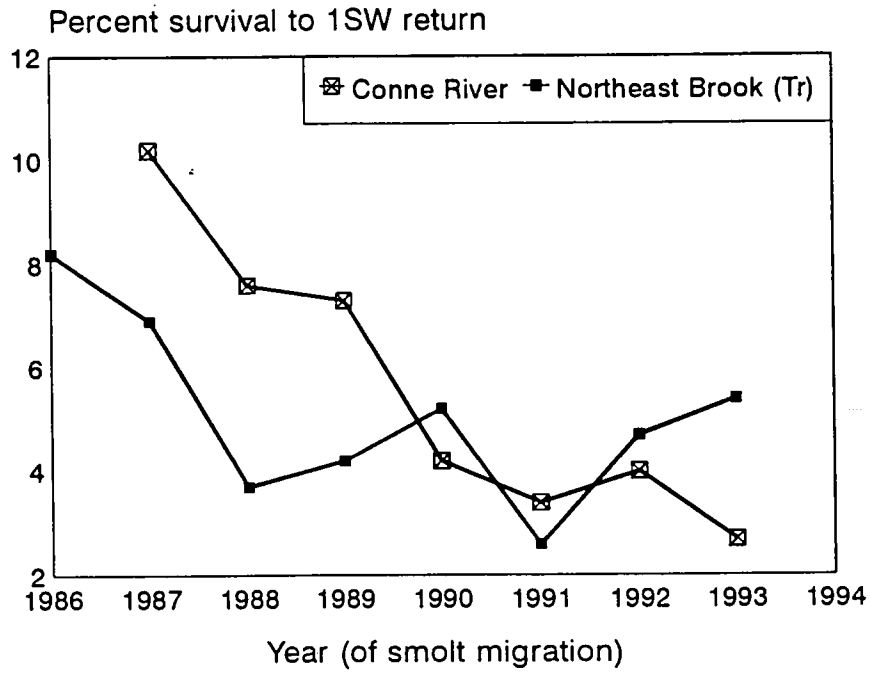


Fig. 9. Daily counts of adult Atlantic salmon at the upstream fish counting fence in relation to river water temperatures at Conne River, 1986-94.



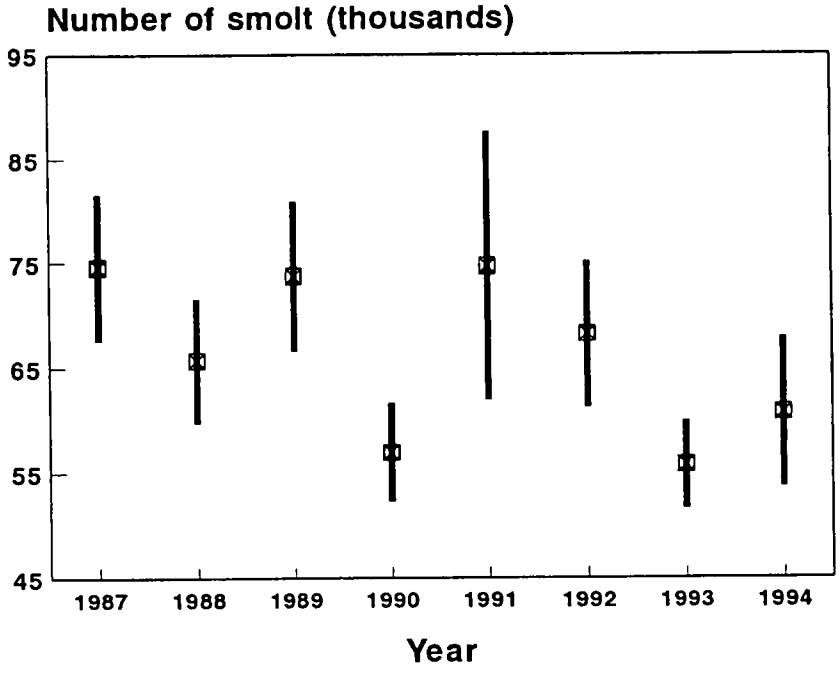


Fig. 10. Estimates of sea survival from smolt to returning small salmon at Conne River, SFA 11, and Northeast Brook, Trepassey, SFA 9, Newfoundland. Lower panel shows the estimated smolt runs at Conne River, 1987-94. Vertical bars illustrate 95% confidence limits.

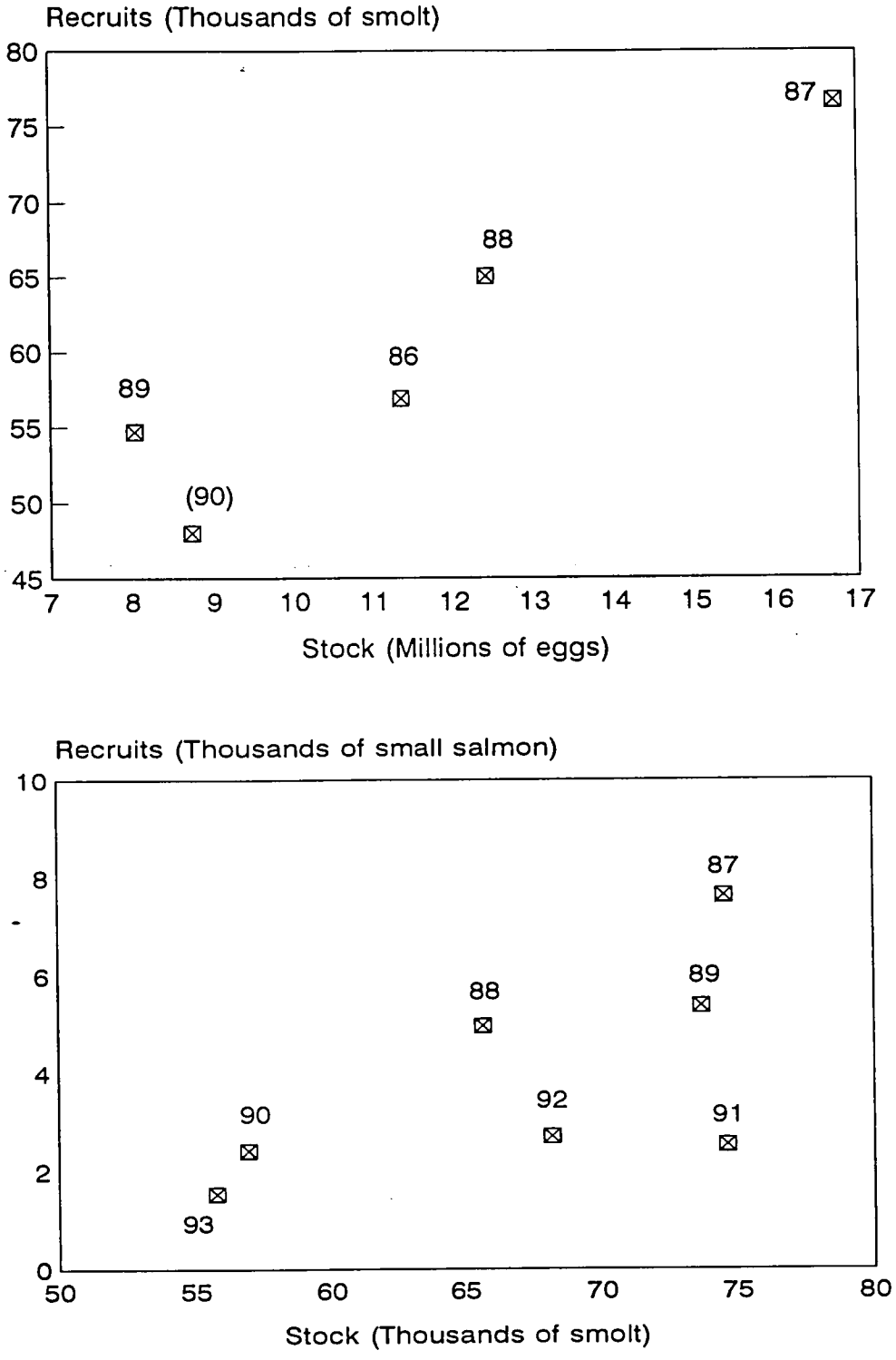


Fig. 11. Relationships between estimated egg deposition and subsequent smolt production, by year class (year of egg deposition indicated, upper panel), and smolt production (year of smolt run) by smolt class and corresponding return of adult small salmon (lower panel). Brackets around the 1990 year class in the upper figure indicate incomplete information on numbers of age 4 smolt which will migrate in 1995.

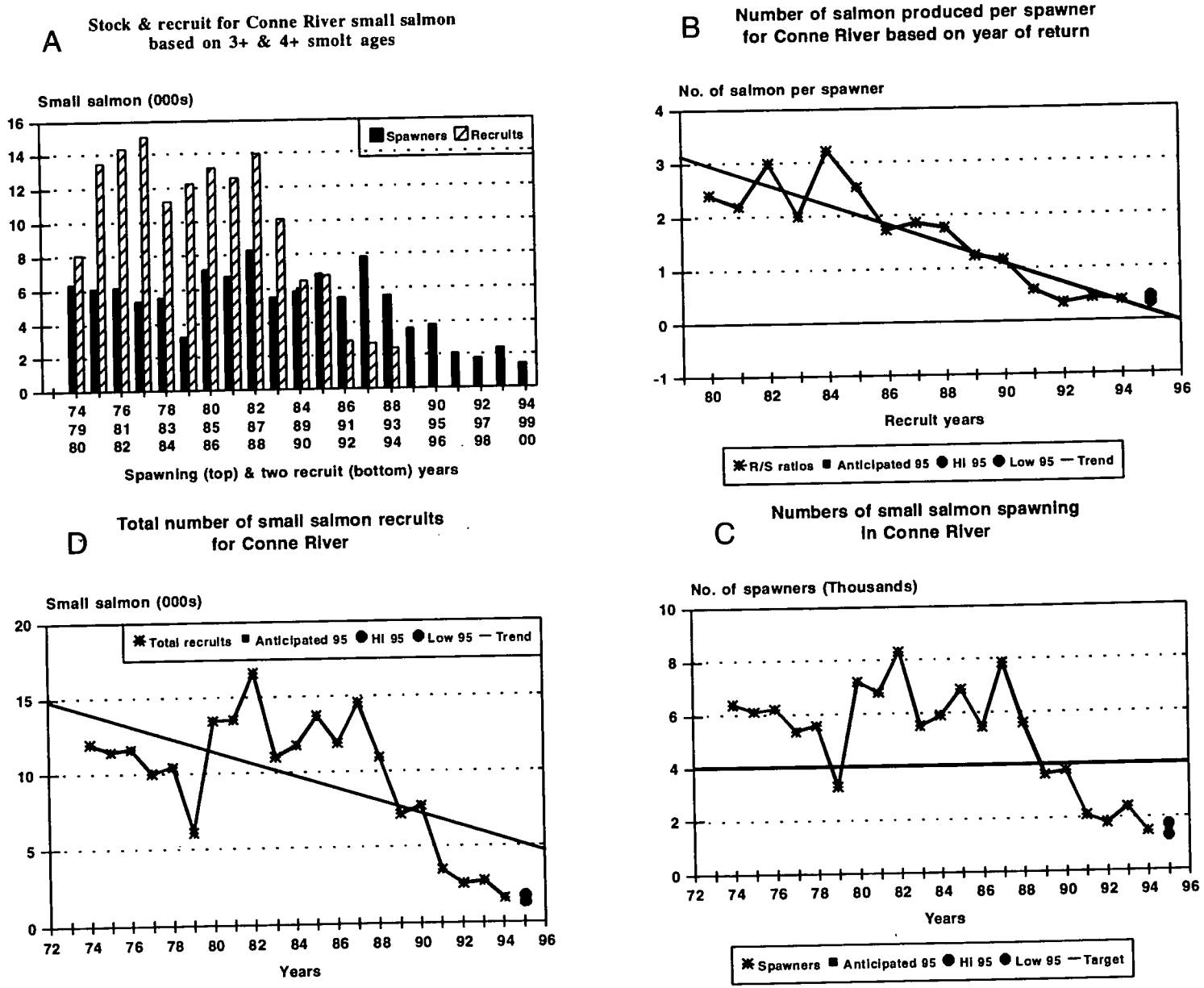


Fig. 12. Comparisons of spawning stock and recruits for Conne River small salmon.

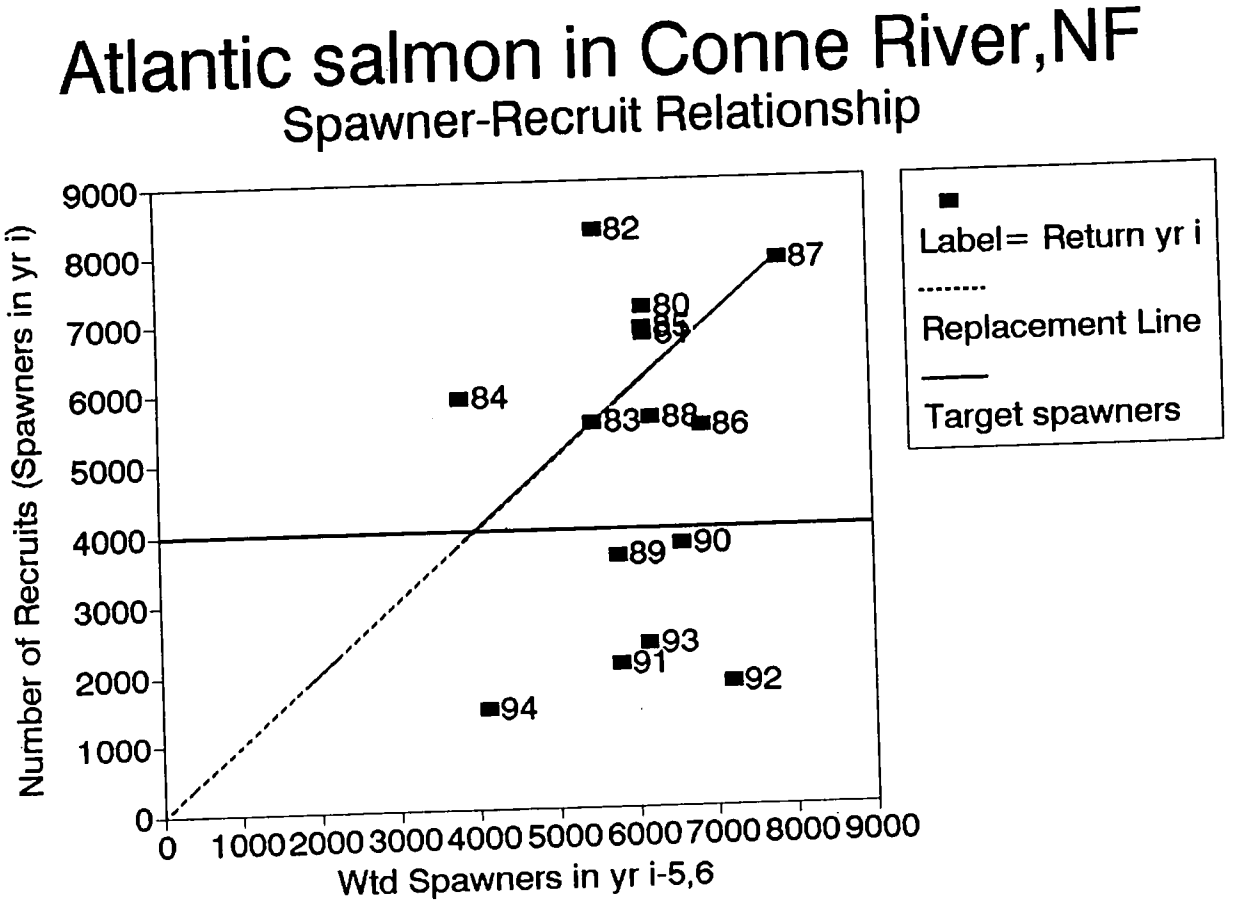


Fig. 13. Comparisons of small salmon spawners and lagged estimates of their parents in years i-5 and i-6, for Conne River, Newfoundland.

STOCK: Conne River, Newfoundland, SFA 11. Drainage area = 602 km ^{2}
TARGET: 7.8 million eggs (~4000 small salmon) calculated as fluvial area x 2.4 eggs/m^2 and egg/recruit applied to total population as derived from assumed commercial exploitation rates.

Year	1989	1990	1991	1992	1993	1994	MIN[1]	MAX[1]	MEAN[1]
HARVEST:									
First Nations									
Large	1	11	3	5	3	0	0	11	3
Small	381	948	281	483	417	0	18	948	459
Recreational									
Small	1036	767	108	329	0	0	0	3302	1824
Returns:									
Large	320	372	89	159	100	100	89	516	355
Small	4968	5368	2411	2523	2703	1533	2411	10155	6472
Escapement:									
Large	319	361	87	153	97	99	87	488	345
Small	3609	3765	2062	1783	2353	1435	2062	7823	4709
% Target eggs met:									
	103	112	51	51	61	40	51	214	131

[1] Minimum, maximum and mean recreational catch for period 1974-91; other mean data for 1986-91 to coincide with the pre-moratorium period. Angling catches are DFO statistics. First Nations' catch in salt water includes some salmon from other rivers. First Nations' fishery quota of 1200 fish has been in effect since 1986, but reduced to 500 fish for 1993. First Nations' fishery closed in 1994.

Data and methodology: Smolts used in adult forecasts are surveyed by mark-recapture. Returning adult salmon are enumerated at a fish counting fence. A video camera system introduced in 1993.

State of the stock: Target requirements were met from 1986-90. Since then between 51-61% until 1994 when only 40% of the target was obtained. Low sea survival continues to impact on salmon returns. An enhancement project was initiated in 1994. Assuming survival to the fry stage, this would result in a potential egg deposition equivalency of 55% of the target being achieved.

Forecast: Estimated smolt output in 1994 was 60,762 (53,759-67765); 9% higher than 1993. At 4% survival, the approximate average recorded during 1990-92, no more than 2,400 fish would be expected to return in 1995. A sea survival of about 7% will be needed in order for total returns to meet or exceed the 4,000 salmon necessary to reach the target egg deposition. Sea survival of 7-10% has been recorded at Conne River in past years. Survival of salmon appears to be associated with timing of the smolt run and smolt condition. Assuming this association holds, then a preseason forecast is not optimistic in terms of achieving the target. In-season monitoring could be used to update managers on changing conditions as the 1995 run progresses. An alternate forecast based on the number of recruits produced per spawner is consistent with the above in terms of anticipated low returns in 1995. This technique forecasts 1300-1730 small salmon returns for 1995.