Department of Fisheries and Oceans
Canadian Stock Assessment Secretariat
Research Document 97/34

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Ministère des pêches et océans
Secrétariat canadien pour l'évaluation des stocks
Document de recherche 97/34

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Stock status of Atlantic salmon from Conne River, SFA 11, Newfoundland, 1996

J. B. Dempson and G. Furey

Science Branch
Department of Fisheries and Oceans
P. O. Box 5667
St. John's, Newfoundland, A1C 5X1

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Contents

Abstract

Results obtained from a fish counting fence provided the basis for the assessment of the Conne River Atlantic salmon stock in 1996. Returns to home waters (river and estuary) were 4440 salmon < 63 cm in length and 179 salmon ³ 63 cm in size. This represented an increase of 27% for small salmon in comparison with 1995 and were the highest returns since 1989. Large salmon returns increased by 63% over 1995. Sea survival to 1SW salmon increased to the highest level since 1989-90 (5.76%). The **Management Target** was met for the first time in six years (1990). Conne River Atlantic salmon returns from smolts that were reared in an aquaculture facility at Roti Bay contributed about 5% of the 1996 egg deposition. A mark-recapture study suggested a smolt run in 1996 of over 90,000, the highest to date. Adult salmon returns in 1997 are expected to be above the **Management Target** assuming that sea survival is at least as high as it was in the previous year. The commercial salmon fishery moratorium has had a negligible impact on the Conne River salmon stock. Total salmon returns, sea survival and proportion of large salmon in the run were all higher during the premoratorium period (1986-1991). The commercial salmon moratorium coincided with a period of declining sea survival of Conne River salmon. Finally, the distinction between the current **Management Target** and the **conservation egg requirement** for Conne River is clarified.

Résumé

Les résultats obtenus d'un barrage de dénombrement des poissons servent de point de départ pour l'évaluation en 1996 des stocks de saumon de l'Atlantique de la rivière Conne. Cette année-là, 4 440 saumons de plus de 63 cm de longueur et 179 saumons de moins de 63 cm sont retournés dans leurs eaux natales (rivière et estuaire). Cela représente une augmentation de 27 % de petits saumons par rapport à 1995 et le taux de retour le plus élevé depuis 1989. Les retours à la frayère de gros saumons ont augmenté de 63 % par rapport à 1995. La survie en mer de saumons unibermarins a atteint son plus haut niveau depuis 1989-1990 (5,76 %). La **Cible de gestion** a été atteinte pour la première fois en six ans (1990). Les retours à la frayère des saumons de l'Atlantique de la rivière Conne libérés au stade de saumoneaux par la pisciculture de Roti Bay ont contribué pour environ 5 % à la ponte de 1996. Une étude de marquage-recapture permettait d'espérer pour 1996 une remonte de plus de 90 000 saumoneaux, la plus abondante jusqu'à maintenant. Les retours aux frayères de saumons adultes en 1997 devraient être supérieurs à la **Cible de gestion,** en supposant que le taux de survie en mer soit au moins comparable à celui de l'année précédente. Le moratoire sur la pêche commerciale de saumon a eu un impact négligeable sur les stocks de saumons de la rivière Conne. Le total des retours aux frayères de saumons, le taux de survie en mer et la proportion de gros saumons dans la remonte étaient plus élevés pendant la période prémoratoire (1986-1991). Le moratoire sur la pêche commerciale du saumon a coïncidé avec une période de déclin du taux de survie en mer du saumon de la rivière Conne. Enfin, la distinction entre l'actuelle **Cible de gestion** et les **objectifs de conservation basés sur le nombre minimal nécessaire d'oeufs** pour la rivière Conne est éclaircie.

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 (*Salmo salar*). Mark-recapture studies were initiated in 1987 to survey the number of migrating smolts. These operations continued in 1996. Previous estimates of the total return of small salmon have ranged from a low of 1533 in 1994 to 10155 in 1987.

Conne River is currently managed against a **Management Target** rather than a conservation requirement. The **Management Target** was based upon the estimated number of spawners required to produce the highest recorded returns to the river, which occurred in 1987. The returns were adjusted to account for the total population prior to any sea fisheries by using an assumed commercial exploitation rate.

The **Management Target** was met or exceeded from 1986-90, but declined to 40% in 1994 (Dempson MS 1993; Dempson et al. MS 1994a; Dempson et al. MS 1995). Stocking of reared fry in 1995, from brood fish maintained in 1994, increased the 'equivalent' egg deposition in 1994 to 58% of the **Management Target**. Increased sea survival over the 1994-95 period resulted in 81% of the **Management Target** being met in 1995 (Dempson and Furey MS 1996). Smolt production has varied from about 56000 to 75000 ($\bar{x}$ = 65927, coefficient of variation, C.V., = 11.2%).

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 and 1995, this closure was continued and extended to the Indian Band Council's food fishery. Both fisheries remained closed in 1996.

This paper summarizes smolt production and returns of adult Atlantic salmon to Conne River in 1996. In addition, information on environmental characteristics during the 1996 season is described, biological characteristic data for Atlantic salmon are updated, in-season and pre-season forecast results are compared with actual results, and the impact of the commercial salmon moratorium on Conne River salmon assessed. The distinction between the **Management Target** versus a **conservation requirement**, as used for other Newfoundland rivers, is clarified.

Noteworthy events or changes in 1996

The following summarizes noteworthy changes to fishery regulations and other observations/events occurring in 1996:

- recreational and native food fisheries closed for the entire season;
- sea survival from smolts to 1SW salmon was the highest value recorded (5.8%) since 1989-90;
- **Management Target** achieved for the first time since 1990;
- 1SW salmon survivors from the sea cage rearing experiment using wild Conne River smolts at Roti Bay were released and contributed to the 1996 spawning escapement;
- smolt production in 1996 was the highest on record.

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. Environmental conditions

Water temperature information was obtained from a continuous recording Hugrun thermograph located in the lower Conne River (April 25 - September 25, 1996) (Fig. 2). 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.

3. Biological characteristics

Biological characteristic information on adult salmon, including fork length, whole weight, and age was derived from sampling salmon captured at the fish counting fence, many of which were subsequently retained in cages for brood stock use. Adult salmon samples were obtained over the period from May 31 to July 26, 1996. Biological data on Atlantic salmon smolts were obtained from specimens sampled at the downstream fish counting fence trap.

Estimates of the numbers of salmon of different life stages (1SW, 2SW, consecutive and alternate spawners) that have returned to Conne River were derived following methods reported in Dempson and Reddin (MS 1995). Salmon returning to the river are categorized as small (<63 cm) or large (≥ 63 cm) salmon. Biological characteristic data were similarly partitioned into these respective size classes and applied to numbers of returning fish. Data were available for 1815 small salmon, but only 55 large salmon. For small salmon, year specific information was applied from 1986 to 1990, and 1995-1996. For years 1991-1994, the average

contribution for the years 1986-94 were used. With respect to large salmon, numbers from 1986 to 1994 were as reported in Dempson and Reddin (MS 1995) and were derived using the average values for the 1986-1994 period. Updated values for 1995 and 1996, however, were obtained using the overall 1986-1996 information. Survival of repeat spawning salmon was determined by adding the subsequent estimates of consecutive spawners in year i+1 for both small and large salmon with the number of alternate spawners in year i+2. This value was then divided by the corresponding estimated number of 1SW fish from year i. Consecutive or alternate spawners, then, are all assumed to be associated with the previous 1SW component by a time span of either one or two years.

Analyses of smolt condition were updated following the general methods outlined in Dempson et al. (MS 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.

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 21 to September 23, 1996 (Table 1). The counting fence was monitored as a cooperative project between DFO and the Conne River Indian Band.

During 1996, 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 openings in the fish counting fence but were recorded on the video camera system. The video camera system utilized a positive image horizontally directed camera (Panasonic model WV-BD400) positioned on the substrate and angled to view an opening in the fish counting fence. 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 generally from early evening until about 0900 hours from June 14 until August 16.

In addition to wild salmon returns, there were also returns from Conne River salmon smolts that were transferred in 1995 to Roti Bay, reared in an aquaculture sea cage and subsequently released in the early summer of 1996 as 1SW fish. These fish were all externally tagged (Floy 'T-bar' anchor tags) to differentiate them from wild salmon. An evaluation of the cage rearing results is presented elsewhere (Dempson et al. MS 1997 unpublished report).

Total river returns

Total river return (TRR) of adult salmon was estimated from:

$$TRR = C + Mb + Cn$$

where, C = the count of salmon at the counting fence
Mb = the known mortalities below the counting fence, and
Cn = the estimated catch of Conne River origin salmon in the native food fishery (0 in 1996).

The count of salmon at the fence was a total of both wild and cage released salmon.

Spawning escapement

Spawning escapement (SE) was estimated as:

$$SE = FR - Ma - Br$$

where, FR = the number of fish released at the counting fence
Ma = the number of known mortalities above the fence
Br = 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 now to either the current **Management Target** or the **conservation egg requirement.** That is, no additional adjustments have been made to account for any unknown or assumed mortality of fish up to the time of spawning. Thus, the potential egg deposition could overestimate the actual egg deposition.

Egg deposition

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

$$ED = SE \times PF \times F$$

where, PF = proportion of females
F = fecundity at size

An estimate of fecundity was obtained from the relationship derived in 1987 (October 27-30) from ripe salmon (Dempson et al. MS 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. For 1996, the mean length and proportion of females from all years were used ($\bar{x}$ = 50.7 cm, N = 1149, and includes repeat spawning females < 63 cm; percentage female was 78%).

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 MS 1989, MS 1990).

The **Management Target** (**MT**) has been maintained as in past years at 7.8 million eggs. This was equivalent to about 4000 salmon < 63 cm in size.

In order to compare correctly and evaluate Conne River against other Newfoundland salmon rivers for which stock assessments are done, a corresponding **conservation egg requirement** (**ER**) has been calculated. The calculation follows methods summarized in O'Connell and Dempson (1995) for average potential smolt production:

fluvial habitat	=	13180 units @ 3 smolt/unit
lacustrine habitat	=	3187 hectares @ 7 smolt/unit

Corresponding egg deposition requirements were derived using egg-to-smolt survival rates of 0.0125 and 0.019 for fluvial and lacustrine habitats, respectively. The **conservation egg requirement** then, equals 4,337,358 eggs versus 7.8 million as a **Management Target.**

The equivalent total number of spawners (TNS) associated with the **conservation egg requirement** was calculated as follows:

$$TNS = \frac{ER}{[\ (PS \times PF_s \times F_s)\ ]}$$

where,

PS = proportion small salmon (< 63 cm) in TRR, 1992-96 (= 0.958)
PF_s = proportion female small salmon, 1992-96 (= 0.769)
F_s = fecundity of small salmon at size ($\bar{x}$ length, 1992-96 = 50.5 cm, = 2379)

Thus, TNS = 2475 small salmon.

5. Net-marked salmon

Surveys of net-marked salmon returning to Conne River were carried out from June 7 - July 20, 1996, but only on those fish clearly observed in the fish counting fence trap.

6. Smolt production

A mark-recapture study was carried out to estimate the smolt production in 1996. The study was similar to those carried out in 1987-95, the design of which is summarized in Dempson and Stansbury (1991) and uses the estimator described in Schwarz and Dempson (1994). As in 1995, the downstream smolt trap was monitored 24 hours of the day.

During 1996, 3373 smolts were tagged and released at the upstream partial counting fence site (Fig. 1). At the downstream recapture site, 14575 smolts were caught including 499 tagged smolts.

7. In-season and pre-season forecasts of salmon abundance

In-season forecasts

In-season forecasts of small salmon abundance were generated from regressions of counts to date versus total count for the year. Ten years of data (1986-1995) were available. Various in-season dates were chosen starting from June 18 until July 1.

The usefulness of this approach was later evaluated by comparing respective 'forecasts' relative to the current number of spawners required to meet or exceed conservation requirements (~4000 small salmon) using data through until 1996 with in-season dates extended until July 5. This was done for each of the 11 years by deleting the year in question (year for which results were being predicted) from the regression and using the remaining 10 years to generate the forecasts.

Pre-season forecasts

Two pre-season forecasts were examined for Conne River. The first was derived from a relationship between the median date of smolt run timing and subsequent survival to 1SW salmon. The second forecast is based on a relationship between an index of marine thermal habitat (Reddin and Friedland 1993; Dempson and Reddin MS 1995) and subsequent survival to 1SW salmon.

8. Impact of commercial salmon fishery moratorium

With respect to Conne River, the following factors were addressed in conjunction with identifying any impact that the closure of the commercial salmon fishery may have had:

- total returns of small salmon
- total returns of 1SW salmon
- sea survival from smolts to small salmon
- sea survival from smolts to 1SW salmon
- size composition of adults (length and weight)
- ratio of small to large salmon in total river returns
- proportion of repeat spawning salmon

Data were analysed using a nonparametric two-sample Wilcoxon test. Two time periods were considered: premoratorium = 1986-1991 and postmoratorium = 1992-1996.

Results and Discussion

1. Landings

Landings in the recreational fishery are summarized in Table 2. As indicated above, no recreational fishing has been allowed since 1992. In past years, angling exploitation rates varied from 0.181 to 0.285 (Dempson et al. MS 1994a).

Native food fishery catches for past years are also summarized in Table 2. This fishery last occurred in 1993.

2. Environmental conditions

Mean air temperature in April 1996 was the warmest since 1988. Similarly, an air temperature index (Dempson et al. MS 1994b) for the period April 1 to May 15, was also the warmest since 1988 (Fig. 3b). Warm air temperatures that occurred during the first five days of May (mean = 7.2 °C) were followed by colder conditions that persisted until May 17. Water temperatures (Fig. 2) followed a similar pattern. Generally warmer average water temperatures contributed to an early smolt run with mean daily temperatures exceeding 10 °C in late April and early May. Water temperatures, however, also decreased with the onset of cooler conditions (Fig. 2). Over 55% of the smolt run, however, was complete by the end of the first week in May.

Water temperatures increased over the summer with the warmest temperatures occurring in early August (Fig. 2). During this period, mean daily temperatures exceeded 20 °C on a number of occasions (Fig. 2). The maximum water temperature occurred on August 7 (25 °C).

Water levels were moderate during much of May and June (Fig. 2). Exceptions, however, occurred in early and mid-May, and especially during early July when rain storms caused river discharge levels to increase rapidly (Fig. 2). Water levels remained at relatively low levels throughout much of August into mid-September.

3. Biological characteristics

Adult samples

Table 3 summarizes annual biological characteristic data of Atlantic salmon from Conne River, 1986-1996. Mean weight of 1SW salmon in 1994 and 1995 is lower by comparison with earlier years. This may have been because measurements were taken from salmon maintained in cages for brood stock. Thus, data were recorded in September and not in June or July as in past years. In 1996, although only 19 fish were measured, the mean weight of 1SW salmon was the highest recorded. However, these weights were all taken June 19 from fish held for radio tag implementation. Thus, mean weight may be positively biased.

Repeat spawning salmon are separated into consecutive and alternate categories. Consecutive spawners are typically less than 63 cm in fork length ($\bar{x}$ = 508 mm, Table 3) while alternate spawners average 690 mm in length (Table 3) (Fig. 4). As acknowledged in past reports, not all size classes of fish can be sampled representatively. However, with respect to salmon less than 63 cm in length, only 93 (5.12%) out of 1815 samples at Conne River were either consecutive (N = 92) or alternate (N = 1) spawning fish. Length-frequency distributions of 1SW, 2SW, consecutive, and alternate spawners sampled at Conne River are illustrated in Figure 4.

Survival of repeat spawning salmon has been generally less than 10% (Table 4). In recent years, however, there is a indication that the contribution of repeat spawners has changed dramatically (Table 4). Even without the contribution of alternate spawning salmon in 1997 added in, estimates of the number of consecutive repeat spawners in 1996 from 1SW salmon in 1995 will yield a survival of over 20%. The number of samples obtained in 1996 for biological characteristic information was relatively small (N = 97), but samples were obtained over the most of the temporal duration of the run.

As specified above in Methods section 3, consecutive or alternate spawners were all assumed to be associated with the previous 1SW component by a time span of either one or two years. This is not entirely correct, but the relative magnitude of the error induced is minimal. With respect to the small salmon category, 6 of the 92 fish classed as consecutive spawners were fish that have spawned on two previous occasions. One of these was from 1986, three from 1992 and two from 1994. We note that the

overall average life stage contributions were used for the 1992 and 1994 years. For large salmon, average information was used for all years, but it is noted that eight of 55 fish were fish that had spawned on at least two prior occasions.

Smolt samples

The analysis of smolt condition indicated significant differences among years ($F = 31.06$, $P = 0.0001$) (Fig. 3a). Lowest condition was in 1992 followed by 1994, 1990, and 1991. Previously, it was noted that years in which smolts had a higher condition were often those that were associated with warmer spring temperatures (Fig. 3c). There was also an indication that smolt condition was associated with subsequent sea survival, as higher survival of smolts often occurred in years where condition was greater (Fig. 3d). This pattern, however, was not consistent with results obtained in some of the recent years (example 1995). We note that smolt condition in 1996 was the fourth highest recorded.

Farmed (hatchery) smolt

In 1996, biological data were obtained from 59 smolts believed to be of farmed origin. Fish were initially identified from their grey-green colouration and obvious dorsal fin wear. Subsequent examination of scales confirmed their aquaculture origin.

Mean length of these fish ranged from 122 to 169 mm ($\bar{x}$ = 148 mm) while mean weight varied from 14.8 to 43.3 g ($\bar{x}$ = 29.0 g). These data are consistent with the size of wild smolts at Conne River (Table 3). In contrast with wild smolts where the sex ratio is biased towards females (~73%), 47.5% of the sample of farmed smolts were female (N = 28).

Run timing

Figure 5 illustrates the run timing (median date) 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 run were typically later (7 days) during 1991-94 (May 21) in comparison with the pre-1990 period (May 14), with 1992 characterized by the latest run timing recorded (May 24). While the median timing 1995 was the earliest since 1990, smolt timing in 1996 was the earliest recorded over the 10 years of investigations (May 3), and was over two weeks earlier than run timing during in the early 1990's. As discussed later in Section 7 (*In-season forecasts*), smolt run timing is associated with subsequent survival to 1SW salmon.

Median timing of the adult run of salmon during the late 1980's (1986-89; June 22) was about one week earlier than timing

during the early 1990's (1990-94; July 1), with 1991 characterized as the latest recorded (July 6) (Fig. 5). The warmer conditions experienced during the spring of 1996 also affected the run of adult salmon as timing was the earliest since 1989 (Fig. 5; June 27). We note that the median run timing of returning adult small salmon is also correlated with Station 27 water temperatures, 0-20 m depth, for either May ($r^2 = 0.538$, $P < 0.05$), June ($r^2 = 0.680$, $P < 0.01$), or combination index of the two months ($r^2 = 0.666$, $P < 0.01$).

The following text table summarizes the air temperature index, smolt run timing statistic (day of the year) and percent survival from smolt to small salmon or 1SW salmon:

Smolt Year	Air temperature index (April 1-May 15)	Median Day run timing	% survival to small	% survival to 1SW
1987	5.48	Day 131	10.2	10.04
1988	4.77	136	7.6	6.94
1989	4.08	138	7.3	7.16
1990	3.46	138	4.2	4.05
1991	2.87	141	3.4	3.23
1992	2.36	145	4.0	3.79
1993	2.34	143	2.7	2.63
1994	2.69	142	5.8	5.66
1995	1.80	139	7.2	5.76
1996	3.69	124		
1997	1.60			

Rainbow trout

Updated records on the numbers of rainbow trout encountered at Conne River are provided in Table 5. Previous occurrences are reported in past assessment reports.

4. Estimated returns and spawning escapement

There were 4436 salmon < 63 cm and 179 salmon ≥ 63 cm counted at the fish counting fence on Conne River in 1996 (Tables 6 and 7). This represents an increase of 26.7% in the number of small salmon in comparison with 1995 and 189% more than in 1994. Large salmon numbers increased by 62.7% from the previous year. The single largest daily run occurred on July 3 (755 small salmon) (Fig. 6) Only 126 small salmon, or 2.8% of the run in 1996 occurred after July 31. Owing to the inoperation of the fence July 15 and 16, the above represent minimum numbers although 93% of the total count of small salmon occurred prior to July 15.

Partitioning the count of salmon among the various ways fish were enumerated in 1996 is as follows:

	Small Salmon		Large Salmon	
	N	%	N	%
Fence opening	15	< 1	0	0
Counting fence trap	2466	56	125	70
Video camera chamber	1955	44	54	30
Total	4436	100	179	100

With respect to the video camera system, salmon generally migrated all night long. The period from 2230 to 0229 hours accounted for 55% of the total. This pattern of movement was consistent with that observed at Conne River in past years. A total of 1287 fish were associated with time of fish passage as follows:

Time (hours)	Number of fish	%
2030 - 2229	407	32
2230 - 0029	340	26
0030 - 0229	369	29
0230 - 0429	158	12
0430 - 0900	13	1

Total returns (Fig. 7) of adult salmon to Conne River in 1996 are summarized in Tables 6 and 7 for small and large salmon, respectively.

Total returns of small salmon (4440) were 27% higher than in 1995 while large salmon returns (179) increased by 63%. Returns, also include 286 fish that were Conne River salmon smolts that were reared in an aquaculture sea cage at Roti Bay and released in the early summer of 1996.

Sea survival

Sea survival from smolts to small salmon has increased from 2.7% (2.6-3.0%) in 1994 (return year) to 7.2% (6.4-8.3%) in 1996 (Fig. 7, Table 8). This represents the highest survival recorded in six years. Corresponding sea survival to 1SW salmon was also the highest recorded since 1990 (adjusted for the return of Roti Bay released salmon). Sea survival from smolts to 1SW salmon

declined significantly (r^2 = 0.872, P = 0.0021) over the period through to adult returns in 1994 (Fig. 7).

Potential spawning escapement in 1996 was estimated to be 4402 small salmon and 179 large salmon (Tables 6 and 7). As stated above, this includes 286 salmon Conne River salmon reared in an aquaculture cage at Roti Bay. Mean number of eggs per female for the wild salmon was 2402 using average size data of females for all years. Cage reared salmon averaged 45.3 cm in length. The number of eggs per female was then 1834. Females represented 78% of the run. Estimated total number of eggs deposited was:

small salmon (wild) = 7.7116 million eggs
small salmon (cage) = 0.4091 million eggs
large salmon (wild) = 0.6122 million eggs

for a total egg deposition of 8.733 million, or 112% of the current **Management Target** and a 38% increase in egg deposition from 1995. Ninety-five percent (95%) of the total egg deposition was obtained from wild salmon returns while cage released salmon contributed approximately 5%.

In contrast with the **Management Target**, the corresponding **conservation egg requirement** met is also shown in the bottom of Table 7. Thus, in comparing Conne River to other salmon rivers assessed, the **conservation egg requirement** has been achieved in each year but 1991, 1992, and 1994. However, over 90% of the requirement was met in both 1991 and 1992.

Relationships between estimated egg deposition and subsequent smolt output were based on limited data and as such, have not been conclusive. Previously, higher egg depositions produced more smolt; this pattern has now changed with the low egg deposition from 1992 (~4 million eggs) that has already produced over 75 thousand smolts to age 3+.

Estimates of egg-to-smolt survival are now available for six year-classes (1986 to 1990; the 1991 year-class complete only to age 4 smolts in 1996). These values, by year-class, are:

Year-class (eggs)	Estimated egg deposition	Smolt Production	Survival (%)	Eggs per 100 m^2
1986	11,340,000	56,873	0.50	860
1987	16,730,000	76,655	0.46	1269
1988	12,420,000	65,038	0.52	942
1989	8,040,000	55,335	0.68	610
1990	8,730,000	68,720	0.79	662
1991	3,980,000	(56,783)[1]	1.43	302
1992	3,970,000			
1993	4,760,000			
1994	3,120,000			

[1] to age 4 smolts in 1996

Egg-to-smolt survival, has more than doubled from the average of the previous five values (mean = 0.59%). The dramatic increase in the egg-to-smolt survival coincided with the first of several successive years in which the egg depositions were below the conservation requirement of 7.8 million eggs. Similarly, egg deposition in 1992 was also approximately 4 million eggs. Smolts produced to date from the 1992 year class are now complete to age 3. However, egg-to-smolt survival is already 1.9% and will easily exceed 2%. We note that, relative to the estimated 13,180 units (1 unit = 100 m^2) of rearing habitat in the Conne River system, egg deposition rates per unit have ranged from 610 to 1269 m^2, coinciding with egg-to-smolt survivals of 0.50 to 0.77%. Beginning with 1991, egg-to-smolt survival either has, or will have increased to 1.4-2% at corresponding fluvial egg deposition rates of approximately 300 m^2.

5. Net-marked salmon

The following summarizes observations of net marked fish at Conne River during 1996.

Date	Number of fish observed	Number scarred	Percent Scarred
June 7-16	60	1	1.7
June 17-21	87	7	8.0
June 22-26	248	21	8.5
June 27-July 1	259	11	4.2
July 2-6	105	12	11.4
July 7-11	168	8	4.8
July 13-20	74	2	2.7
Total	1001	62	6.2

Numbers of net marked salmon varied on each occasion with no apparent increasing or decreasing trend. Results are comparable with those obtained in 1995.

6. Smolt production

The estimated number of smolts in 1996 was 94088 (95% confidence limit = 79867-108309) (Table 8). This was the highest production in the ten year time series and was largely derived from the 1992 spawning escapement which was estimated to have produced about four million eggs. The number of smolts in each age group is

summarized in Table 9. It is noted that the proportion of age 4+ smolts in 1996 was the lowest to date (Table 9).

While some farmed (aquaculture) smolts were readily observed at the downstream Conne River partial fish counting fence (N = 79), only two (2) of 243 (0.8%) smolts sampled throughout the smolt run were believed to have been of aquaculture origin. Given the low proportion in the sample, no correction was made to the estimated number of smolts in the 1996 run.

7. In-season and pre-season forecasts of salmon abundance

In-season forecasts

In-season forecasts of salmon abundance in 1996 ranged from a low of 4178 salmon based on June 23 information to a high of 4752 using June 28 data. The actual return was 4436 small salmon.

Figure 7 illustrates the sequential regressions of in-season counts to various dates with the corresponding total run for the year beginning with June 18. At Conne River, the cumulative count to June 18 has ranged from a high of 33.8% of the total run in 1987 to a low of 2.0% in 1990 (average for all years was 13.6%). For all in-season dates, the relationship is highly significant (Fig. 8). As expected, the r^2 value increases as the season progresses as more and more of the final total is being accounted for.

For the years 1986-1989, all in-season dates would have yielded a correct conclusion that the conservation number of salmon would be achieved (Table 10). Similarly, for 1991-95, results from all in-season dates suggested that the conservation level would not be achieved which is what actually occurred. The one exception was 1990. Here, for the June 18 to July 3 dates, results would have suggested that the conservation level would not have been reached when in reality the 4321 salmon returned to Conne River. By July 5, however, a correct result would have been obtained. Thus, for all combinations of years and in-season dates (N = 66; 11 years x 6 in-season dates), in only 5 cases would incorrect 'advice' have been given. In this particular case it would have been to error on the conservative side.

Results from above suggest that more often than not, correct in-season predictions can be given as early as June 18 in the majority of cases. This provides a quick and easy method that managers or field staff can use to ascertain in-season information relative to opening fisheries. Note that corrections for salmon taken in food fisheries or recreational fisheries have not been factored into the numbers used; only actual returns to the fish counting fence.

Pre-season forecasts

Figure 9 illustrates the relationships between sea survival to 1SW salmon with (a) median timing of the smolt run from the previous year and (b) an index of marine thermal habitat (January-March). In the first case (a), the later the timing of the outward smolt migration then the lower the subsequent survival to 1SW adult salmon. A 'prediction' for 1996 returns based on this relationship up until 1995 would have yielded a survival of 5.56%. Estimated survival of 1SW salmon from smolts out in 1995 was 5.76%.

Timing of the 1996 smolt run was the earliest recorded. Thus, it falls outside the bounds of the existing relationship. Should this pattern hold, however, then sea survival and corresponding returns should be high. Results in 1997 could further serve to evaluate the usefulness of this approach. We note, however, that the functional significance of this relationship is currently unknown.

Regarding the index of marine thermal habitat (Fig. 9b), a prediction based on results to 1995 would have suggested a survival of 6.05%. As noted above, survival to 1SW salmon was estimated to be 5.76%. Table 11 summarizes the marine thermal habitat data to March 1997. Plots using the January, February, January-February, and January-March data are illustrated in Figure 10. Current information from this index suggests a survival of 7.5 to 8.2%. We caution, however, that despite these apparent relationships, sea survival cannot be predicted with a high degree of accuracy.

Overall, however, a combination of the above approaches could provide managers with an initial forecast of returns approximately one year in advance (median smolt timing relationship). This could be modified later when the thermal habitat index is obtained. These pre-season predictions could be modified to fine tune and correct anomalous predictions using in-season information as the run progresses.

At present, there are some indicators as discussed above that would suggest returns in 1997 should exceed the **Management Target** as well as the **conservation egg requirement.** These indicators include: 1) earliest smolt run timing in 1996; 2) highest smolt production, and overall increased sea survival in recent years in comparison with the early 1990's; and 3) apparent improved marine thermal conditions in the January to March 1997 period. In addition to these factors, it is noted that there was an escapement of approximately 150 thousand Saint John River origin salmon from sea in Bay D'Espoir in February, 1996. Some of these salmon could return to local rivers as 1SW fish in 1997, while other survivors may return as 2SW fish in 1998. A comprehensive sampling program should be carried out to estimate the relative contribution of these fish to wild salmon returns at Conne River in 1997.

carried out to estimate the relative contribution of these fish to wild salmon returns at Conne River in 1997.

8. Impact of commercial salmon fishery moratorium

Returns of either small salmon or 1SW salmon were 54.6% or 57.7% lower respectively, during the moratorium years in comparison with the premoratorium period. These differences were significant at P = 0.055 (Table 12). Sea survival of smolts to either small salmon or 1SW salmon was 30-40% greater during the premoratorium years, but the differences were not statistically significant (Table 12). As noted above in Results section 4 (*Sea survival*), there was a significant decline in survival through to the 1994 adult salmon return year. Survival has increased during the past two return years.

There was no change in the proportion of large salmon, or in the proportion of repeat spawning salmon in the run during premoratorium versus moratorium periods. Fork length of 1SW salmon was significantly larger (by 0.87 cm) (P = 0.0001) during the moratorium years. However, there was no corresponding difference when salmon weight was considered (P = 0.724) (Table 11).

In summary, the commercial salmon moratorium coincided with a period of declining sea survival that resulted in fewer adult salmon returning to the river. This included a lower proportion of large salmon returns.

Acknowledgements

We again wish to acknowledge the support and cooperation of the Conne River Indian Band during all aspects of the 1996 project.

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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
1995	May 2	June 8	May 30	Oct 16
1996	April 26	June 11	May 21	Sept 23 *

* Fence inoperable in 1996 during the following dates:
July 14, 2400 hrs - July 17, 1400 hrs
July 25, 2230 hrs - July 26 0600 hrs

Note: past documents list previous years' fence inoperation dates

Table 2. Atlantic salmon landings (in numbers of fish) in the recreational fishery, 1974-1996, and in the native food fishery, 1986-1996, at Conne River, Newfoundland. Note that the recreational fishery has been closed since 1993 while the food fishery has been closed since 1994.

	Recreational Fishery				Native Food Fishery			
	Effort	Salmon catch				Salmon catch		
Year	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
1995	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	0

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

Quotas of 100 and 330 small salmon were in effect in 1991 and 1992, respectively.

Table 3. Summary of biological characteristics for Atlantic salmon samples from Conne River, Newfoundland (SFA 11), 1986-1996.

		Fork length (mm)					Whole weight (g)					River age (y)					Sex Ratio	
Lifestage	Year	N	Mean	SD	Min	Max	N	Mean	SD	Min	Max	N	Mean	SD	Min	Max	N	% female
Smolt	1986	145	153	12.0	125	210						145	3.25	0.48	2	5		
	1987	271	144	16.5	106	198	271	29.1	9.9	11.5	73.8	271	3.32	0.54	2	5	270	77
	1988	328	147	15.7	102	201	328	32.3	10.4	12.4	78.8	328	3.41	0.51	3	5	327	73
	1989	288	152	21.3	98	265	288	35.0	14	9.8	123.2	288	3.25	0.53	2	5	288	79
	1990	271	148	21.2	100	253	271	30.5	13.1	10.3	122.8	271	3.29	0.49	2	5	271	74
	1991	246	153	19.9	104	244	246	33.5	13.6	12.6	112.5	246	3.19	0.44	2	5	245	66
	1992	169	149	15.6	116	189	169	30.1	8.9	14.9	59.2	169	3.28	0.51	2	5	169	71
	1993	246	149	16.5	114	198	246	31.6	10.3	15.7	71.7	246	3.26	0.45	3	5	246	67
	1994	208	148	15.1	116	190	208	29.6	8.3	16.0	59.2	208	3.20	0.41	2	4	208	74
	1995	249	143	15.2	103	179	249	28.6	8.3	10.3	50.6	249	3.31	0.51	2	5	249	73
	1996	243	151	16.0	102	224	243	32.9	10.2	16.3	93.8	243	3.16	0.47	2	5	243	73
TOTAL		2664	149	17.6	98	265	2519	31.4	11.2	9.8	123.2	2664	3.27	0.50	2	5	2516	73
1 SW	1986	357	506	23.0	440	570	357	1451	220.4	900	2900	357	3.38	0.57	2	5	356	76
	1987	373	509	23.3	430	580	373	1492	247.5	600	2600	373	3.18	0.46	2	5	327	78
	1988	267	506	26.1	440	600	267	1352	226.5	1000	2200	267	3.14	0.42	2	4	261	80
	1989	140	512	23.3	460	580	140	1411	201.7	1000	2000	140	3.18	0.50	2	5	135	79
	1990	174	508	23.4	449	575	142	1454	184.4	1100	2000	174	3.27	0.52	2	5	141	81
	1991	39	514	22.8	455	552	34	1362	172.4	1000	1700	39	3.18	0.39	3	4	33	70
	1992	77	505	22.4	453	580	36	1363	276.1	900	2000	77	3.18	0.53	2	5	43	79
	1993	39	513	30.8	475	620						39	3.05	0.32	2	4		
	1994 *	73	510	25.8	405	580	69	1272	193.9	800	1800	73	3.12	0.44	1	4	71	75
	1995 *	111	498	24.8	433	573	107	1144	184.4	800	1700	111	3.14	0.42	2	5	105	77
	1996	72	518	21.8	475	573	19	1523	219.1	1160	1920	72	3.22	0.51	2	5	2	100
TOTAL		1722	508	24.3	405	620	1542	1408	239.4	600	2900	1722	3.22	0.49	1	5	1474	78

* Samples of 1SW salmon in 1994 and 1995 were obtained from fish held for brood stock. Thus fish were sampled in September in each of these years.

Table 3. (Continued) Summary of biological characteristics for Atlantic salmon samples from Conne River, Newfoundland (SFA 11), 1986-1996.

		Fork length (mm)					Whole weight (g)					River age (y)					Sex Ratio	
Lifestage	Year	N	Mean	SD	Min	Max	N	Mean	SD	Min	Max	N	Mean	SD	Min	Max	N	% female
2 SW	1986	1	630				1	2600				1	3.00				1	100
	1989	2	665	21.2	650	680	1	2700				2	3.50	0.71	3	4	1	100
	1992	1	650				1	2700				1	4.00					
	1994	1	700									1	3.00					
	1995	2	735	49.5	700	770						2	3.00	0.00	3	3		
	1996	2	665	14.1	655	675						2	2.50	0.71	2	3		
TOTAL		9	679	41.6	630	770	3	2667	57.5	2600	2700	9	3.11	0.60	2	4	2	100
Consecutive Spawning Grilse																		
	1986	1	560				1	1800				1	3.00				1	100
	1987	31	511	24.5	460	576	31	1331	232.3	1020	2100	31	3.61	0.62	2	5	30	100
	1988	5	556	24.1	530	590	5	1640	260.8	1500	2100	5	2.80	0.84	2	4	5	40
	1989	6	575	23.5	550	610	6	1767	233.8	1500	2000	6	3.00	0.00	3	3	6	50
	1990	3	564	51.4	505	601						3	3.33	0.58	3	4		81
	1991	4	586	49.9	548	659	1	1400				4	3.50	0.58	3	4	1	100
	1992	8	581	43.6	530	660						8	3.50	0.53	3	4		
	1993	3	617	56.9	570	680						3	2.67	1.15	2	4		
	1994	15	564	36.1	510	640	14	1714	455.5	1200	2900	15	3.20	0.56	2	4	15	73
	1995	2	547	3.5	544	549	2	1500	141.4	1400	1600	2	3.00	0.00	3	3	2	100
	1996	19	572	60.8	505	795						19	3.16	0.37	3	4	2	50
TOTAL		97	553	48.8	460	795	60	1504	345.3	1020	2900	97	3.31	0.60	2	5	62	82
Alternate Spawning Grilse																		
	1986	1	600				1	2400				1	3.00				1	100
	1989	13	683	18.9	660	710	2	3350	212.1	3200	3500	13	3.08	0.28	3	4	2	100
	1991	2	700	29.0	679	720						2	3.50	0.71	3	4		
	1992	8	682	44.4	630	770						8	2.88	0.35	2	3	1	100
	1993	6	675	35.1	640	710						6	3.33	0.52	3	4		
	1994	3	703	45.1	660	750						3	3.00	0.00	3	3		
	1995	5	730	29.2	710	780						5	3.00	0.00	3	3		
	1996	4	710	21.2	695	740						4	3.25	0.50	3	4		
TOTAL		42	690	36.5	600	780	3	3033	568.6	2400	3500	42	3.10	0.37	2	4	4	100

Table 4. Numbers of small and large Conne River Atlantic salmon partitioned by life stage, and subsequent estimates of percent survival of previous spawning fish. Bracketed value for 1995 is preliminary pending alternate large salmon numbers in 1997.

	Small salmon			Large salmon			Percent survival of previous spawners
		Previous spawners			Previous spawners		
Year	1SW	Consecutive	Alternate	2SW	Consecutive	Alternate	
1986	8256	23	23	50	40	322	14
1987	9376	779	0	63	50	403	4.6
1988	7487	140	0	51	41	328	7
1989	4764	204	0	31	31	250	4.1
1990	5277	91	0	45	36	290	4.6
1991	2302	109	0	11	9	69	9
1992	2409	114	0	19	16	124	8.7
1993	2581	122	0	12	10	78	6.2
1994	1464	69	0	12	10	78	14.1
1995	3440	62	0	18	10	82	(24.6)
1996	3323	831	0	29	16	134	

* example of survival calculation from 8256 1SW salmon in 1986:
779 consecutive spawners from 1987 + 50 (large) consecutive spawners from 1987 + 328 (large) alternate spawners from 1988
= 1157/8256 * 100 = 14.0%

Table 5. Summary of rainbow trout occurrences and captures at Conne River, 1996, with corresponding size data where available.

Year	Date	Location/gear	Length (mm)
1996	May 22	Adult trap	380
	May 29	Smolt trap	325
	May 30	Smolt trap	300-350
	June 17	Diving observation (N = 11)	300-400
	June 20	Diving observation (N = 3)	300-400
	June 29	Diving observation (N = 8)	300-400
	July 1	Video camera (N = 2)	300-400
	July 9	Audlt trap	400
	July 27	Audlt trap (N = 2)	185, 435
	July 31	Fence mortality	300-400
	August 5	Audlt trap (N = 3)	300-400
	August 7	Audlt trap	390
	August 8	Audlt trap (N = 2)	337, 385
	August 9	Audlt trap (N = 2)	352, 309
	September 2	Adult trap	300-400
	September 16	Adult trap	300-400

Table 6. Total estimated returns of small salmon to Conne River, Newfoundland, with a summary of mortalities and removals and estimated spawning escapement, 1986-96.

	Year										
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Returns											
* Food Fishery (estuary)	766	451	506	317	831	234	403	347	0	0	0
Angling below fence				180	213	70	137	0	0	0	0
Mortalities below fence	21	17	3	2	3	2	0	1	0	2	4
Count at fence	7515	9287	7118	4469	4321	2086	1973	2355	1533	3500	4436
Estimated count		400				19	10				
Total Returns	8302	10155	7627	4968	5368	2411	2523	2703	1533	3502	4440
1 - Released at fence	7515	9687	7118	4469	4321	2105	1983	2355	1533	3500	4436
Removals and mortalities											
Mortalities above fence	27	21	7	4	2	5	8	2	5	7	9
Angling above fence	2060	1598	1544	856	554	38	192	0	0	0	0
Brood stock removal		245							93	117	25
2 - Total	2087	1864	1551	860	556	43	200	2	98	124	34
Spawning escapement											
(1) - (2)	5428	7823	5567	3609	3765	2062	1783	2353	1435	3376	4402
Egg deposition											
in millions of eggs	9.86	14.66	10.65	6.95	7.50	3.68	3.45	4.43	2.78	5.95	8.12
% of Management Target met	126	188	137	89	96	47	44	57	36	76	104
% of Conservation egg requirement met	227	338	246	160	173	85	80	102	64	137	187

* 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.

Note: Results for 1994 are for wild fish only, and do NOT include any impact of the egg deposition 'equivalency' from fry reared in 1994-95.

Table 7. Total estimated returns of large salmon to Conne River, Newfoundland, with a summary of mortalities and removals and estimated spawning escapement, 1986-96. Total estimated egg deposition from small and large salmon are also indicated along with the combined estimate of the percentage of the Management Target or Conservation egg requirement met.

	Year										
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Returns											
* Food Fishery (estuary)	14	18	2	1	11	2	4	2	0	0	0
Angling below fence	0	0	0	0	0	0	0	0	0	0	0
Mortalities below fence	1	0	0	0	0	0	1	0	0	0	0
Count at fence	397	498	418	319	361	87	154	98	100	110	179
Estimated count											
Total Returns	412	516	420	320	372	89	159	100	100	110	179
1 - Released at fence	397	498	418	319	361	87	154	98	100	110	179
Removals and mortalities											
Mortalities above fence	1	0	0	0	0	0	1	1	0	2	0
Angling above fence	0	0	0	0	0	0	0	0	0	0	0
Brood stock removal		10							1	0	0
2 - Total	1	10	0	0	0	0	1	1	1	2	0
Spawning escapement											
(1) - (2)	396	488	418	319	361	87	153	97	99	108	179
Egg deposition											
in millions of eggs	1.48	2.07	1.77	1.09	1.23	0.30	0.52	0.33	0.34	0.37	0.61
% of Management Target me	19	27	23	14	16	4	7	4	4	5	8
% of Conservation egg requirement met	34	48	41	25	28	7	12	8	8	9	14
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	6.32	8.73
Egg deposition per unit fluvial habitat	860	1269	942	610	662	302	301	361	237	480	663
Total % Management Target	145	214	159	103	112	51	51	61	40	81	112
Total % Conservation requirement met	261	386	286	185	201	92	92	110	72	146	201

* 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 remaining years, the weighted mean (0.833) was used.

One unit of fluvial habitat = 100 m^2.
Conne River has an estimated 13,180 units of accessible fluvial habitat.

Table 8. Estimates of Atlantic salmon smolts from Conne River, 1987 - 1996, along with subsequent survival to both small salmon in year i + 1, and to 1SW salmon (repeat spawning fish omitted).

	Number of smolts			Population estimate			Survival		
	Upper site	Lower site							
Year (i)	Tagged & released	Total number Captured	Tag Recoveries	N	Confidence interval	Coeffiicient of variation %	% survival to small salmon year i + 1	Survival range	% survival to 1SW salmon year i + 1
1987	4975	14314	990	74585	67597 - 81573	5.1	10.2	9.3 - 11.3	10.04
1988	3235	19515	1054	65692	59862 - 71522	4.8	7.6	6.9 - 8.3	7.25
1989	2699	16928	604	73724	66598 - 80850	5.1	7.3	6.7 - 8.1	7.16
1990	3719	13881	945	56943	52315 - 61571	4.4	4.2	3.9 - 4.6	4.04
1991	3753	9581	398	74645	62033 - 87527	9.0	3.4	2.9 - 4.1	3.23
1992	3758	10229	529	68208	61334 - 75052	5.4	4.0	3.6 - 4.4	3.78
1993	2456	15992	735	55765	51666 - 59864	3.9	2.7	2.6 - 3.0	2.63
1994	2366	11875	479	60762	53759 - 67765	6.2	5.8	5.2 - 6.5	5.66
1995	2558	12260	545	62749*	55300 - 70197	6.3	7.2	6.4 - 8.3	5.76
1996	3373	14575	499	94088	79867 - 108309	8.0			

* Of these fish, 5016 smolt were transferred to sea cage holding facilities at Roti Bay.

Table 9. Estimated total number of smolts in each age group, Conne River, Newfoundland, 1987-96. Lower chart indicates the percentage of smolts at each river age.

	River age (y)				
Year	2	3	4	5	Total
1987	1492	49226	22375	1492	74585
1988	0	40072	24963	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
1995	627	42670	18825	627	62749
1996	2823	75270	14113	1882	94088

	Percent in each age group				Number of
Year	2	3	4	5	samples
1987	2	66	30	2	271
1988	0	61	38	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
1995	1	68	30	1	249
1996	3	80	15	2	243

Table 10. Cumulative numbers of small salmon to various dates along with predicted in-season final counts. Predicted values are also shown as a proportion of the Management Target of 4000 small salmon. Predicted values for each year were derived from respective regressions using all years but the one being predicted.

Year	Total fence count small	Number of small numbers to date						Total salmon count predicted from regressions						Predicted values as a proportion relative to Management Target*					
		June 18	June 23	June 28	July 1	July 3	July 5	June 18	June 23	June 28	July 1	July 3	July 5	June 18	June 23	June 28	July 1	July 3	July 5
1986	7515	1883	3530	3941	5573	5853	5968	6848	6711	6301	7415	7396	7399	1.71	1.68	1.58	1.85	1.85	1.85
1987	9287	3138	5551	6298	7151	7335	7422	11380	10053	10006	9149	8880	8933	2.84	2.51	2.50	2.29	2.22	2.23
1988	7118	943	1990	3821	4858	5196	5257	4509	4573	6201	6537	6612	6514	1.13	1.14	1.55	1.63	1.65	1.63
1989	4469	1095	3027	3522	3962	4044	4085	5186	6514	6164	5778	5546	5369	1.30	1.63	1.54	1.44	1.39	1.34
1990	4321	88	563	1853	2358	2554	3342	2443	2674	3672	3773	3731	4439	0.61	0.67	0.92	0.94	0.93	1.11
1991	2086	63	163	370	415	592	876	2756	2418	1691	1522	1500	1485	0.69	0.60	0.42	0.38	0.38	0.37
1992	1973	105	571	824	993	1073	1138	2886	3054	2450	2354	2194	1898	0.72	0.76	0.61	0.59	0.55	0.47
1993	2355	149	617	876	1196	1327	1480	2940	3063	2459	2549	2451	2293	0.74	0.77	0.61	0.64	0.61	0.57
1994	1533	65	348	607	788	878	944	2857	2804	2209	2178	2036	1732	0.71	0.70	0.55	0.54	0.51	0.43
1995	3500	377	764	1340	1510	1780	2365	3392	3121	2995	2780	2854	3299	0.85	0.78	0.75	0.70	0.71	0.82
1996	4436	923	1535	2599	2924	3745	3782	4732	4178	4752	4465	5173	4982	1.18	1.04	1.19	1.12	1.29	1.25

* Management Target = 4000 small salmon

Table 11. Marine thermal habitat units along with estimates of sea survival to small salmon or 1SW salmon at Conne River.

Year	Thermal habitat units								Sea survival	
	Jan	Feb	March	April	May	June	Jan-March	Jan-Feb	Small	1SW
1986	1832	1688	1547	1674	1880	2366	5067	3520		
1987	1711	1627	1471	1658	1655	1754	4809	3338		
1988	1747	1698	1622	1676	1864	2022	5067	3445	10.2	10.04
1989	1807	1642	1552	1552	1665	1985	5001	3449	7.6	7.25
1990	1526	1503	1491	1318	1543	1747	4520	3029	7.3	7.16
1991	1403	1357	1519	1529	1592	2050	4279	2760	4.2	4.04
1992	1474	1381	1378	1395	1582	1891	4233	2855	3.4	3.23
1993	1441	1252	1242	1353	1517	1923	3935	2693	4.0	3.78
1994	1487	1329	1373	1403	1711	1955	4189	2816	2.7	2.63
1995	1444	1311	1279	1378	1679	1941	4034	2755	5.8	5.66
1996	1647	1470	1419	1495	1859	2086	4536	3117	7.2	5.76
1997	1791	1594	1605				4990	3385		

Table 12. Results of nonparametric Wilcoxon Two-sample tests comparing various factors relative to premoratorium (1986-1991) and moratorium (1992-1996) periods at Conne River, SFA, Newfoundland.

Factor	Lifestage or Group	Mean values: Premoratorium (1986-1991)	Mean values: Moratorium (1992-1996)	Wilcoxon Two-sample test: Z	Wilcoxon Two-sample test: P
Salmon counts	Small	6471.8	2940.2	-1.917	0.055
Salmon counts	1SW	6243.7	2643.4	-1.917	0.055
Sea survival	1SW	6.28	4.46	-1.102	0.270
Sea survival	Small	6.52	4.93	-1.102	0.270
Proportion of large salmon		0.052	0.045	-0.825	0.409
Fork length	1SW	502.5	511.2	3.847	0.0001
Whole weight	1SW	1398.7	1414.0	0.353	0.724
Proportion of repeat spawners		7.22	13.4	1.39	0.165

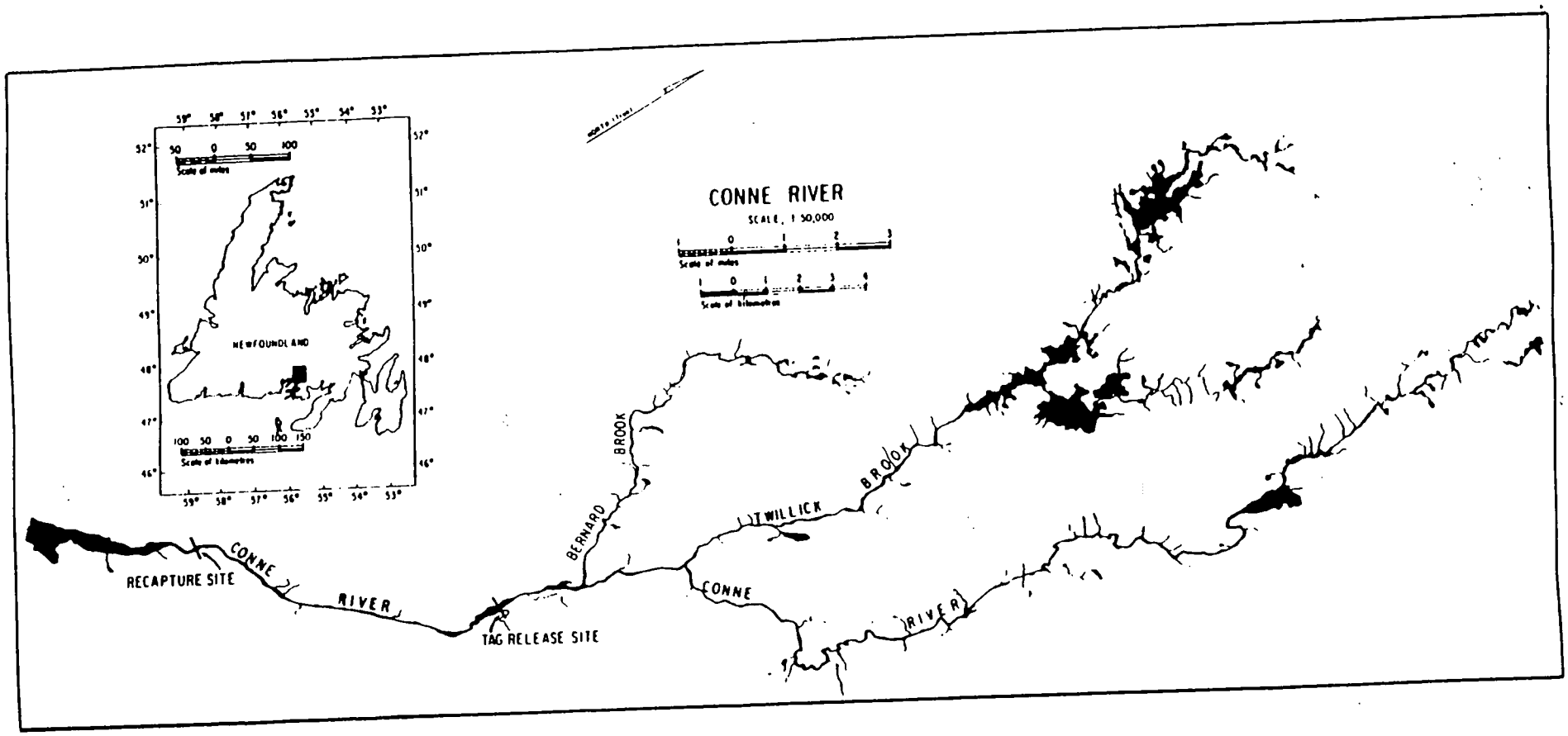


Fig. 1. Conne River, Newfoundland, SFA 11, illustrating the location of the fish counting fences used for the mark-recapture survey. The recapture site is also the location of the upstream adult salmon counting facility.

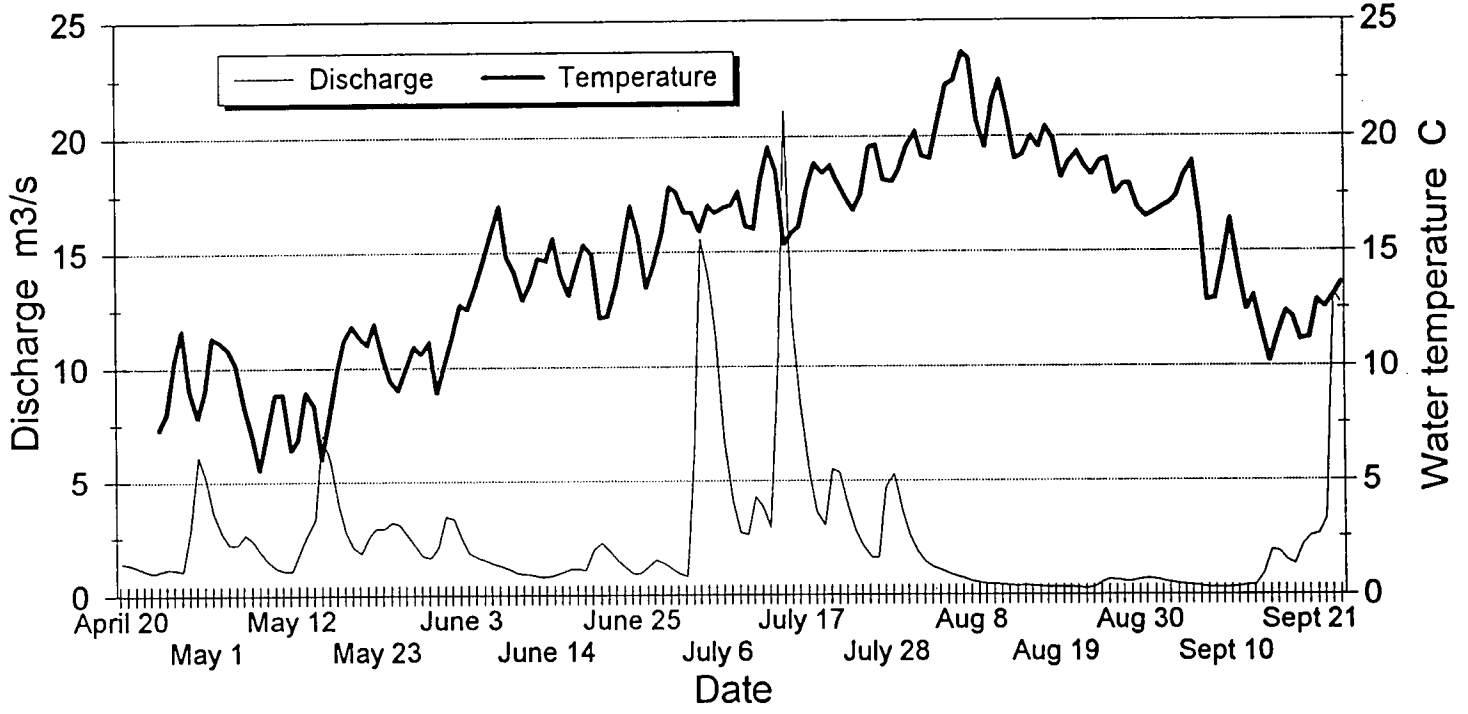


Figure 2. Discharge and temperature profile from April 20 - Sept 25, 1996, at Conne River, Newfoundland. Discharge data from the Environment Canada monitoring station located below Conne Pond. Temperature data from a Hugrun thermograph located at the lower (adult) fish counting fence site.

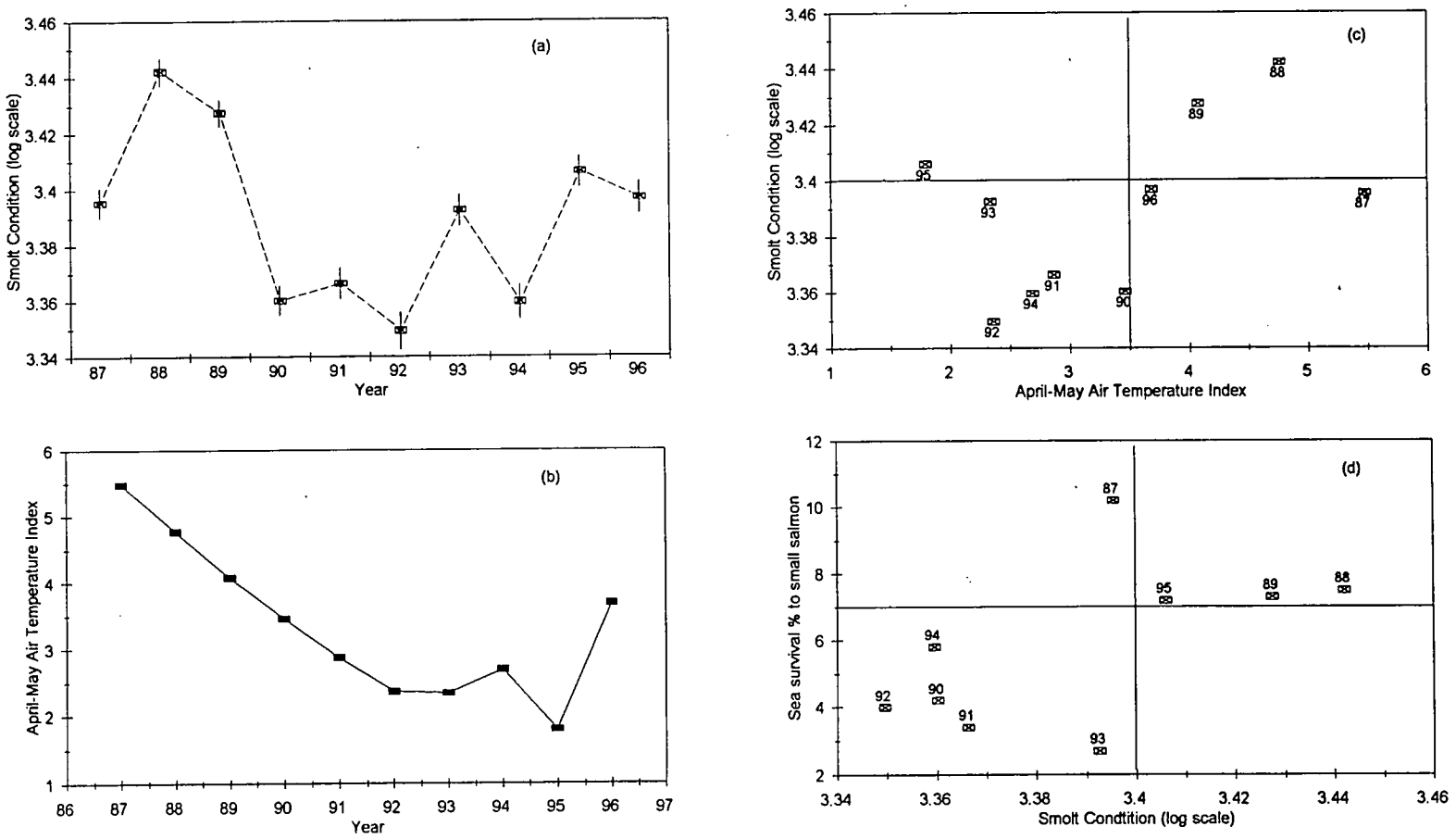


Figure 3. Trends in (a) Conne River smolt condition (adjusted weight, log scale) and (b) the April-May air temperature index over years, along with (c) smolt condition versus the air temperature index, and (d) sea survival (%) of small salmon versus smolt condition in the previous year. Years shown refer to the smolt year class.

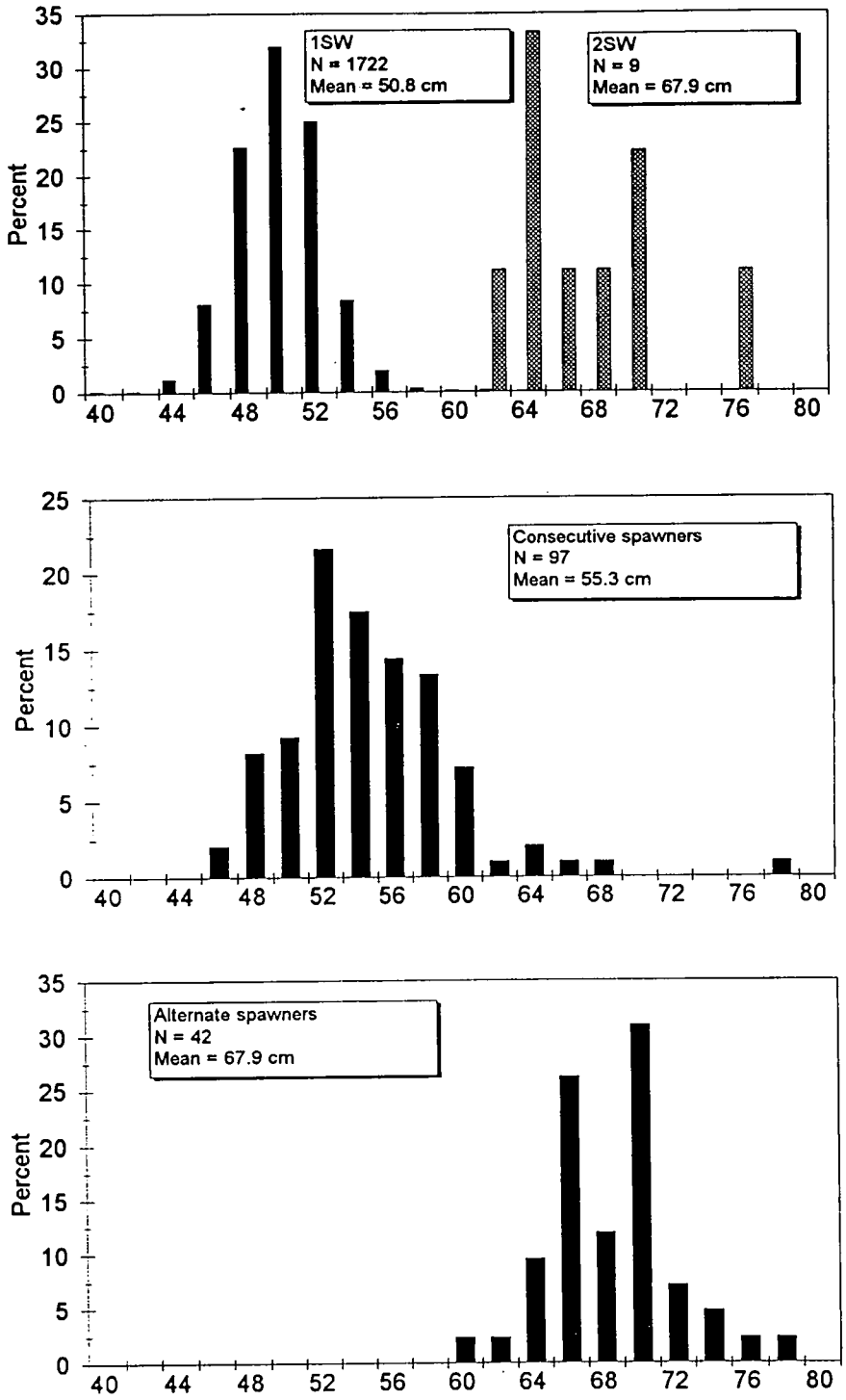
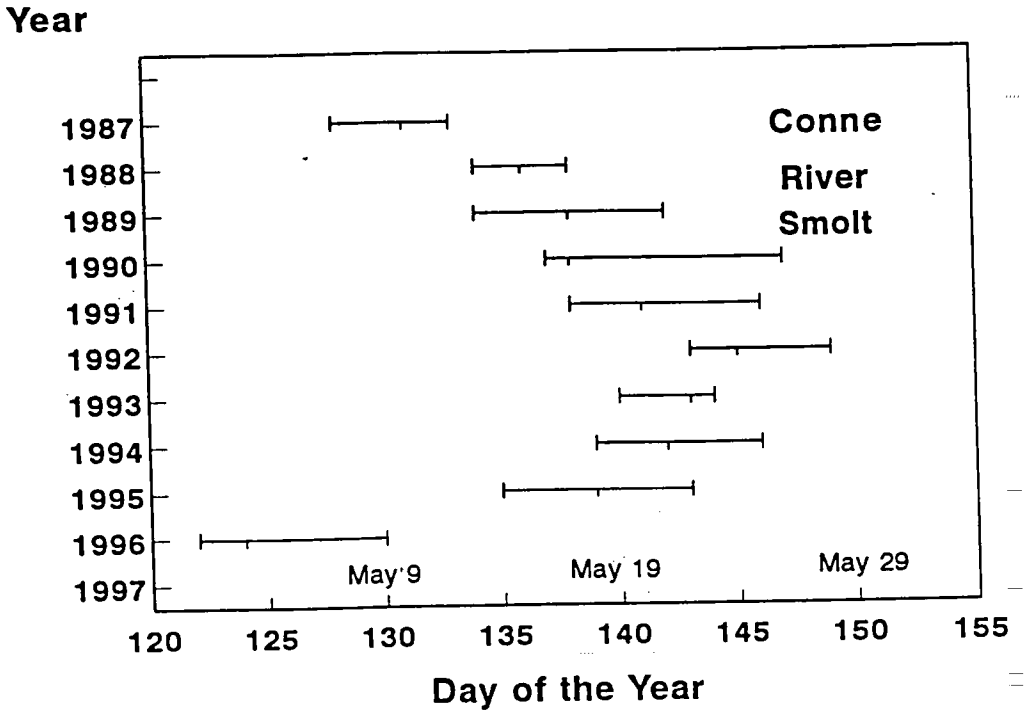


Figure 4. Length-frequency distribution of 1SW, 2SW, consecutive and alternate spawners, all years (1986-1996) combined, at Conne River, Newfoundland.



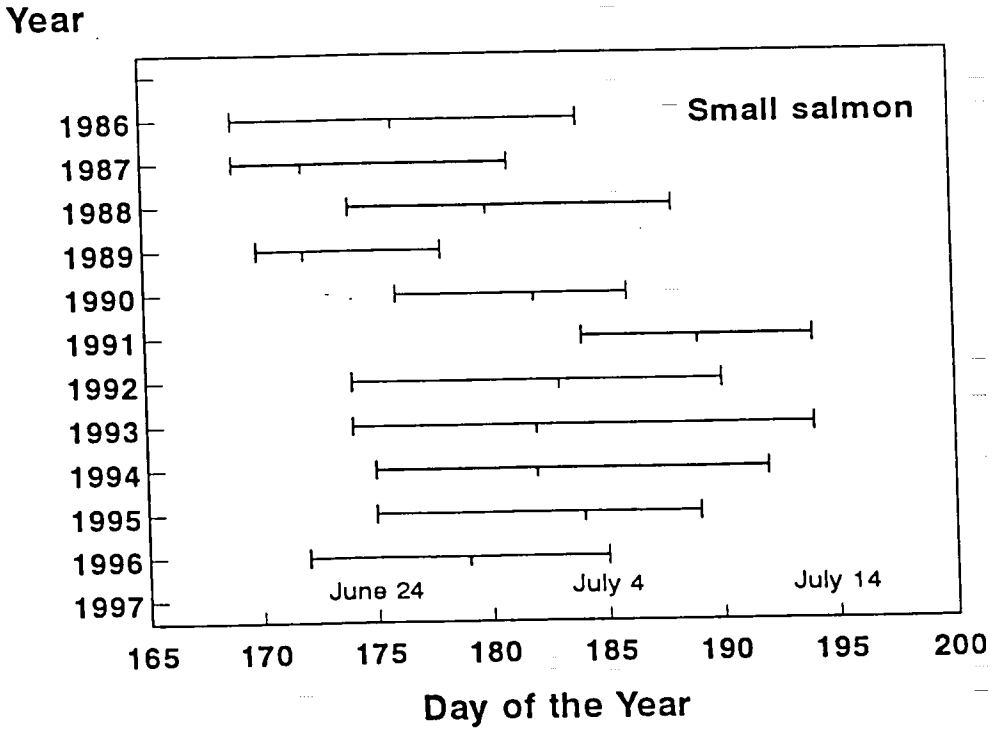
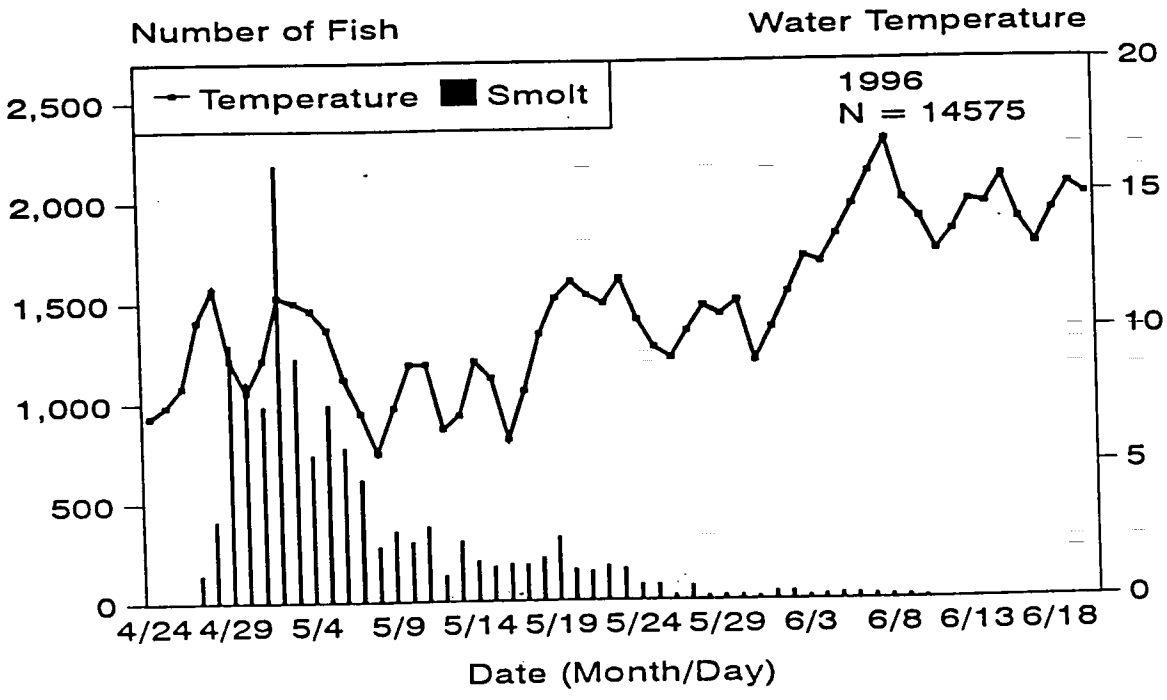


Fig. 5. Run timing of smolt and adult small salmon at Conne River, Newfoundland. The median (50th) date, along with the 25th and 75th percentiles of the run are illustrated.



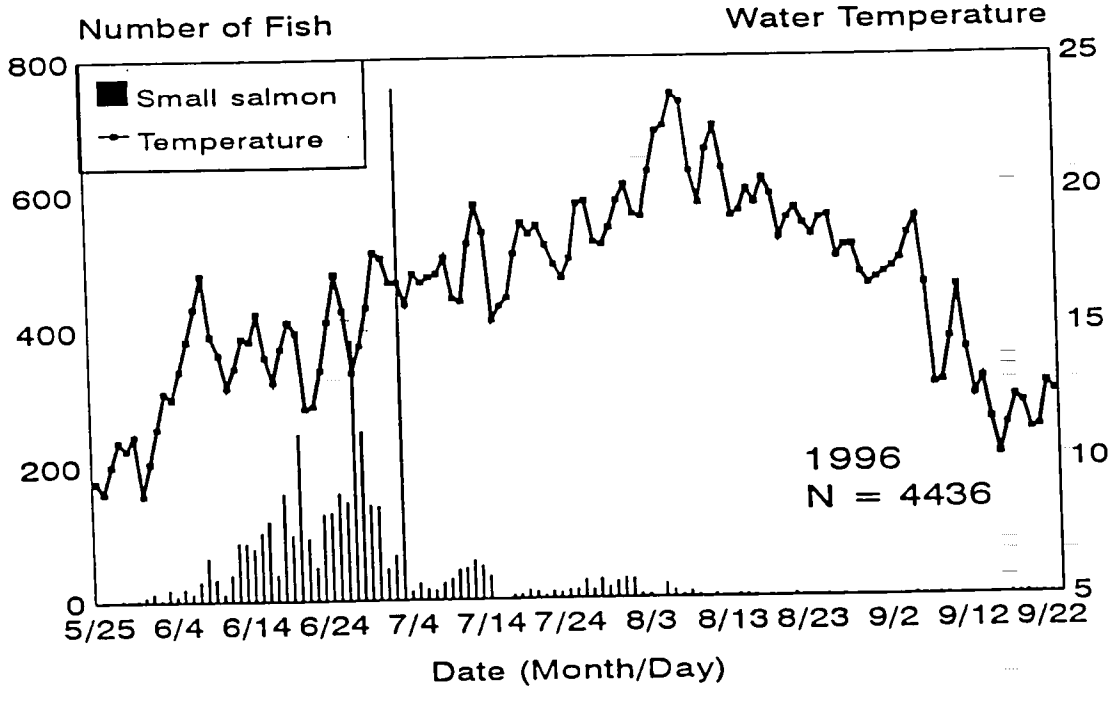


Fig. 6. Daily count of Atlantic salmon smolt at the downstream partial fish counting fence trap (upper panel) and number of adult small salmon returning to the to the river (lower panel). Mean daily river water temperatures are indicated on both graphs.

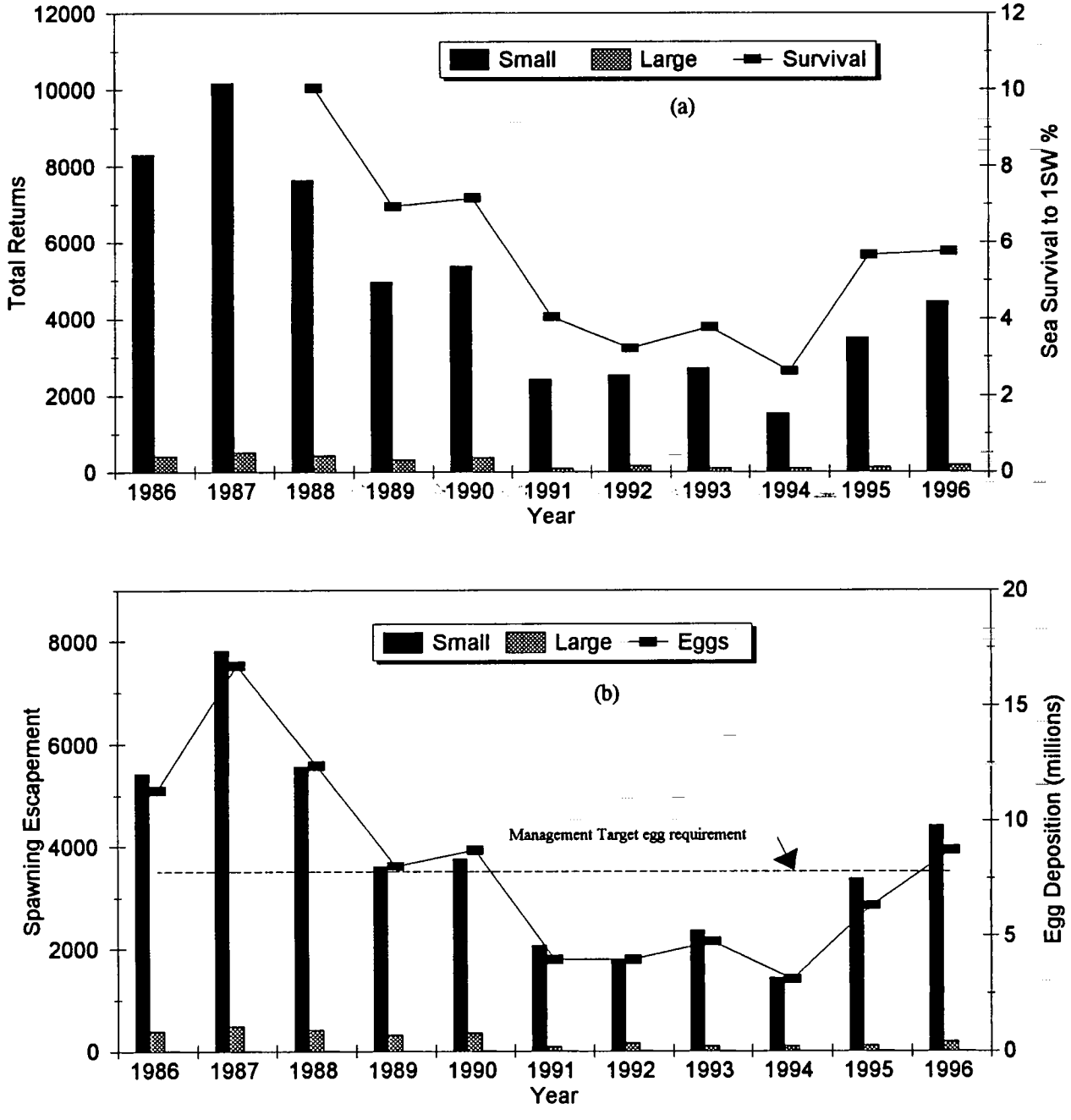


Figure 7. Total returns of small and large Atlantic salmon to Conne River, Newfoundland along with estimated sea survival from smolts to 1SW salmon (a). Survival estimates correspond to the year of adult return. Lower panel (b) illustrates the trend in spawning escapments and estimated egg deposition. The dashed horizontal line represents the current Management Target egg requirement.

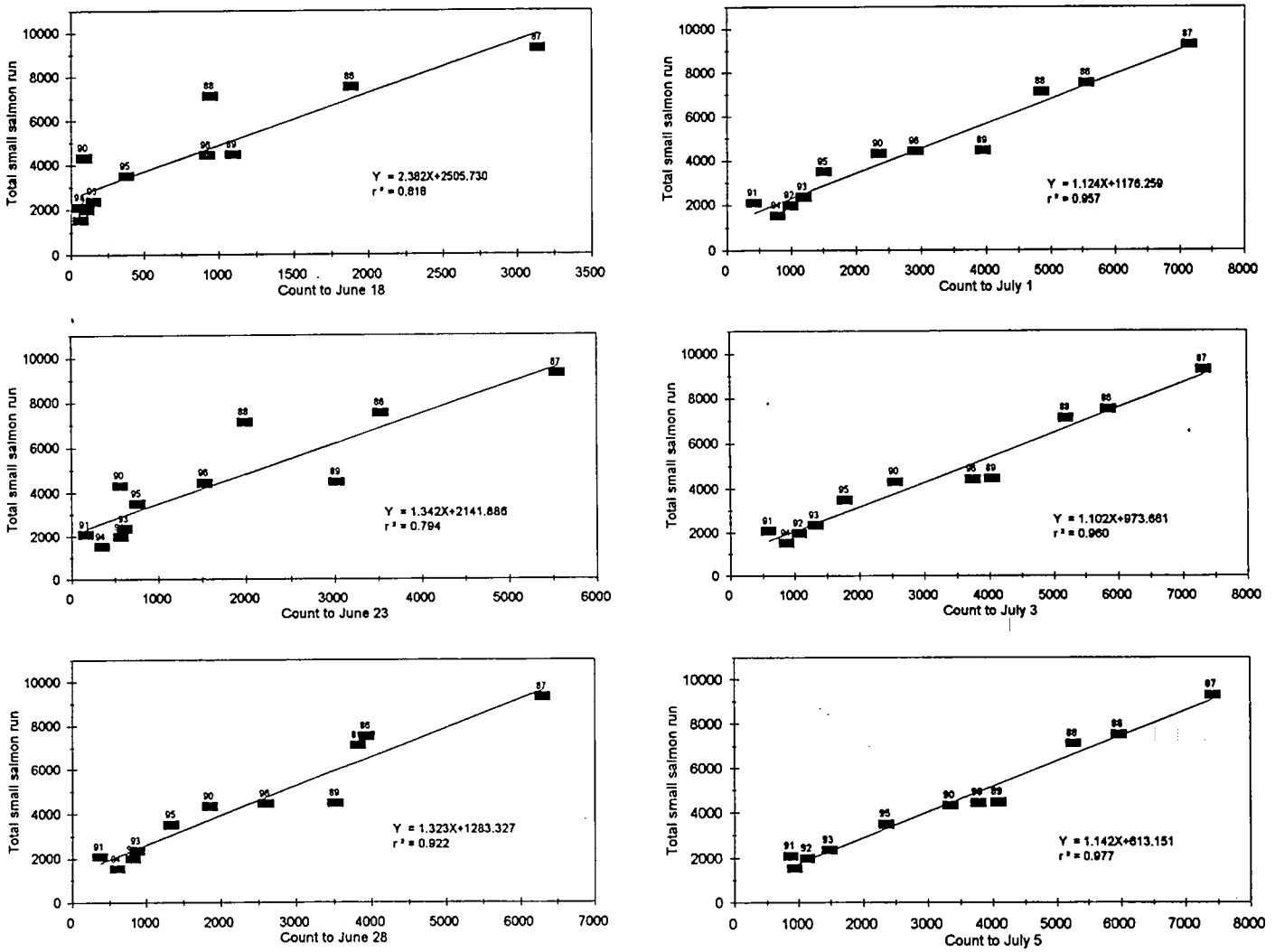


Figure 8. Regressions of cumulative counts of small salmon to various dates with corresponding total counts of small salmon for the year, Conne River, Newfoundland, 1986-1996.

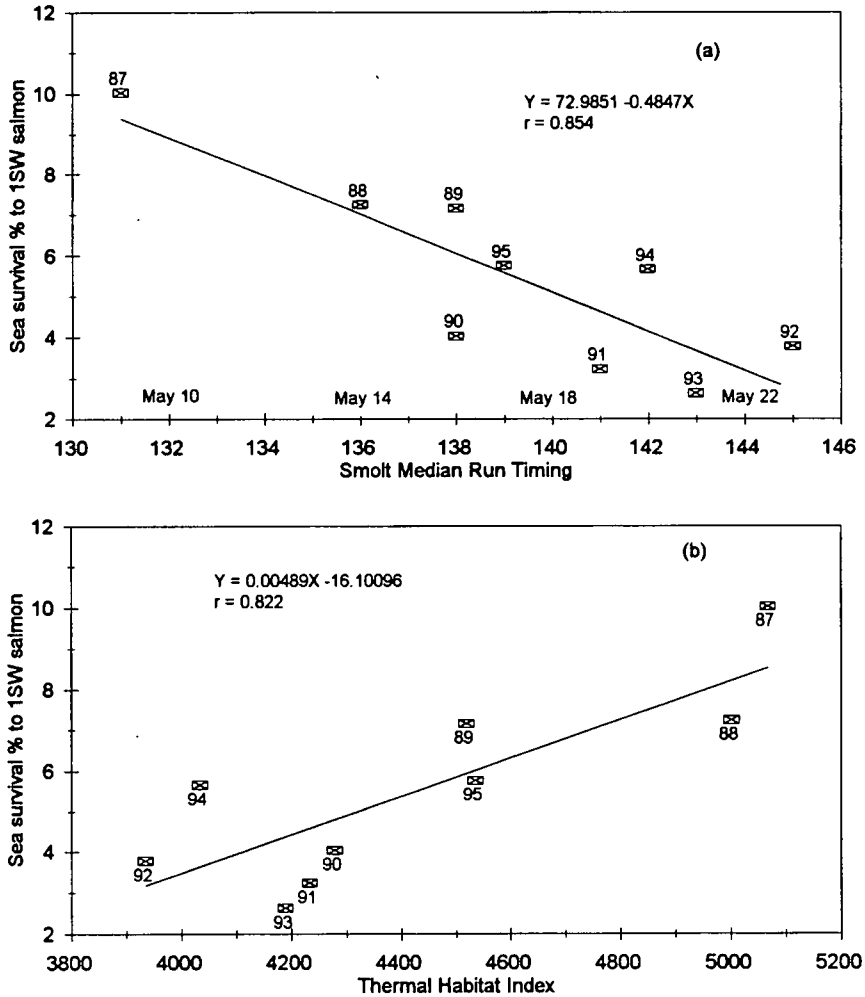


Figure 9. Relationships between (a) median timing of the Conne River smolt run in year i with surival to 1SW salmon in year i+1; and (b) index of marine thermal habitat in year i (January - March) with sea survival to 1SW salmon returning in the same year. Years shown represent the smolt year class.

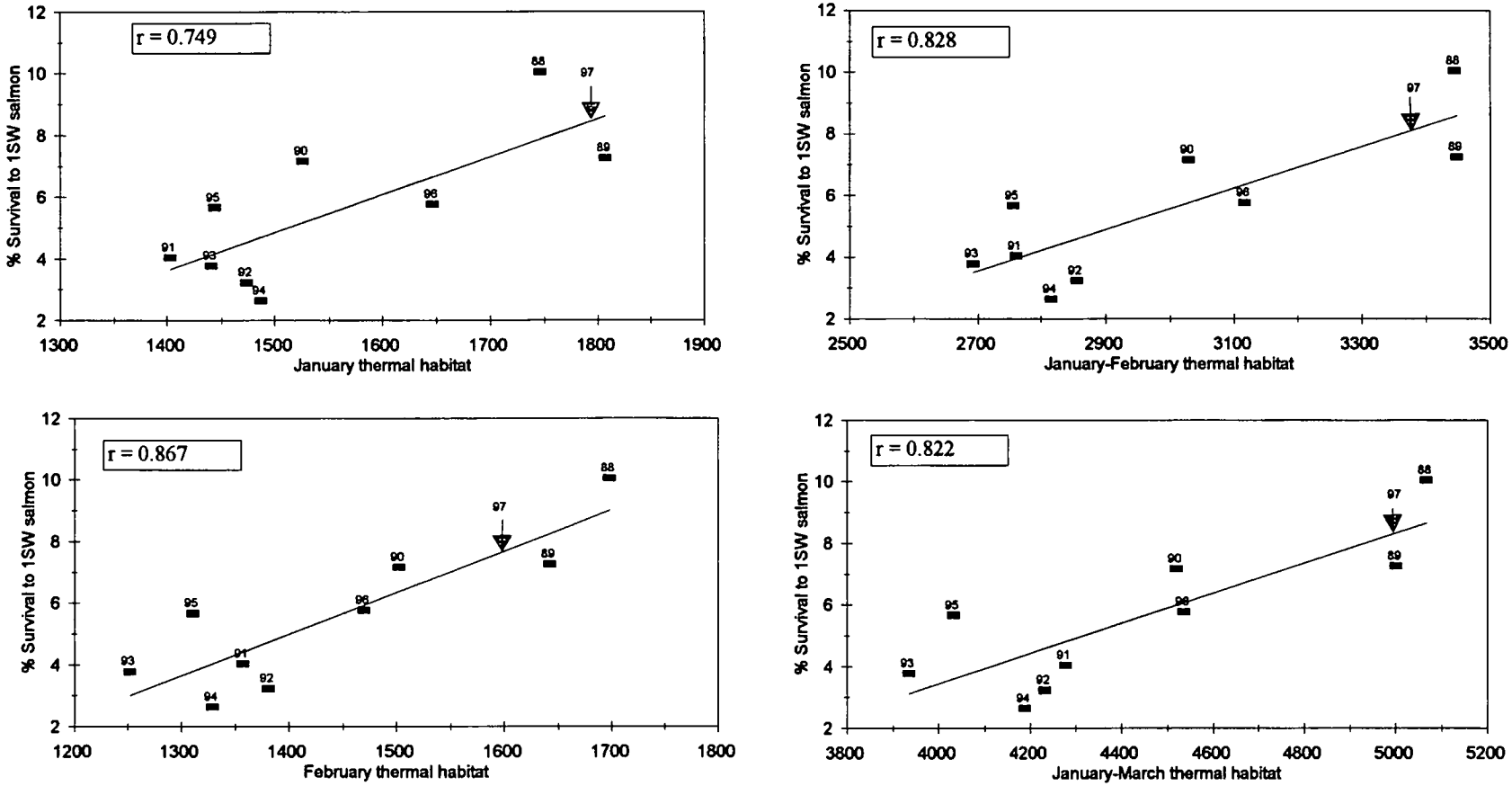


Figure 10. Relationships between sea survival to 1SW salmon and various monthly or grouped monthly indices of marine thermal habitat. Arrows indicate predicted survivals based on corresponding 1997 thermal habitat values. Year labels refer to year of 1SW adult salmon returns.

STOCK: Conne River (SFA 11) **Drainage area:** 602 km^2

MANAGEMENT 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	1991	1992	1993	1994	1995	1996	MIN[1]	MAX[1]	Mean[1]
Total Returns:									
Small	2411	2523	2703	1533	3502	4440	2411	10155	6472
Large	89	159	100	100	110	179	89	516	355
First Peoples' harvest									
Small	281	483	417	0	0	0	18	948	459
Large	3	5	3	0	0	0	0	11	3
Recreational harvest									
Small (retained)	108	329	0	0	0	0	0	3302	1824
Large (retained)	0	0	0	0	0	0	0	-	-
Small (released)	-	-	-	-	-	-	-	-	-
Large (released)	-	-	-	-	-	-	-	-	-
Other Mortalities including broodstock removal									
Small	7	8	3	98	126	38	-	-	-
Large	0	2	2	1	2	0	-	-	-
Spawners:[2]									
Small	2062	1783	2353	1435	3376	4402	2062	7823	4709
Large	87	153	97	99	108	179	87	488	345
Management Target - % eggs met:	51%	51%	61%	40%	81%	112%	51%	214%	131%
Smolt count[3]	74645	68208	55765	60762	62749	94088	55765	94088	68716
Sea Survival[4]	3.4%	4.0%	2.7%	5.8%	7.2%	-	2.7%	10.2%	5.8%

[1] Min, max and mean recreational harvest calculated for period 1974-91; other mean data for 1986-91 to coincide with the pre-moratorium period. Angling harvests are DFO statistics. First Peoples harvest in salt water includes some salmon from other rivers. First Peoples fishery quota of 1200 fish has been in effect since 1986, but reduced to 500 fish for 1993. First Peoples fishery closed in 1994 and 1995.

[2] Hook and release mortality is 10% of released salmon

[3] Min., max. and mean for the period 1987 to 1996.

[4] Sea survival of smolt to small salmon returns. Min. and max. are for 1987 to 1995 smolt migrations.

Data and methodology: Smolts estimates are derived from mark-recapture surveys. Returning adult salmon are enumerated at a fish counting fence. A video camera system was introduced in 1993.

State of the stock: The Management Target requirement was met from 1986-90 and again in 1996. Only 40-61% of the target was achieved from 1991-1994 but rose to 81% in 1995. Sea survival increased to the highest value in six years (7.2%). An enhancement project was initiated in 1994 with approximately 128 thousand fry released in 1995. Note that these fry have not been included in terms of the percentage target achieved in the above table.

Forecast: Estimated smolt output in 1996 was the highest on recored: 94,088 (79,867-108,309). Given the high smolt run, a survival of only 4.25% should result in 4000 adult salmon returns in 1997. With survival in 1997 similar to that for 1SW salmon in the previous year, then returns should easily exceed 4000 fish and could approach 5400 1SW salmon. In addition, other relationships between (a) median timing of the smolt run and sea survival, and (B) an index of marine thermal habitat and sea survival, both suggest high returns in 1997. In-season monitoring should be used to update managers on changing conditions as the 1997 run progresses. Over 130 thousand Saint John River origin salmon reportedly escaped in February, 1996, from an aquaculture sea cage in Bay d'Espoir. Some of these fish could begin to return to local rivers, including Conne River, as 1SW salmon in 1997.