Department of Fisheries and Oceans
Canadian Stock Assessment Secretariat
Research Document 97/40

Not to be cited without
permission of the authors[1]

Ministère des pêches et océans
Secrétariat canadien pour l'évaluation des stocks
Document de recherche 97/40
Ne pas citer sans
autorisation des auteurs[1]

Status of Atlantic Salmon (*Salmo salar* L.) in Middle Brook and Terra Nova River (SFA 5), Biscay Bay River (SFA 9), and Northeast River, Placentia (SFA 10), Newfoundland, in 1996

by

M. F. O'Connell and D. G. Reddin
Science Branch
Department of Fisheries and Oceans
P.O. Box 5667
St. John's, Newfoundland A1C 5X1

Abstract

The status of Atlantic salmon stocks was determined for Middle Brook and Terra Nova River in Salmon Fishing Area (SFA) 5, Biscay Bay River in SFA 9, and Northeast River in SFA 10 in 1996. Assessments were also conducted in relation to the commercial salmon fishery moratorium which entered its fifth year in 1996. Conservation egg requirement was achieved in all five years of the moratorium for Middle Brook and Northeast River and in three out of five years for Biscay Bay River (which included 1996). Although conservation requirement has never been achieved in Terra Nova River, egg depositions during the moratorium tended to be higher than prior to the moratorium. However, it should be noted that accessible rearing habitat above the lower Terra Nova River fishway more than doubled with the opening of the area above Mollyguajeck Falls in the early 1990s. There were significant increases in returns of small and large salmon and proportions of large salmon in moratorium years (1992-96) over pre-moratorium years (1984-91) for all rivers except Biscay Bay River. Contrary to expectations, proportions of repeat spawning grilse in the small salmon category decreased significantly in Terra Nova River and Biscay Bay River and also decreased in Middle Brook, but not significantly; however the proportion for Northeast River did increase, but not significantly. Weights and lengths of small salmon observed during the moratorium were significantly higher than recorded prior to the moratorium for all rivers. Condition index increased significantly over that of the pre-moratorium period for Biscay Bay River and Northeast River while the reverse was true for Terra Nova River; there was no significant difference for Middle Brook. Compared to the late 1970s and early 1980s, estimated total population sizes of small salmon for Middle Brook and Biscay Bay River have been quite low. It is anticipated that returns of small salmon for Middle Brook and Biscay Bay River in 1997 will exceed conservation requirement.

Résumé

En 1996, on a établi l'état des stocks de saumon de l'Atlantique dans la zone de pêche du saumon (ZPS) 5 pour les rivières Middle Brook et Terra Nova, la ZPS 9 pour la rivière Biscay Bay et la ZPS 10 pour la rivière Northeast. De plus, des évaluations ont été faites relativement au moratoire de la pêche commerciale du saumon qui en était à sa cinquième année en 1996. On a réussi à répondre aux besoins en matière d'oeufs de conservation pendant chacune des cinq années du moratoire dans les rivières Middle Brook et Northeast et pendant trois des cinq années dans la rivière Biscay Bay (y compris l'année 1996). Bien que les besoins en matière de conservation n'aient jamais été comblés dans la rivière Terra Nova, la ponte a eu tendance à être plus élevée pendant le moratoire qu'avant. Il faudrait cependant noter que la zone d'élevage accessible en amont de la passe migratoire située dans la basse partie de la rivière Terra Nova a plus que doublé avec l'ouverture de la zone au-dessus des chutes Mollyguajeck au début des années 1990. Si l'on compare les données des années du moratoire (1992-1996) à celles des années qui l'ont précédé (1984-1991), il y a eu des augmentations subtantielles des remontées de petits et gros saumons et des proportions de gros saumons dans toutes les rivières, sauf dans la rivière Biscay Bay. Contrairement à ce à quoi on pouvait s'attendre, les proportions de petits saumons ayant déjà frayé ont diminué considérablement dans la rivière Terra Nova et la rivière Biscay Bay. Elles ont diminué également dans la rivière Middle Brook, mais de façon moins substantielle. Cependant, cette proportion a augmenté dans la rivière Northeast, mais pas de façon significative. Le poids et la longueur des petits saumons observés pendant le moratoire étaient considérablement plus élevés que les données de poids et de longueur consignées avant le moratoire, et ce, dans toutes les rivières. L'indice des conditions a augmenté considérablement par rapport à la période antérieure au moratoire pour les rivières Biscay Bay et Northeast alors que ce fut le contraire dans la rivière Terra Nova. Il n'y a eu aucune différence significative dans la rivière Middle Brook. Si l'on compare les données actuelles à celles de la fin des années 1970 et du début des années 1980, les tailles de l'ensemble de la population de petits saumons prévues pour les rivières Middle Brook et Biscay Bay ont été très faibles. On prévoit que les remontées de petits saumons dans les rivières Middle Brook et Biscay Bay en 1997 dépasseront les besoins en géniteurs pour assurer la conservation.

Introduction

In this paper, we examine the status of Atlantic salmon in Middle Brook and Terra Nova River, Bonavista Bay (SFA 5), Biscay Bay River, St. Mary's Bay (SFA 9), and Northeast River, Placentia Bay (SFA 10) in 1996, the fifth year of the commercial salmon fishery moratorium. The location of each river is shown in Fig. 1. Anticipated impacts of the moratorium on the Atlantic salmon populations in these rivers include: increases in the numbers of small and large salmon returning to the rivers and in the percentage of conservation requirement achieved; increases in the proportion of large salmon; changes in biological characteristics, e.g., increases in weight, length, and condition. These aspects are compared for two time periods, moratorium (1992-96) and pre-moratorium (1984-91). The pre-moratorium period selected corresponds to the years of a major management plan introduced in 1984 (O'Connell *et al.* 1992a; May 1993; Mullins and Caines MS 1994), which was modified in 1990 and 1991 to include a commercial fishery quota in each SFA (O'Connell *et al.* MS 1992b). Elements of this management regime continued into the moratorium years. All the above measures were aimed at increasing river escapements. Also, a moratorium on the Northern Cod Fishery was implemented in early July of 1992, which should have resulted in the elimination of by-catch in cod fishing gear in SFAs 1-9. A moratorium on cod fishing in SFAs 10-14A went into effect in August 1993. These moratoria continued in 1996.

Counts of small and large salmon are used in conjunction with recreational fishery data and biological characteristics data to calculate total river returns and egg depositions. Stock status is evaluated relative to conservation egg requirements developed for all rivers. An analysis of trends in the numbers of small salmon recruits and spawners for 1974-96 is provided for Middle Brook and Biscay Bay River as well as anticipated adult returns in 1997.

Management Measures Since 1992

The introduction of the five-year moratorium on the commercial fishery in insular Newfoundland in1992 was a major change in the management of Atlantic salmon. The moratorium was coupled with a commercial license retirement program. A quota on the number of fish that could be retained in the recreational fishery was introduced in each SFA in 1992 and 1993. The quota was assigned for each SFA as a whole and not administered on an individual river basis. Only hook-and-release fishing was permitted after the quota was caught.

Recreational fishery quotas were eliminated in 1994. In place of quotas, for insular Newfoundland, the season bag limit for retained small salmon was lowered from eight to six fish, three to be caught prior to July 31 and three after that date. Hook-and-release fishing only was permitted after the bag limit of three was reached in each time period. These measures remained in effect in 1995 and 1996. As in previous years, retention of large salmon was not permitted in insular Newfoundland.

Atlantic Salmon Enhancement - Terra Nova River

Terra Nova River has undergone Atlantic salmon enhancement programs since the early 1950s. A fishway was built around impassable falls located approximatley 22 km from the mouth of the river in 1952 (Porter *et al.* 1974). This structure (upper fishway) provided access for anadromous Atlantic salmon upstream as far as the complete obstruction at Mollyguajeck Falls. Colonization of the newly accessible area depended on adults straying from below the fishway. A fishway (lower) was built around falls located approximately 8 km from the mouth of the river in 1954 in order to facilitate the upstream movement of adults. Anadromous Atlantic salmon were introduced into the area above Mollyguajeck Falls in 1985-89. Adults were collected from the upper fishway and transferred above the falls by helicopter. In order to allow the progeny of these transferred fish to access their natal areas, passage through Mollyguajeck Falls was made possible by blasting pools in the river bed. A swim-up fry stocking program utilizing broodstock from the upper fishway was initiated above Mollyguajeck Falls in 1994 and continued in 1996.

The falls in Middle Brook and Northeast River were not complete obstructions and only impeded adult migration during low water conditions. The fishways for these rivers were installed to ease passage during low flows, similar to the situation for the lower Terra Nova River fishway.

Methods

Recreational catch and effort information and counts of adult salmon in 1996 were compared to two pre-salmon moratorium means (1984-89 and 1986-91) and to the 1992-95 mean during the moratorium. The 1984-89 mean corresponds to years under the major management changes in the commercial fishery in the Newfoundland Region, cited above. The 1986-91 mean incorporates the quota years of 1990 and 1991. The mix of management measures in effect during 1984-89 on the one hand and the imposition of commercial quotas in 1990 and 1991 on the other, should be kept in mind when making evaluations based on the 1986-91 mean.

ADULT SALMON COUNTING EQUIPMENT

Adult salmon were counted in traps installed in the fishways located in Middle Brook, lower Terra Nova River, and Northeast River. In Biscay Bay River, counts were obtained with the salmonid Silhouette Imaging and Counting System (Pippy *et al.* 1997) using both the semi-automatic (video tape recording system) and fully automatic (computer-based system) methods.

RECREATIONAL FISHERY DATA

Catch and effort data for each river were collected by Department of Fisheries and Oceans (DFO) Officers and processed by DFO Science Branch staff. Data for Maccles Brook were included in the totals for Terra Nova River. Rivers with counting facilities have angling catches separated above and below the counting facilities. Procedures for the collection and compilation of recreational fishery data are described by Ash and O'Connell (1987). Angling data for 1987 were not included in the means because in that year the rivers were closed to angling for nearly the entire season due to drought conditions.

BIOLOGICAL CHARACTERISTICS

Biological characteristics information (obtained by sampling recreational catches) used to calculate egg depositions and for the comparison of biological characteristics during and prior to the moratorium for adults < 63 cm in length (small salmon) is shown in Tables 1-4. In instances where sample sizes were small (N < 20), the means of the various parameters for either the mortatorium period (1992-96) or the pre-moratorium period (1984-91) were used.

A mean weight of 3.13 kg and a proportion of female value of 0.77 (O'Connell *et al.* MS 1997a) was used for fish ≥ 63 cm in length (large salmon) for all years and all rivers.

Fecundity was determined from ovaries collected in the recreational fishery. Ovaries were stored in Gilson's fluid until ovarian tissue had broken down after which time eggs were transferred to 10% formalin. Eggs, which for the most part were in early stages of development, were counted directly. Relative fecundity values used for each river are shown in Table 5. In years when the sample size was small (N < 20), the mean fecundity for all years combined for a given river was used. The same relative fecundity was used for both small and large salmon.

TOTAL RIVER RETURNS, SPAWNING ESCAPEMENT, AND EGG DEPOSITION

Calculations were performed for small and large salmon separately. Total egg deposition was obtained by summing depositions for grilse and large salmon.

Total River Returns

Total river returns (TRR) were calculated as follows:

$$TRR = RC_b + C + HRM_b \qquad (1)$$

where,

RC_b = recreational catch below counting facility
C = count of fish at counting facility
HRM_b = hook-and-release mortalities (10% of hook-and-release fish) below counting facility in 1993-96

For Terra Nova River, recreational catch below the fishway did not include that of Maccles Brook. Partial counts of small and large salmon for Biscay Bay River were adjusted to total counts. For each each year in question, fish by-passed the counting fence for an approximate 24 hour period. The average count for 3-5 days immediately prior to flood conditions each year was used to fill in missing data.

Spawning Escapement

Spawning escapement (SE) was calculated according to the formula:

$$SE = FR - RC_a - BR - HRM_a \quad (2)$$

where,

FR = fish released at counting facility
RC_a = recreational catch above counting facility
BR = broodstock removal (Terra Nova River in 1994-96; Biscay Bay River in 1985-90)
HRM_a = hook-and-release mortalities (10% of hook-and-release fish) above counting facility in 1993-96

A number of mortalities of small salmon occurred in Northeast River (49) and Middle Brook (16) subsequent to being counted in 1996 which were deducted from FR in equation 2. These mortalities resulted from unusually high flood conditions in Northeast River and from modifications to the trap configuration in Middle Brook.

Egg Deposition

Egg deposition (ED) was calculated as follows:

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

where,

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

For Terra Nova River, spawning escapements and egg depositions were calculated for the area above the lower fishway, including the area above Mollyguajeck Falls.

The phenomenon of atresia occurs in Atlantic salmon in insular Newfoundland (O'Connell and Dempson MS 1997). Since egg deposition calculations above were based on eggs in early stages of development, they should be regarded as potential egg depositions.

CONSERVATION EGG DEPOSITION AND SPAWNER REQUIREMENTS

The conservation egg deposition and spawner requirements for each river were developed by O'Connell and Dempson (MS 1991a,b) (Table 6). The egg requirement for fluvial parr rearing habitat (Elson 1957) for all rivers was 240 eggs/100 m^2 (Elson 1975); the requirement for lacustrine habitat was 368 eggs/ha (O'Connell and Dempson 1995). The adult conservation requirement for each river was calculated in terms of small salmon only. Egg deposition from large salmon was considered as a buffer.

NUMBER OF RECRUITS AND SPAWNERS, 1974-96, AND ANTICIPATED RETURNS IN 1997

It is possible to retrospectively estimate total population size of small salmon (or total number of small salmon recruits), prior to any exploitation, for several year classes in some rivers with counting facilities, and to use the ratio of recruits to spawners to estimate anticipated returns one year in advance. A calculation of anticipated total returns (small plus large salmon) is also possible. Details of the calculations are presented below and were used for the Middle Brook and Biscay Bay River stocks.

Since the implementation of the commercial fishery moratorium in 1992, the total number of small salmon recruits (TNR) for Middle Brook and Biscay Bay River were equivalent to TRR (equation 1). Prior to 1992, TNR was calculated using a commercial fishery exploitation rate (μ_c) of 0.60 (Anon. MS 1990) according to the equation:

$$TNR = TRR/(1 - \mu_c) \qquad (4)$$

For the period 1974-83, TRR for Biscay Bay River was calculated as the ratio of total recreational catch (RC_t) and the average recreational fishery exploitation rate (μ_r) for the years 1989-91 (prior to recreational quotas) of 0.14, or

$$TRR = RC_t/\mu_r \qquad (5)$$

For the years 1974-83, TRR for Middle Brook was determined by applying the average proportion of total recreational catch below the fishway ($P\_RC_b = 0.74$) for 1984-91 to total recreational catch and counts of small salmon according to the equation

$$TRR = (RC_t \times P\_RC_b) + C \qquad (6)$$

Spawning escapement for Middle Brook for 1974-83 was calculated using the average proportion of total recreational catch above the fishway ($P\_RC_a = 0.26$) for 1984-91 in the relationship

$$SE = C - (RC_t \times P\_RC_a) \text{ or } TRR - RC_t \qquad (7)$$

Age composition of Middle Brook and Biscay Bay River smolts was adjusted to reflect only the 3+ and 4+ age groups, i.e., the minimal numbers of 2+ and 5+ year old smolts present were not considered; the resultant proportions of 3+ and 4+ smolts were 0.5 and 0.5 for Middle Brook, and 0.74 and 0.26 for Biscay Bay River. The ratio of recruits to spawners (R/S) was calculated incorporating smolt age composition of small salmon according to the equation

$$R/S = [(TNR_{i+5} \times P\_3+) + (TNR_{i+6} \times P\_4+)]/SE_i \qquad (8)$$

where,

TNR_{i+5} and TNR_{i+6} = small salmon recruits in years i+5 and i+6
SE_i = spawning escapement (small salmon) in year i
P_3+ and P_4+ = proportion of 3+ and 4+ smolts, respectively

Anticipated returns of small salmon (AR_s) in 1997 was calculated as the product of the average R/S and SE for each smolt-age grouping separately and then summed. The average R/S for 1993-96 was used for both the 3+ and 4+ smolt-age groups for Middle Brook and Biscay Bay River. The equation was as follows:

$$AR_s = (R/S\_3+_i \times SE_{i-5}) + (R/S\_4+_i \times SE_{1-6}) \qquad (9)$$

where,

R/S_3+_i and R/S_4+_i = small salmon recruits per spawner with smolt ages 3+ and 4+ in 1997 (year i)
SE_{i-5} and SE_{i-6} = spawning escapement (small salmon) in years i-5 and i-6

A similar calculation was performed with the minimum and maximum R/S corresponding to the mean for each smolt-age grouping to obtain an estimate of the range of anticipated returns.

Anticipated total returns (AR_t), or the sum of small and large salmon, was determined as follows:

$$AR_t = AR_s/P\_AR_s \qquad (10)$$

where,

P_AR_s = mean proportion of small salmon in escapements for 1993-96

A measure of the precision of estimates of anticipated returns of small salmon for 1995 (O'Connell *et al.* MS 1995) and 1996 (O'Connell *et al.* MS 1996) was obtained by comparison to actual returns for 1995 and 1996.

ANALYSIS TO DETECT RECRUITMENT OVERFISHING

Anon. (MS 1994) defined recruitment overfishing as a level of fishing mortality that reduces the ability of a population to persist, more specifically, the failure of a cohort of spawners to replace itself as a result of fishing. One way to evaluate Atlantic salmon stocks in terms of recruitment overfishing is through the examination of spawner-to-spawner relationships. Estimated numbers of spawners obtained from parental spawning cohorts of small salmon were traced backward, beginning with the estimate of the number of spawners for the current year. Data sets (Middle Brook and Biscay Bay River) were examined to see if numbers of spawners, which were made up of a range of chronological ages, were sufficient to replace the weighted sum of spawning parents of the same sea age. The appropriate weighting for historical spawners was determined from the average smolt-age distribution. This technique, demonstrating the use of the necessary lags and river-age distributions, is found in Anon. (MS 1994).

IMPACTS OF THE MORATORIUM

Total returns of small and large salmon, proportion of large salmon, proportion of repeat spawning grilse in the small salmon category, and weight and length of small salmon (sexes combined plus unsexed fish) for the moratorium period 1992-96 were compared to that of the the pre-moratorium period 1984-91 using the Wilcoxon two-sample test (Z) in the NPAR1WAY Procedure of SAS (SAS Institute 1985).

Adjusted mean weight standardized to length as a covariate (both variables ln transformed) was used as a measure of condition following the general linear model approach outlined in Dempson *et al.* (1994) and Winters and Wheeler (1994). An analysis was first run for each river comparing slopes of individual regressions between pre-moratorium and moratorium periods. If slopes were not significantly different, the analysis was run with a common slope model and adjusted means standardized to the overall mean length. In the event a significant difference was found between slopes, the model was run with a common slope and the r^2 and residual error mean square thus obtained compared with that of the multiple slope model. If the change in these parameters was negligible, then the common slope model was run as above (Dempson *et al.* MS 1994; Winters and Wheeler 1994). Analyses were carried out using the GLM Procedure of SAS (SAS Institute 1985).

Results

RECREATIONAL FISHERY

Catch and effort data for each river are presented in Appendices 1-4. Catches for all years prior to 1992 represent retained catch for the entire angling season. Total catch for 1996 (retained plus released fish), effort, and catch per unit of effort (CPUE) are compared to years prior to 1992 and 1992-95. There was no estimate of released fish during the period of retention of catch in 1992 which could impact on comparisons. The total number of fish retained in 1996 is also shown.

Calculation of CPUE in terms of retained fish only was not possible since effort figures apply to both retained and released fish collectively.

The objective of implementing SFA quotas on the retention of small salmon in the recreational fishery was to constrain catches to levels observed just prior to the moratorium, with the intent of not reallocating catch from the commercial fishery to the recreational fishery. This was also the objective of the split seasonal bag limit (three fish prior to and after July 31) since historically the major proportion of total seasonal catch has been taken prior to July 31. The objective was met more or less for Middle Brook (Appendix 1) but for Terra Nova River, retained catch in 1994-96 nearly doubled that of 1992 and 1993 (Appendix 2). Biscay Bay River (Appendix 3) was closed to angling during peak periods in July in both 1994 and 1995 as a result of high water temperatures and low water levels. In spite of this, the catch for 1995 was substantially higher than in 1992 and 1993 and was the fourth highest on record; the catch in 1996 decreased from that of 1995. It should be noted that the quota for retained fish for SFA 9, which includes Biscay Bay River, was not caught in 1993. Northeast River (Appendix 4) was also closed to angling during peak periods in July in both 1994 and 1995 due to low water levels and high water temperatures; the number of small salmon retained in 1996 was by far the highest in recent years and the second highest on record.

COUNTS AT COUNTING FACILITIES

Counts of small and large salmon at the Middle Brook and lower Terra Nova River fishways for the period 1974-96 are shown in Table 7 and Fig. 2. The count of small salmon at the Middle Brook fishway in 1996 increased over 1995 (54%) and the 1984-89 (91%), 1986-91 (132%), and 1992-95 (21%) means. The count of small salmon for Terra Nova River in 1996 decreased from that of 1995 (11%), which was the second highest on record, exceeded the 1984-89 (56%) and 1986-91 (74%) means, and was similar to the 1992-95 mean. The count of large salmon for Middle Brook in 1996 decreased slightly (4%) from that of the record high in 1995 and remained substantially over the 1984-89, 1986-91, and 1992-95 means (540, 928, and 66%, respectively). The Terra Nova River count of large salmon in 1996 decreased (27%) from the record high in 1995 but remained above the means (265, 247, and 15%, respectively). As a result of a combination of the loss of the flow control dam above the lower Terra Nova River fishway and exceptionally high water levels in 1993, some fish bypassed the fishway and hence counts of small and large salmon for that year are partial. However, even the partial counts were the highest on record (highest up to that point for large salmon), and for this reason they were included in the mean for 1992-95.

Counts of small and large salmon for the Biscay Bay River counting fence and the Northeast River fishway are presented in Table 8 and Fig. 3. The count of small salmon in Biscay Bay River in 1996 increased over 1995 (10%) but decreased from the means (33, 16, and 9%, respectively). The 1996 count of small salmon for Northeast River was the highest on record and increased substantially over 1995 and the means (85, 137, 129, and 58%, respectively). The count of large salmon for Biscay Bay River in 1996 was the highest recorded, increasing markedly over 1995 and the means (166, 85, 86, and 102%, respectively). The count of large salmon in 1996 for Northeast

River was also the highest on record (increases of 66, 490, 547, and 93%, respectively over 1995 and the means).

RUN TIMING

Figs. 4-7 show the daily cumulative percentage of small salmon counted each year during 1985-96 for each river. The days are standardized for all years and the date on which the first fish was counted is denoted by an arrow. The latest median count observed for Middle Brook (Fig. 4) occurred in 1991 followed very closely by 1992 and 1993. The median date for 1996 was the earliest in recent years, just a few days ahead of 1995. Other early years included 1987 and 1989. The latest median date for Terra Nova River (Fig. 5) occurred in 1991 followed closely by 1993 and 1985. The earliest median date occurred in 1987; 1995 and 1996 were the earliest in recent years. The latest median date for Biscay Bay River (Fig. 6) by far occurred in 1991. There were several median dates comparable to 1996 in the past; the earliest was in 1989. Median dates for Northeast River (Fig. 7) in 1985 and 1991 were similar and the latest. Run timing comparable to 1996 occurred during several years in the past for this river; the earliest median date was in 1989.

TOTAL RIVER RETURNS, SPAWNING ESCAPEMENT, AND PERCENTAGE OF CONSERVATION REQUIREMENT ACHIEVED

Total river returns, spawning escapements, potential egg depositions, and percentage of conservation egg requirement achieved for Middle Brook and Terra Nova River are shown in Table 9. The percentage of conservation egg requirement achieved for 1984-96 is also shown in Fig. 8. Conservation requirement was achieved in all moratorium years in Middle Brook but in only one year (1984) prior to the moratorium. The percentages of conservation requirement met during the moratorium years for Terra Nova River were generally higher than during pre-moratorium years, with record highs being recorded during the moratorium. Biscay Bay River (Table 10 and Fig. 8) achieved conservation requirement in three of the five moratorium years and came close in one year (1993); requirement was met in six out of eight pre-moratorim years. Conservation requirement was achieved in all years in Northeast River; percentages during the moratorium were consistently higher than prior to the moratorium (Table 10 and Fig. 8).

TRENDS IN TOTAL NUMBERS OF RECRUITS AND SPAWNERS

The estimated numbers of small salmon recruits and corresponding numbers of spawners for each year class for Middle Brook and Biscay Bay River are shown in Tables 11-12 and Figs. 9A and 10A. There was a lot of variability in recruitment from a given spawning for both rivers. The ratio of total number of small salmon recruits to spawners (R/S) in 1996 increased over that of 1995 in both rivers (Figs. 9B and 10B). In spite of the increase in 1996 for Biscay Bay River, there was a significant overall decline since 1980 ($r^2 = 0.68$; df = 15; $P < 0.01$). The trend for Middle Brook was not significant ($P > 0.05$). Expressing conservation requirement in terms of small salmon adults (horizontal line in Figs. 9C and 10C), it is evident that for Middle Brook the requirement was achieved in 1975, 1977-84, and during all moratorium years and for Biscay Bay River in 1979-88, 1990, and in 1992 and 1994 of the moratorium years. There has been a decline in numbers of small salmon recruits since 1981 for Middle Brook and 1980 for Biscay Bay River (Figs. 9D and 10D). The lowest recruitment for the entire time series for Middle Brook was in 1992 and for Biscay Bay River it was in 1991.

ANTICIPATED RETURNS IN 1997

The estimated number of small salmon recruits anticipated for 1997 for Middle Brook, based on the average R/S for each smolt-age grouping and assuming natural survival rates remain the same, is approximately 2690; corresponding low and high values are approximately 1770 and 3240 (Table 11 and Fig. 9D). Average anticipated returns are above the conservation requirement. The estimated return of 1648 small salmon for 1996 compares to an actual return of 2112. An idea of the precision of estimates of anticipated returns for small salmon recruits can be obtained by examining the differences between estimated and observed returns for 1995 and 1996 shown in Table 11. The variability described in Fig. 9A must be kept in mind with respect to estimates of anticipated returns. The anticipated number of small salmon recruits for Biscay Bay River in 1997 is around 1865 with corresponding low and high values of approximately 955 and 3410 (Table 12 and Fig. 10D). Anticipated returns of small salmon in 1997 are above conservation requirement (Fig. 10C), bearing in mind the variability shown in Fig. 10A. The estimated number of small salmon returns for 1996 was 711 compared to an actual return of 1217. The precision of estimated versus observed small salmon returns for 1995 and 1996 is shown in Table 12.

RECRUIT OVERFISHING

During the commercial fishery moratorium years 1992-96, numbers of spawners in Middle Brook were above the replacement (diagonal) line and the conservation requirement (horizontal) line (Fig. 11). The years 1985-91 were below both lines.

Spawners for Biscay Bay River 1992, 1994, and 1996 were on or above the replacement line but not 1993 and 1995 (Fig. 12). Moratorium years 1993 and 1995 were also below the conservation requirement (horizontal) line.

IMPACTS OF THE MORATORIUM

The results of statistical analysis on data presented in Tables 1-4, comparing the moratorium years with pre-moratorium years are summarized in Table 13. There were significant increases in all factors during the moratorium for Middle Brook; the porportion of repeat spawning grilse in the small salmon category decreased but not significantly ($P > 0.05$). There were significant increases in all factors for Terra Nova except for the proportion of repeat spawning grilse which showed a significant decline. There were no significant differences in returns of small and large salmon and proportion of large salmon for Biscay Bay River. However, there were significant increases in weight and length while the proportion of repeat spawning grilse decreased significantly. For Northeast River, there was an increase in all factors during the moratorium and significantly so except for the proportion of repeat spawning grilse.

Individual regressions of ln whole weight on ln fork length during and prior to the moratorium are presented in Table 14. There was no significant difference in slopes for Middle Brook (F = 1.64; P = 0.2009) and Biscay Bay River (F = 0.020; P = 0.6551). The common slope model showed there was no significant difference in adjusted means for Middle Brook but there was a significant increase during the moratorium over pre-moratorium years for Biscay Bay River (Table 15). Slopes were significantly different between the two time periods for Terra Nova River (F = 8.39; P = 0.0039) and Northeast River (F = 5.72; P = 0.0173). Differences in r^2 and residual (error) mean square between the multiple slopes model and the common slope model were < 1% for Terra Nova River and 1.3% for each parameter for Northeast River. Adjusted means from the common slope model were therefore used as an index of condition. There was a significant increase during the moratorium over pre-moratorium years for Northeast River while Terra Nova River showed the opposite (Table 15).

Discussion

In the present assessment, biological characteristics information was updated and applied on an individual year basis for each river to a larger extent than previously, when there was greater reliance on default values. Consequently, the percentage of conservation egg requirement achieved for each year since 1989 has changed from that reported in previous documents (see O'Connell *et al.* MS 1996). Also, for the first time, a factor of 10% for hook-and-release mortality was applied in the calculation of total river escapements and spawning escapements for the years 1993-96, the only years with sufficient information on numbers of released fish. The mortality rate of 10% was arbitrarily chosen. Brobbel *et al.* (1996) reported a mortality rate of 12% for bright Atlantic salmon angled to exhaustion under controlled conditions in the Miramichi River, New Brunswick. These mortalities occurred within 12 hours and mean water temperature during the angling period was 16 °C.

As anticipated, with the closure of the commercial salmon fishery, there were significant increases in the numbers of small and large salmon and proportions of large salmon entering Middle Brook, Terra Nova River, and Northeast River. Contrary to expectations, there were no such increases for Biscay Bay River. Northeast River was the only one to show an increase in the proportion of repeat spawning grilse in the small salmon component. Other anticipated results of the removal of size-selective commercial fishing gear were increases in mean weight and mean length and improved condition. With respect to condition, it was felt that commercial gear selectively removed the better conditioned or more robust fish. There were significant increases in weight and length of small salmon during the moratorium for all rivers. The response for condition index was mixed: there was no significant change for Middle Brook; Biscay Bay River and Northeast River showed significant increases; Terra Nova River had a significant decrease.

It was not possible to meaningfully compare biological charcateristics of large salmon before and during the moratorium because of insufficient sample sizes. This stems largely from the fact that the retention of large salmon in the recreational fishery has been prohibited since 1984. Sampling of large salmon at counting facilities has been kept to a mimimum in order to minimize the risk of mortality to this valuable component of the stock.

Conservation egg requirement was achieved in all five years of the moratorium for Middle Brook and Northeast River and in three out of five years for Biscay Bay River. Requirement has never been reached in Terra Nova River but egg depositions tended to be higher during the moratorium. It should be noted that accessible rearing habitat above the lower Terra Nova River fishway more than doubled with the opening of the area above Mollyguajeck Falls. The first returns resulting from the adult transfers in 1985-89 were expected beginning in 1990. With the absence of counts of the numbers of adults ascending Mollyguajeck Falls since 1990, it is not possible to assess the results of the adult stocking. Broodstock used for swim-up fry stocking in the area above Mollyguajeck Falls since 1994 were simply deducted from spawning escapement, i.e., no attempt was made at this stage to backcalculate fry into egg equivalents.

Estimated total population sizes of small salmon since 1989 for Middle Brook and Biscay Bay River have been quite low compared to the late 1970s and early 1980s. Had there been a commercial fishery in 1992-96, total river returns and spawning escapements would probably have continued at the low levels indicative of the period 1989-91. Anticipated total returns of small salmon in 1997 will exceed conservation requirement for both rivers. These predictions were based on fixed parameter values (smolt-age composition and commercial and recreational fishery exploitation rates) and assumes constant natural survival rates both in freshwater and in the sea. The use of constants in the prediction of adult returns is risky since the parameters are most likely subject to annual variability. For instance, smolt-to-adult survival has been shown to be highly variable in Northeast Brook, Trepassey (SFA 9) and Conne River (SFA 11) (O'Connell *et al.* MS 1997b). Each of these rivers, Rocky River (SFA 9), and Campbellton River (SFA 4) showed an increase in smolt-adult survival in 1996 over 1995. Western Arm Brook (SFA 14A) showed a decline from 1995, but survival for 1995 was the highest since 1983 and that of 1996 the second highest.

Increased returns of adults with a smolt age of 3+ years, the progeny of increased numbers of spawners in the first year of the moratorium in 1992, are expected in 1997. The magnitude of these returns will depend on the strength of the 3+ age component which varies among the four rivers and can vary annually. The first year of major returns will be in 1998 when the 4+ smolt-age component from the 1992 spawning and the the 3+ smolt-age component from the 1993 spawning are recruited. This expectation assumes that overall survival will not fall below that currently being observed.

Cautions associated with the parameter values used to calculate the conservation egg requirement have been discussed previously by O'Connell and Dempson (1995) and will not be dealt with here. In the above analysis, total conservation egg requirement came from small salmon and the contribution from large salmon was considered as a buffer. Recently, managers have expressed an interest in setting conservation requirements for both small and large salmon. Using the biological characteristics information and relative proportions of small and large salmon presented above and computational formulae presented in O'Connell *et al.* (MS 1997a), it is possible to derive a conservation requirement for each component for each of the above rivers. These separate requirements have to be viewed from both the biological and operational perspectives. On the biological side, the proportion of eggs to come from each component should reflect natural stock characteristics. This may not be readily defined due to potential modifications in proportions resulting from decades of size-selective commercial fisheries. On the operational side, Figs. 13-16 give an idea of the outcome of selecting various proportions of the conservation egg requirement to come from small salmon on the proportionate contributions required from large salmon in order to achieve conservation egg requirement for each river. By selecting a percentage contribution for small salmon and locating the corresponding point on the small salmon curve, then drawing a line from this point vertically to meet the curve for large salmon, the number of small and large salmon corresponding to the point on each curve can be read from the y-axis. The tradeoff between each component in numbers needed to meet egg requirement is quite apparent. However, the question of whether a particular choice of proportions is biologically appropriate for the population and the long-term biological consequences of such a choice still has to be considered.

Acknowledgements

The Biscay Bay River counting fence was operated by the Southern Avalon Development Association through a Canada/Newfoundland Agreement on Salmonid Enhancement and Conservation (CASEC) grant and funding from the Department of Fisheries and Oceans (DFO), St. John's, NF. The adult counts for Middle Brook, Terra Nova River, and Northeast River were obtained through contractual arrangements with the Salmonid Association of Eastern Newfoundand and funding provided by DFO. We thank C. C. Mullins for providing Figs. 13-16.

References

Anon. MS 1990. Report of the Study Group on the North American salmon fisheries, Halifax, Nova Scotia, 26 February - 2 March, 1990. ICES C.M. 1990/M3: 111 p.

Anon. MS 1994. Report of the meeting of the Working Group on North Atlantic salmon (Copenhagen). Cons. Int. Explor. Mer., C.M. 1994/Assess:16, 182 p.

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

Brobbel, M. A., M. P. Wilkie, K. Davidson, J. D. Kieffer, A. T. Bielak, and B. L. Tufts. 1996. Physiological effects of catch and release angling in Atlantic salmon (*Salmo salar*) at different stages of freshwater migration. Can. J. Fish. Aquat. Sci. 53: 2036-2043.

Dempson, J. B., M. F. O'Connell, and D. E. Stansbury. MS 1994. 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.

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

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

May, A. W. 1993. A review of management and allocation of the Atlantic salmon resource in Atlantic Canada. p. 220-232. *In* Mills, D. [ed.] Salmon in the sea and new enhancement strategies. Fishing News Books. 423 p.

Mullins, C. C., and D. Caines. MS 1994. The status of Atlantic salmon stocks in the Gulf of St. Lawrence, western Newfoundland and southern Labrador. DFO Atlantic Fisheries Res. Doc. 94/83. 29 p.

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

O'Connell, M. F., and J. B. Dempson. MS 1991b. Atlantic salmon (*Salmo salar* L.) target spawning requirements for selected rivers in salmon fishing area 5 (Bonavista Bay), Newfoundland. CAFSAC Res. Doc. 91/17. 10 p.

O'Connell, M. F., and J. B. Dempson. 1995. Target spawning requirements for Atlantic salmon, *Salmo salar* L., in Newfoundland rivers. Fisheries Management and Ecology 2: 161-170.

O'Connell, M. F., and J. B. Dempson. 1997. Follicular atresia in Atlantic salmon (*Salmo salar* L.) in Newfoundland rivers. DFO, CSAS Res. Doc. in prep.

O'Connell, M. F., J. B. Dempson, C. C. Mullins, D. G. Reddin, N. M. Cochrane, and D. Caines. MS 1997b. Status of Atlantic salmon (*Salmo salar* L.) of the Newfoundland Region, 1996. DFO CSAS Res. Doc. 97/42. 104 p.

O'Connell, M. F., J. B. Dempson, T. R. Porter, D. G. Reddin, E.G.M. Ash, and N. M. Cochrane. MS 1992b. Status of Atlantic salmon (*Salmo salar* L.) stocks of the Newfoundland Region, 1991. CAFSAC Res. Doc. 92/22. 56 p.

O'Connell, M. F., J. B. Dempson, and D. G. Reddin. 1992a. Evaluation of the impacts of major management changes in the Atlantic salmon (*Salmo salar* L.) fisheries of Newfoundland and Labrador, Canada, 1984-1988. ICES J. mar. Sci.: 49-69.

O'Connell. M. F., D. G. Reddin, P. G. Amiro, F. Caron, T. L. Marshall, G. Chaput, C. C. Mullins, A. Locke, S. F. O'Neil, and D. K. Cairns. MS 1997a. Estimates of conservation spawner requirements for Atlantic salmon (*Salmo salar* L.) for Canada. DFO, CSAS Res. Doc. in prep.

O'Connell, M. F., D. G. Reddin, and C. C. Mullins. 1995. Status of Atlantic salmon (*Salmo salar* L.) in eight rivers in the Newfoundland Region, 1994. DFO Atlantic Fisheries Res. Doc. 95/124. 49 p.

O'Connell, M. F., D. G. Reddin, and C. C. Mullins. 1996. Status of Atlantic salmon (*Salmo salar* L.) in eight rivers in the Newfoundland Region, 1995. DFO Atlantic Fisheries Res. Doc. 96/106. 52 p.

Pippy, J.H.C., W. G. Whelan, and M. F. O'Connell. 1997. A field guide to counting and measuring salmonids using the silhouette imaging and counting system (SIACS). Can. MS Rep. Fish. Aquat. Sci. 2386: xi + 88 p.

Porter, T. R., L. G. Riche, and G. R. Traverse. 1974. Catalogue of rivers in insular Newfoundland. Volume D. Resource Development Branch, Newfoundland Region, Department of Environment, Fisheries and Marine Service Data Record Series No. NEW/D-74-9, 316 p.

Winters, G. H., and J. P. Wheeler. 1994. Length-specific weight as a measure of growth success of adult Atlantic herring (*Clupea harengus*). Can. J. Fish. Aquat. Sci. 51: 1169-1179.

SAS Institute. 1985. SAS user's guide: statistics, version 5, edition. SAS Institute inc., Cary, North Carolina.

Table 1. Biological characteristics data for female small salmon and with sexes combined plus unsexed fish by year and for pre-moratorium (1984-91) and moratorium (1992-96) periods for Middle Brook, Bonavista Bay (SFA 5), Newfoundland. WW = whole weight (kg); FL = fork length (cm); RS = repeat spawning grilse.

	Sexes combined plus unsexed								Females						%	
Year	$\bar{X}$ WW	SD	N	$\bar{X}$ FL	SD	N	% RS	N	$\bar{X}$ WW	SD	N	$\bar{X}$ FL	SD	N	Female	N
1984	1.48	0.39	155	49.9	4.31	155	7.7	12	1.48	0.40	121	49.8	4.43	121	79	121
1985	1.48	0.35	115	49.5	4.46	115	4.4	5	1.51	0.34	89	50.2	4.20	89	82	89
1986	1.63	0.47	54	52.2	4.56	55	18.2	10	1.58	0.47	41	52.0	4.75	42	86	42
1987	1.33	0.34	19	49.9	3.14	19	15.8	3	1.30	0.33	7	49.5	3.36	7	41	7
1988	1.32	0.41	46	49.3	3.47	47	0.0	0	1.37	0.51	22	49.7	3.82	22	71	22
1989	1.48	0.30	9	51.5	4.37	15	26.7	4	1.80		1	53.3	0.35	2	100	2
1990	1.67	0.24	16	52.3	2.39	16	25.0	4	1.69	0.27	11	52.7	2.67	11	85	11
1991	1.50	0.45	11	53.4	4.82	11	9.1	1	1.40	0.50	4	51.5	5.34	4	50	4
1992	1.64	0.43	78	53.6	3.96	93	8.2	6	1.74	0.40	37	54.1	3.27	48	83	48
1993	1.72	0.44	120	53.7	4.38	137	0.8	1	1.65	0.42	71	53.2	4.40	79	76	79
1994	1.78	0.40	72	53.2	3.61	73	1.6	1	1.75	0.33	33	53.0	3.42	34	74	34
1995	1.55	0.45	83	51.3	4.11	83	2.5	2	1.47	0.34	33	51.5	4.31	33	62	33
1996	1.96	0.42	73	54.2	3.74	73	15.7	11	1.95	0.38	41	54.2	3.58	41	82	41
Pre-moratorium																
1984-9	1.48	0.40	425	50.2	4.34	433	9.1	39	1.50	0.40	296	50.4	4.34	298	78	298
Moratorium																
1992-9	1.72	0.45	426	53.2	4.12	459	5.1	21	1.71	0.41	215	53.3	3.96	235	76	235

Table 2. Biological characteristics data for female small salmon and with sexes combined plus unsexed fish by year and for pre-moratorium (1984-91) and moratorium (1992-96) periods for Terra Nova River, Bonavista Bay (SFA 5), Newfoundland. WW = whole weight (kg); FL = fork length (cm); RS = repeat spawning grilse.

	Sexes combined plus unsexed								Females						%	
Year	$\bar{X}$ WW	SD	N	$\bar{X}$ FL	SD	N	% RS	N	$\bar{X}$ WW	SD	N	$\bar{X}$ FL	SD	N	Female	N
1984	1.59	0.40	118	50.2	4.43	118	12.7	15	1.57	0.36	73	50.2	3.74	73	74	73
1985	1.49	0.33	119	51.0	3.98	132	10.6	14	1.53	0.37	13	51.8	4.30	24	76	25
1986	1.70	0.37	93	53.4	3.66	93	27.2	25	1.63	0.32	31	52.7	3.45	31	65	31
1987	1.56	0.34	59	51.9	3.60	58	18.6	11	1.52	0.32	36	51.5	3.48	35	72	36
1988	1.81	0.40	47	52.8	3.67	46	31.9	15	1.70	0.65	4	50.0	5.72	4	57	4
1989	1.67	0.33	32	51.3	3.78	32	22.6	7							0	0
1990	1.65	0.36	50	52.0	3.86	50	10.6	5	1.70	0.39	5	51.0	4.47	5	100	5
1991	1.43	0.39	29	51.3	3.07	29	6.9	2	1.00	0.00	2	49.5	4.95	2	100	2
1992	1.76	0.37	84	53.0	3.65	95	1.1	1	1.30	0.30	6	49.3	2.64	6	75	6
1993	1.70	0.36	47	53.9	3.62	47	0.0	0	1.60	0.40	11	52.6	4.58	11	79	11
1994	1.80	0.42	82	54.8	3.72	83	10.4	8	1.75	0.50	15	55.0	5.33	16	84	16
1995	1.69	0.40	53	53.4	3.93	53	9.8	5	1.47	0.30	11	51.7	3.49	11	65	11
1996	1.71	0.42	63	53.7	4.27	63	13.1	8	1.57	0.39	19	52.4	4.53	19	76	19
Pre-moratorium 1984-91	1.61	0.38	547	51.6	4.03	558	16.9	94	1.56	0.35	164	51.1	3.85	174	72	176
Moratorium 1992-96	1.74	0.40	329	53.8	3.86	341	6.8	22	1.58	0.41	62	52.7	4.63	63	76	63

Table 3. Biological characteristics data for female small salmon and with sexes combined plus unsexed fish by year and for pre-moratorium (1984-91) and moratorium (1992-96) periods for Biscay Bay River, St. Mary's Bay (SFA 9), Newfoundland. WW = whole weight (kg); FL = fork length (cm); RS = repeat spawning grilse.

	Sexes combined plus unsexed								Females						%	
Year	$\bar{X}$ WW	SD	N	$\bar{X}$ FL	SD	N	% RS	N	$\bar{X}$ WW	SD	N	$\bar{X}$ FL	SD	N	Female	N
1984	1.62	0.41	118	51.6	3.45	134	5.9	8	1.62	0.43	77	51.6	3.65	84	66	85
1985	1.67	0.29	133	52.9	3.27	156	22.5	34	1.63	0.26	92	52.8	2.90	106	72	106
1986	1.75	0.36	149	53.3	3.68	152	22.4	34	1.76	0.36	114	53.4	3.58	116	76	116
1987	1.68	0.38	36	53.1	3.90	186	22.1	34	1.63	0.38	26	52.6	4.02	136	73	137
1988	1.60	0.33	106	51.7	3.91	210	13.3	28	1.63	0.32	82	52.0	3.87	156	75	156
1989	1.87	0.35	13	53.7	3.68	13	23.1	3	1.74	0.29	6	52.3	3.47	6	60	6
1990	1.72	0.40	30	53.1	3.33	30	10.0	3	1.72	0.43	16	53.5	4.16	16	55	16
1991			0	54.4	3.20	46	13.0	6			0	55.1	3.25	25	54	25
1992			0	51.5	2.12	2	0.0	0			0	53.0		1	100	1
1993	1.90	0.39	17	54.7	3.47	17	11.8	2	2.10	0.38	9	56.4	3.56	9	56	9
1994	1.89	0.36	20	55.0	2.63	20	0.0	0	1.88	0.44	12	54.8	3.05	12	67	12
1995	2.00	0.27	49	55.0	2.56	49	4.1	2	1.99	0.28	32	54.9	2.70	32	65	32
1996	1.91	0.33	25	55.2	2.50	25	16.0	4	1.93	0.36	20	55.5	2.66	20	83	20
Pre-moratorium 1984-91	1.67	0.36	585	52.7	3.72	927	16.8	150	1.67	0.35	413	52.6	3.72	645	71	647
Moratorium 1992-96	1.94	0.32	111	54.9	2.70	113	7.1	8	1.97	0.34	73	55.2	2.84	74	69	74

Table 4. Biological characteristics data for female small salmon and with sexes combined plus unsexed fish by year and for pre-moratorium (1984-91) and moratorium (1992-96) periods for Northeast River, Placentia Bay (SFA 10), Newfoundland. WW = whole weight (kg); FL = fork length (cm); RS = repeat spawning grilse.

	Sexes combined plus unsexed								Females						%	
Year	$\bar{X}$ WW	SD	N	$\bar{X}$ FL	SD	N	% RS	N	$\bar{X}$ WW	SD	N	$\bar{X}$ FL	SD	N	Female	N
1984	1.50	0.18	25	52.1	2.40	27	3.7	1	1.51	0.19	22	52.2	2.32	24	89	24
1985	1.55	0.24	51	51.6	3.26	51	7.8	4	1.56	0.24	47	51.8	3.25	47	92	47
1986	1.67	0.25	68	53.1	2.39	69	2.9	2	1.69	0.25	63	53.3	2.36	63	93	63
1987	1.40		1	52.6	5.09	2	0.0	0	1.40		1	49.0		1	100	1
1988	1.61	0.27	44	52.6	3.38	43	6.8	3	1.63	0.27	33	52.8	3.56	33	94	33
1989	1.71	0.22	24	53.7	2.85	25	8.0	2	1.72	0.24	19	53.9	2.64	19	95	19
1990	1.60	0.31	49	54.6	2.32	49	4.1	2	1.56	0.29	40	54.4	2.33	40	87	40
1991	1.00		1	47.5		1	0.0	0	1.00		1	47.5		1	100	1
1992			0	53.5	2.95	10	0.0	0			0	53.6	3.13	9	100	9
1993	1.83	0.31	23	54.2	3.08	24	4.8	1	1.76	0.33	10	52.9	1.97	10	83	10
1994	1.62	0.44	30	55.2	3.14	30	40.9	9	1.73	0.24	5	55.0	2.69	5	100	5
1995	1.77	0.47	48	55.4	3.76	48	31.1	14	1.72	0.37	25	54.7	3.21	25	100	25
1996	1.83	0.44	71	55.5	3.71	70	30.0	21	1.81	0.42	45	55.3	3.45	44	98	45
Pre-moratorium 1984-91	1.61	0.26	263	52.9	2.96	267	5.2	14	1.61	0.26	226	53.0	2.91	228	92	228
Moratorium 1992-96	1.78	0.43	172	55.1	3.53	182	26.8	45	1.78	0.38	85	54.7	3.24	93	97	94

Table 5. Relative fecundity values used to calculate egg depositions for each river in SFAs 5, 9, and 10.

River	Year	Relative fecundity (No. eggs/Kg)	N
SFA 5			
Middle Brook	1984	1896	102
	1985	1993	84
	1986	1955	36
	1987	2160	5
	1988	2259	10
	1990	1896	10
	1993	2150	31
	Years combined	1980	278
Terra Nova River	1984	1709	46
	1985	2163	7
	1986	1410	15
	1987	2323	3
	1990	2281	5
	1993	1794	8
	Years combined	1761	84
SFA 9			
Biscay Bay River	1984	1874	72
	1985	2194	81
	1986	2141	114
	1987	2130	26
	1988	1940	75
	1994	2007	5
	Years combined	2060	373
SFA 10			
Northeast River, Placentia	1984	2332	21
	1985	2205	39
	1986	2282	45
	1988	2472	34
	1990	2500	41
	1993	2144	5
	Years combined	2352	186

Table 6. Atlantic salmon conservation requirement for each river in terms of eggs and small salmon.

River	Conservation requirement	
	Eggs (Millions)	Small salmon (No.)
SFA 5		
Middle Brook	2.342	1012
Terra Nova River	14.303	7094
SFA 9		
Biscay Bay River	2.951	1134
SFA 10		
Northeast River, Placentia	0.719	224

Table 7. Counts of Atlantic salmon at Middle Brook fishway 1974-96, and lower Terra Nova River fishway 1978-96, Bonavista Bay (SFA 5). Partial counts are in parentheses and are not included in means.

	Middle Brook		Terra Nova River	
Year	Small	Large	Small	Large
1974	(770)	(77)		
1975	(1119)	(9)		
1976				
1977				
1978	1403	16	810	20
1979	(1350)	(54)	569	170
1980	1712	91	843	39
1981	2414	39	1115	90
1982	1281	20	963	19
1983	1195	75	1210	57
1984	1379	57	1233	107
1985	904	27	1557	112
1986	1036	15	1051	140
1987	914	19	974	56
1988	772	14	1737	206
1989	496	19	1138	142
1990	745	13	1149	144
1991	562	14	873	114
1992	1182	43	1443	270
1993	1959	87	(2713)	(470)
1994	1513	90	1571	242
1995	1139	168	2258	634
1996	1751	161	2005	464
$\bar{X}$ 84-89	917	25	1282	127
95% LCL	610	8	965	75
95% UCL	1223	42	1598	179
N	6	6	6	6
$\bar{X}$ 86-91	754	16	1154	134
95% LCL	540	13	835	83
95% UCL	969	18	1473	185
N	6	6	6	6
$\bar{X}$ 92-95	1448	97	1996	404
95% LCL	845	14	1046	111
95% UCL	2052	180	2946	697
N	4	4	4	4

Table 8. Counts of Atlantic salmon at the Biscay Bay River counting fence, St. Mary's Bay (SFA 9), 1983-96, and the Northeast River fishway, Placentia Bay SFA (10), 1974-95. Partial counts are in parentheses and are not included in means. Adjusted counts are bold and in italics.

	Biscay Bay River		Northeast River	
Year	Small salmon	Large salmon	Small salmon	Large salmon
1974			223	9
1975			(186)	(36)
1976			294	56
1977				
1978			390	32
1979			454	37
1980			433	34
1981			334	62
1982			86	36
1983	2330	88	233	22
1984	2430	83	419	44
1985	***1665***	***25***	384	0
1986	2516	101	725	39
1987	1302	106	325	16
1988	1695	61	543	11
1989	***912***	***107***	706	15
1990	1657	71	551	25
1991	394	35	353	8
1992	***1442***	***51***	921	46
1993	***1107***	***120***	847	65
1994	1592	68	677	70
1995	1071	56	663	74
1996	1182	149	1225	123
$\bar{X}$ 84-89	1753	81	517	21
95% LCL	1096	47	339	3
95% UCL	2411	114	695	39
N	6	6	6	6
$\bar{X}$ 86-91	1413	80	534	19
95% LCL	647	49	356	7
95% UCL	2178	111	711	31
N	6	6	6	6
$\bar{X}$ 92-95	1303	74	777	64
95% LCL	897	23	574	44
95% UCL	1709	124	980	83
N	4	4	4	4

Table 9. Total river returns, spawning escapement, and percentage of conservation requirement achieved in terms of small salmon and eggs for Middle Brook and Terra Nova River (SFA 5), 1984-96.

Year	Total returns		Prop.	Spawning escapement		Egg deposition (Millions)		% cons. req. achieved		Eggs per
	Small	Large	Large	Small	Large	Small	Large	Small	Eggs	240 sq. m
				Middle Brook						
1984	1675	57	0.033	1265	57	2.804	0.260	125	131	1161
1985	1283	27	0.021	745	27	1.838	0.130	74	84	745
1986	1547	15	0.010	758	15	2.014	0.071	75	89	789
1987	1053	19	0.018	866	19	2.006	0.091	86	90	794
1988	1337	14	0.010	629	14	1.211	0.067	62	55	484
1989	626	19	0.029	461	19	1.068	0.091	46	49	439
1990	1070	13	0.012	721	13	1.670	0.062	71	74	656
1991	763	14	0.018	485	14	1.124	0.067	48	51	451
1992	1563	43	0.027	1140	43	3.260	0.205	113	148	1312
1993	2247	88	0.038	1909	84	5.148	0.436	189	238	2115
1994	1844	90	0.047	1423	90	3.648	0.429	141	174	1544
1995	1448	168	0.104	1037	168	1.872	0.801	103	114	1012
1996	2112	161	0.071	1605	161	5.081	0.767	159	250	2215
				Terra Nova River						
1984	1534	107	0.065	1100	107	2.184	0.440	16	18	80
1985	2012	112	0.053	1431	112	2.830	0.475	20	23	101
1986	1459	140	0.088	974	140	1.817	0.593	14	17	74
1987	1404	56	0.038	940	56	1.812	0.237	13	14	63
1988	2114	206	0.089	1617	206	3.198	0.873	23	28	125
1989	1377	142	0.093	1085	142	2.146	0.602	15	19	84
1990	1518	144	0.087	1052	144	2.081	0.610	15	19	82
1991	1127	114	0.092	815	114	1.612	0.483	11	15	64
1992	1780	270	0.132	1371	270	2.899	1.144	19	28	124
1993	3050	472	0.134	2620	467	5.540	1.977	37	53	230
1994	2035	246	0.108	1305	232	2.759	0.985	18	26	115
1995	2638	638	0.195	1835	587	3.881	2.486	26	45	195
1996	2575	472	0.155	1577	429	3.334	1.818	22	36	158

Table 10. Total river returns, spawning escapement, and percentage of conservation requirement achieved in terms of small salmon and eggs for Biscay Bay River, St. Mary's Bay (SFA 9), and Northeast River, Placentia Bay (SFA 10), 1984-96.

	Total returns		Prop.	Spawning escapement		Egg deposition (Millions)		% cons. req. achieved		Eggs per
Year	Small	Large	Large	Small	Large	Small	Large	Small	Eggs	240 sq. m
				Biscay Bay River						
1984	2430	83	0.033	2108	83	4.224	0.374	186	156	562
1985[1]	1926	25	0.013	1397	25	3.597	0.132	123	126	456
1986	2688	101	0.036	2184	101	6.255	0.520	193	230	829
1987	1393	106	0.071	1171	106	2.968	0.543	103	119	430
1988	1802	61	0.033	1333	61	3.161	0.285	118	117	422
1989[1]	1004	107	0.096	828	107	2.022	0.531	73	87	312
1990	1670	73	0.042	1328	73	3.244	0.362	117	122	441
1991	394	35	0.082	384	35	0.938	0.174	34	38	136
1992[1]	1467	51	0.034	1393	51	3.901	0.253	123	141	508
1993[1]	1117	120	0.097	814	120	2.280	0.595	72	97	352
1994	1600	68	0.041	1382	68	3.869	0.337	122	143	515
1995	1151	56	0.046	754	56	2.009	0.278	66	77	280
1996	1217	149	0.109	974	149	2.727	0.739	86	117	424
				Northeast River, Placentia						
1984	459	44	0.087	389	44	1.219	0.247	174	204	1084
1985	519	0	0.000	346	0	1.095	0.000	154	152	810
1986	879	39	0.042	645	39	2.313	0.214	288	352	1870
1987	350	16	0.044	317	16	1.104	0.091	142	166	884
1988	637	11	0.017	451	11	1.708	0.065	201	247	1312
1989	809	15	0.018	599	15	2.087	0.085	267	302	1606
1990	699	25	0.035	526	25	1.785	0.150	235	269	1431
1991	368	8	0.021	349	8	1.216	0.045	156	175	933
1992	956	46	0.046	919	46	3.732	0.260	410	555	2953
1993	980	65	0.062	842	65	3.419	0.368	376	527	2801
1994	710	70	0.090	670	70	2.721	0.396	299	434	2306
1995	774	74	0.087	646	74	2.613	0.419	288	422	2243
1996	1420	123	0.080	1102	123	4.598	0.696	492	736	3916

[1]Based on adjusted count.

Table 11. Data used to estimate total stock size and anticipated returns in 1997 for Middle Brook. The smolt age distribution is 50% 3+ and 50% 4+. Conservation requirement =1012.

Spawning Year (i)	Recruit years (i+5)	Recruit years (i+6)	Total river escapement Year i	Total recruits Year i	Spawning escapement Year i	Recruits at smolt age 3+ (i+5)	Recruits at smolt age 4+ (i+6)	Total	No. of recruits/spawner (R/S ratio) 3+ (i+5)	4+ (i+6)	Total	Recruit Year	Smolt age distribution 3+	4+
74	79	80	975	2438	903	1714	2641	4355	1.8978	2.9250	4.8228	4.9290	0.5	0.5
75			1426	3565	1318	2641	3560	6201	2.0040	2.7011	4.7050	6.3337	0.5	0.5
76	81	82	1053	2633	980	3560	2068	5628	3.6327	2.1097	5.7423	2.8800	0.5	0.5
77			2883	7208	2684	2068	1838	3905	0.7703	0.6846	1.4549	1.8395	0.5	0.5
78	83	84	1692	4230	1591	1838	2094	3931	1.1549	1.3160	2.4709	2.8521	0.5	0.5
79			1371	3428	1363	2094	1604	3698	1.5361	1.1766	2.7128	1.9899	0.5	0.5
80	85	86	2113	5283	1972	1604	1934	3538	0.8133	0.9806	1.7939	1.6979	0.5	0.5
81			2848	7120	2696	1934	1316	3250	0.7173	0.4882	1.2055	1.3525	0.5	0.5
82	87	88	1654	4135	1523	1316	1671	2988	0.8642	1.0973	1.9616	2.3137	0.5	0.5
83			1470	3675	1374	1671	783	2454	1.2163	0.5695	1.7858	1.1881	0.5	0.5
84	89	90	1675	4188	1265	783	1338	2120	0.6186	1.0573	1.6759	2.8526	0.5	0.5
85			1283	3208	745	1338	954	2291	1.7953	1.2802	3.0755	2.5384	0.5	0.5
86	91	92	1547	3868	758	954	782	1735	1.2582	1.0310	2.2892	1.9334	0.5	0.5
87			1053	2633	866	782	1124	1905	0.9024	1.2973	2.1998	3.0835	0.5	0.5
88	93	94	1337	3343	629	1124	922	2046	1.7862	1.4658	3.2520	3.4658	0.5	0.5
89			626	1565	461	922	724	1646	2.0000	1.5705	3.5705	2.5747	0.5	0.5
90	95	96	1070	2675	721	724	1056	1780	1.0042	1.4646	2.4688	3.6420		
91			763	1908	485	1056			2.1773					
92	97	98	1563	1563	1140									
93			2247	2247	1909									
94	99	00	1844	1844	1423									
95			1448	1448	1037									
96	01	02	2112	2112	1605									
97														
98	03	04												

Anticipated returns in 1997 (based on the mean R/S in 1993-96)

Source	R/S ratios 3+	R/S ratios 4+	No. of small 3+	No. of small 4+	Total	Total 1.06
Mean	1.7419	1.4496	1986	703	2689	2854
Hi	2.1773	1.5705	2482	762	3244	3443
Low	1.0042	1.2973	1145	629	1774	1883

Estimate of precision

Comparison of observed & expected in 1995-96

Recruit Year	R/S ratios 3+	R/S ratios 4+	Est. no. of small 3+	Est. no. of small 4+	Total	Difference (Obs-exp)	%
95*	1.5530	1.2575	1120	580	1699	-251	-17
96**	1.4145	1.3339	686	962	1648	464	22
						Mean	2

* From O'Connell et al. (MS 1995)

** From O'Connell et al. (MS 1996)

Table 12. Data used to estimate total stock size and anticipated returns in 1997 for Biscay Bay River.
Conservation spawning requirement =1134.

Spawning Year (i)	Recruit years (i+5)	Recruit years (i+6)	Total river escapement Year i	Total recruits Year i	Spawning escapement Year i	Recruits at smolt age 3+ (i+5)	Recruits at smolt age 4+ (i+6)	Recruits at smolt age Total	No. of recruits/spawner (R/S ratio) 3+ (i+5)	No. of recruits/spawner (R/S ratio) 4+ (i+6)	No. of recruits/spawner (R/S ratio) Total	Recruit Year	Smolt age distribution 3+	Smolt age distribution 4+
74	79	80	507	1268	436	2459	1314	3772	5.6388	3.0128	8.6517	8.6516	0.74	0.26
			771	1928	663	3739	1969	5708	5.6388	2.9693	8.6081	8.3992	0.74	0.26
76	81	82	1200	3000	1032	5604	1704	7307	5.4299	1.6508	7.0807	7.1301	0.74	0.26
			1029	2573	885	4849	1922	6771	5.4793	2.1720	7.6513	9.5342	0.74	0.26
78	83	84	864	2160	743	5470	1580	7050	7.3623	2.1257	9.4880	6.0590	0.74	0.26
			1329	3323	1143	4496	1252	5747	3.9333	1.0953	5.0286	3.1454	0.74	0.26
80	85	86	2021	5053	1738	3563	1747	5310	2.0500	1.0053	3.0553	2.9142	0.74	0.26
			3029	7573	2605	4973	905	5878	1.9090	0.3476	2.2566	1.4909	0.74	0.26
82	87	88	2621	6553	2254	2577	1171	3748	1.1433	0.5196	1.6629	1.8306	0.74	0.26
			2957	7393	2543	3334	653	3986	1.3109	0.2566	1.5675	1.1377	0.74	0.26
84	89	90	2430	6075	2108	1857	1086	2943	0.8811	0.5149	1.3961	2.7265	0.74	0.26
			1926	4815	1397	3090	256	3346	2.2115	0.1833	2.3948	0.5171	0.74	0.26
86	91	92	2688	6720	2184	729	381	1110	0.3337	0.1746	0.5084	1.1017	0.74	0.26
			1393	3483	1171	1086	290	1376	0.9271	0.2480	1.1751	0.8681	0.74	0.26
88	93	94	1802	4505	1333	827	416	1243	0.6201	0.3121	0.9322	1.7420	0.74	0.26
			1004	2510	828	1184	299	1483	1.4300	0.3614	1.7914	1.0028	0.74	0.26
90	95	96	1670	4175	1328	852	316	1168	0.6414	0.2383	0.8796	2.5835		
			394	985	384	901			2.3453					
92	97	98	1467	1467	1393									
			1117	1117	814									
94	99	00	1600	1600	1382									
			1151	1151	754									
96	01	02	1217	1217	974									
98	03	04												

Anticipated returns in 1997 (based on the mean R/S in 1993-96)

Source	R/S ratios 3+	R/S ratios 4+	No. of small 3+	No. of small 4+	No. of small Total	Total 1.07
Mean	1.2592	0.2899	1754	111	1865	1998
Hi	2.3453	0.3614	3267	139	3406	3648
Low	0.6201	0.2383	864	91	955	1023

Estimate of precision

Comparison of observed & expected in 1995-96

Recruit Year	R/S ratios 3+	R/S ratios 4+	Est. no. of small 3+	Est. no. of small 4+	Total	Difference (Obs-exp)	%
95*	0.9924	0.2449	1318	203	1521	-370	-23
96**	0.9046	0.2740	347	364	711	506	44
						Mean	10

NB - the average used for anticipated returns is for 4 years.

* From O'Connell et al. (MS 1995)

** From O'Connell et al. (MS 1996)

Table 13. Results of statistical analyses comparing various factors between the moratorium (1992-96) and pre-moratorium (1984-91) periods for each river.

Factor	Middle Brook		Terra Nova River		Biscay Bay River		Northeast River	
	Z	P	Z	P	Z	P	Z	P
Total river returns (No.) - small salmon	2.42	0.0157	2.42	0.0157	1.10	0.2723	2.27	0.0233
- large salmon	2.72	0.0066	2.85	0.0043	0.37	0.7144	2.85	0.0043
Proportion of large salmon	2.56	0.0104	2.85	0.0043	1.10	0.2723	2.27	0.0233
Proportion of repeat spawning grilse	-1.39	0.1643	-1.98	0.0481	-1.98	0.0478	1.40	0:1620
Whole weight (kg)	-8.36	0.0001	4.79	0.0001	7.88	0.0001	4.14	0.0001
Fork length (cm)	-10.22	0.0001	7.59	0.0001	6.91	0.0001	6.13	0.0001

Table 14. Individual regressions of ln whole weight (kg) on ln fork length (cm) for the moratorium (1992-96) and pre-moratorium (1984-91) periods for each river.

River	Period	Equation	r-sq.	P	df
Middle Brook	Pre-moratorium	$\ln Y = 2.5720 \ln X - 15.6286$	0.7074	0.0001	423
	Moratorium	$\ln Y = 2.7369 \ln X - 16.6602$	0.6493	0.0001	388
Terra Nova River	Pre-moratorium	$\ln Y = 2.3787 \ln X - 14.4027$	0.6303	0.0001	543
	Moratorium	$\ln Y = 2.7471 \ln X - 16.7428$	0.7323	0.0001	327
Biscay Bay River	Pre-moratorium	$\ln Y = 2.5591 \ln X - 15.5484$	0.7344	0.0001	501
	Moratorium	$\ln Y = 2.6623 \ln X - 16.1587$	0.5996	0.0001	92
Northeast River	Pre-moratorium	$\ln Y = 2.0489 \ln X - 12.3841$	0.4917	0.0001	260
	Moratorium	$\ln Y = 2.6438 \ln X - 16.1066$	0.5503	0.0001	95

Table 15. Adjusted means (ln scale) resulting from the general linear model analyses for the moratorium (1984-91) and pre-moratorum (1992-96) periods and overall model r-square for each river. See text for more details.

River	Period	Adjusted mean ln scale (P)	Model r-sq. (P)
Middle Brook	Pre-moratorium Moratorium	0.4283 (0.8964) 0.4268	0.7009 (0.0001)
Terra Nova River	Pre-moratorium Moratorium	0.4879 (0.0030) 0.4585	0.6735 (0.0001)
Biscay Bay River	Pre-moratorium Moratorium	0.4999 (0.0010) 0.5402	0.7401 (0.0001)
Northeast River	Pre-moratorium Moratorium	0.4866 (0.0161) 0.5098	0.5412 (0.0001)

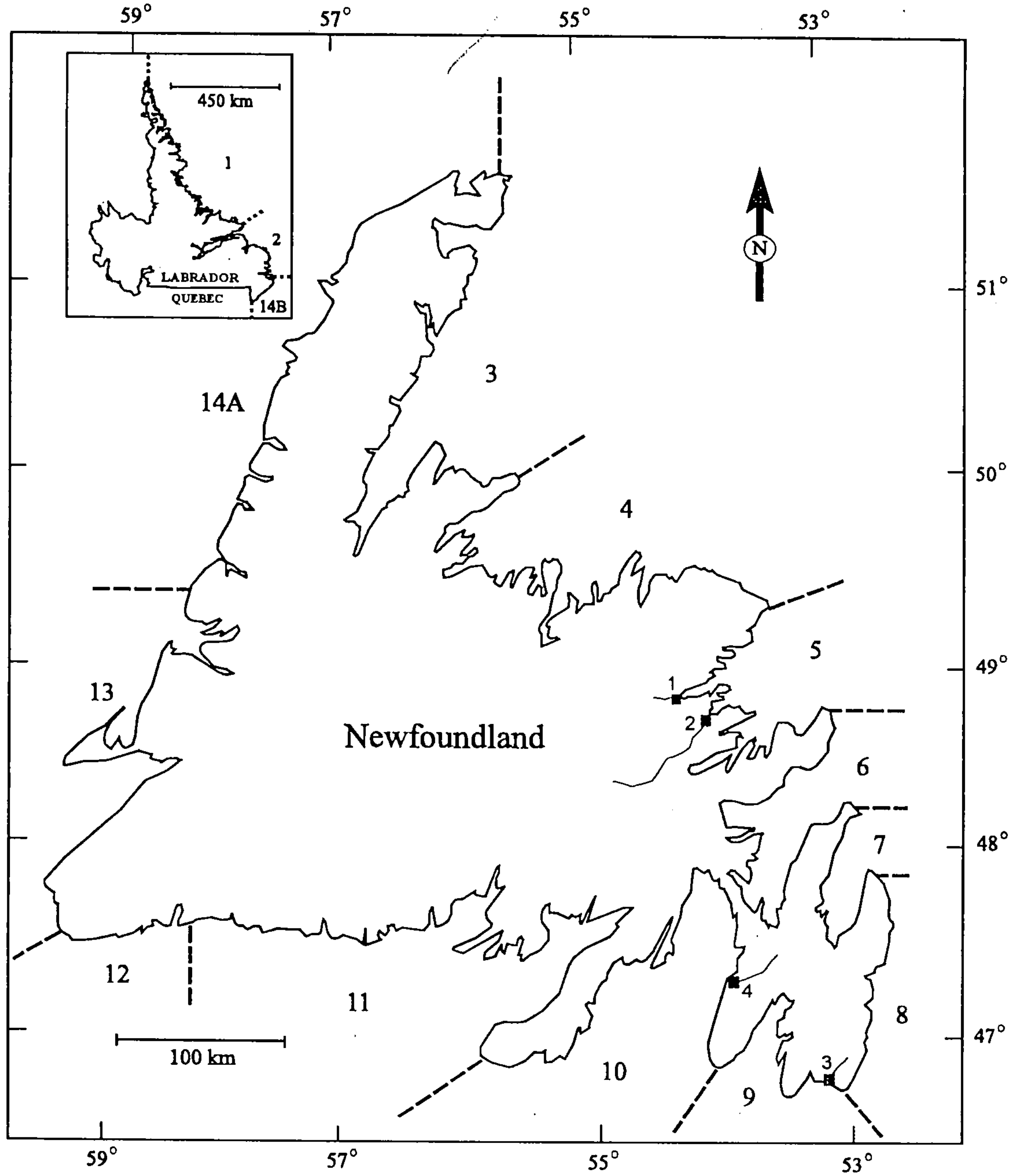

Fig. 1. Map showing Salmon Fishing Areas of Newfoundland and Labrador and the locations of the four rivers mentioned in the text (1) Middle Brook; (2) Terra Nova River; (3) Biscay Bay River; (4) Northeast River, Placentia.

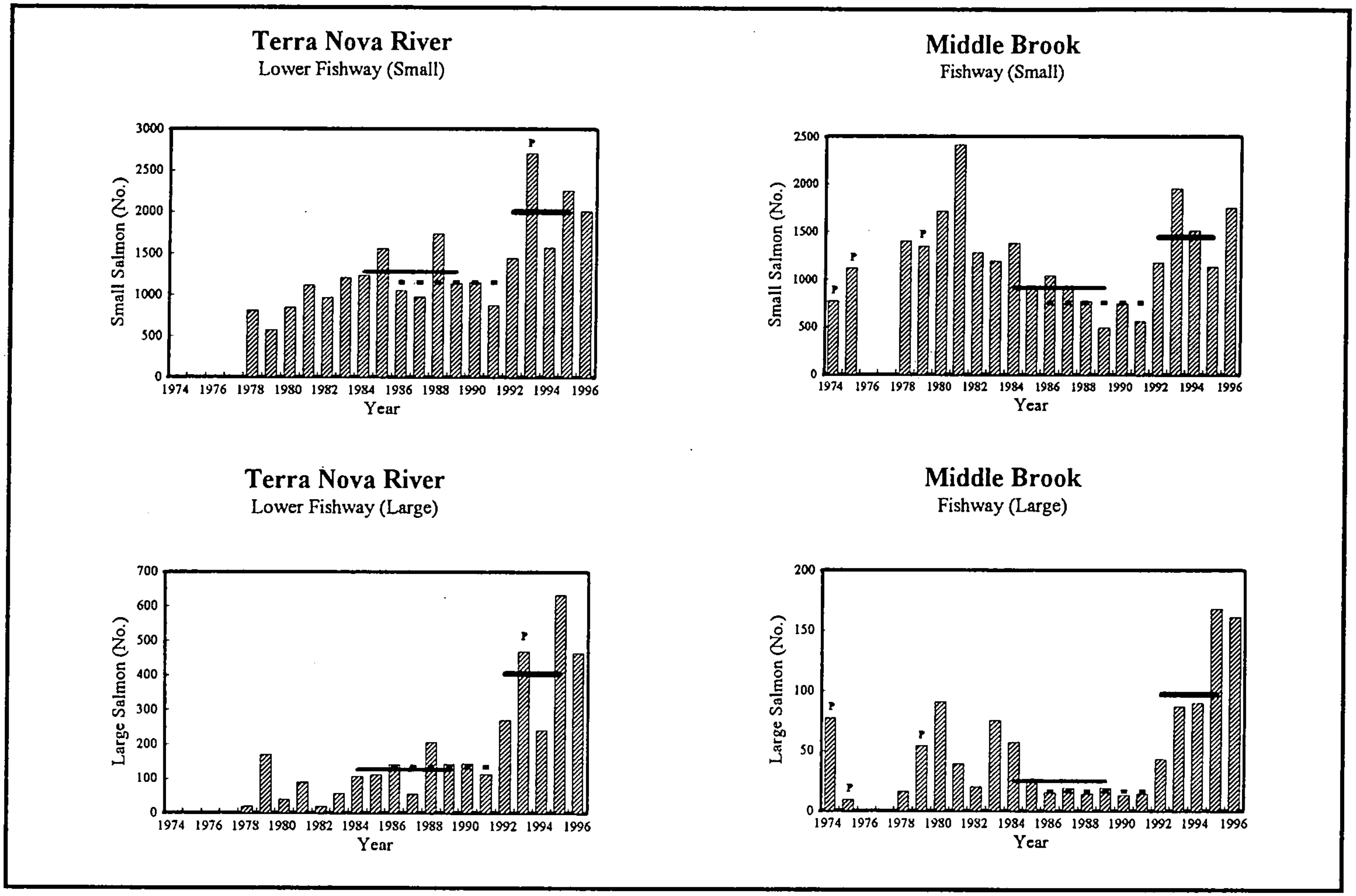

Fig. 2. Counts of small and large salmon at the lower Terra Nova River fishway and Middle Brook fishway, 1974-96. The thin solid horizontal line represents the 1984-89 mean, the broken line the 1986-91 mean and the thick solid line the 1992-95 mean. P = partial count not included in means.

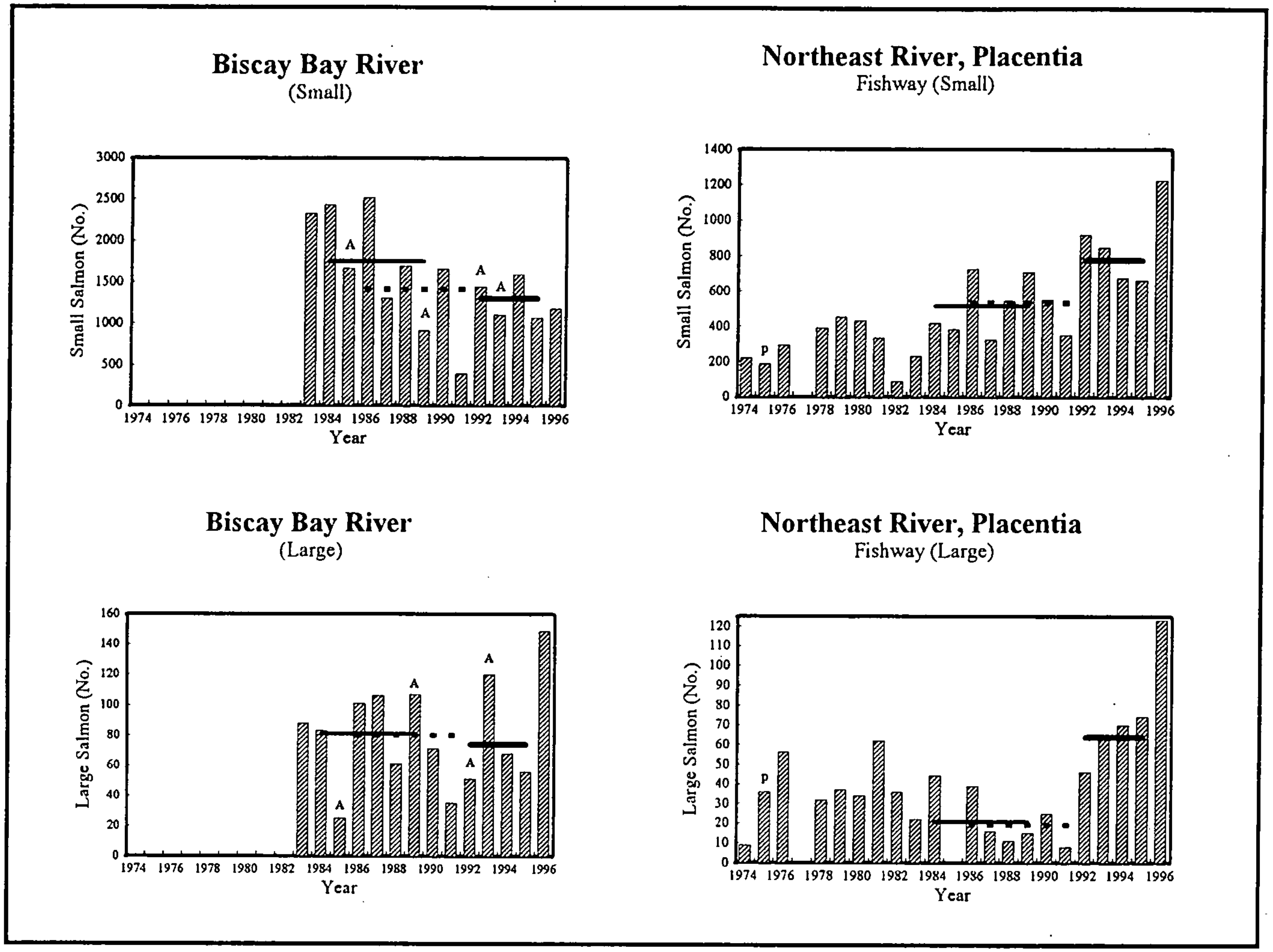

Fig. 3. Counts of small and large salmon at the Biscay Bay River counting fence, and the Northeast River fishway, 1974-96. The thin solid horizontal line represents the 1984-89 mean, the broken line the 1986-91 mean and the thick solid line the 1992-95 mean. A = adjusted count and P = partial count not included in means.

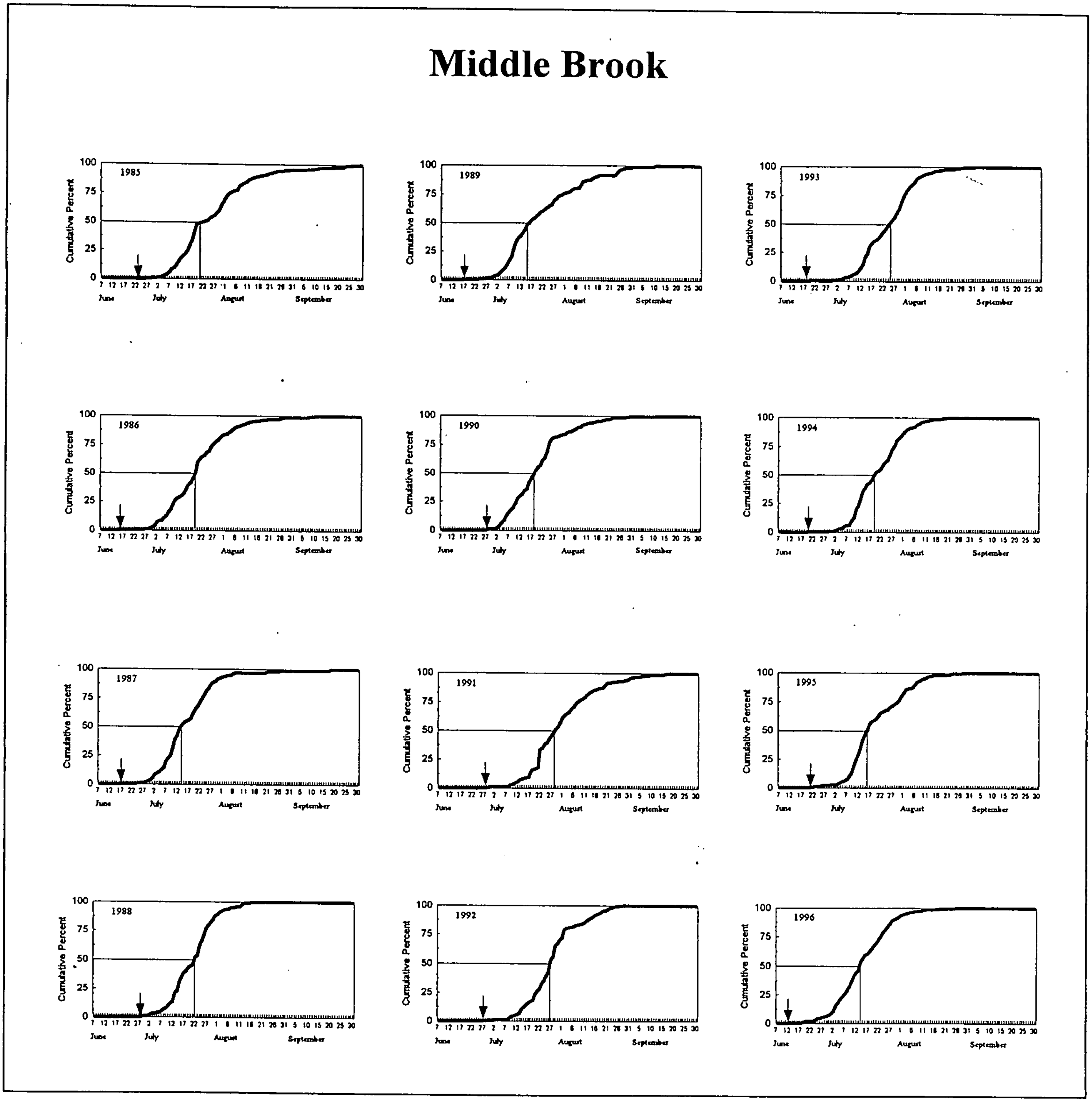

Fig. 4. Cumulative percentage of small salmon counted by day for Middle Brook in 1985-96. Days are standardized for all years and the date on which the first fish was counted is denoted by an arrow.

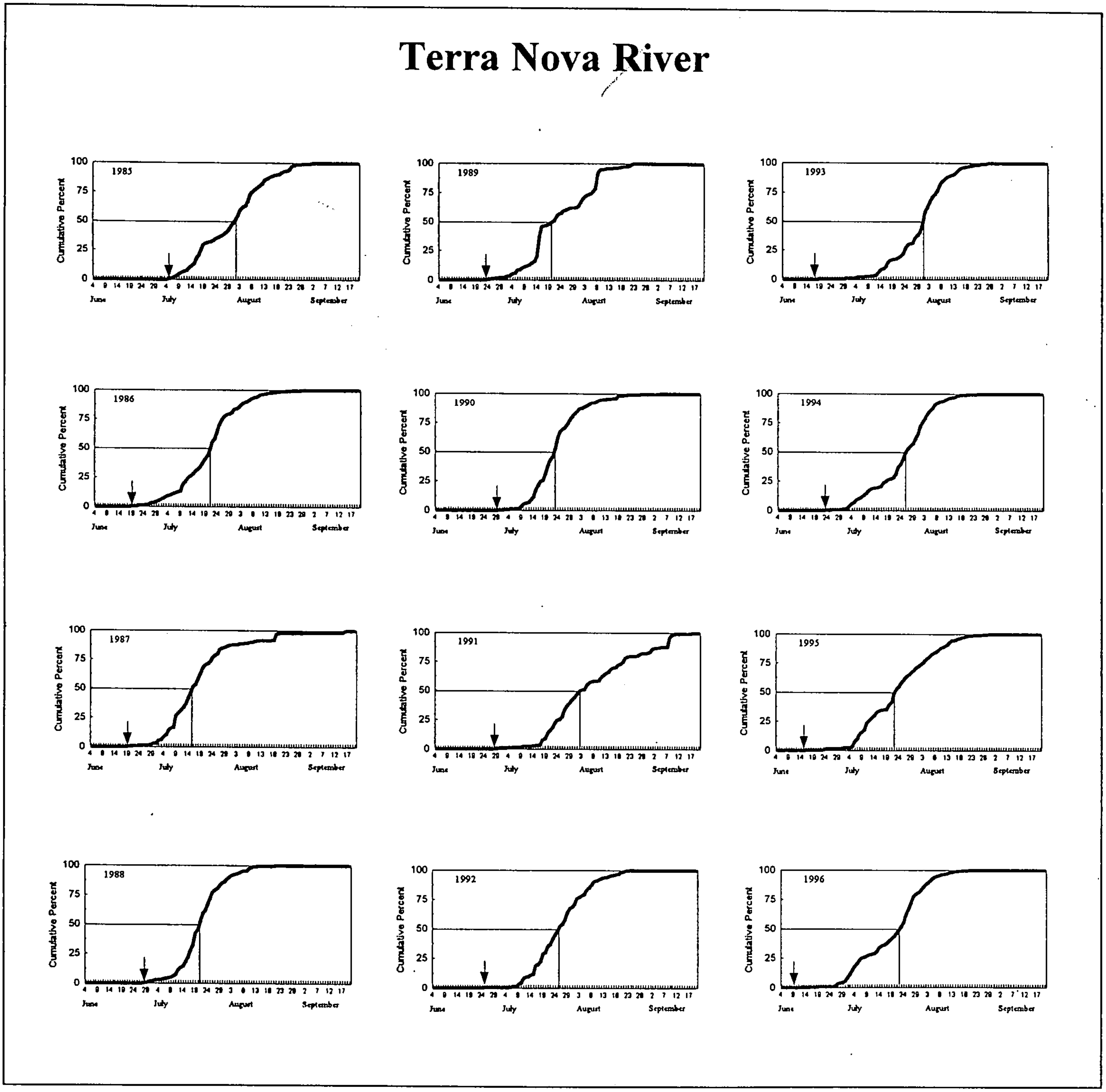

Fig. 5. Cumulative percentage of small salmon counted by day for Terra Nova River in 1985-96. Days are standardized for all years and the date on which the first fish was counted is denoted by an arrow.

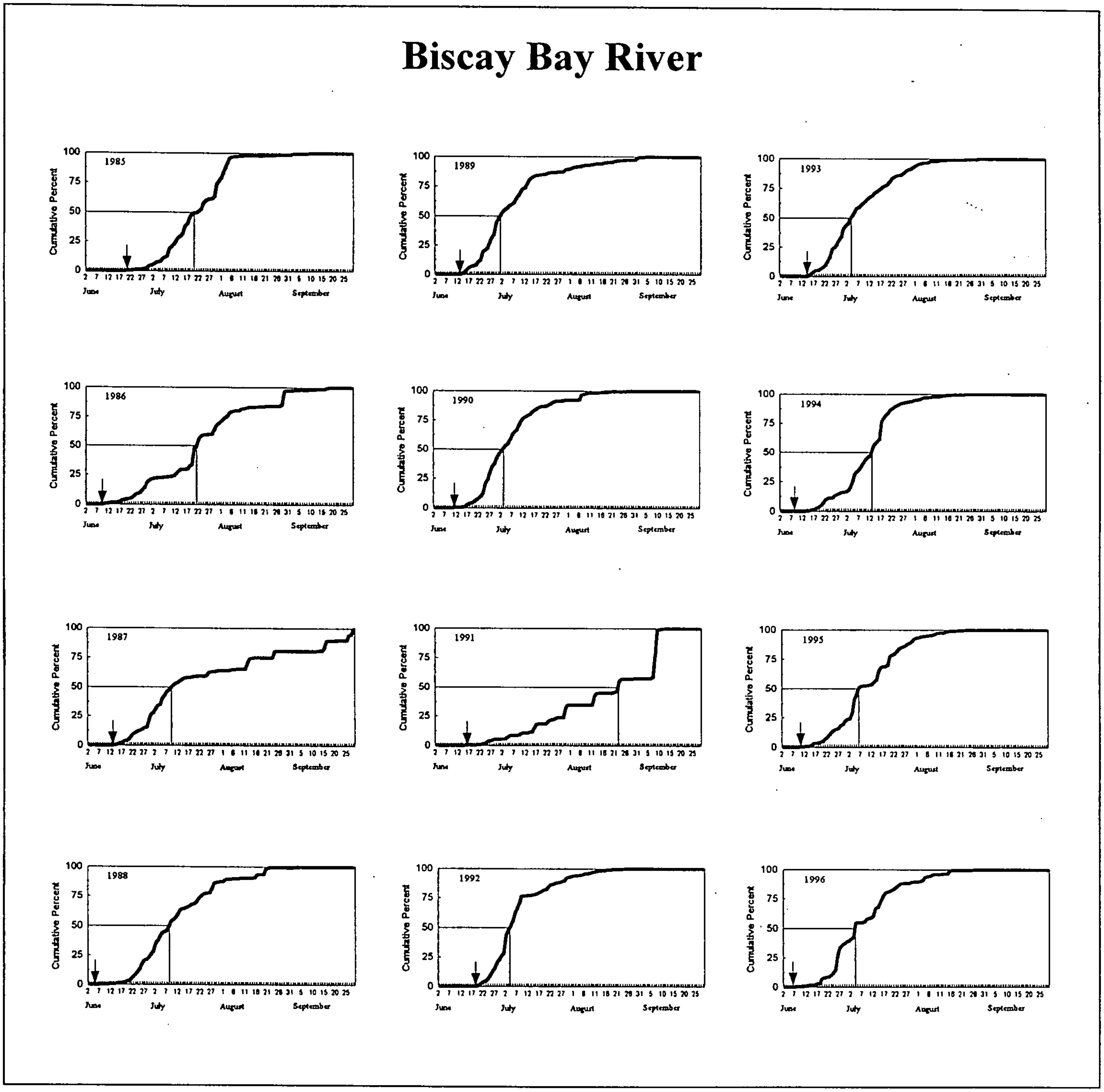

Fig. 6. Cumulative percentage of small salmon counted by day for Biscay Bay River in 1985-96. Days are standardized for all years and the date on which the first fish was counted is denoted by an arrow.

Northeast River (Placentia)

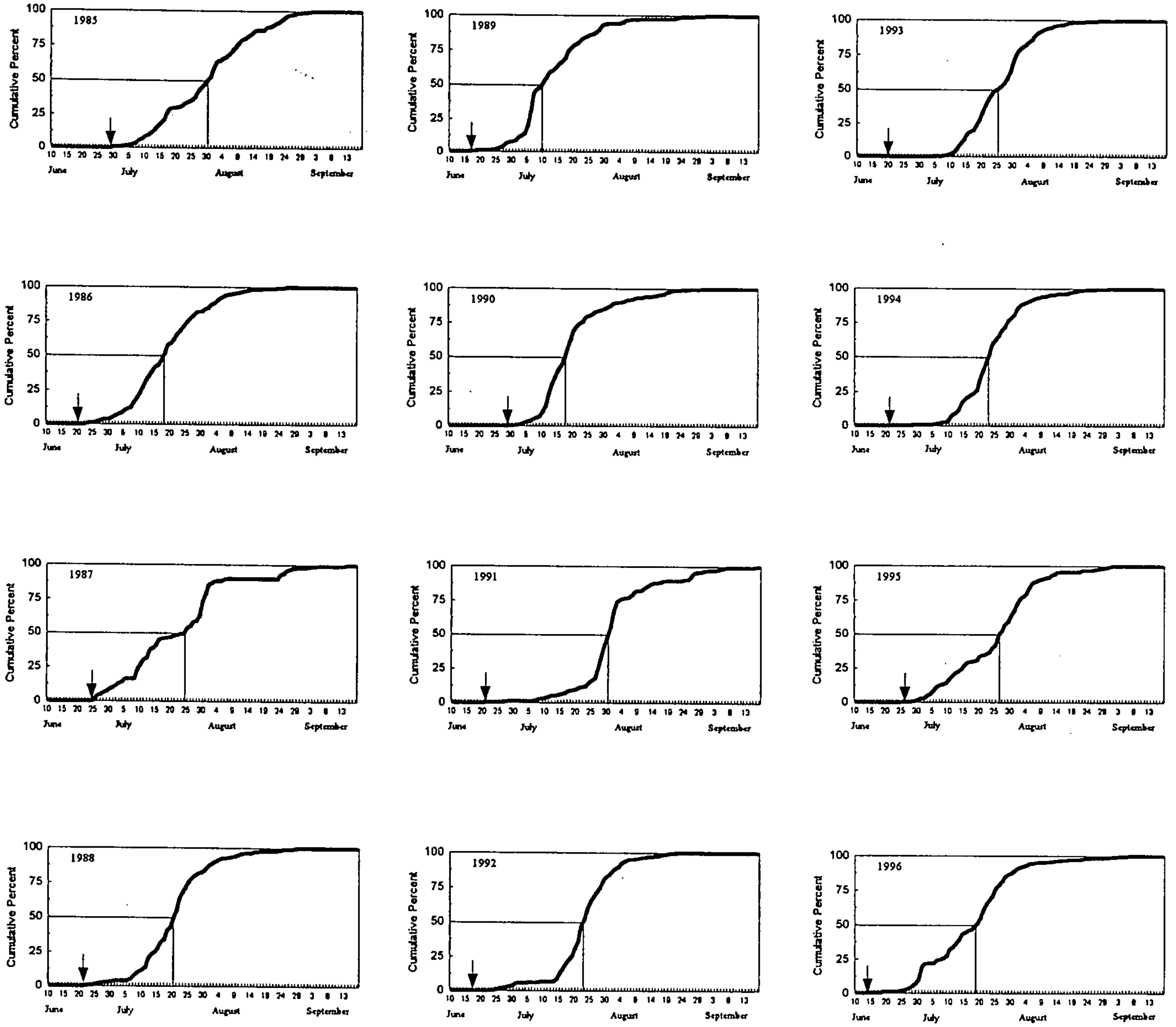

Fig. 7. Cumulative percentage of small salmon counted by day for Northeast River, Placentia in 1985-96. Days are standardized for all years and the date on which the first fish was counted is denoted by an arrow.

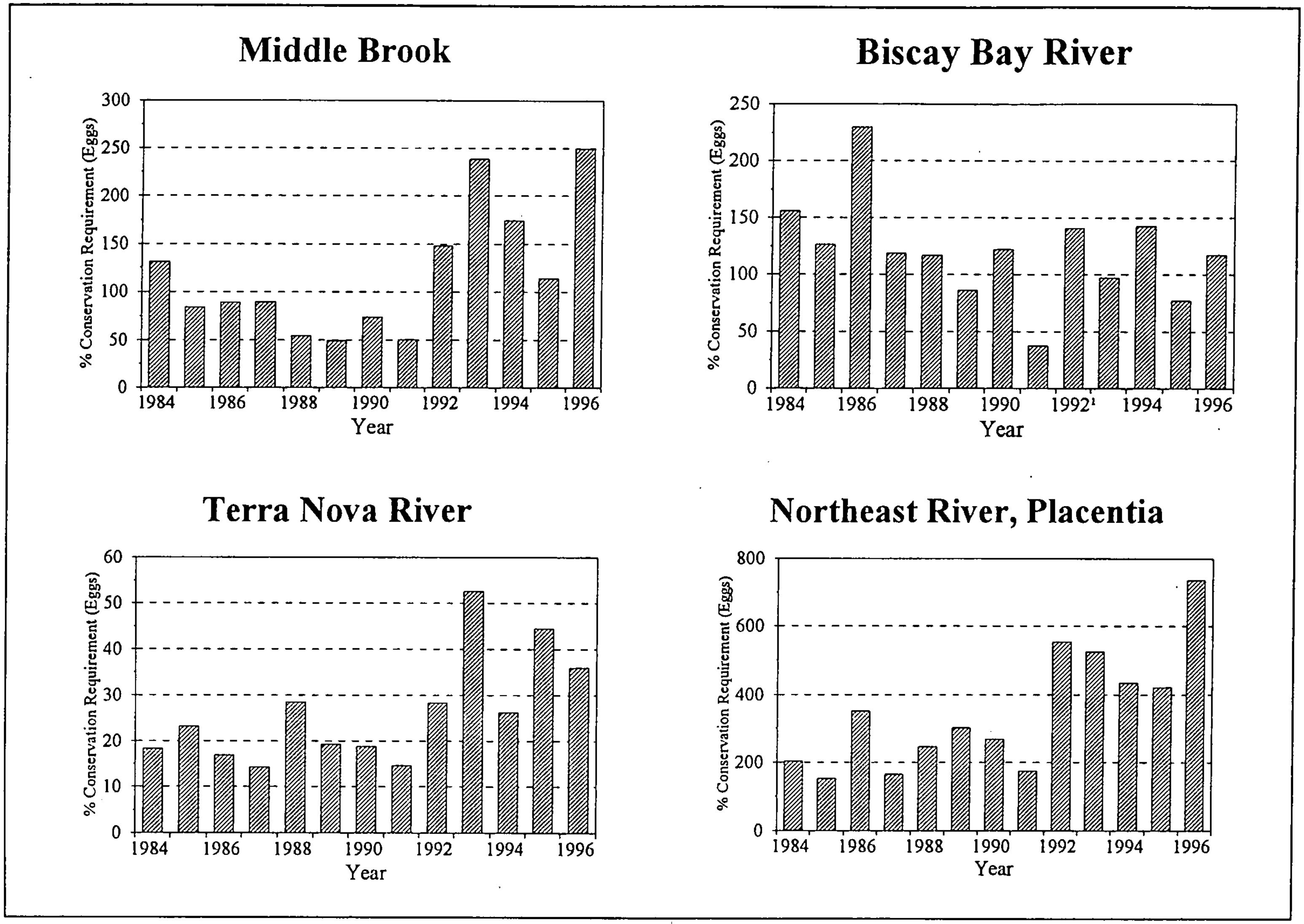

Fig. 8. Percentage conservation egg requirement achieved for Middle Brook and Terra Nova River (SFA 5), Biscay Bay River (SFA 9) and Northeast River, Placentia (SFA 10), 1984-96.

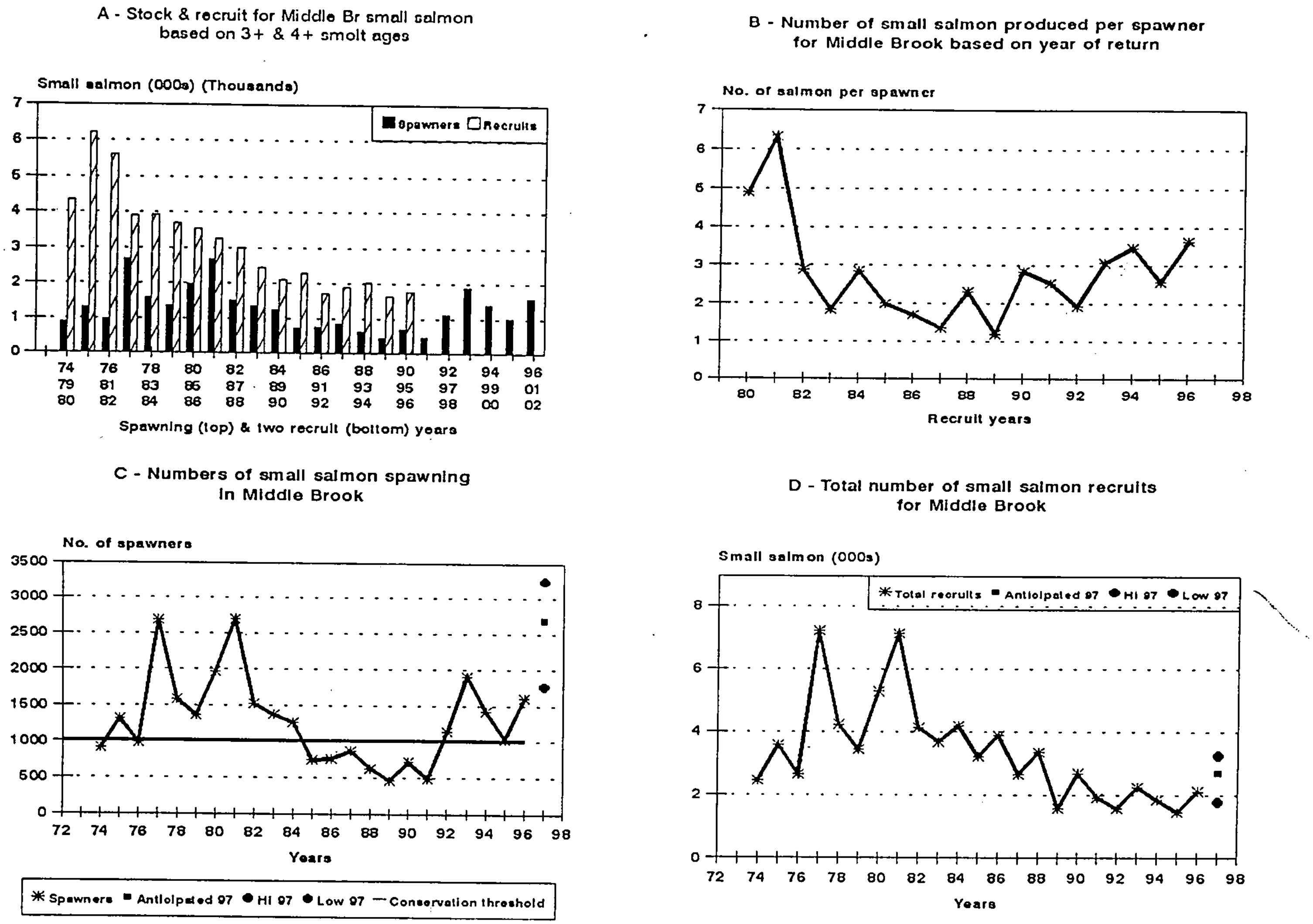

Fig. 9. Number of small salmon spawners and recruits, lagged and totalled according to smolt age (A), number of small salmon produced (years i+5,6) per spawner (year i) (B), number of small salmon spawners, 1975-96, and anticipated returns in 1997 in relation to conservation spawner requirement (C), and the total number of small salmon produced (recruits), 1975-96, and anticipated returns for 1997 (D) for Middle Brook.

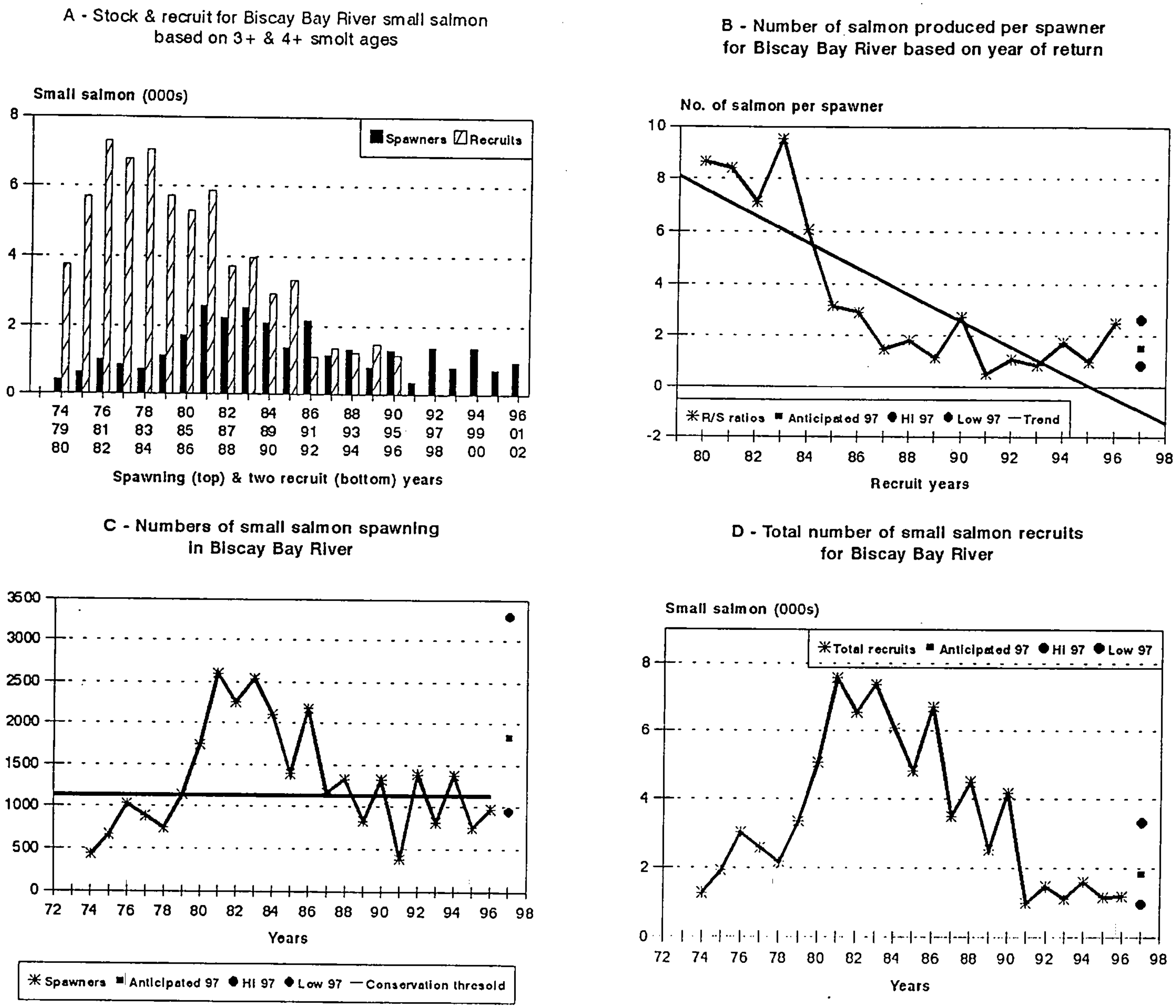

Fig. 10. Number of small salmon spawners and recruits, lagged and totalled according to smolt age (A), number of small salmon produced (years i+5,6) per spawner (year i) (B), number of small salmon spawners, 1975-96, and anticipated returns in 1997 in relation to conservation spawner requirement (C), and the total number of small salmon produced (recruits), 1975-96, and anticipated returns for 1997 (D) for Biscay Bay River.

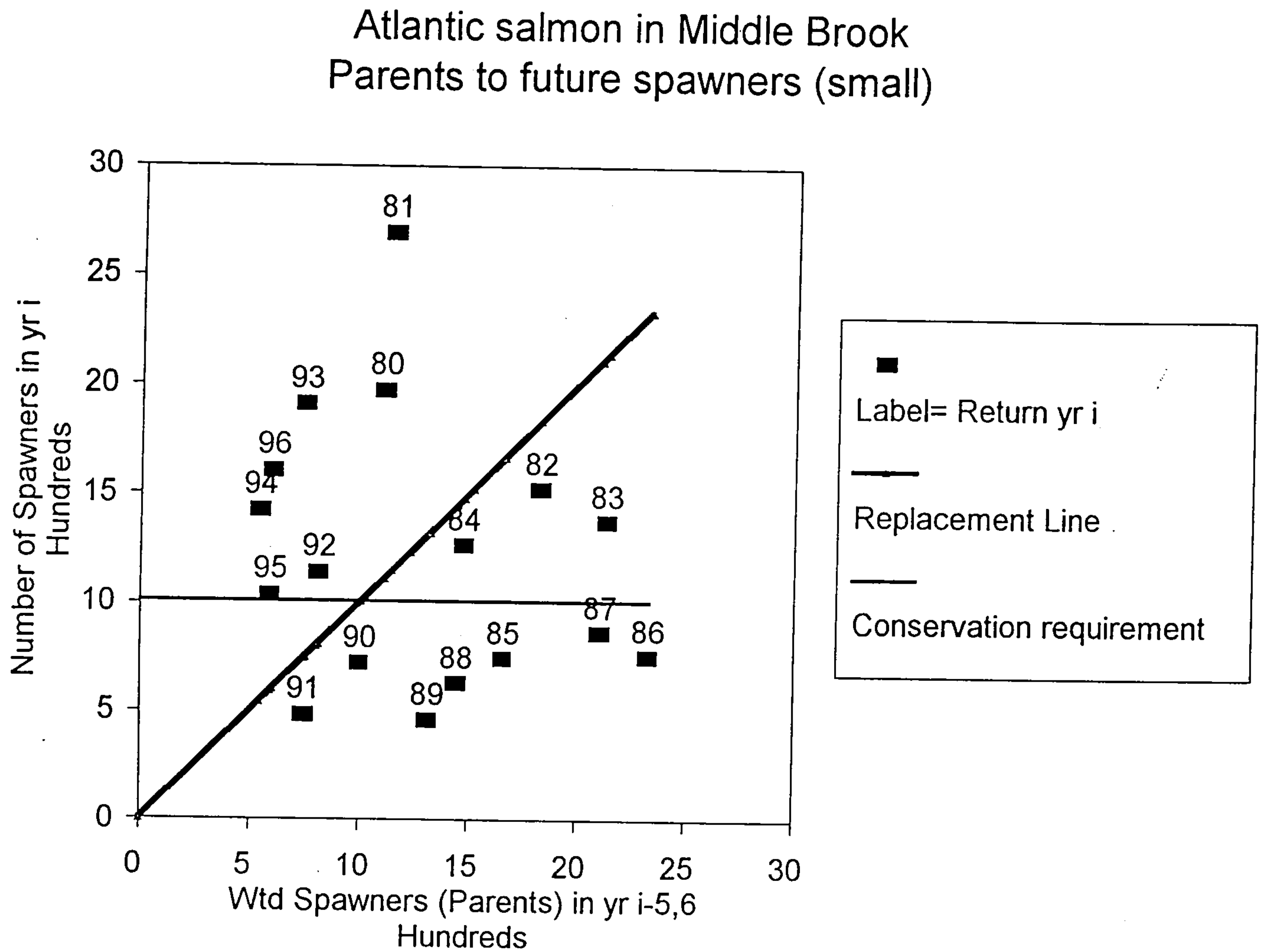

Fig. 11. The relationship between parents and spawners (after exploitation), the replacement (diagonal) line, and conservation spawner requirement (horizontal) line for small salmon for Middle Brook.

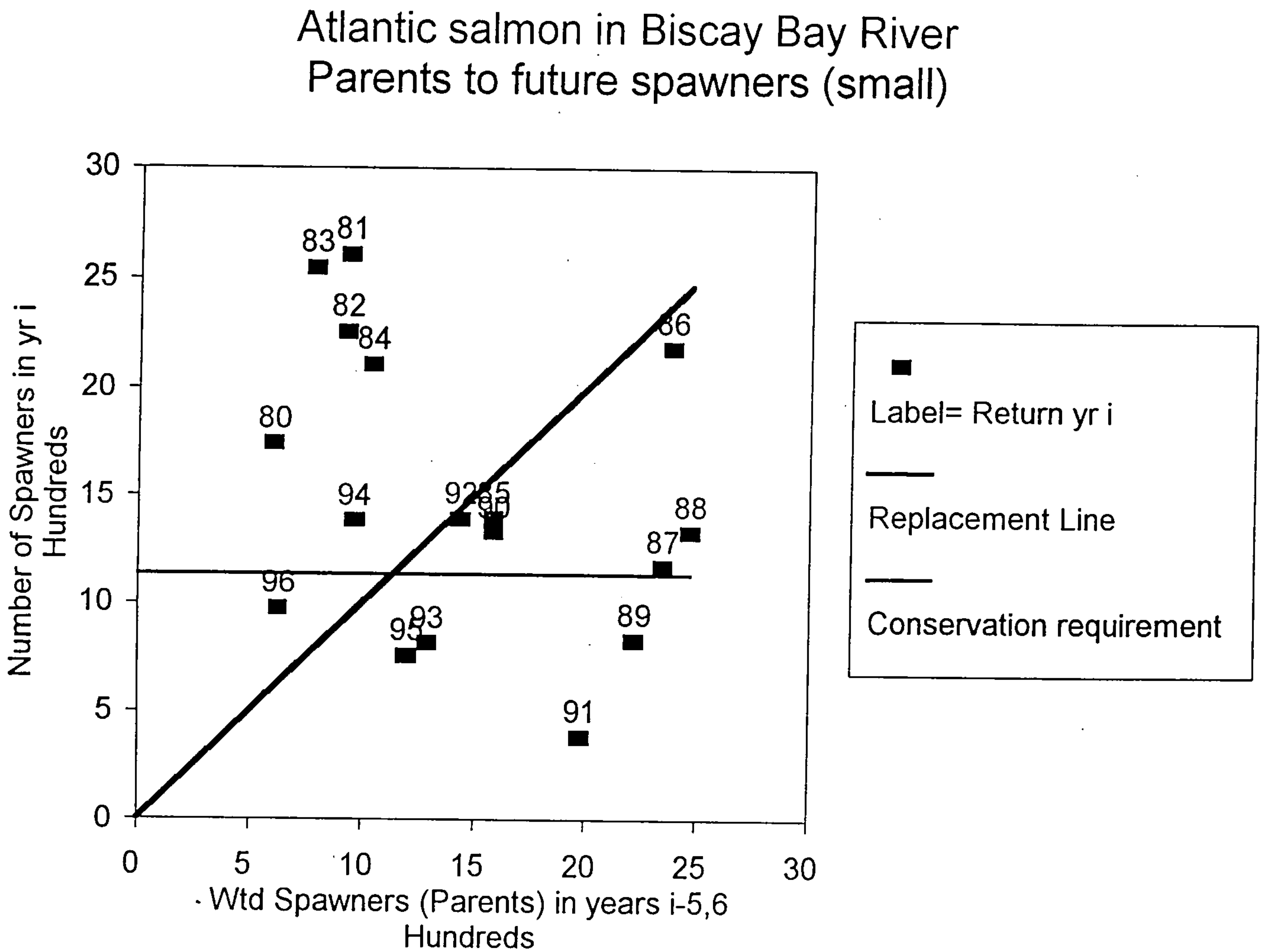

Fig. 12. The relationship between parents and spawners (after exploitation), the replacement (diagonal) line, and conservation spawner requirement (horizontal) line for small salmon for Biscay Bay River.

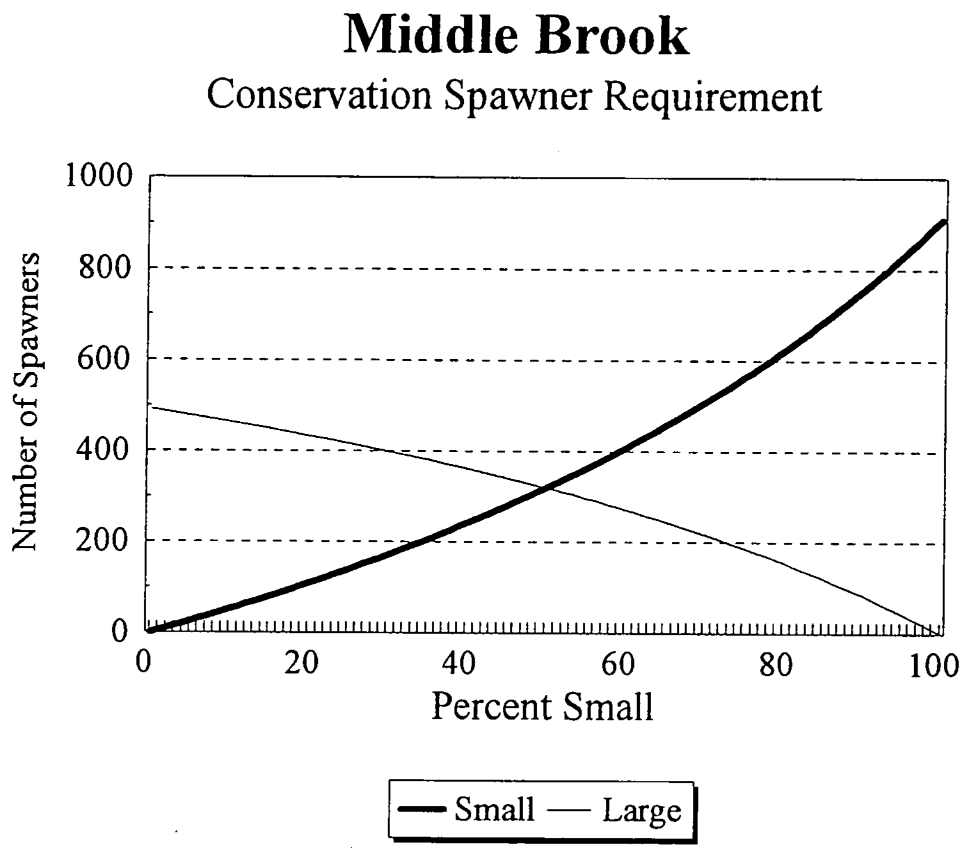

Fig. 13. Graphic representation showing the impact of selecting a particular percentage of conservation egg requirement to come from small salmon on the number of large salmon required to make up the remainder of the egg requirement, for Middle Brook. See text for further explanation.

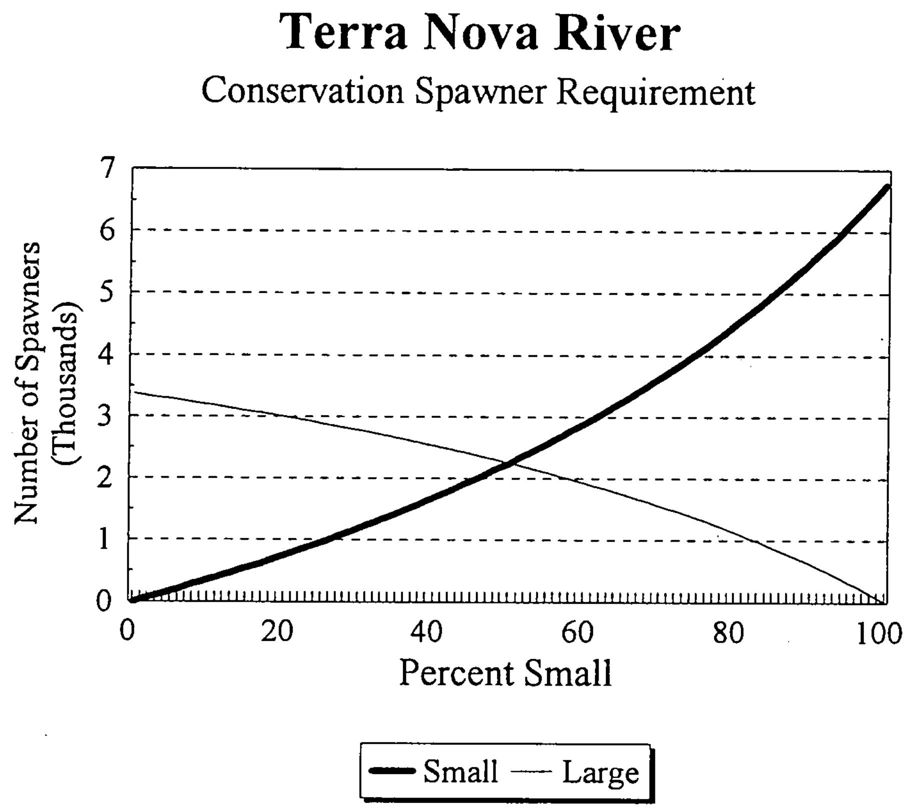

Fig. 14. Graphic representation showing the impact of selecting a particular percentage of conservation egg requirement to come from small salmon on the number of large salmon required to make up the remainder of the egg requirement, for Terra Nova River. See text for further explanation.

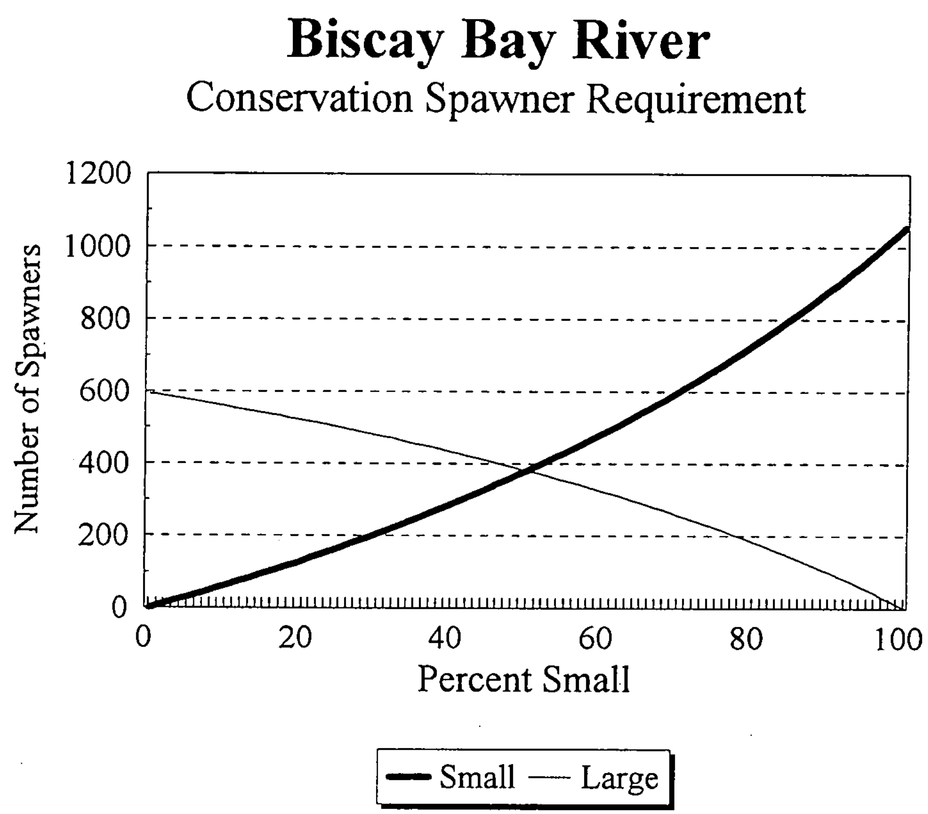

Fig. 15. Graphic representation showing the impact of selecting a particular percentage of conservation egg requirement to come from small salmon on the number of large salmon required to make up the remainder of the egg requirement, for Biscay Bay River. See text for further explanation.

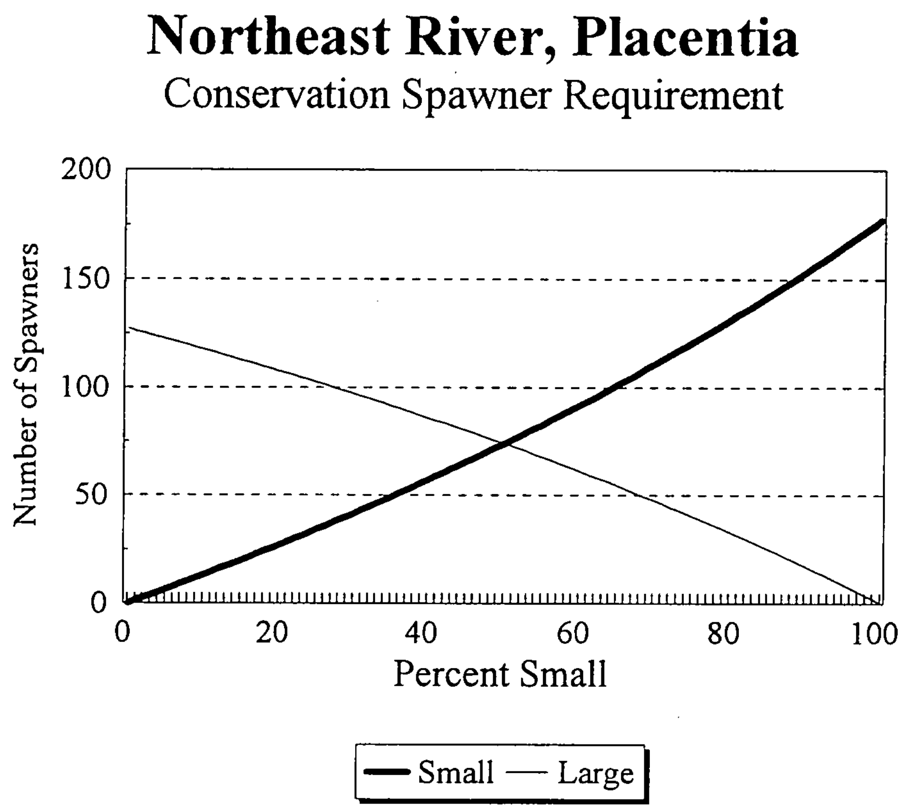

Fig. 16. Graphic representation showing the impact of selecting a particular percentage of conservation egg requirement to come from small salmon on the number of large salmon required to make up the remainder of the egg requirement, for Northeast River, Placentia. See text for further explanation.

Appendix 1. Atlantic salmon recreational fishery catch and effort data for Middle Brook, Bonavista Bay (SFA 5), 1974-96. Ret. = retained fish; Rel. = released fish.

	Effort	Small (<63 cm)			Large (>=63 cm)			Total (Small + Large)			
Year	Rod Days	Ret.	Rel.	Tot.	Ret.	Rel.	Tot.	Ret.	Rel.	Tot.	CPUE
1974	1823	277	.	277	11	.	11	288	.	288	0.16
1975	1635	415	.	415	8	.	8	423	.	423	0.26
1976	1339	280	.	280	2	.	2	282	.	282	0.21
1977	1511	767	.	767	3	.	3	770	.	770	0.51
1978	1322	391	.	391	1	.	1	392	.	392	0.30
1979	211	28	.	28	0	.	0	28	.	28	0.13
1980	1358	542	.	542	2	.	2	544	.	544	0.40
1981	1574	587	.	587	0	.	0	587	.	587	0.37
1982	2481	504	.	504	8	.	8	512	.	512	0.21
1983	1505	372	.	372	20	.	20	392	.	392	0.26
1984	2712	410	.	410	0	.	0	410	.	410	0.15
1985	2319	538	.	538	*	.	0	538	.	538	0.23
1986	2307	789	.	789	*	.	0	789	.	789	0.34
1987	840	187	.	187	*	.	0	187	.	187	0.22
1988	1545	708	.	708	*	.	0	708	.	708	0.46
1989	712	165	.	165	*	.	0	165	.	165	0.23
1990	949	349	.	349	*	.	0	349	.	349	0.37
1991	903	278	.	278	*	.	0	278	.	278	0.31
1992	1584	423	17	440	*	0	0	423	17	440	0.28
1993	1327	299	387	686	*	37	37	299	424	723	0.54
1994	2049	409	122	531	*	0	0	409	122	531	0.26
1995	2657	402	82	484	*	0	0	402	82	484	0.18
1996	2481	476	153	629	*	0	0	476	153	629	0.25
84-89 $\bar{X}$	1919.0	522.0	.	522.0	.	.	.	522.0	.	522.0	0.27
95% CL	988.5	308.0	.	308.0	.	.	.	308.0	.	308.0	0.15
N	5	5	0	5	0	0	0	5	0	5	5
86-91 $\bar{X}$	1283.2	457.8	.	457.8	.	.	.	457.8	.	457.8	0.36
95% CL	809.1	341.2	.	341.2	.	.	.	341.2	.	341.2	0.09
N	5	5	0	5	0	0	0	5	0	5	5
92-95 $\bar{X}$	1904.3	383.3	152.0	535.3	.	9.3	9.3	383.3	161.3	544.5	0.29
95% CL	929.2	90.4	258.6	170.5	.	29.4	29.4	90.4	287.1	198.3	0.21
N	4	4	4	4	0	4	4	4	4	4	4

1987 DATA NOT INCLUDED IN MEAN.

IN THE ABOVE TABLE A PERIOD INDICATES NO DATA FOR THAT YEAR.

CPUE IS BASED ON RETAINED + RELEASED FISH FOR 1992 - 96 AND ON RETAINED FISH ONLY PRIOR TO 1992.

* NOT ALLOWED TO RETAIN LARGE SALMON IN INSULAR NEWFOUNDLAND.

Appendix 2. Atlantic salmon recreational fishery catch and effort data for Terra Nova River, Bonavista Bay (SFA 5), 1974-96. Ret. = retained fish; Rel. = released fish.

	Effort	Small (<63 cm)			Large (>=63 cm)			Total (Small + Large)			
Year	Rod Days	Ret.	Rel.	Tot.	Ret.	Rel.	Tot.	Ret.	Rel.	Tot.	CPUE
1974	2098	243	.	243	5	.	5	248	.	248	0.12
1975	1723	506	.	506	2	.	2	508	.	508	0.29
1976	1236	424	.	424	7	.	7	431	.	431	0.35
1977	1956	850	.	850	13	.	13	863	.	863	0.44
1978	1608	628	.	628	6	.	6	634	.	634	0.39
1979	910	537	.	537	15	.	15	552	.	552	0.61
1980	872	512	.	512	22	.	22	534	.	534	0.61
1981	1303	739	.	739	33	.	33	772	.	772	0.59
1982	1174	465	.	465	24	.	24	489	.	489	0.42
1983	2157	486	.	486	43	.	43	529	.	529	0.25
1984	2042	636	.	636	0	.	0	636	.	636	0.31
1985	1810	751	.	751	*	.	0	751	.	751	0.41
1986	1485	620	.	620	*	.	0	620	.	620	0.42
1987	1764	546	.	546	*	.	0	546	.	546	0.31
1988	1613	682	.	682	*	.	0	682	.	682	0.42
1989	1946	357	.	357	*	.	0	357	.	357	0.18
1990	2165	624	.	624	*	.	0	624	.	624	0.29
1991	1701	448	.	448	*	.	0	448	.	448	0.26
1992	2488	409	141	550	*	0	0	409	141	550	0.22
1993	3925	484	569	1053	*	62	62	484	631	1115	0.28
1994	5853	822	178	1000	*	44	44	822	222	1044	0.18
1995	6042	696	132	828	*	72	72	696	204	900	0.15
1996	5933	896	260	1156	*	113	113	896	373	1269	0.21
84-89 $\bar{X}$	1779.2	609.2	.	609.2	.	.	.	609.2	.	609.2	0.34
95% CL	285.8	186.1	.	186.1	.	.	.	186.1	.	186.1	0.13
N	5	5	0	5	0	0	0	5	0	5	5
86-91 $\bar{X}$	1782.0	546.2	.	546.2	.	.	.	546.2	.	546.2	0.31
95% CL	338.2	170.4	.	170.4	.	.	.	170.4	.	170.4	0.12
N	5	5	0	5	0	0	0	5	0	5	5
92-95 $\bar{X}$	4577.0	602.8	255.0	857.8	.	44.5	44.5	602.8	299.5	902.3	0.20
95% CL	2688.0	302.4	334.6	360.4	.	50.7	50.7	302.4	355.9	399.8	0.09
N	4	4	4	4	0	4	4	4	4	4	4

1987 DATA NOT INCLUDED IN MEAN.

IN THE ABOVE TABLE A PERIOD INDICATES NO DATA FOR THAT YEAR.

CPUE IS BASED ON RETAINED + RELEASED FISH FOR 1992 - 96 AND ON RETAINED FISH ONLY PRIOR TO 1992.

* NOT ALLOWED TO RETAIN LARGE SALMON IN INSULAR NEWFOUNDLAND.

Appendix 3 Atlantic salmon recreational fishery catch and effort data for Biscay Bay River, St. Mary's Bay (SFA 9), 1974-96. Ret. = retained fish; Rel. = released fish.

	Effort	Small (<63 cm)			Large (>=63 cm)			Total (Small + Large)			
Year	Rod Days	Ret.	Rel.	Tot.	Ret.	Rel.	Tot.	Ret.	Rel.	Tot.	CPUE
1974	1043	71	.	71	1	.	1	72	.	72	0.07
1975	1553	108	.	108	0	.	0	108	.	108	0.07
1976	1074	168	.	168	0	.	0	168	.	168	0.16
1977	1607	144	.	144	0	.	0	144	.	144	0.09
1978	1790	121	.	121	5	.	5	126	.	126	0.07
1979	612	186	.	186	5	.	5	191	.	191	0.31
1980	392	283	.	283	32	.	32	315	.	315	0.80
1981	1181	424	.	424	31	.	31	455	.	455	0.39
1982	1044	367	.	367	9	.	9	376	.	376	0.36
1983	1064	414	.	414	10	.	10	424	.	424	0.40
1984	915	322	.	322	0	.	0	322	.	322	0.35
1985	1121	290	.	290	*	.	0	290	.	290	0.26
1986	1124	393	.	393	*	.	0	393	.	393	0.35
1987	1062	101	.	101	*	.	0	101	.	101	0.10
1988	1221	349	.	349	*	.	0	349	.	349	0.29
1989	965	102	.	102	*	.	0	102	.	102	0.11
1990	1165	232	.	232	*	.	0	232	.	232	0.20
1991	1134	10	.	10	*	.	0	10	.	10	0.01
1992	954	75	63	138	*	0	0	75	63	138	0.14
1993	1593	299	38	337	*	0	0	299	38	337	0.21
1994	1406	214	43	257	*	0	0	214	43	257	0.18
1995	1715	386	112	498	*	0	0	386	112	498	0.29
1996	1723	238	50	288	*	0	0	238	50	288	0.17
84-89 $\bar{X}$	1069.2	291.2	.	291.2	.	.	.	291.2	.	291.2	0.27
95% CL	156.3	139.4	.	139.4	.	.	.	139.4	.	139.4	0.11
N	5	5	0	5	0	0	0	5	0	5	5
86-91 $\bar{X}$	1121.8	217.2	.	217.2	.	.	.	217.2	.	217.2	0.19
95% CL	118.5	200.9	.	200.9	.	.	.	200.9	.	200.9	0.17
N	5	5	0	5	0	0	0	5	0	5	5
92-95 $\bar{X}$	1417.0	243.5	64.0	307.5	.	0.0	0.0	243.5	64.0	307.5	0.22
95% CL	531.1	210.8	53.7	240.3	.	0.0	0.0	210.8	53.7	240.3	0.10
N	4	4	4	4	0	4	4	4	4	4	4

1987 DATA NOT INCLUDED IN MEAN.

IN THE ABOVE TABLE A PERIOD INDICATES NO DATA FOR THAT YEAR.

CPUE IS BASED ON RETAINED + RELEASED FISH FOR 1992 - 96 AND ON RETAINED FISH ONLY PRIOR TO 1992.

* NOT ALLOWED TO RETAIN LARGE SALMON IN INSULAR NEWFOUNDLAND.

Appendix 4. Atlantic salmon recreational fishery catch and effort data for Northeast River, Placentia Bay (SFA 10), 1974-96. Ret. = retained fish; Rel. = released fish.

	Effort	Small (<63 cm)			Large (>=63 cm)			Total (Small + Large)			
Year	Rod Days	Ret.	Rel.	Tot.	Ret.	Rel.	Tot.	Ret.	Rel.	Tot.	CPUE
1974	1721	142	.	142	0	.	0	142	.	142	0.08
1975	877	121	.	121	4	.	4	125	.	125	0.14
1976	1164	147	.	147	1	.	1	148	.	148	0.13
1977	1465	180	.	180	1	.	1	181	.	181	0.12
1978	1237	161	.	161	0	.	0	161	.	161	0.13
1979	969	138	.	138	0	.	0	138	.	138	0.14
1980	1612	246	.	246	6	.	6	252	.	252	0.16
1981	2339	349	.	349	0	.	0	349	.	349	0.15
1982	1303	150	.	150	0	.	0	150	.	150	0.12
1983	2037	165	.	165	0	.	0	165	.	165	0.08
1984	988	70	.	70	0	.	0	70	.	70	0.07
1985	1276	173	.	173	*	.	0	173	.	173	0.14
1986	862	234	.	234	*	.	0	234	.	234	0.27
1987	349	36	.	36	*	.	0	36	.	36	0.10
1988	772	186	.	186	*	.	0	186	.	186	0.24
1989	852	210	.	210	*	.	0	210	.	210	0.25
1990	786	173	.	173	*	.	0	173	.	173	0.22
1991	153	19	.	19	*	.	0	19	.	19	0.12
1992	485	37	189	226	*	0	0	37	189	226	0.47
1993	592	132	61	193	*	0	0	132	61	193	0.33
1994	313	39	5	44	*	0	0	39	5	44	0.14
1995	544	127	8	135	*	0	0	127	8	135	0.25
1996	2883	268	7	275	*	0	0	268	7	275	0.10
84-89 $\bar{X}$	950.0	174.6	.	174.6	.	.	.	174.6	.	174.6	0.18
95% CL	245.8	78.2	.	78.2	.	.	.	78.2	.	78.2	0.11
N	5	5	0	5	0	0	0	5	0	5	5
86-91 $\bar{X}$	685.0	164.4	.	164.4	.	.	.	164.4	.	164.4	0.24
95% CL	372.4	105.0	.	105.0	.	.	.	105.0	.	105.0	0.03
N	5	5	0	5	0	0	0	5	0	5	5
92-95 $\bar{X}$	483.5	83.8	65.8	149.5	.	0.0	0.0	83.8	65.8	149.5	0.31
95% CL	193.8	84.1	137.0	126.9	.	0.0	0.0	84.1	137.0	126.9	0.19
N	4	4	4	4	0	4	4	4	4	4	4

1987 DATA NOT INCLUDED IN MEAN.

IN THE ABOVE TABLE A PERIOD INDICATES NO DATA FOR THAT YEAR.

CPUE IS BASED ON RETAINED + RELEASED FISH FOR 1992 - 96 AND ON RETAINED FISH ONLY PRIOR TO 1992.

* NOT ALLOWED TO RETAIN LARGE SALMON IN INSULAR NEWFOUNDLAND.