ASSESSMENT OF ATLANTIC SALMON (Salmo salar) IN THE MARGAREE RIVER, NOVA SCOTIA 1990

by

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ABSTRACT

The recreational catch of Atlantic salmon from the Margaree River between June 1 and Oct. 15, 1990 was estimated by creel survey at 252 grilse (<63 cm fork length) and 1,693 MSW released. Exploitation rate estimates for the fall recreational fishery, based on recaptures of salmon tagged and released at the estuary, were 25% and 17% for grilse and MSW respectively. These rates are almost double the previous estimates for 1988 and 1989. Escapement in 1990 was 4 to 15 times requirements.

The exploitation rates derived are kill (single capture) estimates. When these are applied to released fish, which probably include multiple captures, estimated returns are inflated. Thus, escapements for 1990 are considered to be maximum estimates.

RÉSUMÉ

Depuis 1 juin au 15 octobre 1990, les prises récréatives de saumon atlantique de la rivière Margaree s'élevaient à 252 unibermarins (< 63 cm de longueur à la fourche) et 1,693 rédibermarins. Les taux d'exploitations durant l'automne, estimés par l'entremise de captures de saumons étiquetés dans l'estuaire, se situaient à 25% et 17% sur les unibermarins et rédibermarins respectivement. Ces taux sont supérieurs aux estimés de 1988 et 1989. Le retour de saumons en 1990 était de 4 à 15 fois supérieure aux besoins de géniteurs pour la rivière Margaree.

Ces taux d'exploitation ont tendance à exagérer le niveau de la remontée, étant des estimés de taux de captures pour des poissons retenus. Puisque les rédibermarins doivent être remis à l'eau et que les saumons pourraient être pris plus qu'une fois dans la pêche récréative, la remontée en 1990 est un estimé maximum.

INTRODUCTION

This is the seventh assessment of the Margaree River Atlantic salmon (Salmo salar) resource. Previous assessments have been presented for the 1983, 1985 to 1989 salmon returns (Gray and Chadwick 1984; Claytor and Chadwick 1985; Claytor and Leger 1986; Claytor et al. 1987; Claytor and Chaput 1988; Claytor and Jones 1990).

The Margaree River is situated on Cape Breton Island, Inverness County, Nova Scotia (Fig. 1). The two principal branches, the Southwest and the Northeast Margaree meet at Margaree Forks to form the Margaree River which flows into the Gulf of St. Lawrence. Most of the recreational fishery takes place in the Northeast Margaree and Margaree River proper although the Southwest Margaree is fished in the fall. The Margaree River salmon has traditionally been considered as having two run components, the summer run which for statistical purposes ends on August 31, and the fall run occurring from September 1 onwards.

Since 1979, numerous regulatory restrictions have been imposed in order to increase the summer component (Chaput and Claytor 1988). Mandatory release of MSW salmon ($\geq$ 63 cm fork length) angled before Sept. 1 has been in place since 1979. Since 1985, all MSW salmon have been released regardless of date. There was no change in the recreational fishery regulations in 1990; season June 1 to Oct. 15, maximum of 10 grilse kept (< 63 cm fork length), all kept grilse to be tagged, all MSW released. Restrictions on the commercial fishery were introduced in 1984 through a season reduction from 8 to 3 weeks followed by closure of the fishery in 1985. The commercial fishery of Salmon Fishing Area 18 (Gulf Nova Scotia) has remained closed since 1985. Commercial landings prior to 1985 are summarized in Claytor and Jones (1990).

On Oct. 5, 1990, a two week extension to the angling season to Oct. 31 was announced. The extension had been requested by the Margaree Salmon Association and was announced at the annual meeting of the association by the Regional Director General, Dept. of Fisheries and Oceans, Gulf Region.

MATERIALS AND METHODS

Estimation of Sport Catch

Sport catch estimates were obtained from three sources. Fisheries officers from the Dept. of Fisheries and Oceans (DFO) at Margaree Forks, Nova Scotia have provided angling estimates from 1947 to 1990. Sport catches for 1984 to 1989 were obtained from Nova Scotia license stub returns (LIC) (O'Neil et al. 1985, 1986, 1987, S. O'Neil, DFO Halifax, Nova Scotia). Preliminary 1990 estimates were obtained from S. O'Neil, DFO Halifax, Nova Scotia. The estimation procedures for the LIC returns are outlined in Claytor and O'Neil (1990b). Angling catch as estimated from creel surveys for 1987 to 1989 are also presented (Claytor and Jones 1990).

1990 Creel Method

The creel census conducted in 1990 differs from previous creels of 1987 to 1989. An access site survey analogous to a bus route was conducted. The theoretical basis for such a survey has been described by Robson and Jones (1989) and behaviour of the statistical estimators has been reported by Jones et al. (1990). A total of 10 index pools were selected along the main Margaree and the Northeast Margaree River (Fig. 1). The creel clerk travelled sequentially in an upstream direction from one pool to the next monitoring the catch and effort at each pool. Observed effort (total minutes fished by all anglers at each pool) and observed catch was recorded by the clerk. Observed effort represents time when anglers were actually fishing. Observed catch categories were similar to previous creel surveys, kept for grilse, release methods for grilse and MSW salmon (removed hook by hand, cut line, other intentional release) and lost category for grilse and salmon (Claytor and Chaput 1988). The period of observation was one hour at each pool. The starting pool on any given day was selected randomly.

Sampling during the entire season was stratified into 8 strata and selection of days and periods to be sampled was made independently in each stratum. The 8 strata were:

1) summer, weekday, June
2) July
3) Aug.
4) summer, weekend, June
5) July
6) Aug.
7) fall, weekday, Sept. 1 to Oct. 15
8) weekend, Sept. 1 to Oct. 15.

Proportion of weekdays covered was 2/3 whereas weekend coverage was 3/4. Days were divided into AM and PM periods. Replication within the AM/PM cells was also included in the design such that within day variation could be considered. The randomization procedure is more fully described in Appendix 1. The variance estimate calculated (Yates/Grundy estimate, Robson 1990) represents the variance of the total for the stratum rather than the variance associated with the mean of the stratum.

Estimates of total effort and catch by season (summer, fall) and for the entire year were obtained by:

Total (effort or catch) = sum of stratum effort or catch for all strata

Variance (effort or catch) = sum of stratum variance for all strata.

Std Error = square root of variance.

95% confidence intervals for total effort or catch were calculated using the approximation to the normal distribution, i.e. plus or minus two standard errors.

In order to estimate the effort for the entire river, angler counts at each of 32 pools, including the 10 index pools, were obtained using selected sampling periods during weekday and weekend strata and AM / PM categories. A total of 13 river counts were obtained, 9 for the summer and 4 from the fall. Estimates of effort during the river counts are based on roddays, one angler observed equals 1 rodday.

Logbook Reports

Volunteer angler logbook reports detailing daily catch by size, effort in hours and pools fished were received and processed as in previous assessments.

Estimation of Exploitation Rates

Exploitation rate estimates on grilse and MSW salmon during the fall are available for 1988 and 1989 (Claytor and O'Neil 1990a). An exploitation rate estimate for the fall fishery was also calculated in 1990 through tagging of salmon and recaptures in the angling fishery.

Tagging Procedures

Trapnets identical in construction and installation to previous studies (Claytor and Chaput 1988) were fished in the Margaree River tidal waters between Sept. 6 and Oct. 16. All salmon captured in the trapnets were marked using Carlin tags with a single steel wire attachment. Recoveries of tags from the angling fishery were obtained from logbook anglers and returns by mail.

Tag Loss Estimate

All salmon collected for broodstock on Aug. 27, 1990 were marked with Carlin tags prior to confinement in the holding tanks at Margaree Fish Culture Station. Tagging method was similar to that used at the estuarine trapnets. The ratio of tags lost to tags initially placed divided by the number of days since marking provided the estimate of tag loss.

Nonreporting Rate Estimate

A nonreporting rate estimate was calculated using the ratio of tags returned to total catch reported from the logbook anglers and the tags returned from index pools to estimated catch at index pools from the creel survey.

Spawning Requirements and Spawning Escapement

Spawning requirements for the Margaree have been calculated (Claytor and Jones 1990). Spawning escapement to Margaree River was calculated as follows (Claytor and Jones 1990):

$$\frac{\text{Sport Catch (SC)}}{\text{Sport Catch (SC) + Spawners}} = \text{Exploitation Rate (ER)}$$

$$\text{Spawners} = \frac{\text{SC (1 - ER)}}{\text{ER}}$$

For the years 1947 to 1986, DFO estimates of catch were used. For 1987 to 1990, creel survey estimates of sport catch are used. Hook and release regulations for MSW have been in effect since 1979 and consequently, hook and release fish are added to the spawner calculation above. Egg deposition and spawner requirements for the Margaree River were calculated as in Table 12. Broodstock collections were subtracted from egg deposition estimates resulting in net egg deposition in the river.

Hatchery Releases and Returns

Releases of hatchery fish by life stage were obtained from L. Forsythe, DFO, Margaree Fish Culture Station, Nova Scotia. The proportion of hatchery and wild salmon returning to Margaree river were determined from angler logbook, creel survey, broodstock collections and trapnet catches. Identification of hatchery released fish was based upon the absence of the adipose fin.

RESULTS

Angling catch estimates from DFO for 1947 to 1990 are presented in Table 1. Nova Scotia license stub (LIC) catch estimates for 1984 to 1989 and preliminary estimates for 1990 are presented in Table 2.

The creel catch for 1990 from the 10 index pools was estimated at 168 grilse (95% C.I. 58 to 278) and 725 MSW released (95% C.I. 390 to 1060) (Table 3). Catch of grilse from the summer was estimated at 135 whereas fall catch was 33 (Table 3). The precision of the estimated grilse catch by season was $\pm$ 75% for the summer season and $\pm$ 128% for the fall on account of the small numbers of grilse observed (Table 3). MSW estimated catch in the summer was 192 and 533 for the fall with a precision of $\pm$ 65% for summer and 58% for fall (Table 3). Precision of the estimated catch for the entire angling season is better, $\pm$ 66% for grilse and $\pm$ 46% for MSW (Table 3). Estimates of effort expended are almost 5 times more precise at $\pm$ 10% for the whole season (Table 3).

Estimates of effort for the entire river were obtained by weighting the estimated effort at the 10 index pools by the proportion of effort at the ten pools relative to effort on the entire river. Catch from the entire river for the summer was estimated using the proportion of effort expended at the index pools. This estimate assumes that catch is directly related to effort regardless of location on the river which may not be true. However, a majority (71% by rodday) of the effort in the summer was recorded from the index pools therefore, the expansion to entire river catch using effort should be reasonable. The proportion of the catch at index pools for the fall was directly estimated from tag returns. The proportion of tags returned from index pool angling to total tags returned from known pools was used to expand the creel estimates of grilse and MSW to catch from the entire river for the fall (Table 3). This expansion for the fall resulted in an estimated hook and release estimate of 1,421 MSW and 61 grilse kept(Table 3). Total catch for 1990 was estimated at 252 grilse and 1693 MSW released (Table 3). Overall effort per day expended in the fall was twice the summer effort; summer effort was expended over 3 months while fall effort occurred over 1.5 months (Table 3).

The relative catches of grilse and MSW since 1985 by collection method are distributed as follows:

Grilse	
DFO Statistics	1989 < 1990 < 1985 < 1986 < 1987 < 1988
LIC Statistics	1985 < 1990 < 1989 < 1986 < 1988 < 1987
Creel	1989 < 1990 < 1987 < 1988
MSW	
DFO Statistics	1989 < 1985 < 1990 < 1987 < 1988 < 1986
LIC Statistics	1990 < 1985 < 1989 < 1987 < 1988 < 1986
Creel	1988 < 1989 < 1987 < 1990

DFO and creel estimates follow a similar progression of catches of grilse, 1988 catch being largest and 1989 catch being least. LIC statistics were somewhat different with 1988 and 1987 inverted from Creel and DFO. MSW catch progression corresponds most closely between DFO and LIC. Creel estimates indicated that 1988 was lower than other years, LIC and DFO indicated 1988 as second largest only to 1986.

The catch proportions by season were different among DFO and creel statistics. In 1990, creel estimates indicated that the grilse catch was 24% fall angling which contrasts with DFO values of 59% fall angling (Table 4). MSW releases were less different between DFO and creel, 1990 values were 61% fall release by DFO versus 84% fall releases from creel. Estimates from previous years were closer (Table 4).

Logbook returns indicated that catch per unit effort (CPUE = fish per hour) for MSW was highest in August and overall summer CPUE as high as fall values (Tables 5 & 6). Similarly, CPUE for grilse was highest in August with summer CPUE as high as fall. This differs from the creel data which suggested that catches for grilse were best in July but low in June and fall (Table 6). MSW CPUE was highest in fall followed by August and June but summer CPUE was half

that of the fall (Table 6).

Proportions MSW in the creel estimates were 59% for summer and 94% for fall (Table 7). Proportions from logbook returns were 55% for summer and 58% for fall (Table 7). The estimated proportion from the trapnet catches in the fall was 64% MSW, which was most different from the proportions in the creel survey.

Extension of the Margaree Angling season to Oct.31, 1990

On October 5, 1990, a two week extension to the angling season for the Margaree River was announced. Conditions applied to the extension were:

1) all waters upstream of Cranton Bridge were closed to angling after October 15,

2) all waters of the Southwest Margaree would remain open,

3) that the angling group which requested the extension would provide monitoring of the fishery to allow immediate closure if fish in spawning condition were being angled.

The fishery remained open to October 31 and the catch estimated by the volunteers undertaking a creel on the river was 29 grilse kept or released, 118 MSW released (W. Barrington, DFO Conservation and Protection Branch, Margaree Forks, NS).

Distribution of Tagging and Recaptures

Tags were recovered in the angling fishery for all tag groups released from the estuary trapnets between weeks 36 and 40 except for grilse released in week 38 and MSW released in week 36 (Table 8). With only one exception, salmon tagged in weeks 41 and 42 (Oct. 8 to 16) were not recovered in the fishery. Because the fishery ended Oct. 15 and mean time to recapture was 7.7 and 10.9 days for MSW and grilse respectively, salmon tagged during weeks 41 and 42 were considered unavailable to the fishery and omitted from subsequent analyses.

Estimation of Tag Loss

Of eighteen tagged fish examined from the broodstock tanks 21 days after tagging, 5 MSW did not have tags and tagging scars were observed. On that basis, a tag loss rate of 0.013 tags per day was estimated (Table 9). The mean times between tagging at the trapnets and recoveries in the recreational fishery were 10.9 days for grilse and 7.7 days for MSW. The proportions of tags available to the recreational fishery from the trapnet tagging were calculated to be 0.86 for grilse and 0.90 for MSW (Tables 9 & 10).

Estimation of Nonreporting Rate

The total estimated catch and releases from logbook anglers for the fall were 28 grilse and 39 MSW released (Table 5). These values are based on 24 logbook reports for September and 18 for October. Total tag returns from the logbook anglers were 3, 2 grilse and 1 MSW. An estimate of the nonreporting rate from the angling fishery was calculated using total tags to harvest from the logbook anglers versus total tags returned from index pools to estimated harvest from the index pools (Table 9). Assuming that 100% of observed tags are returned by logbook anglers, a nonreporting rate of 0.49 was estimated for the fall 1990 (Table 9). A range of nonreporting rates using the 95% confidence interval for index pool catch resulted in nonreporting rates of 0% (actually -31%) to 68% (Table 9). The value is just within the range of values estimated from other angling fisheries and is substantially higher than the 33% nonreporting rate value estimated by Claytor and O'Neil (1990a).

Exploitation Rate (ER)

The exploitation rate (ER) on grilse in the fall for Margaree River was estimated at 0.25 whereas that for MSW was 0.17 after adjusting for tag loss and nonreporting rate (Table 10). These exploitation rates are twice previously estimated fall exploitation rates for the Margaree from 1988 and 1989. Grilse exploitation rates have consistently been estimated to be greater than the MSW exploitation rates, as shown below:

	Exploitation Rate		
Year	Grilse	MSW	Reference
1988	16%	8%	Claytor and O'Neil (1990a)
1989	10%	7%	Claytor and O'Neil (1990a)

Estimates of Returns in 1990

Returns to the Margaree River in the fall 1990 based on creel catch estimates and estimated exploitation rates were 244 grilse and 8,359 MSW (Table 11). Over the range of exploitation rates estimated for fall 1990, the returns of grilse were 156 to 469 and 5,263 to 15,789 for MSW (Table 11). The returns estimate for grilse (156) at the higher exploitation rate is not reasonable given that a total of 154 grilse were marked and released in the estuary between Sept. 4 and Oct. 15.

Egg Deposition

Spawning requirements for Margaree River are estimated to be 1036 MSW and 582 grilse (Table 12). Egg depositions using angling catches and exploitation rates of 20.6 and 37.9% for 1947 to 1989 have been provided by Claytor and Jones (1990). At the exploitation rates (25% for grilse, 17% for MSW) estimated in 1990, egg depositions from fall MSW were almost 9 times requirement and the lower estimate was 3 times requirement (Table 11). At the exploitation rates used in

previous assessments, summer returns of MSW would have provided all the required egg deposition at the 20.6% ER but not at the 37.9% ER (Table 11). Egg depositions for the total returns were between 59 and 63 million eggs, 10 times requirements within a range of 24 to 100 million (3 to 15 times requirements) (Table 11). Using the historical exploitation rates of 20.6 and 37.9%, estimated egg depositions for 1990 were 53 and 29 million eggs respectively, ranging between 22 and 85 million at 20.6% ER and 12 to 46 million at 37.9% ER. These values are twice the previously estimated high depositions of 1987.

Hatchery Contributions

Hatchery releases by life stage into Margaree River are summarized for 1976 to 1990 (Table 13). Hatchery returns in summer 1990 made up 28% of the grilse samples and 35% of the MSW samples. Fall proportions for hatchery fish were substantially less at 4.3% for grilse and 6.2% for MSW (Table 14).

Estimated contributions of hatchery fish to total returns based on a fixed exploitation rate for summer and fall have ranged between 17 and 55% for grilse and 11 to 17% for MSW since 1987 and were 22% and 11% respectively in 1990 (Table 15).

In 1990, approx. 380,000 eggs were removed during the broodstock collection.

Sea Migrations

Margaree River salmon have been intercepted in fisheries throughout the northwest Atlantic including Greenland, Newfoundland, Labrador and Quebec (Table 16).

DISCUSSION

Estimates of tag loss rate to the angling fishery from the tagging trapnets for 1990 (0.14 for grilse and 0.10 for MSW) are lower than values estimated previously (0.26) (Claytor and O'Neil 1990b). The nonreporting rate value for 1990 was higher than the 33% value used previously and almost outside the range of values (20 to 50%) included by Claytor and O'Neil (1990b). This difference in the nonreporting rate accounted in large part for the higher exploitation rate values estimated for grilse and MSW in 1990 compared to those estimated previously (14 to 20% for grilse, 6 to 10% for MSW) (Claytor and O'Neil 1990b).

The exploitation rate was higher in 1990 than in 1989 based on the number of returns to tags placed; 31 tags out of 439 salmon marked in 1990 (7.1%) compared to 19 returns out of 425 salmon tagged in 1989 (4.5%). The returns in 1988 were similar to 1990, 25 out of 328 tags applied (7.6%). These suggest that

the exploitation rates are probably at the upper end of the range estimated for grilse and MSW and that the mean estimates for 1990 are reasonable (25% for grilse and 17% for MSW). Although higher than recent estimates for the fall, these values are closer to the 20.6% value obtained by Marshall (1982) using data from Hayes (1949). Exploitation has consistently been higher on grilse than on MSW.

Creel surveys have been previously described as a cost-effective method of obtaining unbiased harvest statistics from small angling fisheries (Claytor and O'Neil 1990b). The creel survey conducted in 1990 was based upon a sampling design which allowed the quantification of the variance and an estimation of confidence intervals. Since estimates of catch were obtained from observed catch and effort rather than interviews and collation of unobserved catches and effort, these values are unbiased and provide the best indication of trends in the fishery. The precision of the grilse estimate for the fall is poor ($\pm$ 128%) and is a reflection of the low observed catch. Precision for MSW was substantially better at $\pm$ 58% and overall estimates of harvest are within 66 and 46% for grilse and MSW respectively. This is the first estimate of harvest statistic precision for the Margaree recreational fishery and improvements in precision would be possible only through increased creel effort or increased fishing success on the part of the anglers. Precision of the estimates is improved as more data values other than 0 are recorded, as reflected in the effort estimate for 1990.

Previously, Claytor and O'Neil (1990a) had used proportion MSW in the trapnet catches and population estimates of returns to validate the creel estimation method over LIC and DFO statistics. In 1990, a population estimate was not calculated because of insufficient number of recaptures at the upper net from lower net tagging. In contrast to previous years, the proportion of MSW in the trapnet catches was greatly different from the proportion in the creel estimated catch for the fall. This discrepancy could have arisen from two sources:

1) the trapnets were catching proportionally more grilse than MSW,
2) grilse were being harvested disproportionately from pools other than the index pools,

Hypothesis 1 is possible. Of the five recaptures in the upper net of salmon tagged at the lower net, 4 were grilse. The ratio of grilse recaptured to grilse marked from the lower net was 0.058 (4 of 69). In contrast, 121 MSW were marked and released giving a ratio of recaptured to marked of 0.008, one salmon for every seven grilse recaptured. In 1988, the ratios of recaptured to marked were 0.03 for grilse and 0.05 for MSW or almost one to one, while in 1989, ratios were 0.075 for grilse and 0.020 for MSW or almost 4 grilse for every salmon. These data suggest that in 1989 and 1990, the trapnets were capturing a greater proportion of grilse than MSW entering the river.

Hypothesis 2 does not appear plausible. The estimated proportional effort for the river was 51% at index pools and 54% of the grilse recaptures were reported from the index pools. The similarity of these proportions does not support the second hypothesis.

The proportion of MSW in the logbook reported catch was closer to trapnet proportion than the creel proportion and this would suggest that the creel estimates were inaccurate. Creel and logbook proportions were similar during the summer but differed dramatically in the fall. Since the creel methodology was consistent during the entire season, it can only be concluded that the logbooks are biased. Individuals may have been targeting certain pools of the river where they would likely capture grilse rather than MSW fish, which would account for the differences between creel and logbook proportions.

The application of the exploitation rates determined in 1990 to estimates of hook and release MSW from the creel suggest that spawning escapements for Margaree were 4 to 15 times required.

One of the difficulties in applying the exploitation rates derived in 1990 and in previous assessments to the creel estimates of MSW releases is that the exploitation rate estimates are kill estimates whereas MSW release probably include multiple releases. The exploitation rates are kill exploitation rate values because tags are removed from grilse and MSW when they are captured, even if released. There is anecdotal evidence from anglers of fish being caught with previous angling scars (for ex. flies still in the jaw). In addition, one tagged MSW in 1987 was angled twice on the Margaree, it was released with the tag still in place one day and angled the next day from a pool farther up river.

If kill exploitation rates are applied to hook and release fish, the estimated returns would be inflated. The inflation factor can only be quantified through tagging and releasing of angled fish. The estimate of returns of MSW in the fall of 1990 should be considered as maximum estimates of returns given the likelihood of multiple releases.

A creel survey as undertaken in 1990 provides the only reliable source of catch and effort data. Although Jones et al. (1990) provided an indication of the characteristics of the creel estimator for effort, (it was very close to the t-distribution), the behaviour of the estimator relative to infrequently observed events such as observed catches in Atlantic salmon recreational fisheries remains to be documented.

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Appendix 1. Steps in the creel survey undertaken in 1990.

1) Index pools selected (see Figure 1 for locations).

Lower Thompkins	LTHOM	
Seal	SEAL	
Forks	FORKS	
Doyles Bridge	DOYLES	
Little McDaniel	LMCD	
Cranton Bridge	CRAN	
Redbank	REDB	for June 1 to Aug. 31
Harts	HART	for Sept. 1 to Oct. 15
Hatchery	HATC	
Ross Bridge	ROSS	
Tent	TENT	

2) Selection of sampling periods and dates.
(shuffling down rows)

Ex. June weekend days

Design Matrix

	Before Randomization		After Randomization	
	AM	PM	AM	PM
602	1	1	0	0
603	1	0	1	0
609	0	1	0	1
610	1	0	0	0
616	0	1	1.01	0
617	1.01	0	0	1
623	0	0	1	1
624	0	0	0	0
630	0	0	1	0

1.01 is assigned to AM or PM randomly

Selection of starting pool is done randomly
Direction of travel was upstream
AM period = 600 to 1330 (June 1 to Aug. 31)
sunrise + 7.5 hours (Sept. 1 to Oct 15)
PM period = 1330 to 2100 (June 1 to Aug. 31)
-7.5 hours to sunset (Sept. 1 to Oct. 15)

3) Estimation of catch or effort for the index pools by sampling period.

Ex. June 3, Summer Weekend, AM
T = route time (hrs) = 12.33
w = waiting time at each pool = 1 hr

Pool	Angler #	Effort (mins)		Total
FORKS	-	0	=	0
DOYLES	1	30		
	2	20	=	50
LMCD	1	60		
	2	16		
	3	25	=	101
CRAN	-	0	=	0
REDB	1	25	=	25
HATC	1	52	=	52
	Total Observed Effort			228

$$\text{Effort (603, AM)} = \frac{12.33}{1.0}\,(0 + 50 + 101 + 0 + 25 + 52)$$

= 2811 (mins) or 46.9 hrs.
which is the total estimated effort at the 10 index pools for the AM period, June 3, 1990.

4) Estimation for a stratum, for example June, summer, weekend.

	Design Matrix AM	PM	Weight Matrix Horvitz-Thompson AM	PM
602	0	0	0	0
603	1	0	2.57	0
609	0	1	0	2.57
610	0	0	0	0
616	1	0	2.57	0
617	0	1	0	2.57
623	1	1	2.57	2.57
624	0	0	0	0
630	1	0	2.57	0
Total Periods	9	9	10.28	7.71
	18		18	

	Observed Matrix AM	PM	Estimated Matrix AM	PM
602	0	0	0	0
603	47	0	121	0
609	0	34	0	87
610	0	0	0	0
616	115	0	296	0
617	0	34	0	87
623	110	103	283	265
624	0	0	0	0
630	65	0	167	0

Estimated Total Effort for June, weekends: 1306 hrs

Variance of the total estimate was calculated using the Yates-Grundy variance estimator (Robson, D. 1990, manuscript).

Table 1. Salmon angling catch on Margaree River (1947-1990) as compiled by Department of Fisheries and Oceans fisheries officers (DFO statistics).

Year	1SW	MSW			Total
		Retained	Released	Total	
1947	36	364			400
1948	106	704			810
1949	42	340			382
1950	113	326			439
1951	21	449			470
1952	84	207			291
1953	50	298			348
1954	70	306			376
1955	53	258			311
1956	28	91			119
1957	36	136			172
1958 *	N/A	N/A			334
1959 *	N/A	N/A			235
1960 *	N/A	N/A			140
1961	33	56			89
1962	46	410			456
1963	87	212			299
1964	120	289			409
1965	86	254			340
1966	92	165			257
1967	100	271			371
1968	65	203			268
1969	218	141			359
1970	86	217			303
1971	21	94			115
1972	42	105			147
1973	166	117			283
1974	60	107			167
1975	36	64			100
1976	96	82			178
1977	69	141			210
1978	25	158			183
1979	604	63	19	82	686
1980	173	143	2	145	318
1981	909	106	34	140	1049
1982	692	103	76	179	871
1983	69	109	43	152	221
1984	148	12	109	121	269
1985	223	0	313	313	536
1986	295	0	754	754	1049
1987	353	0	408	408	761
1988	435	0	580	580	1015
1989	179	0	244	244	423
1990	208	0	314	314	522

* Information regarding 1SW and MSW salmon for 1958-1960 are not available

Table 2. Salmon angling catch from the Margaree River, 1984-1990, based on Nova Scotia license stubs. N/A not available.

	No. of Anglers	Grilse			MSW			Unknown	Rod-days
		Retain	Release	Total	Retain	Release	Total		
1984	678	190	50	241	9	294	303	4	6,669
1985	793	399	110	509	0	1,215	1,215	3	7,824
1986	1,131	650	132	782	0	2,636	2,636	2	10,232
1987	1,441	826	151	977	0	1,857	1,857	0	12,887
1988	N/A	784	N/A	N/A	0	2,017	2,017	N/A	15,080
1989	N/A	428	125	553	0	1,549	1,549	N/A	13,234
1990	597	420 to date	91	511	0	1,213	1,213	N/A	12,977

Rod-days are defined as one angler fishing for any portion of one day.
1990 values are preliminary.

Table 3. Estimation of total catch and effort (hours) from the Margaree River, June 1 to Oct. 15, 1990. Adjusted catch for the fall based on recaptures of salmon marked prior to week 41 (Table 8).

		Estimate of Total	C.I. (95%) Lower	Upper	Precision +/- %
Estimates of catch and effort at the index pools					
SUMMER	GRILSE	135	33	237	75.4%
	MSW	192	68	316	64.7%
	EFFORT	10562	9257	11867	12.4%
FALL	GRILSE	33	-9	75	128.4%
	MSW	533	222	844	58.4%
	EFFORT	11991	10083	13899	15.9%
TOTAL	GRILSE	168	58	278	65.6%
	MSW	725	390	1060	46.2%
	EFFORT	22553	20241	24865	10.3%

River Counts (# of anglers)

	Total at Index Pools	Total from 32 Pools	Proportion Effort
Summer (N=9)	82	116	0.707
Fall (N=4)	108	211	0.512

Proportion Catch for Fall based on Tag Returns

	Tags from Index Pools	Tags from All Pools	
Grilse	7	13	0.538
MSW	6	16	0.375

Adjusted Catch (Summer uses proportion effort, Fall uses proportion catch) and Effort (uses proportion effort) for 32 pools.

		Estimate	Range Lower	Upper
SUMMER	GRILSE	191	47	335
	MSW	272	96	447
	EFFORT	14941	13095	16787
FALL	GRILSE	61	0	140
	MSW	1421	591	2252
	EFFORT	23427	19699	27155
TOTAL	GRILSE	252	47	475
	MSW	1693	687	2699
	EFFORT	38368	32794	43942

Table 4. Seasonal grilse and MSW catches according to DFO sport catch and creel estimates, 1984 to 1990.

Type	Year	Grilse			MSW		
		Summer	Fall	% Fall	Summer	Fall	% Fall
DFO	1990	85	123	59%	124	190	61%
	1989	130	49	27%	80	164	67%
	1988	287	148	34%	293	287	49%
	1987	268	85	24%	123	285	70%
	1986	196	99	34%	297	457	61%
	1985	116	107	48%	144	168	54%
	1984	81	67	45%	27	94	78%
Creel	1990	191	61	24%	272	1421	84%
	1989	151	57	27%	152	311	67%
	1988	367	222	38%	190	178	48%
	1987	306	97	24%	242	561	70%

Table 5. Summary of monthly effort, catch and catch per unit effort (CPUE) from logbook anglers on Margaree River, 1990.

SEASON	MONTH	NUMBER LOGBOOKS	EFFORT		GRILSE			SALMON		CATCH/UNIT EFFORT	
			ROD DAYS	HOURS	KEPT	RELEASED	TOTAL	RELEASED	TOTAL	ROD DAYS	HOURLY
SUMMER	JUNE	15	84	346	0	0	0	7	7	0.083	0.020
	JULY	19	128	653	6	0	6	5	11	0.086	0.017
	AUGUST	15	147	714	25	2	27	29	56	0.381	0.078
	SUB-TOTAL		359	1713	31	2	33	41	74	0.206	0.043
FALL	SEPTEMBER	24	189	1069	15	4	19	19	38	0.201	0.036
	OCTOBER	18	117	672	7	2	9	20	29	0.248	0.043
	SUB-TOTAL		306	1741	22	6	28	39	67	0.219	0.038
TOTAL SEASON			665	3454	53	8	61	80	141	0.212	0.041

Table 6. Catch per unit effort (fish per hour) from logbook reports and creel survey.

Period	Grilse		MSW	
	Creel	Logbook	Creel	Logbook
June	0.000	0.000	0.021	0.020
July	0.022	0.009	0.010	0.008
August	0.015	0.038	0.021	0.041
Summer	0.013	0.019	0.018	0.024
Fall	0.003	0.016	0.044	0.022
Total	0.007	0.018	0.032	0.023

Table 7. Percent MSW in observed catches from creel survey, logbook reports and trapnet catches from Margaree River, 1990.

	Creel			Logbooks			Trapnets pre week 41		
	1SW	MSW	% MSW	1SW	MSW	% MSW	1SW	MSW	% MSW
June	0	63	100	0	7	100			
July	66	30	31	6	5	45		N/A	
August	69	99	59	27	29	52			
Summer	135	192	59	33	41	55			
Fall	33	533	94	28	39	58	120	217	64

Table 8. Distribution of recaptures in the angling fishery by standardized week tagging groups for grilse and MSW, fall 1990.

Dates	Standardized Week	Total Tagged	Recaptures in the angling fishery: Index Pools	Other Pools	Unknown Pools	Total Returns	Prop. Returned
Grilse							
Sept. 3 - 9	36	10	0	1	0	1	0.10
Sept. 10-16	37	8	2	0	0	2	0.25
Sept. 17-23	38	16	0	0	0	0	0.00
Sept. 24-30	39	35	2	1	0	3	0.09
Oct. 1 - 7	40	51	3	4	0	7	0.14
Oct. 8 -14	41	33	0	0	0	0	0.00
Oct. 15-21	42	1	0	0	0	0	0.00
	Total	154	7	6	0	13	0.08
MSW							
Sept. 3 - 9	36	14	0	0	0	0	0.00
Sept. 10-16	37	10	1	1	0	2	0.20
Sept. 17-23	38	28	0	1	0	1	0.04
Sept. 24-30	39	88	3	6	0	9	0.10
Oct. 1 - 7	40	77	2	2	1	5	0.06
Oct. 8 -14	41	65	0	1	0	1	0.02
Oct. 15-21	42	3	0	0	0	0	0.00
	Total	285	6	11	1	18	0.06

Table 9. Estimates of tag loss/tagging mortality and nonreporting rate from the recreational fishery, Margaree River, 1990.

Tag Loss Estimate

No. of fish examined	18
No. of fish with tags	13
Days since marking	21

$$\text{Tag Loss} = \frac{\text{Fish examined - fish with tags}}{\text{Fish examined}}$$

$$= \frac{(18 - 13)}{18}$$

$$= 0.278$$

$$\text{Rate per Day} = \text{Tag Loss / Days since tagging}$$

$$= 0.013$$

Nonreporting Rate Estimate

A - Uses the ratio of reported tags to anglers as rate of returns for 100% reporting.

B - Uses ratio of returned tags from index pools and estimated catch from index pools from creel survey as indication of partial returns.

Nonreporting rate = (1 - B/A)

Source	Fall Harvest	Fall Recaptures	Marked/ Total
All Salmon			
Logbooks	67	3	0.0448
Index Pools			
Creel Estimate	566	13	0.0230
C.I.	(222 - 919)		

Nonreporting Rate Estimate = 1 - (0.023 / 0.045)

= 0.487

Range = (-0.31 to 0.68)

Table 10. Estimation of exploitation rates in the recreational fishery, Margaree River, fall 1990. Nonreporting rate estimates from table 9.

Tag loss to the angling fishery

Mean days to recapture in angling fishery			
	Grilse	=	10.9
	MSW	=	7.7
Proportion of grilse tags lost		=	0.14
Proportion of MSW tags lost		=	0.10
Tags placed from both traps	- grilse		120
prior to week 41	- MSW		217
Net tags available to angling	- grilse	=	103
	- MSW	=	195

Reported tags from fishery from pre week 41 tagging groups			
Returns - grilse		=	13
	MSW	=	17

Returns adjusted for nonreporting rates of:

		0	0.49	0.68
Grilse	=	13	25	41
MSW	=	17	33	53

Exploitation Rate Estimates

Grilse	=	0.13	0.25	0.39
MSW	=	0.09	0.17	0.27

Table 11. Estimation of returns and egg deposition of Atlantic salmon using creel catch estimates and range of exploitation rates (ER), Margaree River, 1990.

RETURNS

		Angling Catch		Returns at ER = 20.6%		Returns at ER = 37.9%	
		1SW	MSW	1SW	MSW	1SW	MSW
SUMMER							
	Estimate	191	272	927	1320	504	718
Range	Lower	47	96	227	467	123	254
	Upper	335	447	1627	2170	884	1179

		13%	9%	25%	17%	39%	27%
		1SW	MSW	1SW	MSW	1SW	MSW
FALL							
	Estimate	61	1421	469	15789	244	8359	156	5263
Range	Lower	0	592	0	6578	0	3482	0	2193
	Upper	139	2251	1069	25011	556	13241	356	8337

EGG DEPOSITIONS

SUMMER

		at ER = 20.6%		at ER = 37.9%	
		1SW	MSW	1SW	MSW
	Estimate	0.243	8.559	0.103	4.652
Range	Lower	0.059	3.026	0.025	1.645
	Upper	0.426	14.064	0.181	7.644

FALL

		at ER = 13%	9%	at ER = 25%	17%	at ER = 39%	27%
		1SW	MSW	1SW	MSW	1SW	MSW
	Estimate	0.135	102.344	0.060	54.182	0.031	34.115
Range	Lower	0	42.637	0	22.573	0	14.212
	Upper	0.307	162.122	0.138	85.829	0.072	54.041

TOTAL for river at best fall estimate of ER = 25% on grilse and 17% on MSW

		at 20.6% ER for summer		at 37.9% ER for summer	
		1SW	MSW	1SW	MSW
	Estimated	0.303	62.741 *	0.164	58.834 *
Range	Lower	0.059	25.599 *	0.025	24.218 *
	Upper	0.564	99.893 *	0.319	93.474 *

* indicates minimum egg deposition requirements (6.714 million) have been met.

Table 12. Estimation of spawner requirements for the Margaree River.

MARGAREE RIVER

Rearing Units 27,976 (100 sq. m) (Elson 1975)
Optimal Egg Deposition 240 per rearing unit (Marshall 1982)

Total Egg Requirements = 6,714,240

Biological characteristics

Fecundity		1764 eggs/kg	(Elson 1975)
Grilse	% female	11	(Marshall 1982)
	mean wt	1.7	(Marshall 1982)
MSW	% female	75	(Marshall 1982)
	mean wt	4.9 kg	(Marshall 1982)

Eggs per spawner Grilse = eggs/kg * mean wt(kg) * %female
= 1764 * 1.7 * 11%
= 330

MSW = eggs/kg * mean wt(kg) * %female
= 1764 * 4.9 * 75%
= 6483

Required number of MSW = egg requirements / eggs per MSW
= 6,714,240 / 6483

= 1036 --->> 777 females
259 males

Deficit males = 777 - 259 = 518

Grilse spawners to obtain 518 males = 518 / 89%
= 582

MSW spawners to obtain 518 males = 518 / 25%
= 2072

Spawning Requirements Minimum MSW = 1036
Grilse = 582

Maximum MSW = 3108
All grilse surplus

Table 13. Numbers of salmon smolt and parr released to Margaree River since 1976. MAR, Margaree stock; RB, Rocky Brook stock. Rearing locations are: MAR, Margaree; COB, Cobequid; MER, Mersey.

		Smolt				Parr			
		2+		1+		1+		0+	
Year	Rearing Location	MAR	RB	MAR	RB	MAR	RB	MAR	RB
1976	MAR	8,971							
1977	MAR					5,022			
1978	COB		15,250						
1979	COB		15,927 *						
1980	COB		14,960						
1981	COB		15,950						
1982	MER			8,481		1,098			
1983	COB	13,486						9,853	
	MAR	3,783							
1984	MAR				10,195 @				
	MER			14,483					
	COB	11,210							
1985	MAR			2,669	1,303	5,882	834		
	COB	13,660				7,820	5,860		
1986	MAR			2,105		8,754		25,000	
	COB	8,820	9,684					6,750	
1987	MAR	6,369		8,599		5,400		40,000	
	COB	18,337						12,429	
1988	MAR	4,136		22,313		2,201		40,000	
	COB	12,785						6,300	
1989	MAR	2,600		13,000		10,000		150,000	
	COB	18,500						6,000	
1990	MAR	4,119		14,200		21,425		60,500	
	COB	15,976							

* Millbank broodstock
@ Rocky Brook X Margaree broodstock

Table 14. Numbers of wild and hatchery salmon from summer and fall sampling on Margaree River in 1990.

SEASON	GRILSE			MSW			PERCENT MSW
	WILD	HATCHERY	(% WILD)	WILD	HATCHERY	(% WILD)	
SUMMER							
JUNE 1 - AUG. 31							
ANGLING	31	7	81.6%	34	5	87.2%	50.1%
BROODSTOCK	17	12	58.6%	40	48	45.5%	74.8%
SUB-TOTAL	48	19	71.6%	74	53	58.3%	65.2%
FALL							
SEPT. 1 - OCT. 31							
ANGLING	26	3	89.7%	43	8	84.3%	63.0%
TRAPNETS	150	5	96.8%	273	13	95.5%	64.7%
SUB-TOTAL	176	8	95.7%	316	21	93.8%	64.6%
TOTAL SEASON	224	27	89.2%	390	74	84.1%	64.8%

Table 15. Estimated contribution of hatchery released fish to total returns (calculated using creel angling catch at 20% ER) to the Margaree River, 1987 to 1990.

Grilse

	Summer				Fall					
			Returns at at 20% ER				Returns at at 20% ER			
	Angling Catch	% Hatchery	Hatchery	Wild	Angling Catch	% Hatchery	Hatchery	Wild	Total Returns of 1SW	% Hatchery
1987	306	63	964	566	97	31	150	335	2015	55
1988	367	26	477	1358	222	3	33	1077	2945	17
1989	151	58	438	317	57	6	17	268	1040	44
1990	191	28	267	688	61	4	12	293	1260	22

MSW

	Summer				Fall					
			Returns at at 20% ER				Returns at at 20% ER			
	Angling Catch	% Hatchery	Hatchery	Wild	Angling Catch	% Hatchery	Hatchery	Wild	Total Returns of 1SW	% Hatchery
1987	242	40	484	726	561	4	112	2693	4015	15
1988	190	31	295	656	178	2	18	872	1840	17
1989	152	37	281	479	311	6	93	1462	2315	16
1990	272	42	571	789	1732	6	520	8140	10020	11

Table 16. Summary of maiden tag recaptures from smolt and adult releases in the Margaree River, 1986 to 1990.

RELEASE YEAR	STOCK	NO. TAG STAGE	TAG APPLIED	TYPE	SERIES	GREENLAND 1A	1B	1C	1D	1E	1F	NEWFOUNDLAND 1	2	3	4	8	10	14	QUEBEC Q9	TOTAL RETURNS
1986	Rocky Brook	2+ smolt	7311	CWT	55 0/0		2		2	3	1	1			2					11
1986	Rocky Brook	2+ smolt	3376	CWT	62 2/23															0
1986	Rocky Brook	2+ smolt	1992	CWT	62 2/25		1		1											2
1987	Lake O'Law	1+ smolt	995	CWT	55 16/7															0
1987	Lake O'Law	1+ smolt	1107	CWT	55 16/8															0
1987	Margaree River	2+ smolt	10000	CWT	55 16/16 a										1					1
1987	Margaree River	1+ smolt	8599	CWT	55 16/16 a															0
1987	Lake O'Law	1+ smolt	3080	CWT	55 16/17 a										2					2
1987	Margaree River	2+ smolt	933	Carlin	P22200-P22299 P22500-P23199	1	1	1												3
					P23300-P23499															0
1987	Margaree River	MSW & 1SW	138	Carlin	zz23000-zz23137								1					1	2	4
1988	Margaree River	2+ smolt	4116	CWT	55 16/12								2		2				1	5
		MSW & 1SW	340	Carlin	zz23138-zz23299 zz23401-zz23581															
1989	Margaree River	MSW & 1SW	425	Carlin	zz23583- b zz23999 zz23300-zz23309					1			1	1		1	1			5
1990	Margaree River	MSW & 1SW	576	Carlin	zz23310- c zz23399 zz24000-zz24489															

a May also be Neisiguit River origin as same series used for those released.
b Excluding tags zz23950 and zz23951.
c Excluding tags zz24287,zz24443, and zz24482.

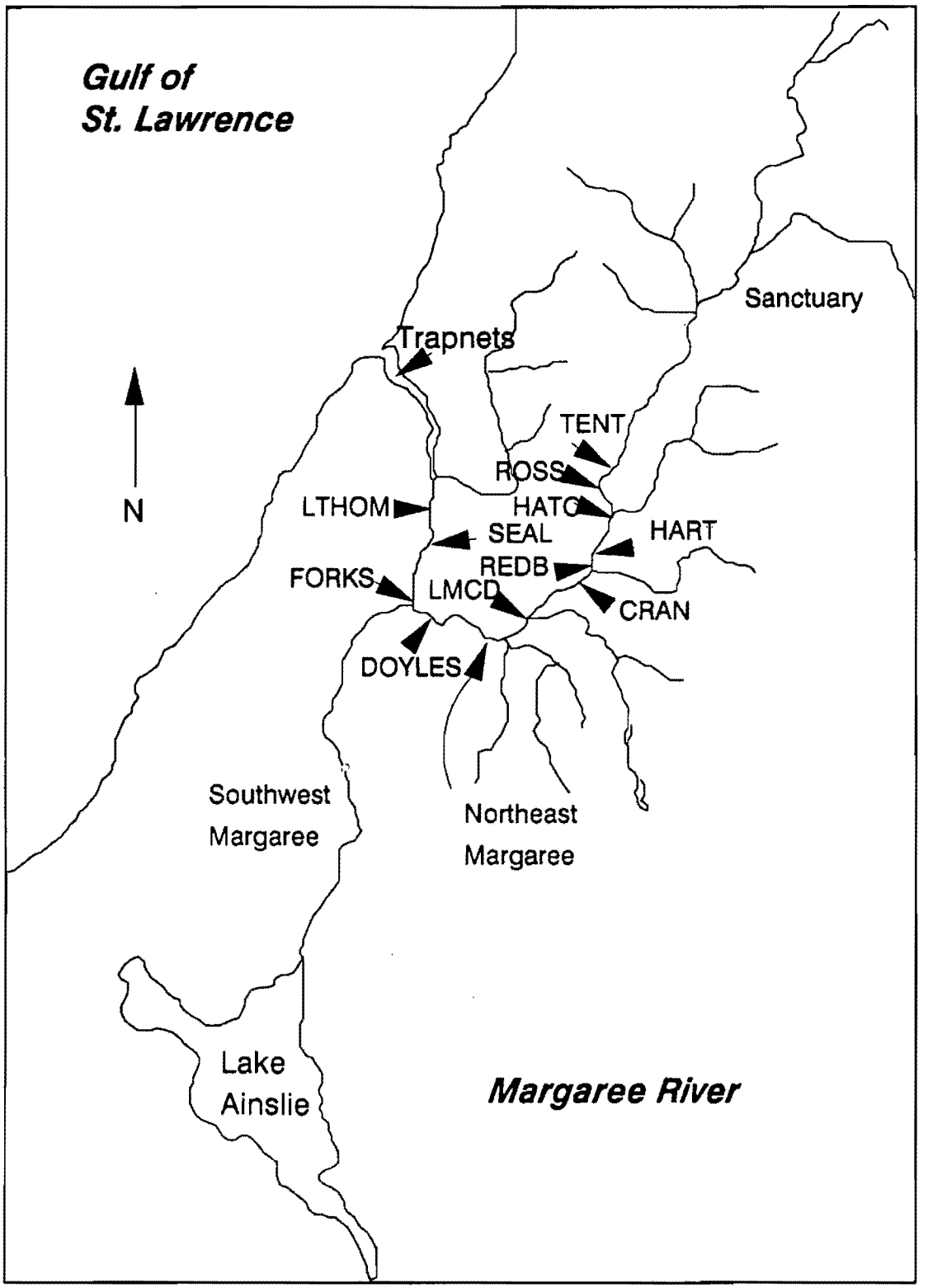

Fig. 1. Margaree River showing index pools for 1990 creel survey and trapnet location.