STATUS OF ATLANTIC SALMON IN THE RESTIGOUCHE RIVER IN 1991

by

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ABSTRACT

During 1991, 956 MSW and 2,522 1SW salmon were harvested by anglers in the Restigouche River (MSW salmon were harvested in Québec tributaries only). Angling catches (including catch and release of MSW salmon in N.B.) of MSW and 1SW salmon in 1991 were 35% and 49% below previous 5 year averages, respectively. Catches per unit effort for 1SW and MSW fish, respectively, were 48% and 33% below the previous 5 year averages for New Brunswick, and the same as the previous 5 year averages for Québec. Native harvest of MSW fish was 32% below the previous 5 year average and harvest of grilse was 81% below average. Based on angling data and an angling exploitation rate assumed to be somewhere between 0.3 and 0.5, returns of Atlantic salmon to the Restigouche River during 1991 were estimated to be between 8,580 and 13,560 MSW (34% below previous 5 year means) and between 5,884 and 9,795 1SW salmon (49% below previous 5 year means). Spawning escapement was estimated as the difference between total returns and losses to angling and native fisheries, poaching, disease, and hatchery broodstock. 1991 escapement was between 5,093 and 9,276 MSW salmon (38% below previous 5 year means) and between 2,522 and 5,885 1SW salmon (49% below previous 5 year means). These spawners would result in a total egg deposition of 30 to 56 million eggs (43% to 78% of requirements). Probabilities that 1991 returns, spawners, and egg deposition were less than previous 5 year means were estimated by a randomization procedure, to be 100%. Probabilities that MSW spawners and egg deposition were below target were 100%, but the target for 1SW spawners was almost certainly met. Electrofishing surveys indicated that densities of 0+, 1+, and 2+ juvenile salmon exceeded previous 5 year averages by 118%, 28%, and 0% respectively. The multiplicative model was used to compare 0+ and 1+ densities in 1991, with previous years. 0+ fry were significantly more abundant in 1991 than in 1972-1987 but not different than in years since. 1+ parr were significantly more abundant in 1991 than in 1972, but not different than all other years.

Assuming average (1987 to 1991) returns of MSW and 1SW salmon in 1992, total returns will be between 11,515 and 18,165 MSW and 10,297 and 17,097 1SW salmon.

RESUME

Au cours de 1991, les pêcheurs sportifs ont capturé 956 saumons pluribermarins (PBM) et 2522 saumons unibermarins (UBM) dans la rivière Restigouche (les saumons PBM n'ont été capturés que dans les affluents du Québec). En 1991, les prises sportives de saumon PBM et UBM (ce qui comprend les saumons PBM capturés et remis à l'eau au N.-B.) étaient respectivement de 35 p. 100 et 49 p. 100 inférieures aux prises moyennes des cinq dernières années. Les prises par unité d'effort pour le poisson UBM et PBM respectivement étaient de 48 p. 100 et de 33 p. 100 inférieures aux moyennes des cinq années antérieures au Nouveau-Brunswick mais elles n'accusaient aucun changement au Québec. Les prises de saumons PBM par les autochtones ont baissé de 32 p. 100 par rapport aux moyennes des cinq années précédentes et celles des madeleineaux de 81 p. 100. Selon les données sur la pêche récréative et le taux d'exploitation estimatif de cette pêche situé entre 0,3 et 0,5, on a évalué que de 8580 à 13 560 saumons de l'Atlantique PBM étaient retournés dans la rivière Restigouche en 1991 (34 p. 100 de moins que la moyenne des cinq années précédentes) et que de 5884 à 9795 saumons UBM étaient remontés (49 p. 100 de moins que la moyenne des cinq ans). Le taux d'échappée des géniteurs a été calculé comme étant la différence entre les remontées totales et les pertes dues à la pêche récréative et autochtone, au braconnage, à la maladie et à la capture de géniteurs destinés aux écloseries. En 1991, entre 5093 et 9276 saumons PBM se sont échappés (38 p. 100 de moins que la moyenne des cinq années précédentes), et de 2522 à 5885 saumons UBM ont réussi à s'échapper (49 p. 100 de moins que la moyenne des cinq ans). Ces géniteurs seraient responsables d'une ponte totale de 30 à 56 millions d'oeufs (de 43 à 78 p. 100 des besoins de ponte). On a évalué à 100 p. 100 la probabilité que la montaison, la quantité de géniteurs et la ponte de 1991 soient inférieures à la moyenne des cinq années précédentes. Cette probabilité avait été calculée selon la méthode de la randomisation. La probabilité que la quantité de géniteurs PBM et la ponte soient inférieures à l'objectif était de 100 p. 100 mais l'objectif lié aux géniteurs UBM a presque certainement été atteint. Des relevés par pêche électrique indiquent que les densités des tacons d'âge 0+, 1+, et 2+ dépassaient les moyennes des cinq années précédentes par 118 p. 100, 28 p. 100 et 0 p. 100 respectivement. On a utilisé le modèle multiplicatif pour comparer les densités des poissons d'âge 0+ et 1+ de 1991 avec celles des années antérieures. Les alevins d'âge 0+ étaient beaucoup plus abondants en 1991 qu'entre 1972 et 1987, mais ils étaient de quantité égale à compter de 1988. Les tacons de 1+ étaient beaucoup plus abondants en 1991 qu'en 1972 mais pas différents de toutes les années suivantes.

En présumant que les remontées de saumons pluribermarins et unibermarins en 1992 soient conformes aux moyennes de 1987 à 1991, la remontée totale devrait se situer entre 11 515 et 18 165 saumons PBM et entre 10 297 et 17 097 saumons UBM.

INTRODUCTION

During 1991, two user groups exploited Atlantic salmon in the Restigouche River: anglers and native fishermen. Regulations controlling the harvest of salmon in 1991 were similar to regulations in 1990. Anglers in New Brunswick tributaries were obliged to release all multi-sea-winter (MSW) salmon (≥ 63 cm) back into the river. Catches of one-sea-winter (1SW) salmon were restricted by season, possession and daily bag limits to ten, six and two fish, respectively. In Québec tributaries, anglers were allowed to retain both 1SW and MSW salmon with daily and seasonal bag limits of one and seven fish, respectively. As in 1990, if the first fish caught in a day was <63 cm, a second fish could be caught and retained irrespective of size. Season opening for Matapedia River was moved ahead to June 1 in 1991. Québec/New Brunswick boundary waters were regulated by the New Brunswick catch and release policy for MSW salmon. Native fishermen at Restigouche, Québec, were allocated a quota of 6818 kg. Native fishermen at Eel River Bar, New Brunswick, were not regulated by quota.

Commercial fisheries in Baie des Chaleurs have been closed in Québec since 1984, and in New Brunswick since 1985. Historical records of commercial landings prior to 1985 can be found in Randall et al. (1990). For both provinces, fishermen were prohibited from landing salmon caught in non-salmon fishing gear (by-catch).

The objective of this report is to provide an evaluation of the status of Atlantic salmon in the Restigouche River for 1991. Angling and native catch and effort data are summarized. Numbers of spawners and egg deposition are estimated from angling data and exploitation rates believed to represent lower and upper limits (the true rate is unknown). Juvenile salmon densities at 8 standard electrofishing sites are presented. Projections of adult salmon returns in 1992 are given.

METHODS

1. Angling catch and effort data.

Angling data from Québec tributaries of the Restigouche River in 1991 were provided by the Ministère du Loisir, de la Chasse et de la Pêche (MLCP); most estimates come directly from angling camp logbooks. Angling data from New Brunswick were provided by DFO fishery officers and by the New Brunswick Department of Natural Resources and Energy (DNRE). DFO fishery officers collect angling data directly from angling camps (daily logbooks) on a monthly

basis. In the New Brunswick portion of the Restigouche system, most angling (82% of 1991 catch) occurs at private or government camps which keep individual records of angling catches. Angling catches in Crown Open waters (3% of 1991 catch) are rough estimates based on personal observations and interviews by the DFO fishery officers. Crown reserve data (15% of 1991 catch) are summarized by DNRE from data records returned by each angling party.

For both Québec and New Brunswick, angled salmon were identified as being either MSW or 1SW. Effort was measured in rod-days, where one rod-day was one angler fishing a river for any portion of one day.

2. **Native landings.**

Landings of Atlantic salmon at Restigouche, Québec (Figure 1) are reported on a weekly basis by the Band Office to MLCP. Landings of salmon at Eel River Bar are reported on a weekly basis by individual gear types (gill nets vs traps) to DFO fishery officers. Based on personal observations of the Eel River fishery, fishery officers adjusted nominal landings upwards by 15% to account for underreporting. This adjustment has been made since 1987.

3. **Within-river mortalities.**

Poaching and disease (PAD) mortality rate was assumed to be 0.14 of the population entering the river (i.e, after estuary harvest, but before angling) for 1SW salmon and 0.16 for MSW salmon, as in previous assessments (Randall et al. 1988). The calculation was made as follows:

headwaters		estuary
angling		estuary harvest
B		A

MSW

PAD = 0.16[B/0.84] because,

PAD = 16% of the population at point A and,

The population at point A = B + 0.16 A
= B/0.84

B, the population available to anglers = angling catch/exploitation rate

B = Catch/Exp

Therefore, **MSW PAD = 0.16[(Catch/Exp)/0.84]**

By similar logic, PAD for 1SW was calculated as:

1SW PAD = 0.14[(Catch/Exp)/0.86]

The mortality rate associated with catch-and-release of MSW salmon was assumed to be 6% (Courtenay et al. 1991).

4. Total returns and spawning escapement.

Total returns were calculated as the sum of estuary harvest (native catch), river harvest, poaching and disease removals, and spawning escapement.

Returns = Estuary harvest + River harvest + PAD + Escapement

River harvest for 1SW fish is the sum of fish lost to angling. River harvest for MSW fish is the sum of fish lost to angling (Québec), mortality associated with catch and release (N.B.), and broodstock collection (Charlo hatchery, N.B.).

Spawning escapement was calculated as angling catch divided by angling exploitation rate minus river harvest. Angling exploitation rate is unknown for the Restigouche River, but Randall et al. (1990) argued that it is probably somewhere between 0.3 and 0.5. Therefore, spawning escapements were calculated for these limits.

A second method of estimating spawning escapement on the Restigouche River is direct counts of spawners during canoe surveys. These data are reported, but not used in calculating total returns or egg depositions, because their accuracy has not yet been adequately calibrated, and because these data have been collected only since 1982.

5. Target egg depositions and required spawners.

Egg deposition requirements for the Restigouche River, to provide a deposition rate of 2.4 eggs per square meter, are 71,443,200 eggs (Randall 1984). About 12,200 MSW salmon are required to produce these eggs, and an additional 2,600.1 SW salmon are required to ensure a 1:1 sex ratio at spawning. Total egg deposition is calculated in this assessment as follows:

Eggs = (MSW spawners*eggs/MSW fish)+(1SW spawners*eggs/1SW fish)

where: eggs/MSW fish=5,933
eggs/1SW fish= 86

Eggs/fish were calculated by Randall (1984) from egg counts made on fish harvested in 1983 by the freshwater, commercial, and native fisheries, and sex ratios of salmon sampled at the Dalhousie trap, 1972-1980.

The probability that spawning escapement, total returns, and egg deposition were different from prior 5 year means and from targets in the case of escapement and eggs, were assessed through a randomization procedure which used the uncertainty in angling exploitation rate (from which returns, escapement and eggs are calculated). The procedure was as follows:

a) Difference from mean of previous 5 years

1. Estimate spawners in the current year and each of the past 5 years, as catch divided by an exploitation rate drawn at random from a uniform distribution between 0.3 and 0.5.

2. Calculate a mean number of spawners (for example) for the previous 5 years, and express the number of spawners in the present year as a proportion of this mean.

3. Repeat steps 1 & 2 1000 times and plot the distribution of the proportions.

b) Difference from target

1. Estimate spawners in the present year, as catch divided by an exploitation rate drawn at random from a uniform distribution between 0.3 and 0.5.

2. Subtract the spawning target from spawners in present year, target.

3. Repeat steps 1 & 2 1000 times and plot residuals.

The SAS program used for these randomization tests is shown in Appendix 1.

6. Recruitment.

Densities of juvenile Atlantic salmon in headwater tributaries of the Restigouche River were determined by electrofishing surveys at 8 of the usual 15 sites during late July, 1991. Densities were calculated by the removal method (Zippin 1956). Ninety-five percent confidence intervals in mean densities among the 8 sites were calculated after individual site counts were transformed (natural logarithms). Densities of salmon fry and parr have been estimated at the same 8 sites each year since 1972.

Densities of fry (0+) and parr (1+) in 1991 were compared to

densities measured from 1972-1990, using the following multiplicative model:

LOGPOP = LOGAREA + YEAR + RIVER + STRORD

Where: LOGPOP: log (population estimate for site)
LOGAREA: log (area of electrofishing site)
YEAR: 1972-1991
RIVER: river of electrofishing site, being the Little Main Restigouche, Main Restigouche, or Kedgwick River.
STRORD: stream order of electrofishing site, being 4,5,6 or 7.

1972-1990 data include all 15 electrofishing sites; 1991 data include only 8 sites. Reference categories were chosen as 1991, Kedgwick River, and stream order 6; the last two being chosen because they contained data in most years. Cells with zero counts were deleted from analysis, because preliminary runs indicated that neither the above model, nor simpler models with one or more predictors omitted, were appropriate. SAS programs used are included in Appendix 2.

7. Forecast.

Returns of MSW salmon and 1SW salmon were predicted from previous 5 year averages. Indices of spawning levels (age 1 parr) in years that will contribute to 1SW and MSW salmon returns in 1992 were also considered. Returns of 1SW fish in 1990 and 1991 were examined as an index of relative survival at sea of cohorts contributing to MSW returns in 1992.

RESULTS AND DISCUSSION

1. Catch and effort.

Angling fisheries

In Québec tributaries of the Restigouche River (Matapedia, mainly upper Patapedia and the upper Kedgwick River), angling catch of MSW salmon in 1991 was 956 fish, a decrease of 8% from the previous 5 year average (Table 1, Appendix 3). (It should be noted that the 1990 data have been revised and so differ from those presented in last year's assessment.) Effort was down 11% from the previous 5 year average to 7,264 rod-days (Table 2). Catch-per-unit-effort (CPUE) was the same as the previous 5 year average, at 0.13 fish/rod-day.

The number of MSW salmon estimated to have been caught and released in New Brunswick waters in 1991 was 2,181 fish, a 42%

decrease from the previous 5 year average (Table 1). Effort decreased 11% from the previous 5 year average to 9,217 rod-days (Table 2). CPUE decreased 33% from the previous 5 year average to 0.24 fish/rod-day.

The total angling catch of MSW salmon in 1991 (Québec and New Brunswick) was 3,137 fish, a decrease of 35% from the 1986-1990 mean (Table 1).

Angling catch of 1SW salmon in Québec tributaries was 535 fish, a decrease of 11% from the previous 5 year mean (Table 1). CPUE was the same as the previous 5 year mean, 0.07 fish/rod-day (Table 2). (Estimates of effort are those reported above for MSW salmon.)

Angling catch of 1SW salmon in New Brunswick was 1,987, a decrease of 54% from the previous 5 year average (Table 1). CPUE decreased 48% from the previous 5 year mean, to 0.22 fish/rod-day (Table 2).

The total angling catch of 1SW salmon (Québec and New Brunswick) was 2,522 fish, 49% below the previous 5 year mean (Table 1).

Native fisheries.

Native landings from Baie des Chaleurs and Restigouche River for the years 1975 to 1991 are presented in Appendix 4. Operating dates of these fisheries, 1979 to 1991, are summarized in Appendix 5. Data sources are given in Appendix 7.

Native fishermen at Restigouche, Québec, reported catching 859 MSW salmon and 9 1SW salmon in 1991 (Table 3), constituting 5,131 kg of the 6,818 kg quota. These harvests are down 19% and up 13% from previous 5 year averages for MSW and 1SW respectively.

Nominal landings by native fishermen at Eel River Bar, New Brunswick, were 252 MSW salmon and 10 1SW salmon, 56% and 89% below previous 5 year means (Table 3).

Total nominal landings of Atlantic salmon in the Restigouche River from all fisheries in 1991 indicate a 23% decrease from the previous 5 year mean for MSW salmon, and a 50% reduction for 1SW salmon (Table 3). Landings from 1970 to 1991 are presented in Table 4. Historical landings prior to 1970 can be found in Courtenay et al. (1991). Previously undocumented 1SW to MSW ratios for angling landings for 1951-59 are given in Appendix 6.

2. Within river mortalities.

Poaching and disease mortalities for MSW salmon were estimated to be 1,992 and 1,195 for exploitation rates of 0.3 and 0.5 respectively. Comparable figures for 1SW salmon were 1,369 and 821.

Mortalities associated with the catch and release of 2,181 MSW salmon in N.B. were estimated to be 131.

The number of MSW fish removed from the river to be used as broodstock at the Charlo hatchery was 94.

3. Spawning escapement and total returns.

Index: Counts at protection barriers

Counts of MSW and 1SW salmon at the NW Upsalquitch protection barrier are not directly comparable to counts in other years because high water conditions in 1991 caused the removal of the barrier on October 16, 2 weeks earlier than counting is normally terminated. Counts to October 16 indicate an average spawning escapement: 930 MSW and 1,267 1SW salmon (both 7% below the 1986-1990 annual means) (Table 5).

For the second year, we report counts of 1SW and MSW at a barrier on the Causapscal River - a tributary of the Matapedia River (Table 5). This fence has been operated by MLCP since 1987, but counts are available only since 1988. Counts of MSW fish (451) were 14% below the 1988-90 average. Counts of 1SW fish (9) were 71% below the 1988-90 average.

Spawning escapement, 1991.

Spawning escapement was estimated using angling catches of 3,137 MSW salmon and 2,522 1SW salmon (Table 1). Total river harvest of MSW salmon was calculated as:

	1991	1990 (revised)
Angling harvest	956	893
Broodstock	94	82
Catch/release mortality	131	171
Total	1181	1146

Returns and spawning escapement were calculated as:

	Exploitation 0.3	0.5	% Change from Previous 5 yr mean
MSW SALMON			
1. Total returns	13,560	8,580	-34
2. Harvest in estuary	1,111	1,111	-32
3. Harvest in river	1,181	1,181	-9
4. PAD	1,992	1,195	-35
5. Spawners	9,276	5,093	-38
6. Target spawners	12,200	12,200	--
% of target (no.)	76	42	-38
1SW SALMON			
1. Total returns	9,795	5,884	-49
2. Harvest in estuary	19	19	-81
3. Harvest in river	2,522	2,522	-49
4. PAD	1,369	821	-49
5. Spawners	5,885	2,522	-49
6. Target spawners	2,600	2,600	--
% of target (no.)	226	97	-49
% of target (eggs)	78	43	-38

PAD is poaching and disease, which was assumed to be 0.16 and 0.14 of river returns of MSW and 1SW salmon, respectively.

Spawning escapement was estimated to be between 42% and 76% of target for MSW, and between 97% and 226% of target for 1SW. Resulting egg deposition was estimated to be between 43% and 78% of target.

In the 1990 assessment of Atlantic salmon in the Restigouche River, returns of MSW and 1SW salmon forecasted to return in 1991 were:

Method	**Forecast**	
	MSW salmon	**1SW salmon**
Five year mean	13,174 - 20,868	11,544 - 19,173

Forecasts were based on returns estimated using angling exploitation rates of 0.5 and 0.3. Actual returns in 1991 calculated in the present assessment were, for MSW fish: 8,580 -

13,560 (65% of the forecast); for 1SW fish: 5,884 - 9,795 (51% of the forecast).

4. Spawning escapement and egg depositions, 1970 to 1991.

Spawning escapements, assuming exploitation rates of 0.3 and 0.5, are summarized for the period 1970 to 1991 in Tables 6 to 9. Spawning escapement for MSW was between 5,093 and 9,276 fish, 38% below previous 5 year averages. Spawning escapement for 1SW was between 2,522 and 5,885 fish, 49% below previous 5 year averages.

Estimated total egg depositions in 1991 were between 30.4 and 55.5 million eggs, 38% below the previous 5 year averages (Tables 10 and 11; Figure 2). In 1991, as in the previous 5 years, 99% of eggs are estimated to have been deposited by MSW fish.

Egg depositions from 1971 to 1990 showed evidence of correlation with resulting 0+ and 1+, but not 2+ juvenile densities (Tables 10 & 11; Figures 3 & 4).

The preceding results indicate that returns, spawners and eggs deposited were fewer in 1991 than average for the previous 5 years, and were below targets. The following results indicate the significance of these differences. (Numbers in brackets refer to Figures showing the distribution of: proportions in the case of comparison to average, residuals in the case of comparison to target):

		PROBABILITY THAT 1991 IS LESS THAN	
		5 YEAR MEAN	TARGET
TOTAL RETURNS	MSW	100% (5)	--
	1SW	100% (6)	--
SPAWNERS	MSW	100% (7)	100% (8)
	1SW	100% (9)	<10% (10)
EGGS	MSW + 1SW	100% (11)	100% (12)

These analyses suggest that 1991 returns, spawners, and egg deposition were significantly smaller than previous 5 year averages. MSW spawners and egg deposition were significantly below target, but the target for 1SW spawners was almost certainly met.

This type of analysis facilitates investigation of other questions about the data, such as, how much would a certain error in catch data change our conclusions about spawning escapement? We investigated this by postulating that the accuracy of our estimates of angling for 1986-1991 was within 20% of true catch (i.e., true catch is between reported catch/1.2 and reported catch/0.8), and repeating the comparison of spawners with prior 5 year mean with catches chosen randomly from this range. These analyses (Figures 15 and 16) show slightly greater standard deviations than the analyses without error (0.138 vs -.120 for MSW; 0.156 vs 0.140 for 1SW) but do not noticeably change the probability that spawners were fewer in 1991 than average.

It is also possible to incorporate additional information in this analysis, when it is available. For example, had we known that the angling exploitation rate in 1991 was between 0.3 and 0.4, rather than 0.3 and 0.5 as assumed for 1986 - 1990, results of the comparison of 1991 spawners to the average would have appeared as in Figures 13 and 14. Despite the larger estimates of spawners in 1991, the probability that 1991 was below average remains 100%.

Taken together, these analyses suggest that even if our estimates of angling catch are fairly inaccurate, the exploitation rate in 1991 would have had to have been dramatically smaller than average for the spawning population to be average.

5. Recruitment.

Average densities of 0+ and 1+ juvenile salmon in 1991 exceeded previous 5 year averages by 118% and 28% respectively (Tables 10 & 11; Figure 17), while the density of 2+ juveniles did not change from the previous 5 year average. These data suggest that spawning levels and/or juvenile survival rates have been increasing in recent years. Variation in densities among individual sites was considerable however, as indicated by the wide confidence intervals (Figure 17).

Analysis by the multiplicative model indicated that fry density (0+) in 1991 was significantly greater than densities measured from 1972-1987, but not significantly different from densities measured in the past 3 years (Figure 18). All predictors used in the model (year, stream-order, area of electroseining site) were significant, with the exception of river. The model explained 43% (r^2) of the variation in the database and appeared to fit the data well (Figure 19).

Parr density (1+) in 1991 was significantly greater than the density measured in 1972, but not significantly different from densities measured in years since then (Figure 20). All predictors used in the model (year, stream order, river) were significant, with the exception of area of electroseining site. The model

explained 35% (r^2) of the variation in the database, and appeared to fit the data well (Figure 21).

6. Forecast for 1992.

Based on mean returns from 1987 to 1991 estimated using a range of angling exploitation rates of 0.5 to 0.3, returns of MSW salmon in 1992 will be 11,515 to 18,165 fish. 1SW returns will be 10,297 to 17,097 fish.

Indices of spawning escapement and adult survival in years that will produce 1SW and MSW salmon returns in 1992 were also considered. For MSW salmon, average returns of 1SW salmon in 1990 and 1991 (i.e., same smolt years that will produce 2SW and 3SW salmon in 1992) were compared to the previous five year averages, as a possible index of sea survival. Also, average 1+ juvenile densities for the period 1987 to 1989 were compared to the previous five year average, as a possible index of recruitment strength. Similarly, for potential returns of 1SW salmon in 1992, age 1+ parr densities for 1989 and 1990 were considered. Forecasting from juvenile densities in these years is based on the fact that in the Restigouche River, most 1SW salmon return to spawn as 3 or 4 year old fish, and most MSW salmon return to spawn as 4 to 6 year old fish (unpublished data). Forecasts from juvenile densities and 1SW returns are as follows:

	Spawning or survival index	
	1SW returns	1+ parr density
Exploitation rate: 0.3		
MSW salmon (1992) (index years)	-29% (1990, 1991)	+26% (1987 - 1989)
1SW salmon (1992) (index years)	-	+54% (1989, 1990)
Exploitation rate: 0.5		
MSW salmon (1992) (index years)	-29% (1990, 1991)	+26% (1987 - 1989)
1SW salmon (1992) (index years)	-	+54% (1989, 1990)

The potential index of sea survival (catch of 1SW in 1990, 1991) predicts a below average return of MSW fish in 1992. The potential recruitment index (1+ density) predicts an above average return of MSW and 1SW fish in 1992.

7. Recommendations.

1. The utility of data gathered at index angling camps, canoe surveys, and barriers should be reviewed. For example, are angling catches of 1SW fish in year x a good predictor of MSW returns in year x+1? Are canoe counts an accurate measure of spawning escapement?

2. The utility of estimates of juvenile abundance for hindcasting parental numbers, and forecasting returns, should be investigated.

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REFERENCES

Courtenay, S.C., G. Landry, A. Madden and R. Pickard. 1991.Status of Atlantic salmon in the Restigouche River in 1990. CAFSAC Res. Doc. 91/13.

Gaudreault, A. 1984. Exploitation du saumon (Salmo salar L.) dans la rivière Ristigouche en Gaspésie. Technical Report, Ministère du Loisir, de la Chasse et de la Pêche, Service de l'aménagement et de l'exploitation de la faune zac Baie des Chaleurs. New Richmond, Québec.

O'Neil, S.F., M. Bernard, P. Gallop and R. Pickard. 1987. 1986 Atlantic salmon sport catch statistics, Maritime Provinces. Can. Data Rep. Fish. Aquat. Sci. No. 663. v + 69 p.

O'Neil, S.F., M. Bernard and J. Singer. 1985. 1984 Atlantic salmon sport catch statistics, Maritime Provinces (Red book). Can. Data Rep. Fish. Aquat. Sci. No. 530. v + 98 p.

O'Neil, S.F., M. Bernard and J. Singer. 1986. 1985 Atlantic salmon sport catch statistics, Maritime Provinces. Can. Data Rep. Fish. Aquat. Sci. No. 600. v + 71 p.

O'Neil, S.F., K. Newbould and R. Pickard. 1989. 1987 Atlantic salmon sport catch statistics, Maritime Provinces. Can. Data Rep. Fish. Aquat. Sci. No. 770. v + 73 p.

O'Neil, S.F., D.A. Stewart, K. Newbould and R. Pickard. 1991. 1988 Atlantic salmon sport catch statistics, Maritime Provinces. Can. Data Rep. Fish. Aquat. Sci. No. 852. v + 79 p.

O'Neil, S.F. and D.A.B. Swetnam. 1984. Collation of Atlantic salmon sport catch statistics, Maritime Provinces, 1970-79. Can. Data Rep. Fish. Aquat. Sci. No. 481. ix + 297 p.

O'Neil, S.F. and D.A.B. Swetnam. 1991. Collation of Atlantic salmon sport catch statistics, Maritime Provinces, 1951-1959. Can. Data Rep. Fish. Aquat. Sci. No. 481. ix + 297 p.

Randall, R.G. 1984. Number of salmon required for spawning in the Restigouche River, N.B. CAFSAC Res. Doc. 84/16.

Randall, R.G., G. Landry, A. Madden and R. Pickard. 1988. Status of Atlantic salmon in the Restigouche River, 1987. CAFSAC Res. Doc. 88/41.

Randall, R.G., G. Landry, A. Madden and R. Pickard. 1990. Status of Atlantic salmon in the Restigouche River in 1989. CAFSAC Res. Doc. 90/2.

Swetnam, D.A. and S.F. O'Neil. 1984. Collation of Atlantic salmon sport catch statistics, Maritime Provinces, 1980-83. Can. Data Rep. Fish. Aquat. Sci. No. 450. ix + 194 p.

Swetnam, D.A.B. and S.F. O'Neil. 1985. Collation of Atlantic salmon sport catch statistics, Maritime Provinces, 1960-69. Can. Data Rep. Fish. Aquat. Sci. No. 533. ix + 289 p.

Zippin, C. 1956. An evalation of the removal method of estimating animal populations. Biometrics 12: 163-189.

Summary Sheet

Stock: Restigouche River, SFA 15
Life Stage: juveniles (0+,1+,2+), 1SW and MSW salmon
Target: 71.4 million eggs (12,200 MSW, 2,600 1SW salmon)

	1986	1987	1988	1989	1990	1991	86-90	91/86-90	MIN	MAX
River harvest										
MSW	1693	1073	1207	1336	1146	1181	1291	-9%	688	6707
1SW	5413	5005	6776	3301	4324	2522	4964	-49%	896	6776
Estuary harvest										
MSW	1576	1902	1430	1649	1606	1111	1633	-32%	23	18180
1SW	30	100	73	163	136	19	100	-81%	0	7339
Spawning Escapement[1]										
MSW (X 1000)	11-19	7-13	10-17	8-13	6-11	5-9	8-15	-38%	1-2	11-19
1SW (X 1000)	5-13	5-12	7-16	3-8	4-10	3-6	5-12	-49%	1-2	7-16
Total Returns[1]										
MSW (X 1000)	16-26	12-18	15-23	12-19	10-16	9-14	13-21	-34%	6-9	23-26
1SW (X 1000)	13-21	12-19	16-26	8-13	10-17	6-10	12-19	-49%	3-4	16-26
% egg target met[1]	89-159	59-105	83-146	63-113	53-95	43-78	70-124	-38%	9-20	89-159
Canoe counts of Spawners										
MSW	9542	8535	9520	12362	( )[2]	7513	9990	-25%	2397[3]	12362
1SW	5190	3930	3861	3970	( )	3836	4238	-9%	986	5190
Barrier Counts of Spawners										
Upsalquitch: MSW	1166	1000	993	894	946	930	1000	-7%	301[4]	1166
1SW	1738	1557	1121	1051	1324	1267	1358	-7%	430	1738
Causapscal: MSW			505	605	456	451	522[5]	-14%[5]		
1SW			49	7	37	9	31	-71%		
Juvenile Densities										
0+	23.9	42.0	53.2	72.1	53.2	106.5	48.9	+118%	5.2[6]	106.5
1+	7.5	9.4	6.1	12.1	12.9	12.3	9.6	+28%	2.4	12.9
2+	2.8	4.7	2.1	1.9	3.1	2.9	2.9	0%	0.4	4.7

[1] Range given reflects uncertainty of angling exploitation rate (assumed to be between 0.3 and 0.5), from which spawning escapement (and therefore eggs), and total returns are derived.
[2] High water prevented field survey.
[3] MIN MAX for years 1982 to present.
[4] MIN MAX for years 1980 to present.
[5] For 1SW and MSW counts at Causapscal River, average is 1988-1990 rather than 1986-90.
[6] MIN MAX for years 1972 to present.

Recreational catches: Have ranged from 2068 - 6181 MSW and 896 - 6776 1SW salmon during the past 10 years. (MSW catch includes catch and release in N.B.) Effort (rod-days) and catch have decreased over recent years.

Methodology: Spawning escapement, losses to poaching and disease, and total returns are all calculated from angling catch divided by exploitation rate. Exploitation rate has not been measured on the Restigouche River since 1977, but is assumed to be between 0.3 and 0.5. Spawning escapement has also been estimated by canoe surveys since 1982 - but was prevented in 1990 by high water. Salmon are counted at headwater protection barriers on the Upsalquitch River (since 1980) and Causapscal River (Matapedia) (since 1988). Juvenile salmon densities were estimated from electrofishing at 15 standard sites (since 1972) except in

1991 when only 8 sites were fished.
MIN MAXs in summary table are for the period 1970 to present unless otherwise stated. River harvest includes mortalities associated with catch and release, and broodstock removals. Estuary harvest is native catch. Upsalquitch barrier counts are incomplete in 1989, 1990, and 1991. Causapscal barrier counts are incomplete in 1990. Juvenile densities are number per 100 square meters.

State of the Stock: Because angling exploitation rates have not been measured in recent years, true spawning escapements are unknown. Potential indices of spawning escapement (canoe counts, barrier counts, and juvenile densities) suggest that the stock is larger now than it was in the early 1980s.

Forecast for 1992: Based on the mean returns from 1987 - 1991, between 12 and 18 thousand MSW and between 10 and 17 thousand 1SW salmon are expected to return in 1992. There is no evidence to suggest that returns will be significantly greater or smaller than average. The ranges given reflect upper and lower exploitation rates used in calculating returns, not confidence limits.

Recommendations: If angling statistics are to be used to estimate spawning escapement, exploitation rates must be measured annually. The utility of data on juvenile densities for hindcasting parental stock and forecasting returns should be investigated. The utility of data from canoe surveys, barrier counts, and index angling camps for estimating spawning escapement should be investigated.

Table 1. Estimated angling catches of salmon in the Restigouche River, 1970 to 1991. Data for 1951-1969 are available in Appendix 6.

	MSW			1SW			Proportion MSW		
Year	PQ	NB	Total	PQ	NB	Total	PQ	NB	Total
1970	326	1716	2042	166	1340	1506	0.66	0.56	0.58
1971	259	757	1016	173	999	1172	0.60	0.43	0.46
1972	1171	3870	5041	111	978	1089	0.91	0.80	0.82
1973	1146	3746	4892	147	1423	1570	0.89	0.72	0.76
1974	1163	4785	5948	129	1038	1167	0.90	0.82	0.84
1975	741	2160	2901	149	1130	1279	0.83	0.66	0.69
1976	1029	4481	5510	377	2345	2722	0.73	0.66	0.67
1977	1579	5128	6707	459	2333	2792	0.77	0.69	0.71
1978	1652	3373	5025	282	1322	1604	0.85	0.72	0.76
1979	826	997	1823	556	1990	2546	0.60	0.33	0.42
1980	2059	4098	6157	409	2833	3242	0.83	0.59	0.66
1981	1408	2832	4240	635	3010	3645	0.69	0.48	0.54
1982	962	1620	2582	402	2449	2851	0.71	0.40	0.48
1983	587	1481	2068	181	715	896	0.76	0.67	0.70
1984a	570	1672	2242	348	1474	1822	0.62	0.53	0.55
1985	752	3563	4315	259	3258	3517	0.74	0.52	0.55
1986	1418	4763	6181	498	4915	5413	0.74	0.49	0.53
1987	873	3203	4076	591	4414	5005	0.60	0.42	0.45
1988	1007	4546	5553	692	6084	6776	0.59	0.43	0.45
1989	1006	3441	4447	450	2851	3301	0.69	0.55	0.57
1990	893	2842	3735	765	3559	4324	0.54	0.44	0.46
1991	956	2181	3137	535	1987	2522	0.64	0.52	0.55
Mean (86-90)	1039	3759	4798	599	4365	4964	0.63	0.47	0.49
1991/Mean	-8%	-42%	-35%	-11%	-54%	-49%	+2%	+11%	+12%

a Estimates of MSW salmon (1984 to 1991) include released fish in New Brunswick. New Brunswick catch-and-release data were estimates from angling lodge logbooks, crown reserve angler questionnaires and DFO fishery officers.

Table 2. Preliminary estimates of angling catch, effort and CPUE in New Brunswick and Quebec portions of the Restigouche River, 1991. Catch, effort and CPUE in 1990 are given for comparison.

		1991			1990			Mean (86-90)			1991/Mean		
		Catch	Effort	CPUE	Catch	Effort	CPUE	Catch	Effort	CPUE	Catch	Effort	CPUE
N.B.	1SW	1987	9217	0.22	3559	11164	0.32	4365	10371	0.42	-54%	-11%	-48%
	MSWa	2181	9217	0.24	2842	11164	0.25	3759	10371	0.36	-42%	-11%	-33%
P.Q.	1SW	535	7264	0.07	765	7907	0.10	599	8193	0.07	-11%	-11%	0%
	MSW	956	7264	0.13	893	7907	0.11	1039	8193	0.13	-8%	-11%	0%

a Estimates of N.B. MSW salmon are released fish.

Table 3. Preliminary estimates of harvest (numbers) of 1SW and MSW salmon in Restigouche River, 1991. Harvests of salmon in 1990 are given for comparison.

		1991		1990		Mean (86-90)		1991/Mean	
Fishery		1SW	MSW	1SW	MSW	1SW	MSW	1SW	MSW
Native									
	N.B.	10	252	120	471	92	579	-89%	-56%
	P.Q.	9	859	16	1135	8	1054	+13%	-19%
Angling									
	N.B.	1987		3559		4365		-54%	
	P.Q.	535	956	765	893	599	1039	-11%	-8%
Total		2541	2067	4460	2499	5064	2672	-50%	-23%

Table 4. Commercial, angling and Native salmon landings from Baie des Chaleurs and Restigouche River, 1970 to 1991. Data sources given in Appendix 7.

	Commercial		Angling		Native		
Year	1SW	MSW	1SW	MSW	1SW	MSW	Total
1970		18180	1506	2042			21728
1971		8967	1172	1016			11155
1972	36	23	1089	5041			6189
1973	1272	295	1570	4892			8029
1974	132	68	1167	5948			7315
1975	163	1026	1279	2901	3	132	5504
1976	5107	225	2722	5510	13	1641	15218
1977	1134	168	2792	6707	19	2950	13770
1978	1522	156	1604	5025	23	129	8459
1979	83	671	2546	1823	169	896	6188
1980	1986	9	3242	6157	58	1827	13279
1981	3045	3534	3645	4240	20	211	14695
1982	2202	4437	2851	2582	160	1676	13908
1983	1552	4569	896	2068	32	1476	10593
1984	7161	2026	1822	570	178	1283	13040
1985	0	0	3517	752	35	1217	5521
1986	0	0	5413	1418	30	1576	8437
1987	0	0	5005	873	100	1902	7880
1988	0	0	6776	1007	73	1430	9286
1989	0	0	3301	1006	163	1649	6119
1990	0	0	4324	893	136	1606	6959
1991	0	0	2522	956	19	1111	4608
Mean (86-90)	0	0	4964	1039	100	1633	7736
1991/Mean	0%	0%	-49%	-8%	-81%	-32%	-40%

Table 5. Counts of salmon at two fish barriers in the Restigouche River system.

Year	1SW	MSW	Total	MSW/1SW
NW Upsalquitch barrier				
1980	843	887	1730	1.05
1981	789	481	1270	0.61
1982	819	622	1441	0.76
1983	430	301	731	0.70
1984	518	642	1160	1.24
1985	748	517	1265	0.69
1986	1738	1166	2904	0.67
1987	1557	1000	2557	0.64
1988	1121	993	2114	0.89
1989a	1051	894	1945	0.85
1990b	1324	946	2270	0.71
1991c	1267	930	2197	0.73
Mean (86-90)	1358	1000	2358	0.75
1991/Mean	-7%	-7%	-7%	-3%
Causapscal barrier				
1988	49	505	554	10.31
1989	7	605	612	86.43
1990d	37	456	493	12.32
1991	9	451	460	50.11
Mean (88-90)	31	522	553	36.35
1991/Mean	-71%	-14%	-17%	+38%

a Count incomplete. Barrier removed October 22 (c.f. October 26-28 in other years) due to budget constraint.
b Count incomplete. Barrier breached October 14 due to high water.
c Count incomplete. Barrier removed October 16 due to high water.
d Count incomplete. Barrier breached August 14 due to high water.

Table 6. Estimated spawners (S) and total returns (R) of MSW salmon in Restigouche River, 1970 to 1991. Spawners were estimated using an angling exploitation rate (u) of 0.3.

Year	Harvest		MSW Released plus P.Q.	PAD	Spawners (S)	Field Spawner Counts	Returns (R)
	Estuary	River					
1970	18180	2042		1297	4765		26284
1971	8967	1016		645	2371		12999
1972	23	5041		3201	11762		20027
1973	295	4892		3106	11415		19708
1974	68	5948		3777	13879		23672
1975	1158	2901		1842	6769		12670
1976	1866	5510		3499	12857		23732
1977	3118	6707		4259	15650		29734
1978	285	5025		3191	11725		20226
1979	1567	1823		1158	4254		8802
1980	1836	6157		3910	14366		26269
1981	3745	4240		2692	9893		20570
1982	6113	2582		1640	6025	3563	16360
1983	6045	2068		1313	4825	2397	14251
1984a	3309	688	2242	1424	6785	5233	12206
1985	1217	1074	4315	2740	13309	7898	18340
1986	1576	1693	6181	3925	18910	9542	26104
1987	1902	1073	4076	2588	12514	8535	18077
1988	1430	1207	5553	3526	17303	9520	23466
1989	1649	1336	4447	2824	13487	12362	19296
1990b	1606	1146	3735	2372	11304		16428
1991	1111	1181	3137	1992	9276	7513	13560
Mean (86-90)	1633	1291	4798	3047	14704	9990	20674
1991/Mean	-32%	-9%	-35%	-35%	-37%	-25%	-34%

a River harvests (1984 to 1991) include catch and release mortalities and broodstock removals.
b High water prevented field spawner count.

Table 7. Estimated spawners (S) and total returns (R) of MSW salmon in Restigouche River, 1970 to 1991. Spawners were estimated using an angling exploitation rate (u) of 0.5.

Year	Harvest		MSW Released plus P.Q.	PAD	Spawners (S)	Field Spawner Counts	Returns (R)
	Estuary	River					
1970	18180	2042		778	2042		23042
1971	8967	1016		387	1016		11386
1972	23	5041		1921	5041		12026
1973	295	4892		1864	4892		11943
1974	68	5948		2266	5948		14230
1975	1158	2901		1105	2901		8065
1976	1866	5510		2099	5510		14985
1977	3118	6707		2555	6707		19087
1978	285	5025		1915	5025		12250
1979	1567	1823		695	1823		5908
1980	1836	6157		2346	6157		16496
1981	3745	4240		1615	4240		13840
1982	6113	2582		984	2582	3563	12261
1983	6045	2068		788	2068	2397	10969
1984a	3309	688	2242	854	3796	5233	8647
1985	1217	1074	4315	1644	7556	7898	11491
1986	1576	1693	6181	2355	10669	9542	16293
1987	1902	1073	4076	1553	7079	8535	11607
1988	1430	1207	5553	2116	9899	9520	14652
1989	1649	1336	4447	1694	7558	12362	12237
1990b	1606	1146	3735	1423	6324		10499
1991	1111	1181	3137	1195	5093	7513	8580
Mean (86-90)	1633	1291	4798	1828	8306	9990	13058
1991/Mean	-32%	-9%	-35%	-35%	-39%	-25%	-34%

a River harvests (1984 to 1991) include catch and release mortalities and broodstock removals.
b High water prevented field spawner count.

Table 8. Estimated spawners (S) and total returns (R) of 1SW salmon in Restigouche River, 1970 to 1991. Spawners were estimated using an angling exploitation rate (u) of 0.3.

Year	Harvest		PAD	Spawners (S)	Field Spawner Counts	Returns (R)
	Estuary	River				
1970	0	1506	817	3514		5837
1971	0	1172	636	2735		4543
1972	36	1089	591	2541		4257
1973	1272	1570	852	3663		7357
1974	132	1167	633	2723		4655
1975	166	1279	694	2984		5123
1976	5120	2722	1477	6351		15670
1977	1153	2792	1515	6515		11975
1978	1545	1604	870	3743		7762
1979	252	2546	1382	5941		10121
1980	2044	3242	1759	7565		14610
1981	3065	3645	1978	8505		17193
1982	2362	2851	1547	6652	1577	13412
1983	1584	896	486	2091	986	5057
1984	7339	1822	989	4251	1374	14401
1985	35	3517	1909	8206	2111	13667
1986	30	5413	2937	12630	5190	21010
1987	100	5005	2716	11678	3930	19499
1988	73	6776	3677	15811	3861	26337
1989	163	3301	1791	7702	3970	12957
1990	136	4324	2346	10089		16895
1991	19	2522	1369	5885	3836	9795
Mean (86-90)	100	4964	2693	11582	4238	19340
1991/Mean	-81%	-49%	-49%	-49%	-9%	-49%

a High water prevented field spawner count.

Table 9. Estimated spawners (S) and total returns (R) of 1SW salmon in Restigouche River, 1970 to 1991. Spawners were estimated using an angling exploitation rate (u) of 0.5.

Year	Harvest		PAD	Spawners (S)	Field Spawner Counts	Returns (R)
	Estuary	River				
1970	0	1506	490	1506		3502
1971	0	1172	382	1172		2726
1972	36	1089	355	1089		2569
1973	1272	1570	511	1570		4923
1974	132	1167	380	1167		2846
1975	166	1279	416	1279		3140
1976	5120	2722	886	2722		11450
1977	1153	2792	909	2792		7646
1978	1545	1604	522	1604		5275
1979	252	2546	829	2546		6173
1980	2044	3242	1056	3242		9584
1981	3065	3645	1187	3645		11542
1982	2362	2851	928	2851	1577	8992
1983	1584	896	292	896	986	3668
1984	7339	1822	593	1822	1374	11576
1985	35	3517	1145	3517	2111	8214
1986	30	5413	1762	5413	5190	12618
1987	100	5005	1630	5005	3930	11740
1988	73	6776	2206	6776	3861	15831
1989	163	3301	1075	3301	3970	7840
1990a	136	4324	1408	4324		10192
1991	19	2522	821	2522	3836	5884
Mean (86-90)	100	4964	1616	4964	4238	11644
1991/Mean	-81%	-49%	-49%	-49%	-9%	-49%

a High water prevented field spawner count.

Table 10. Estimates of total egg deposition and resulting juvenile densities of Atlantic salmon in the Restigouche River, 1971 to 1991. Egg depositions were estimated using an angling exploitation rate (u) of 0.3.

Year (i)	Egg deposition (millions) (year i)	Juvenile salmon densities 0+ (year i+1)	1+ (year i+2)	2+ (year i+3)
	1.	2.	3.	4.
1971	14.3	5.2	2.8	0.6
1972	66.8	22.0	6.1	1.5
1973	72.3	13.1	4.8	1.0
1974	84.5	28.6	6.9	1.4
1975	44.8	13.3	3.9	1.0
1976	83.0	14.7	6.3	1.4
1977	85.2	19.5	5.9	2.1
1978	71.6	6.1	3.8	0.4
1979	26.8	9.3	2.4	0.4
1980	68.3	18.9	3.3	3.1
1981	59.4	11.2	7.8	2.5
1982	36.3	25.4	7.3	1.6
1983	28.8	25.1	10.4	2.8
1984	40.7	25.2	7.5	4.7
1985	79.7	23.9	9.4	2.1
1986	113.3	42.0	6.1	1.9
1987	75.2	53.2	12.1	3.1
1988	104.1	72.1	12.9	2.9
1989	80.7	53.2	12.3	
1990	68.0	106.5		
1991	55.5			
Mean (86-90)	88.3	48.9	9.6	2.9
1991/Mean	-37%	+118%	+28%	0%

Correlations:	n	r	p
ln. 1. with ln. 2.	20	0.52	0.02
ln. 1. with ln. 3.	19	0.46	0.05
ln. 1. with ln. 4.	18	0.35	0.16
ln. 2. with ln. 3.	19	0.81	<0.01
ln. 2. with ln. 4.	18	0.74	<0.01
ln. 3. with ln. 4.	18	0.73	<0.01

Table 11. Estimates of total egg deposition and resulting juvenile densities of Atlantic salmon in the Restigouche River, 1971 to 1991. Egg depositions were estimated using an angling exploitation rate (u) of 0.5.

Year (i)	Egg deposition (millions) (year i)	Juvenile salmon densities 0+ (year i+1)	1+ (year i+2)	2+ (year i+3)
	1.	2.	3.	4.
1971	6.1	5.2	2.8	0.6
1972	28.6	22.0	6.1	1.5
1973	31.0	13.1	4.8	1.0
1974	36.2	28.6	6.9	1.4
1975	19.2	13.3	3.9	1.0
1976	35.6	14.7	6.3	1.4
1977	36.5	19.5	5.9	2.1
1978	30.7	6.1	3.8	0.4
1979	11.4	9.3	2.4	0.4
1980	29.2	18.9	3.3	3.1
1981	25.5	11.2	7.8	2.5
1982	15.5	25.4	7.3	1.6
1983	12.4	25.1	10.4	2.8
1984	22.7	25.2	7.5	4.7
1985	45.1	23.9	9.4	2.1
1986	63.8	42.0	6.1	1.9
1987	42.4	53.2	12.1	3.1
1988	59.3	72.1	12.9	2.9
1989	45.1	53.2	12.3	
1990	37.9	106.5		
1991	30.4			
Mean (86-90)	49.7	48.9	9.6	2.9
1991/Mean	-39%	+118%	+28%	0%

Correlations:	n	r	p
ln. 1. with ln. 2.	20	0.63	<0.01
ln. 1. with ln. 3.	19	0.55	0.02
ln. 1. with ln. 4.	18	0.42	0.08
ln. 2. with ln. 3.	19	0.81	<0.01
ln. 2. with ln. 4.	18	0.74	<0.01
ln. 3. with ln. 4.	18	0.73	<0.01

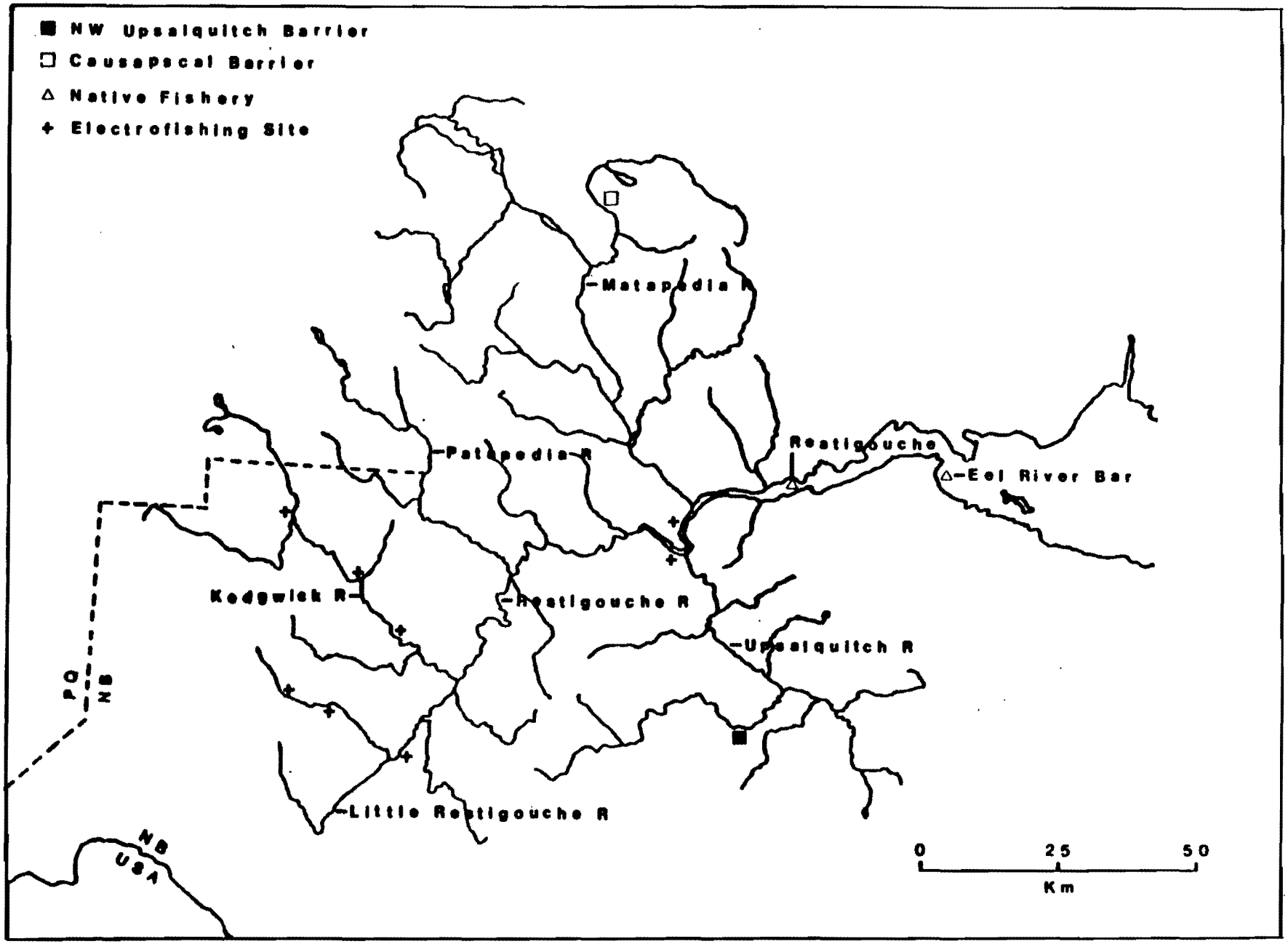


FIGURE 1. Map of the Restigouche River showing the location of electrofishing sites fished in 1991, native fisheries, and barrier fences at which salmon were enumerated.

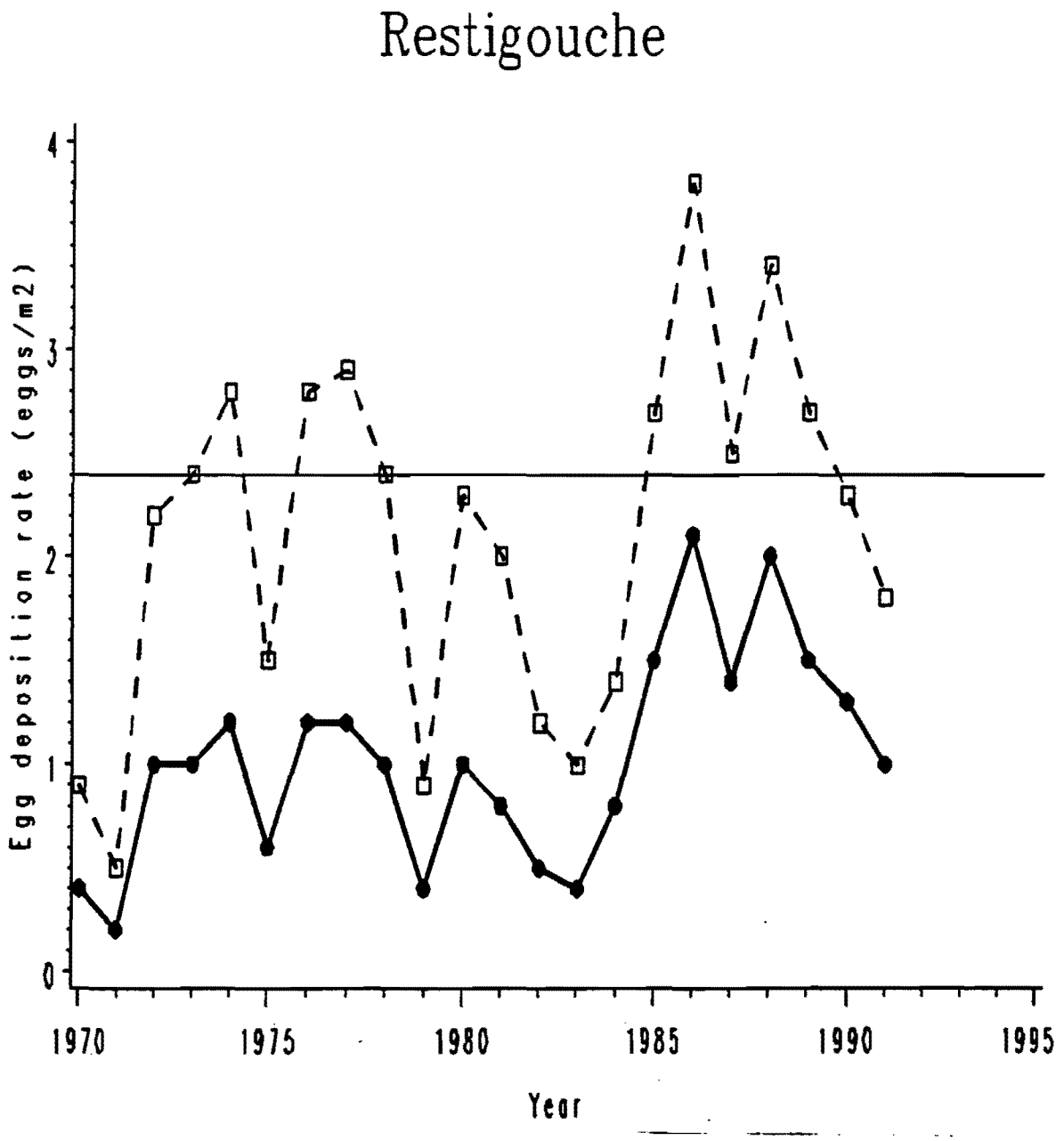
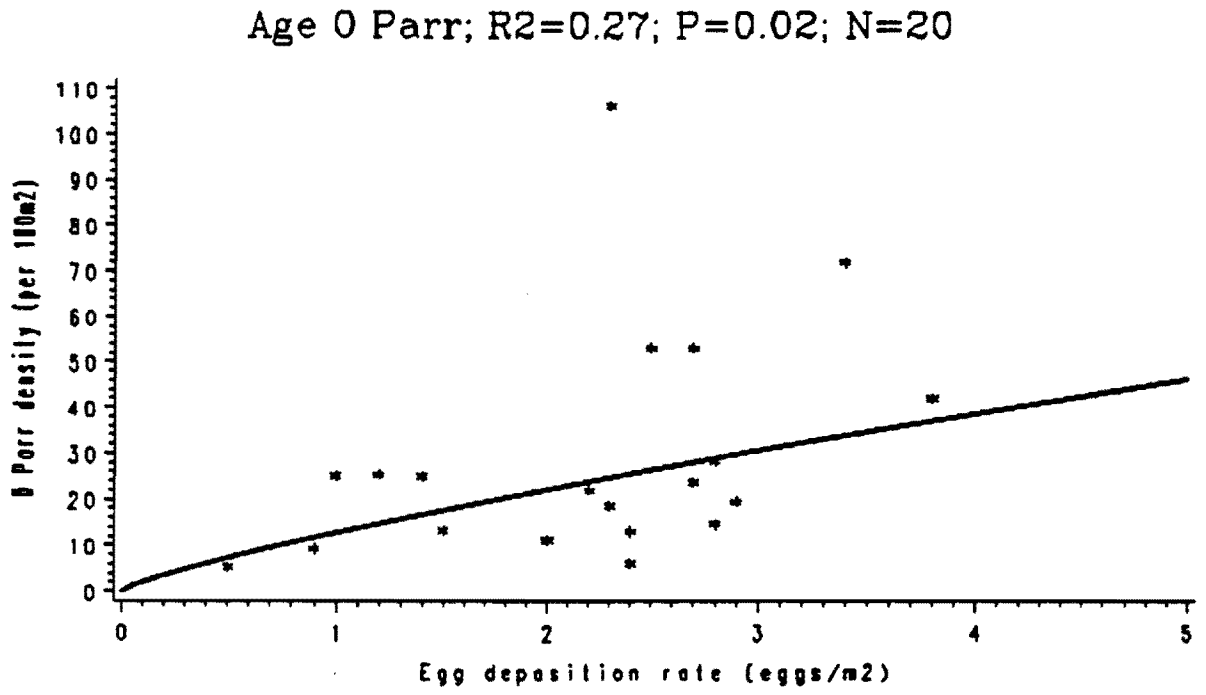


FIGURE 2. Egg deposition rates, 1970-1991, estimated from angling catch data and assumed exploitation rates of 0.3 (squares) and 0.5 (dots). Horizontal line indicates target deposition rate.



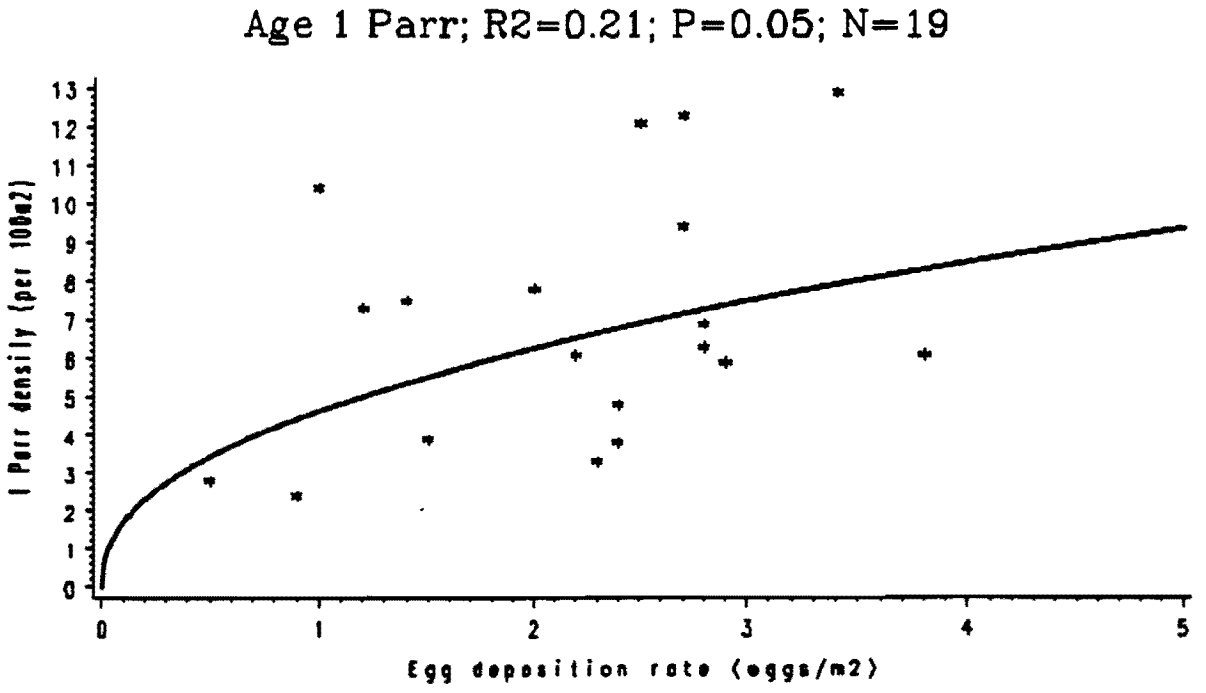
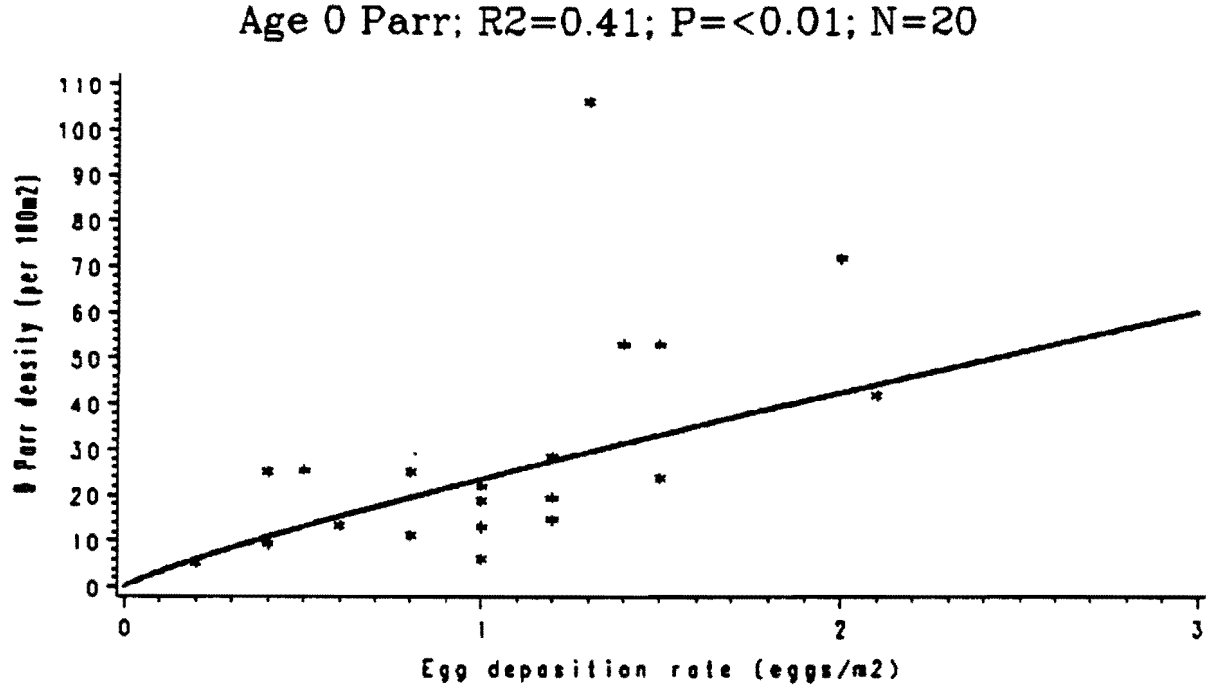


FIGURE 3. Relationship between egg deposition rate and resulting densities of 0+ and 1+ parr in the Restigouche River, 1972-1991. Egg deposition rates were estimated from angling catch and and assumed exploitation rate of 0.3.



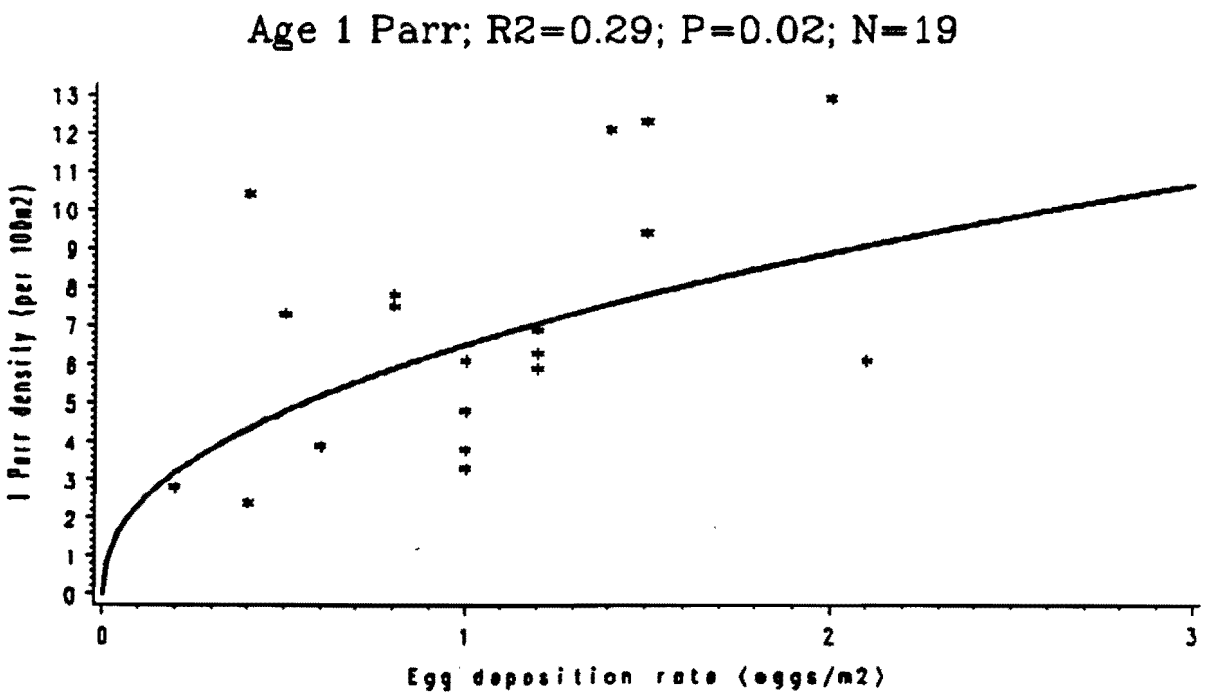


FIGURE 4. Relationship between egg deposition rate and resulting densities of 0+ and 1+ parr in the Restigouche River, 1972-1991. Egg deposition rates were estimated from angling catch and assumed exploitation rate of 0.5.

The SAS System 15:31 Thursday, January 16, 1992
5

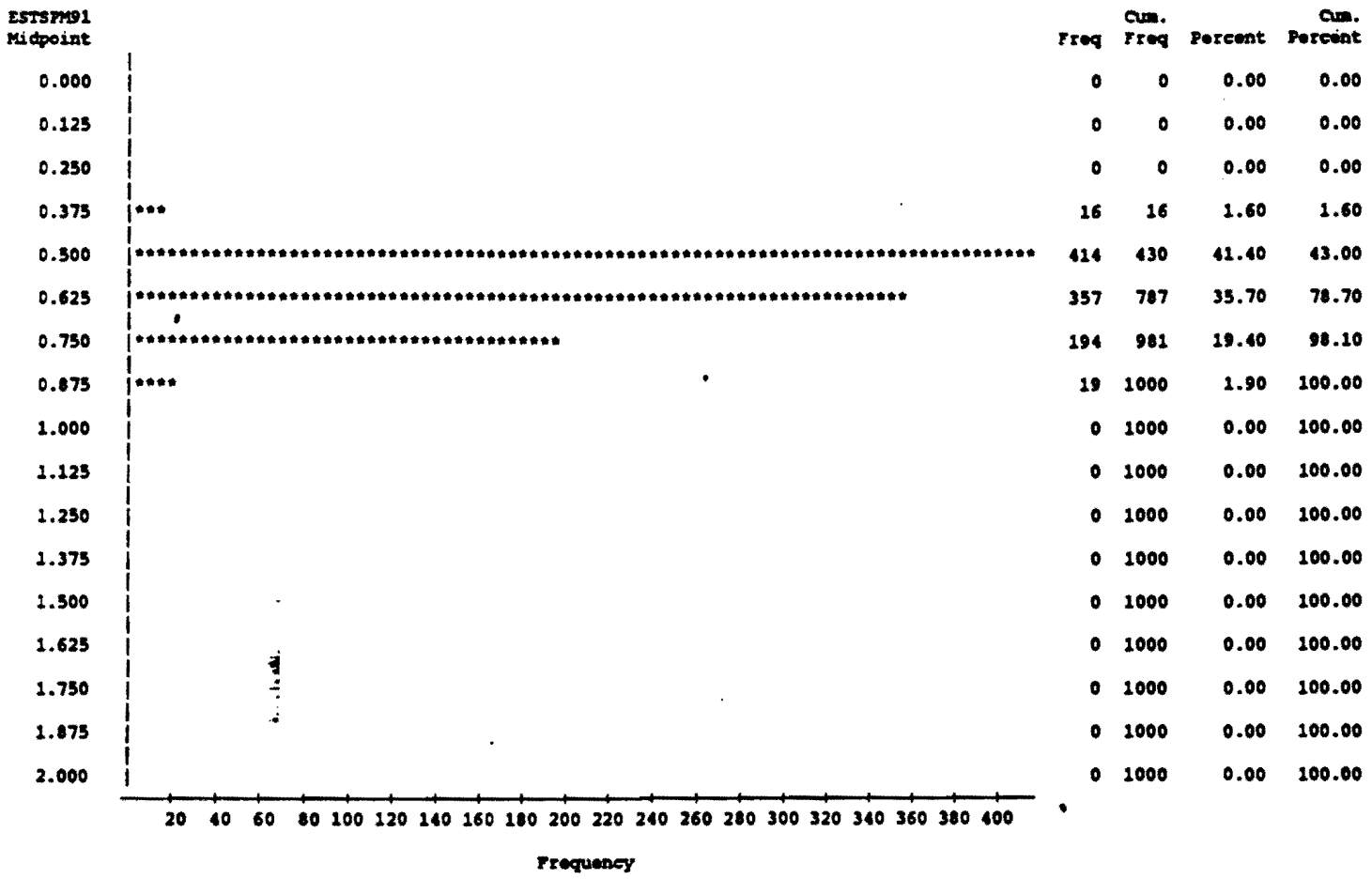


FIGURE 5. Estimated MSW total returns in 1991 as a proportion of the average 1986-1990 from randomization procedure, based on exploitation rates drawn from uniform distribution of 0.3-0.5, 1000 simulations, assume no error in catch data.

LSTSP191 Midpoint		Freq	Cum. Freq	Percent	Cum. Percent
0.000		0	0	0.00	0.00
0.125		0	0	0.00	0.00
0.250	***	21	21	2.10	2.10
0.375	**********	487	508	48.70	50.80
0.500	**********	401	909	40.10	90.90
0.625	**********	91	1000	9.10	100.00
0.750		0	1000	0.00	100.00
0.875		0	1000	0.00	100.00
1.000		0	1000	0.00	100.00
1.125		0	1000	0.00	100.00
1.250		0	1000	0.00	100.00
1.375		0	1000	0.00	100.00
1.500		0	1000	0.00	100.00
1.625		0	1000	0.00	100.00
1.750		0	1000	0.00	100.00
1.875		0	1000	0.00	100.00
2.000		0	1000	0.00	100.00

30 60 90 120 150 180 210 240 270 300 330 360 390 420 450 480

Frequency

FIGURE 6. Estimated 1SW total returns in 1991 as a proportion of the average 1986-1990 from randomization procedure, based on exploitation rates drawn from uniform distribution of 0.3-0.5, 1000 simulations, assume no error in catch data.

ESTSPM91 Midpoint	Freq	Cum. Freq	Percent	Cum. Percent
0.000	0	0	0.00	0.00
0.125	0	0	0.00	0.00
0.250	0	0	0.00	0.00
0.375	171	171	17.10	17.10
0.500	371	542	37.10	54.20
0.625	285	827	28.50	82.70
0.750	152	979	15.20	97.90
0.875	21	1000	2.10	100.00
1.000	0	1000	0.00	100.00
1.125	0	1000	0.00	100.00
1.250	0	1000	0.00	100.00
1.375	0	1000	0.00	100.00
1.500	0	1000	0.00	100.00

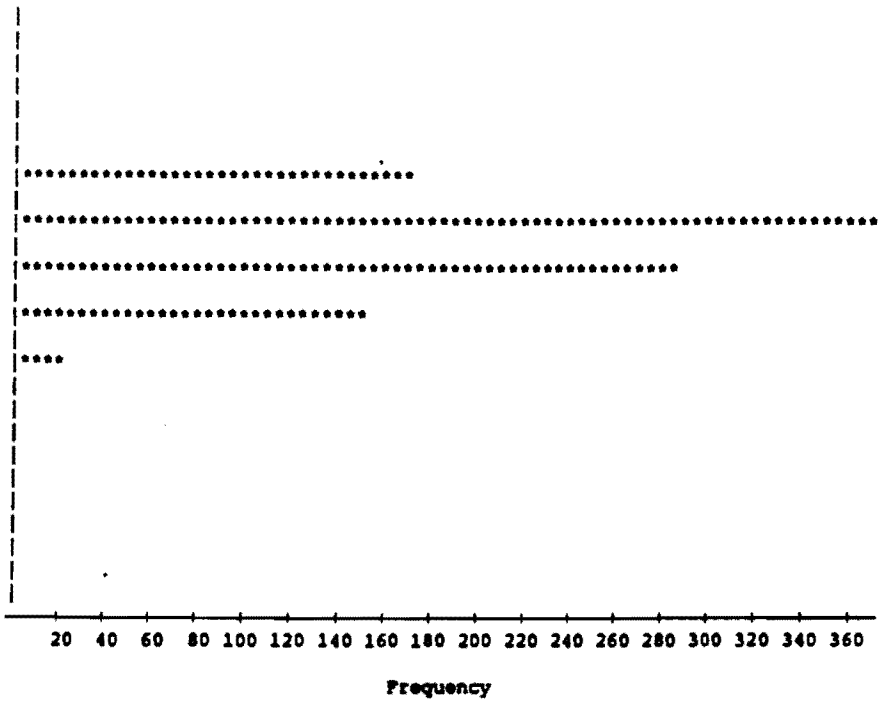


FIGURE 7. Estimated MSW spawners in 1991 as a proportion of the average 1986-1990 from randomization procedure, based on exploitation rates drawn from uniform distribution of 0.3-0.5, 1000 simulations, assume no error in catch data.

The SAS System 11:23 Thursday, January 16, 1992
3

TM Midpoint		Freq	Cum. Freq	Percent	Cum. Percent
-7050	**********	65	65	6.50	6.50
-6750	**********	103	168	10.30	16.80
-6450	**********	110	278	11.00	27.80
-6150	**********	89	367	8.90	36.70
-5850	**********	89	456	8.90	45.60
-5550	**********	84	540	8.40	54.00
-5250	**********	73	613	7.30	61.30
-4950	**********	70	683	7.00	68.30
-4650	**********	58	741	5.80	74.10
-4350	**********	70	811	7.00	81.10
-4050	**********	48	859	4.80	85.90
-3750	**********	44	903	4.40	90.30
-3450	**********	46	949	4.60	94.90
-3150	**********	40	989	4.00	98.90
-2850	******	11	1000	1.10	100.00

10 20 30 40 50 60 70 80 90 100 110

Frequency

FIGURE 8. Estimated MSW spawners in 1991 - spawning target (12,200) from randomization procedure, based on exploitation rates drawn from uniform distribution of 0.3-0.5, 1000 simulations, assume no error in catch data.

The SAS System 11:51 Wednesday, January 15, 199.
18

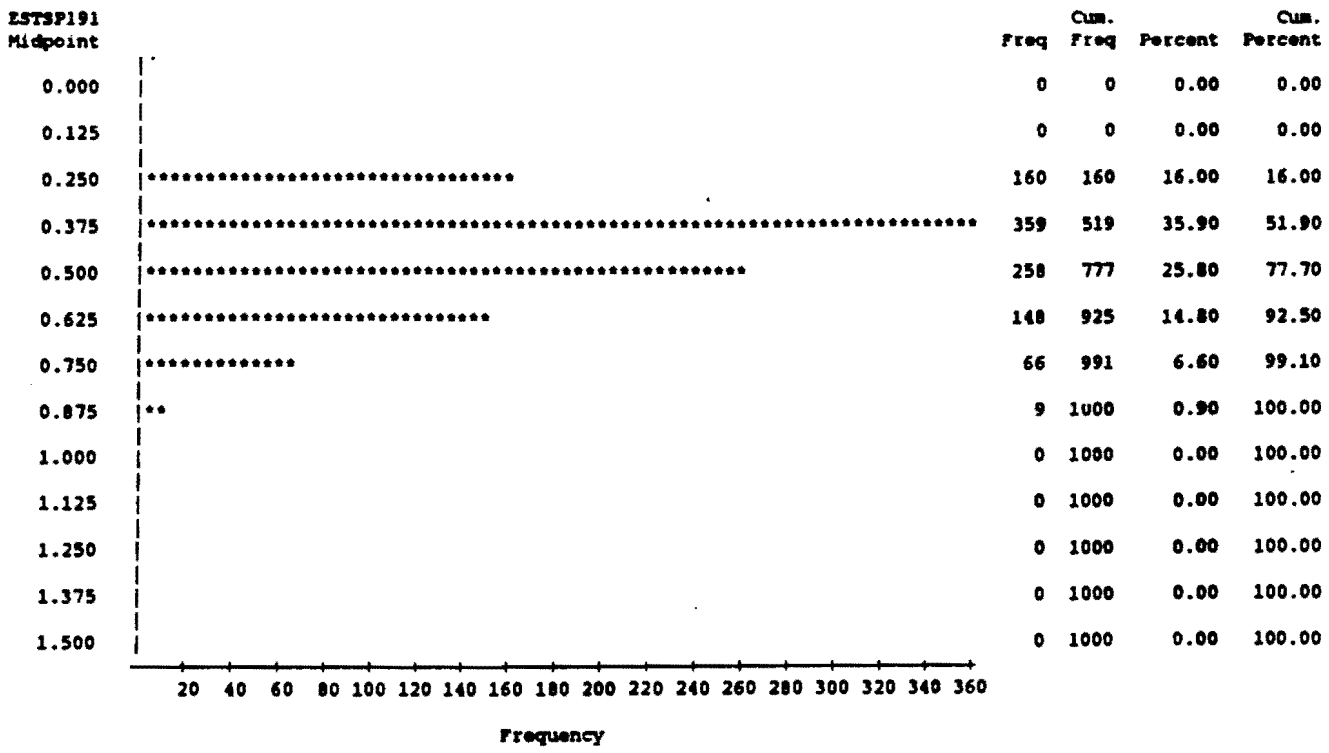


FIGURE 9. Estimated 1SW spawners in 1991 as a proportion of the average 1986-1990 from randomization procedure, based on exploitation rates drawn from uniform distribution of 0.3-0.5, 1000 simulations, assume no error in catch data.

T1 Midpoint	Freq	Cum. Freq	Percent	Cum. Percent
0	109	109	10.90	10.90
250	82	191	8.20	19.10
500	103	294	10.30	29.40
750	96	390	9.60	39.00
1000	96	486	9.60	48.60
1250	88	574	8.80	57.40
1500	70	644	7.00	64.40
1750	62	706	6.20	70.60
2000	63	769	6.30	76.90
2250	47	816	4.70	81.60
2500	56	872	5.60	87.20
2750	54	926	5.40	92.60
3000	41	967	4.10	96.70
3250	33	1000	3.30	100.00

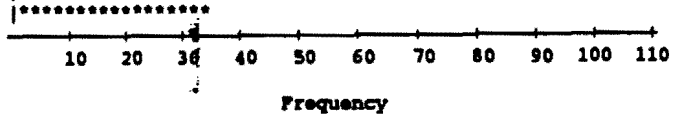


FIGURE 10. Estimated 1SW spawners in 1991 - spawning target (2,600) from randomization procedure, based on exploitation rates drawn from uniform distribution of 0.3-0.5, 1000 simulations, assume no error in catch data.

PE Midpoint		Freq	Cum. Freq	Percent	Cum. Percent
0.42	**********	21	21	2.10	2.10
0.46	**	85	106	8.50	10.60
0.50	***	132	238	13.20	23.80
0.54	***	128	366	12.80	36.60
0.58	**	116	482	11.60	48.20
0.62	***	125	607	12.50	60.70
0.66	**	100	707	10.00	70.70
0.70	**	81	788	8.10	78.80
0.74	*************************************	74	862	7.40	86.20
0.78	******************************	60	922	6.00	92.20
0.82	*******************	37	959	3.70	95.90
0.86	************	25	984	2.50	98.40
0.90	*****	10	994	1.00	99.40
0.94	***	6	1000	0.60	100.00

10 20 30 40 50 60 70 80 90 100 110 120 130

Frequency

FIGURE 11. Estimated egg deposition in 1991 as a proportion of the average 1986-1990 from randomization procedure, based on exploitation rates drawn from uniform distribution of 0.3-0.5, 1000 simulations, assume no error in catch data.

The SAS System 11:23 Thursday, January 16, 1992
5

TE Midpoint	Freq	Cum. Freq	Percent	Cum. Percent
-40500000	59	59	5.90	5.90
-39000000	80	139	8.00	13.90
-37500000	107	246	10.70	24.60
-36000000	78	324	7.80	32.40
-34500000	68	392	6.80	39.20
-33000000	72	464	7.20	46.40
-31500000	76	540	7.60	54.00
-30000000	60	600	6.00	60.00
-28500000	61	661	6.10	66.10
-27000000	52	713	5.20	71.30
-25500000	53	766	5.30	76.60
-24000000	53	819	5.30	81.90
-22500000	41	860	4.10	86.00
-21000000	39	899	3.90	89.90
-19500000	32	931	3.20	93.10
-18000000	37	968	3.70	96.80
-16500000	32	1000	3.20	100.00

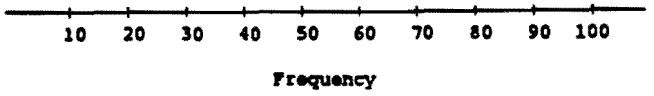
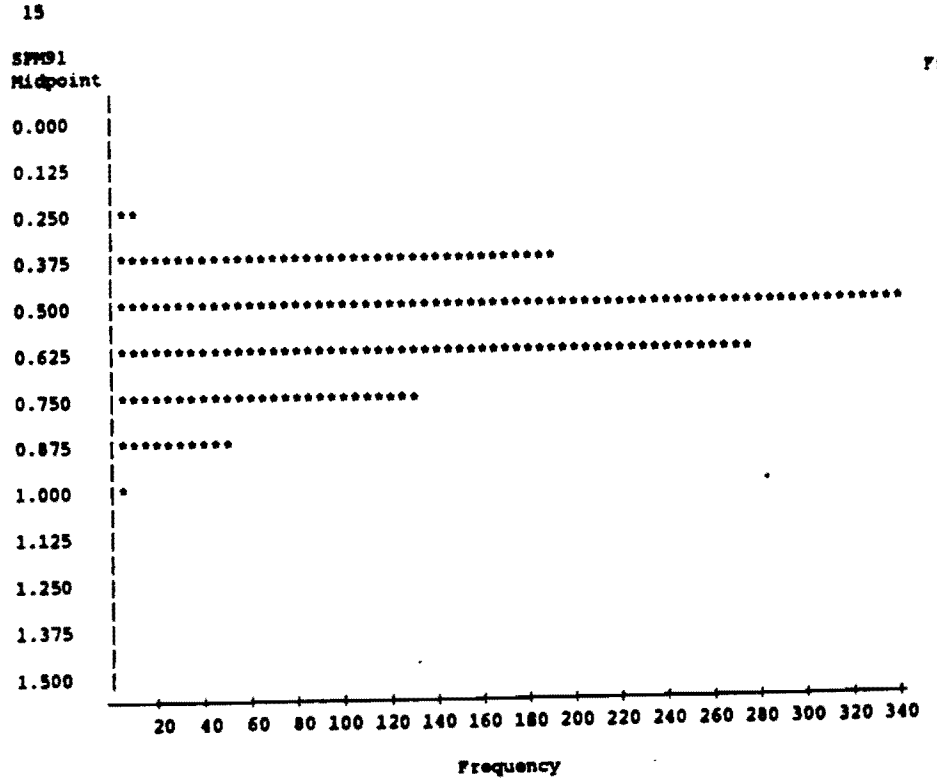


FIGURE 12. Estimated egg deposition in 1991 - spawning target (71.4 million eggs) from randomization procedure, based on exploitation rates drawn from uniform distribution of 0.3-0.5, 1000 simulations, assume no error in catch data.

The SAS System
15



Midpoint	Freq	Cum. Freq	Percent	Cum. Percent
0.000	0	0	0.00	0.00
0.125	0	0	0.00	0.00
0.250	12	12	1.20	1.20
0.375	190	202	19.00	20.20
0.500	340	542	34.00	54.20
0.625	275	817	27.50	81.70
0.750	130	947	13.00	94.70
0.875	50	997	5.00	99.70
1.000	3	1000	0.30	100.00
1.125	0	1000	0.00	100.00
1.250	0	1000	0.00	100.00
1.375	0	1000	0.00	100.00
1.500	0	1000	0.00	100.00

FIGURE 13. Estimated MSW spawners in 1991 as a proportion of the average 1986-1990 from randomization procedure, based on exploitation rates drawn from uniform distribution of 0.3-0.4 for 1991, and 0.3-0.5 for 1986-1990, 1000 simulations, assume no error in catch data.

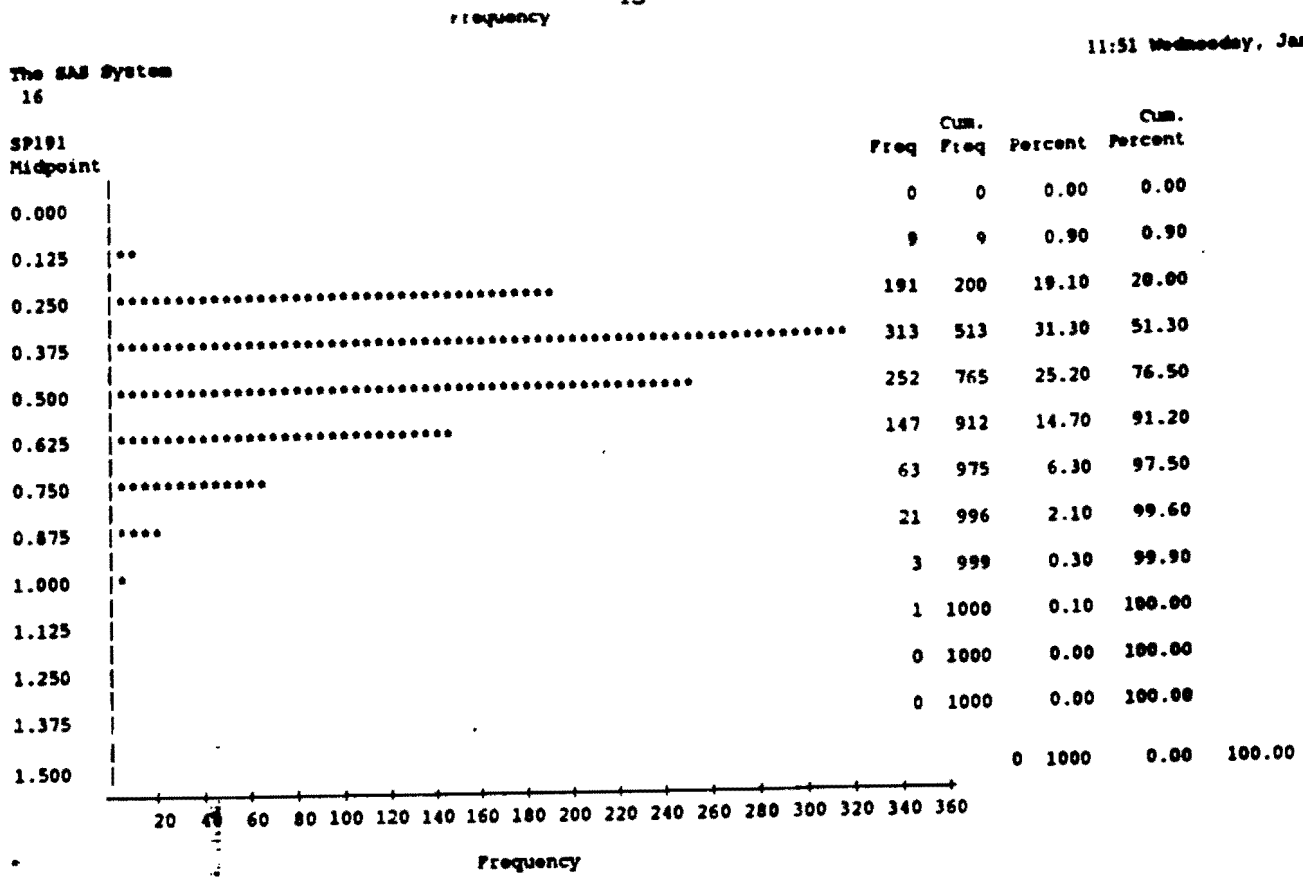
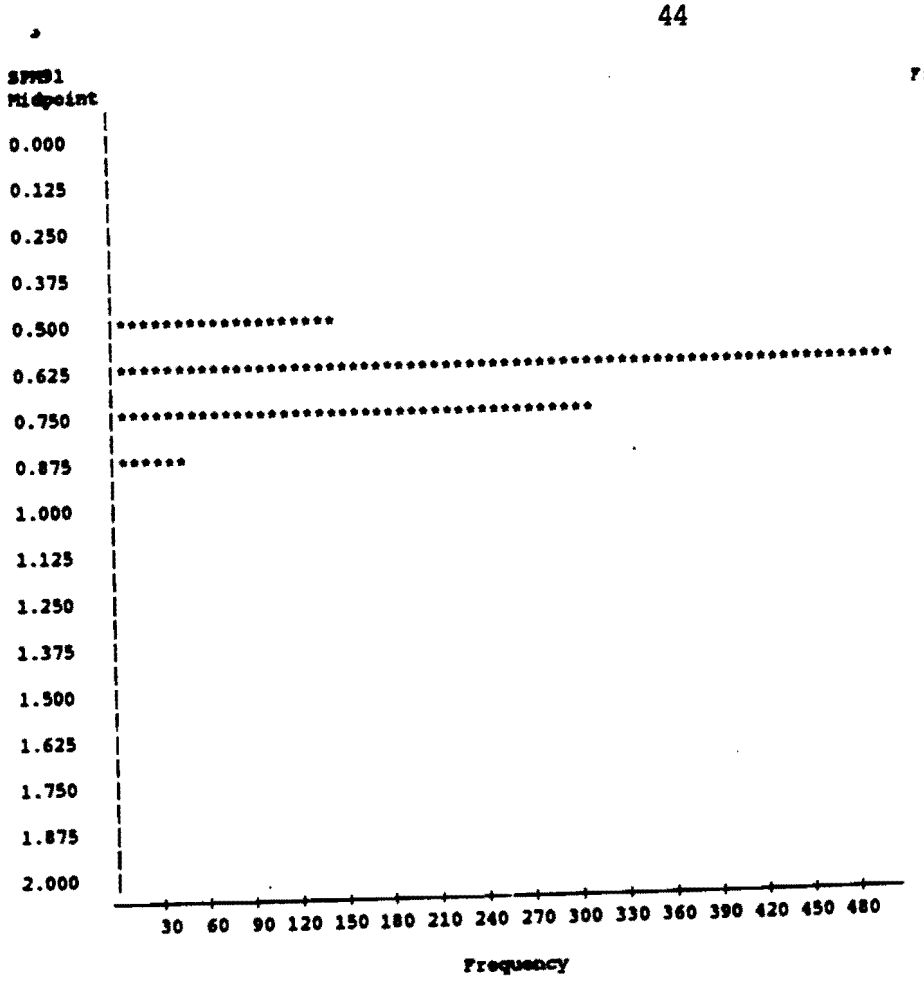
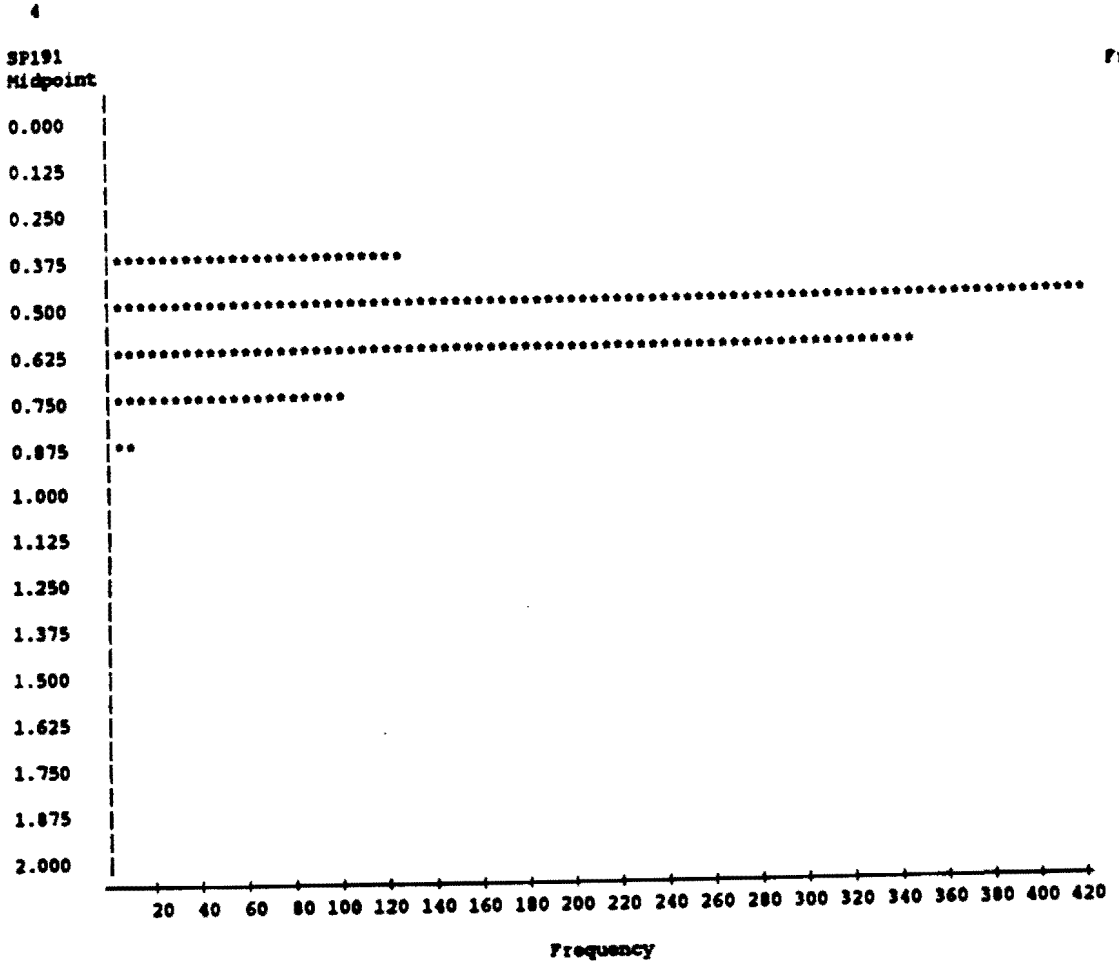


FIGURE 14. Estimated 1SW spawners in 1991 as a proportion of the average 1986-1990 from randomization procedure, based on exploitation rates drawn from uniform distribution of 0.3-0.4 for 1991, and 0.3-0.5 for 1986-1990, 1000 simulations, assume no error in catch data.



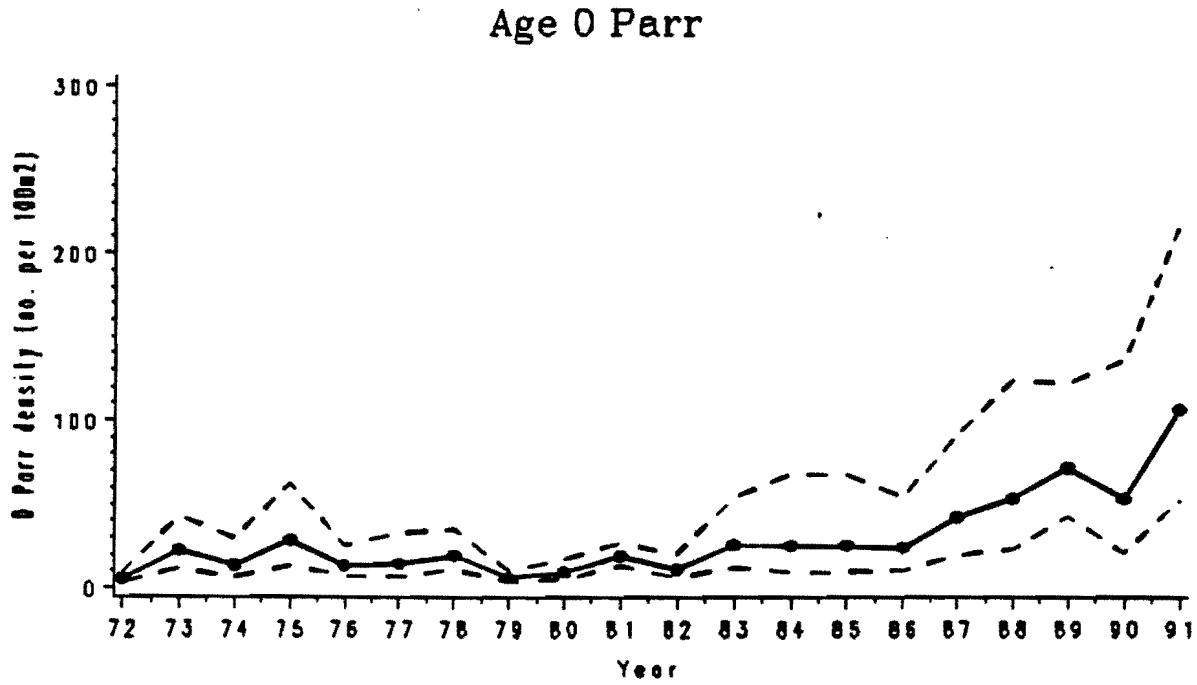
Freq	Cum. Freq	Percent	Cum. Percent
0	0	0.00	0.00
0	0	0.00	0.00
0	0	0.00	0.00
0	0	0.00	0.00
145	145	14.50	14.50
501	646	50.10	64.60
307	953	30.70	95.30
46	999	4.60	99.90
1	1000	0.10	100.00
0	1000	0.00	100.00
0	1000	0.00	100.00
0	1000	0.00	100.00
0	1000	0.00	100.00
0	1000	0.00	100.00
0	1000	0.00	100.00
0	1000	0.00	100.00
0	1000	0.00	100.00

FIGURE 15. Estimated MSW spawners in 1991 as a proportion of the average 1986-1990 from randomization procedure, based on exploitation rates drawn from uniform distribution of 0.3-0.5, 1000 simulations, assume catch estimates are within 20% of true catch (i.e, catch drawn from uniform distribution of C/1.2-C/0.8).



Freq	Cum. Freq	Percent	Cum. Percent
0	0	0.00	0.00
0	0	0.00	0.00
0	0	0.00	0.00
127	127	12.70	12.70
418	545	41.80	54.50
346	891	34.60	89.10
98	989	9.80	98.90
11	1000	1.10	100.00
0	1000	0.00	100.00
0	1000	0.00	100.00
0	1000	0.00	100.00
0	1000	0.00	100.00
0	1000	0.00	100.00
0	1000	0.00	100.00
0	1000	0.00	100.00
0	1000	0.00	100.00
0	1000	0.00	100.00

FIGURE 16. Estimated 1SW spawners in 1991 as a proportion of the average 1986-1990 from randomization procedure, based on exploitation rates drawn from uniform distribution of 0.3-0.5, 1000 simulations, assume catch estimates are within 20% of true catch (i.e., catch drawn from uniform distribution of C/1.2-C/0.8).



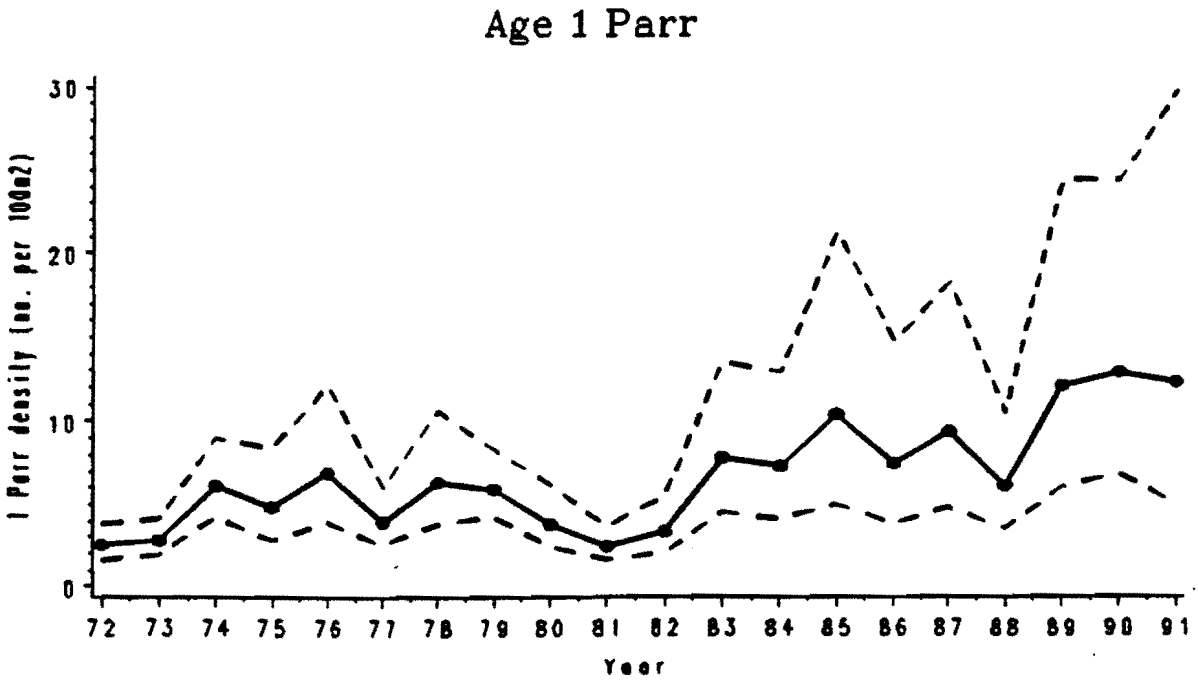


FIGURE 17. Mean densities of 0+ and 1+ salmon parr at 15 sites in the Restigouche River, 1972-1991 (8 sites in 1991). Dashed lines are 95% confidence limits.

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General Linear Models Procedure
Class Level Information

Class	Levels	Values
YEAR	20	1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991
RIVER	3	LMER MSR ZER
STKORD	4	4 5 7 10

Number of observations in data set = 298

NOTE: Due to missing values, only 250 observations can be used in this analysis.

Dependent Variable: LOGPOP

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	24	173.02210336	7.24258764	7.34	0.0001
Error	233	229.85395171	0.98649765		
Corrected Total	257	403.67605587			

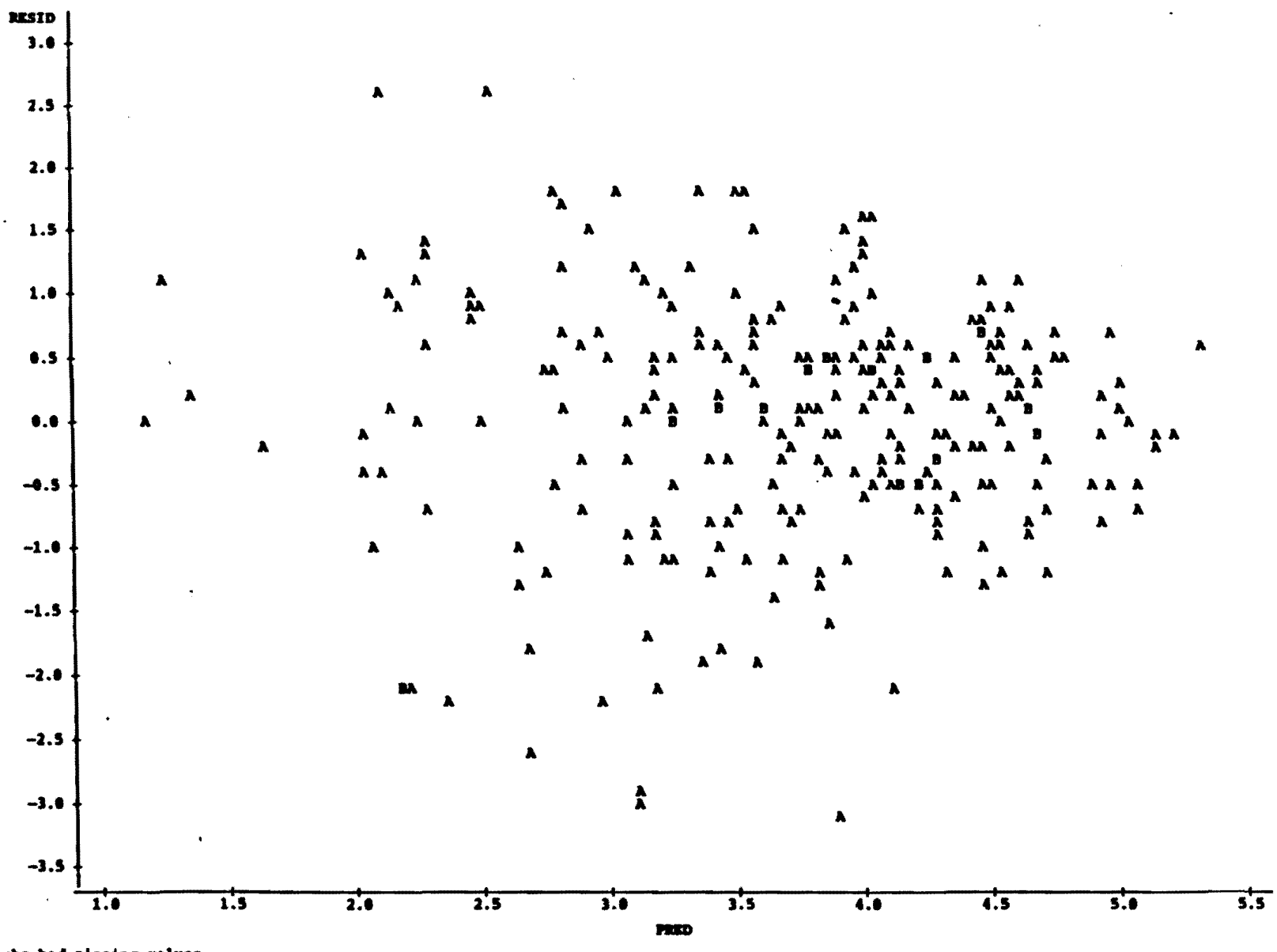
R-Square	C.V.	Root MSE	LOGPOP Mean
0.430598	26.76902	0.99322588	3.71035597

Source	DF	Type I SS	Mean Square	F Value	Pr > F
LOGAREA	1	19.39680384	19.39680384	19.66	0.0001
YEAR	19	88.83960356	4.67576861	4.73	0.0001
RIVER	2	6.84316937	3.42158468	3.06	0.0486
STKORD	2	59.74252660	29.87126330	30.28	0.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
LOGAREA	1	7.00061276	7.00061276	7.10	0.0079
YEAR	19	91.76190108	4.82957374	4.90	0.0001
RIVER	1	0.00245326	0.00245326	0.00	0.9603
STKORD	2	59.74252660	29.87126330	30.28	0.0001

Parameter		Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		0.576244553 B	0.32	0.7473	1.78636626
LOGAREA		0.967078910	2.68	0.0079	0.36097283
YEAR	1972	-3.350618893 B	-4.23	0.0001	0.53792434
	1973	-1.616326796 B	-3.00	0.0030	0.53825588
	1974	-2.620536080 B	-4.64	0.0001	0.56435704
	1975	-1.118921182 B	-2.04	0.0423	0.54813511
	1976	-1.161313455 B	-2.07	0.0001	0.56118805
	1977	-1.045886352 B	-1.76	0.0003	0.59312181
	1978	-1.920885986 B	-3.63	0.0004	0.52954830
	1979	-2.632312649 B	-4.58	0.0001	0.57453212
	1980	-2.395915345 B	-4.30	0.0001	0.55727305
	1981	-1.576261008 B	-2.75	0.0064	0.57315297
	1982	-2.436596528 B	-4.22	0.0001	0.57791241
	1983	-1.407924835 B	-2.48	0.0079	0.56528545
	1984	-1.243013575 B	-2.34	0.0201	0.53110850
	1985	-1.021921719 B	-1.91	0.0575	0.53541121
	1986	-1.380628900 B	-2.75	0.0064	0.50191419
	1987	-1.001428321 B	-2.22	0.0276	0.45180182
	1988	-0.962380097 B	-2.22	0.2698	0.45418137
	1989	-0.339859082 B	-0.76	0.4453	0.44446345
	1990	-0.770610499 B	-1.72	0.0875	0.44913986
	1991	0.000000000 B	.	.	.
RIVER	LMER	-0.008369568 B	-0.05	0.9603	0.16703368
	MSR	-0.533002812 B	-2.58	0.0104	0.20631031
	ZER	0.000000000 B	.	.	.
STKORD	4	-1.546158748 B	-7.55	0.0001	0.20488788
	5	-0.596779266 B	-3.24	0.0014	0.18446267
	7	0.000000000 B	.	.	.
	10	0.000000000 B	.	.	.

FIGURE 18. SAS output of multiplicative model comparing fry (0+) density in 1991 with previous years, in the Restigouche River. Fry densities were measured by electrofishing at 15 standard sites in the river 1972-1990, and at 8 of those sites in 1991.



NOTE: 48 obs had missing values.

FIGURE 19. Scatterplot of residuals vs predicteds from multiplicative analysis given in FIGURE 18.

RESTIGOUCHE PARR, YEAR & STRORD & RIVER EFFECT ONLY, EXCLUDE 0 POPS — 15:40 Wednesday, January 8, 1992 10

General Linear Models Procedure
Class Level Information

Class	Levels	Values
YEAR	20	1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991
RIVER	3	LMRR MRR SKR
STRORD	4	4 5 7 10

Number of observations in data set = 252

RESTIGOUCHE PARR, YEAR & STRORD & RIVER EFFECT ONLY, EXCLUDE 0 POPS — 15:40 Wednesday, January 8, 1992 11

General Linear Models Procedure

Dependent Variable: LOGPOP

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	24	107.80082367	4.49170099	5.18	0.0001
Error	227	196.93661675	0.86756219		
Corrected Total	251	304.73744042			

R-Square	C.V.	Root MSE	LOGPOP Mean
0.353756	37.63417	0.93143018	2.47495904

Source	DF	Type I SS	Mean Square	F Value	Pr > F
LOGABRA	1	0.31201470	0.31201470	0.36	0.5488
YEAR	19	30.65678189	1.61351484	1.86	0.0181
RIVER	2	67.27972809	33.63986405	38.78	0.0001
STRORD	2	9.55149899	4.77574950	5.50	0.0046

Source	DF	Type III SS	Mean Square	F Value	Pr > F
LOGABRA	1	0.07174185	0.07174185	0.08	0.7739
YEAR	19	27.36669878	1.44035162	1.66	0.0444
RIVER	1	53.31027673	53.31027673	61.46	0.0001
STRORD	2	9.55149899	4.77574950	5.50	0.0046

Parameter		Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		2.157116209 B	1.29	0.1969	1.66679398
LOGABRA		0.096753193	0.29	0.7739	0.33645682
YEAR	1972	-1.185794682 B	-2.23	0.0265	0.53103085
	1973	-0.610244424 B	-1.14	0.2565	0.53646537
	1974	-0.051320155 B	-0.10	0.9220	0.52867542
	1975	-0.437671722 B	-0.81	0.4170	0.53828483
	1976	-0.107855128 B	-0.21	0.8353	0.51801177
	1977	-0.697599238 B	-1.35	0.1791	0.51757656
	1978	-0.404650795 B	-0.79	0.4308	0.51267958
	1979	0.044905538 B	0.08	0.9339	0.54118173
	1980	-0.581185110 B	-1.08	0.2805	0.53904107
	1981	-0.781272124 B	-1.38	0.1699	0.56743530
	1982	-0.510316223 B	-0.88	0.3797	0.57975298
	1983	-0.074924953 B	-0.15	0.8827	0.50710064
	1984	-0.134340983 B	-0.27	0.7836	0.48855332
	1985	0.173458947 B	0.34	0.7305	0.50288905
	1986	-0.094599630 B	-0.19	0.8480	0.49290003
	1987	-0.479106479 B	-1.07	0.2862	0.44018551
	1988	-0.600810940 B	-1.34	0.1831	0.44995341
	1989	0.064022919 B	0.14	0.8880	0.45399820
	1990	-0.356717040 B	-0.82	0.4110	0.43307621
	1991	0.000000000 B	.	.	.
RIVER	LMRR	-1.252412684 B	-7.84	0.0001	0.15975693
	MRR	0.813785157 B	4.19	0.0001	0.19411684
	SKR	0.000000000 B	.	.	.
STRORD	4	0.324121990 B	1.73	0.0846	0.18709716
	5	0.563511793 B	3.29	0.0012	0.17124945
	7	0.000000000 B	.	.	.
	10	0.000000000 B	.	.	.

NOTE: The X'X matrix has been found to be singular and a generalized inverse was used to solve the normal equations. Estimates followed by the letter 'B' are biased, and are not unique estimators of the parameters.

FIGURE 20. SAS output of multiplicative model comparing parr (1+) density in 1991 with previous years, in the Restigouche River. Fry densities were measured by electrofishing at 15 standard sites in the river 1972-1990, and at 8 of those sites in 1991.

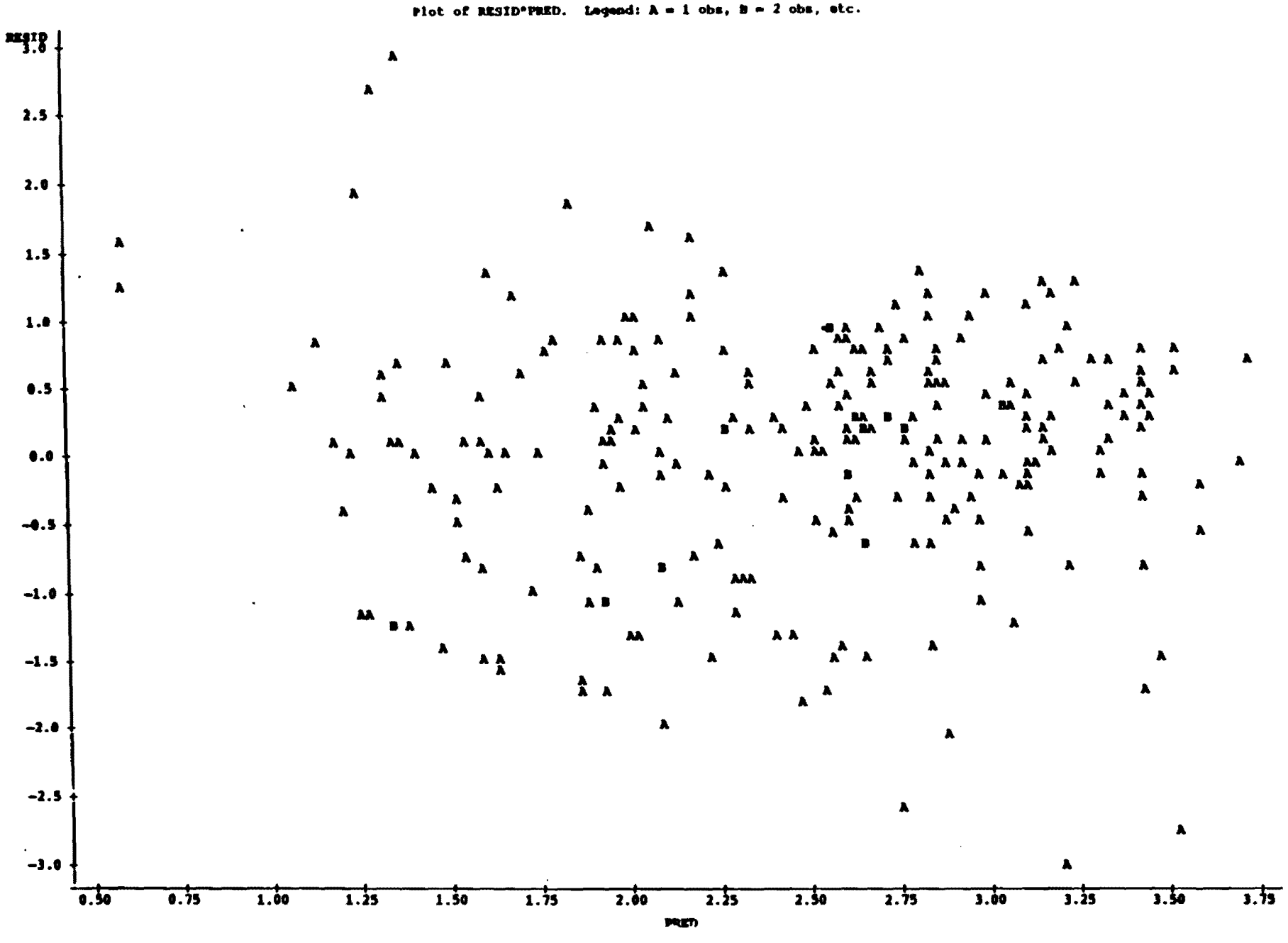


FIGURE 21. Scatterplot of residuals vs predicteds from multiplicative analysis given in FIGURE 20.

APPENDIX 1. SAS program of randomization procedure for comparing estimate of returns, spawners, and egg deposition in 1991, to prior 5 year mean, and targets.

```
/* shelterr.sas - translation of shelton.sas into proc iml   19912-01-13
                  programme to read restigouche river
                  salmon catch data and calulate probability
                  of cuurent year escapement
                  mean of the previous years

   variables estcat esthrv are the observed values, and variables
   estimated from them (estesc estsp91 esteggm estegg91) are assumed to
   have no other error than that in the exploitation rate (.3-.5)

   variables angcat rivhrv are assumed to be the 'true' values, within
   20% of the observed data. variables estimated from them, are then
   assumed to be the 'true' values (esc sp91)                          */

proc iml;
reset nocenter noname linesize=130 pagesize=80;
infile 'restigouche.dat' missover;
create s var {yr nbcat  nbhrv  pqcat  pqhrv bs angcl esthm esthi};
do data ; input yr nbcat nbhrv pqcat pqhrv bs angcl; append; end;
close s; closefile 'restigouche.dat';

use s;
read all var {yr} into year;
read all var {nbcat pqcat angcl} into ac;
read all var {bs} into brood;
read all var {nbhrv pqhrv angcl} into rh;
prop=rh/ac;
explo=.3;
exphi=.5;

cat=ac;

estcat=(cat[,1]+cat[,2])||cat[,3];
esthrv=(rh[,1]+rh[,2]+brood)||rh[,3];
ranlo=cat/1.2;
ranhi=cat/.8;

nr=nrow(cat);
nc=ncol(cat)-1;

iter=1000;
mat0=shape(0,iter,4);
mat=shape(0,iter,8);
do ijk=1 to iter;
seed=0;

do i = 1 to nr;
  do j = 1 to nc+1;
     ac[i,j]=ranlo[i,j]+(ranhi[i,j]-ranlo[i,j])#ranuni(seed);
*    print (cat[i,j]||ac[i,j]);
  end;
end;

angcat=(ac[,1]+ac[,2])||ac[,3];
rivhrv=((ac[,1]#prop[,1])+ac[,2]+brood)||ac[,3];

*print (angcat||rivhrv);

esc=shape(0,nr,nc);
estesc=shape(0,nr,nc);

do i=1 to nr;
   do j=1 to nc;
      exp=(explo+(exphi-explo)#ranuni(seed));
      esc[i,j]=(angcat[i,j]/exp)-rivhrv[i,j];
      estesc[i,j]=(estcat[i,j]/exp)-esthrv[i,j];
*     print (i||j||exp||esc[i,j]);
   end;
end;

/*estsp91 = estesc[nr,]/((estesc[1:nr-1,][+,])/(nr-1));
sp91 = esc[nr,]/((esc[1:nr-1,][+,])/(nr-1));
*print sp91;*/
estsp91 = estesc[nr,];
esteggm = (estesc[1:nr-1,]#shape((5993||86),nr-1,2))[+,+]/(nr-1);
estegg91= ((estesc[nr,])#(5933||86))[+];
mat0[ijk,]=esteggm||estegg91||estsp91;
*mat[ijk,]=sp91||estsp91||
          (esc[1:nr-1,][+,])/(nr-1)||(estesc[1:nr-1,][+,])/(nr-1);
```

```
end;
*print mat0;
fname={ 'eggsm' 'eggs91' 'spm91' 'sp191'};
create done from mat0 [ colname=fname];
append from mat0;

/*fname = ['spm91' 'sp191' 'estspm91' 'estsp191'
                'avgm' 'avg1' 'estavgm' 'estavg1'];
create done from mat [ colname=fname];
append from mat;*/

filename store 'sim2.dat';
data upd;
set done;
file store;
put eggsm eggs91 spm91 sp191;
*put spm91 sp191 estspm91 estsp191 avgm avg1 estavgm estavg1;
run;

data step1;
infile 'sim2.dat';
/*input spm91 sp191 estspm91 estsp191 avgm avg1 estavgm eatavg1;
difm=spm91-estspm91;
difl=sp191-estsp191;
difavgm=avgm-estavgm;
difavg1=avg1-estavg1;
proc means;
     var spm91 sp191 estspm91 estsp191 difm difl difavgm difavg1;
run;
proc chart;
     hbar spm91 sp191/midpoints= 0 to 1.5 by .125;
run;
proc chart;
     hbar estspm91 estsp191/midpoints= 0 to 1.5 by .125;
run;
proc chart;
     hbar difavgm difavg1;
run;
*/

input eggsm eggs91  spm91 sp191;
tm=spm91-12200;
tl=sp191-2600;
te=eggs91-71400000;
pe=eggs91/eggsm;
proc means;
     var   eggsm  eggs91  spm91 sp191 tm tl te pe;
proc chart;
     hbar tm tl;
run;
proc chart;
     hbar te pe;
run;
```

APPENDIX 2a. SAS program of multiplicative model for comparing 0+ fry density in 1991 to densities in prior years.

```
** RESFRY.SAS  RESTIGOUCHE ELECTROFISHING DATA, FRY 1972 TO 1991;
OPTIONS LINESIZE=160 PAGESIZE = 85 NOCENTRE;
FILENAME A '[CHAPUT.RUSSELL]RES7290.AG0';
FILENAME SITE '[CHAPUT.RUSSELL]RESSITES.PRN';
DATA SITES; INFILE SITE; INPUT RIVER$ SITE STRORD;
PROC SORT DATA = SITES; BY SITE;
DATA RESFRY1 ; INFILE A; INPUT SITE YEAR DAY SWEEPS CATCH POP DENSITY FVAL
AREA DEPTH WTARR COND ELF;
*  IF SITE NE 4 AND SITE NE 5 AND SITE NE 28 AND SITE NE 30 AND SITE NE 40
     AND SITE NE 45 AND SITE NE 52 AND SITE NE 55 AND SITE NE 29 AND SITE NE 38
     AND SITE NE 39 AND SITE NE 41 AND SITE NE 42 AND SITE NE 49 AND SITE
     NE 54 THEN DELETE;
  LOGPOP = LOG(POP+0.0000001);
  LOGAREA = LOG(AREA+0.0000001);
  LOGDEN = LOG(DENSITY+0.0000001);
RUN;
/*TITLE 'FRY POPULATION AND DENSITY FOR RESTIGOUCHE, 1972 TO 1991';
PROC CHART DATA = RESFRY1;
  HBAR POP / LEVELS = 50;
  HBAR DENSITY / LEVELS = 50;
ENDSAS;*/
PROC SORT DATA = RESFRY1; BY SITE;
DATA RESFRY; MERGE RESFRY1 SITES;
  BY SITE;
  IF RIVER = 'KR' THEN RIVER = 'EKR';
  IF STRORD = 6 THEN STRORD = 10;

/**  SUMMARY OF SITE NUMBERS BY RIVER AND STREAM ORDER;
PROC TABULATE DATA = RESFRY FORMCHAR(1)=' ' MISSING FORMAT=6.;
  CLASS STRORD RIVER SITE;
  TABLE RIVER*SITE, STRORD/RTS=10;
**  SUMMARY OF AREA AND DEPTH BY SITE AND YEAR;
PROC TABULATE DATA = RESFRY FORMCHAR(1)=' ' MISSING FORMAT=6.1;
  CLASS SITE YEAR;
  VAR AREA DEPTH;
  TABLE AREA DEPTH, SITE, YEAR*SUM/RTS=5;

** NUMBER OF SITES SURVEYED FOR RIVER, STREAM ORDER AND YEAR CATEGORIES;
PROC TABULATE DATA = RESFRY FORMCHAR(1)=' ' MISSING FORMAT=6.;
  CLASS SITE STRORD RIVER YEAR;
  TABLE (RIVER ALL) (STRORD ALL) (SITE ALL), ALL YEAR/RTS=6;
RUN;*/
** SUMMARIES OF CATCH, POPULATION AND DENSITY BY SITE, BY STREAM ORDER
  BY RIVER CATEGORIES FOR ALL YEARS COMBINED;
PROC TABULATE DATA = RESFRY FORMCHAR(1)=' ' MISSING FORMAT=6.;
  TITLE 'RESTIGOUCHE ELECTROFISHING, FRY 1972 TO 1991';
  CLASS STRORD SITE RIVER;
  VAR CATCH POP DENSITY;
  TABLE CATCH POP DENSITY, SITE, (N MEAN*F=6.2 VAR*F=6.2 MIN*F=6.2 MAX*F=6.2
                                  CV*F=6.2)    /RTS=15;
  TABLE CATCH POP DENSITY, STRORD, (N MEAN*F=6.2 VAR*F=6.2 MIN*F=6.2 MAX*F=6.2
                                  CV*F=6.2)    /RTS=15;
  TABLE CATCH POP DENSITY, RIVER, (N MEAN*F=6.2 VAR*F=6.2 MIN*F=6.2 MAX*F=6.2
                                  CV*F=6.2)    /RTS=15;
RUN;
ENDSAS;
/*PROC PLOT DATA = RESFRY;
  PLOT DENSITY*SITE='*';
*  PLOT DENSITY*YEAR='*';
*  PLOT DENSITY*RIVER='*';
* PLOT DENSITY*STRORD='*';
ENDSAS;*/
TITLE 'RESTIGOUCHE FRY, YEAR & STRORD & RIVER EFFECT ONLY, EXCLUDE 0 POPS';
PROC GLM DATA = RESFRY;
  CLASS YEAR RIVER STRORD;
  MODEL LOGPOP = LOGAREA YEAR RIVER STRORD/ SOLUTION;
  OUTPUT OUT = RES P=PRED R=RESID;
/*DATA TEMP; SET RES;
  IF RESID LE -2.5 THEN OUTPUT TEMP;
PROC PRINT DATA = TEMP;
RUN;*/

PROC PLOT DATA = RES;
  PLOT RESID*PRED;
  PLOT RESID*YEAR;
  PLOT RESID*STRORD;
RUN;
```

APPENDIX 2b. SAS program of multiplicative model for comparing 1+ parr density in 1991 to densities in prior years.

```
** RESPARR.SAS  RESTIGOUCHE ELECTROFISHING DATA, PARR 1972 TO 1991;
OPTIONS LINESIZE=160 PAGESIZE = 85 NOCENTRE;
FILENAME A '[COURTEN.CAFSAC]R7291AG1.PRN';
FILENAME SITE '[COURTEN.CAFSAC]RESSITES.PRN';
DATA SITES; INFILE SITE; INPUT RIVER$ SITE STRORD;
PROC SORT DATA = SITES; BY SITE;
DATA RESPARR1 ; INFILE A; INPUT SITE YEAR DAY SWEEPS CATCH POP DENSITY FVAL
AREA DEPTH WTARR COND ELF;
/*TITLE 'PARR POPULATION AND DENSITY FOR RESTIGOUCHE, 1972 TO 1991';
PROC CHART DATA = RESPARR1;
  HBAR POP / LEVELS = 50;
  HBAR DENSITY / LEVELS = 50;
ENDSAS;*/
PROC SORT DATA = RESPARR1; BY SITE;
DATA RESPARR; MERGE RESPARR1 SITES;
  BY SITE;
  IF POP = 0 THEN DELETE;
  IF RIVER = 'KR' THEN RIVER = 'ZKR';
  IF STRORD = 6 THEN STRORD = 10;
* IF SITE NE 4 AND SITE NE 5 AND SITE NE 28 AND SITE NE 30 AND SITE NE 40
     AND SITE NE 45 AND SITE NE 52 AND SITE NE 55 AND SITE NE 29 AND SITE
     NE 38 AND SITE NE 39 AND SITE NE 41 AND SITE NE 42 AND SITE NE 49 AND
     SITE NE 54 THEN DELETE;
   LOGPOP = LOG(POP+0.0000001);
   LOGAREA = LOG(AREA+0.0000001);
   LOGDEN = LOG(DENSITY+0.0000001);
RUN;
/**  SUMMARY OF SITE NUMBERS BY RIVER AND STREAM ORDER;
PROC TABULATE DATA = RESPARR FORMCHAR(1)=' ' MISSING FORMAT=6.;
  CLASS STRORD RIVER SITE;
  TABLE RIVER*SITE, STRORD/RTS=10;
**  SUMMARY OF AREA AND DEPTH BY SITE AND YEAR;
PROC TABULATE DATA = RESPARR FORMCHAR(1)=' ' MISSING FORMAT=6.1;
  CLASS SITE YEAR;
  VAR AREA DEPTH;
  TABLE AREA DEPTH, SITE, YEAR*SUM/RTS=5;

** NUMBER OF SITES SURVEYED FOR RIVER, STREAM ORDER AND YEAR CATEGORIES;
PROC TABULATE DATA = RESPARR FORMCHAR(1)=' ' MISSING FORMAT=6.;
  CLASS SITE STRORD RIVER YEAR;
  TABLE (RIVER ALL) (STRORD ALL) (SITE ALL), ALL YEAR/RTS=6;
RUN;*/
/** SUMMARIES OF CATCH, POPULATION AND DENSITY BY SITE, BY STREAM ORDER
  BY RIVER CATEGORIES FOR ALL YEARS COMBINED;
PROC TABULATE DATA = RESPARR FORMCHAR(1)=' ' MISSING FORMAT=6.;
  TITLE 'RESTIGOUCHE ELECTROFISHING, PARR 1972 TO 1991';
  CLASS STRORD SITE RIVER;
  VAR CATCH POP DENSITY;
  TABLE CATCH POP DENSITY, SITE, (N MEAN*F=6.2 VAR*F=6.2 MIN*F=6.2 MAX*F=6.2
                                  CV*F=6.2)    /RTS=15;
  TABLE CATCH POP DENSITY, STRORD, (N MEAN*F=6.2 VAR*F=6.2 MIN*F=6.2 MAX*F=6.2
                                  CV*F=6.2)    /RTS=15;
  TABLE CATCH POP DENSITY, RIVER, (N MEAN*F=6.2 VAR*F=6.2 MIN*F=6.2 MAX*F=6.2
                                  CV*F=6.2)    /RTS=15;
RUN;*/
/*PROC PLOT DATA = RESPARR;
  PLOT DENSITY*SITE='*';
*  PLOT DENSITY*YEAR='*';
*  PLOT DENSITY*RIVER='*';
* PLOT DENSITY*STRORD='*';
ENDSAS;*/
TITLE 'RESTIGOUCHE PARR, YEAR & STRORD & RIVER EFFECT ONLY, EXCLUDE 0 POPS';
PROC GLM DATA = RESPARR;
  CLASS YEAR RIVER STRORD;
  MODEL LOGPOP = LOGAREA YEAR RIVER STRORD/ SOLUTION;
  OUTPUT OUT = RES P=PRED R=RESID;
/*DATA TEMP; SET RES;
  IF RESID LE -2.5 THEN OUTPUT TEMP;
PROC PRINT DATA = TEMP;
RUN;*/

PROC PLOT DATA = RES;
  PLOT RESID*PRED;
  PLOT RESID*YEAR;
  PLOT RESID*STRORD;
RUN;
```

APPENDIX 3

Angling salmon catches from Restigouche River system, 1970 to 1991. Data sources given in Appendix 7.

	Matapedia		Upsalquitch		Patapedia		Kedgwick		Little Main		Main Restigouche	
Year	1SW	MSW	1SW	MSW	1SW	MSW	1SW	MSW	1SW	MSW	1SW	MSW
1970	162	290	270	122	4	24	323	205			747	1401
1971	153	217	344	90	20	40	128	67			527	602
1972	102	1010	362	984	7	144	165	425			453	2478
1973	147	1098	498	512	0	43	128	548			797	2691
1974	124	1083	433	579	5	63	80	289			525	3934
1975	131	692	462	262	18	31	136	316			532	1600
1976	296	922	767	753	80	88	209	348			1370	3399
1977	278	1312	554	901	181	227	368	684			1411	3583
1978	251	1457	449	507	31	158	143	423			730	2480
1979	466	754	507	135	90	60	316	123			1167	751
1980	311	1784	1178	592	95	229	284	468			1374	3084
1981	485	1176	1234	221	148	175	356	473			1422	2195
1982a	259	841	818	214	143	112	322	190	59	50	1250	1175
1983	154	456	203	218	27	103	68	224	14	0	430	1067
1984b	318	527	483	346	45	58	149	164	102	27	725	1120
1985	208	708	1175	507	103	85	329	184	163	50	1539	2781
1986	387	1293	1397	630	162	188	565	512	481	155	2421	3403
1987	498	817	819	410	193	77	582	410	407	142	2506	2220
1988	580	948	1296	659	188	104	807	708	524	74	3381	3060
1989	409	962	836	515	71	63	208	544	43	31	1734	2332
1990	718	856	905	375	81	45	304	258	152	108	2164	2093
1991	521	940	403	195	30	29	277	403	121	75	1170	1495
Mean (86-90)	518	975	1051	518	139	95	493	486	321	102	2441	2622
1991/Mean	+1%	-4%	-62%	-62%	-78%	-69%	-44%	-17%	-62%	-26%	-52%	-43%

a Prior to 1982 Little Main catches included in Main Restigouche.

b Catches of MSW salmon (1984 to 1991) include released fish in New Brunswick.

APPENDIX 4

Native salmon landings from Baie des Chaleurs and Restigouche River, 1975 to 1991. Data sources given in Appendix 7.

	New Brunswick			Quebec			
Year	1SW	MSW	Total	1SW	MSW	Total	Total
1975	3	132	135				135
1976	13	124	137	0	1517	1517	1654
1977	19	212	231	0	2738	2738	2969
1978	23	129	152				152
1979	84	148	232	85	748	833	1065
1980	34	264	298	24	1563	1587	1885
1981	20	211	231				231
1982	12	155	167	148	1521	1669	1836
1983	0	260	260	32	1216	1248	1508
1984	1	213	214	177	1070	1247	1461
1985	0	241	241	35	976	1011	1252
1986	26	431	457	4	1145	1149	1606
1987	95	916	1011	5	986	991	2002
1988	70	509	579	3	921	924	1503
1989	151	568	719	12	1081	1093	1812
1990	120	471	591	16	1135	1151	1742
1991	10	252	262	9	859	868	1130
Mean (86-90)	92	579	671	8	1054	1062	1733
1991/Mean	-89%	-56%	-61%	+13%	-19%	-18%	-35%

APPENDIX 5

Operating dates of Native fisheries in Baie des Chaleurs and Restigouche River, 1979 to 1991. Data sources given in Appendix 7.

	New Brunswick		Quebec
Year	Gillnet	Trap net	Gillnet
1979	May 14 - October 24		June 6 - August 1
1980	May 19 - July 13		June 2 - July 28
1981	May 15 - August 30		
1982	May 17 - August 1		June 9 - August 2
1983	May 16 - August 28		June 3 - August 7
1984	May 14 - August 27		June 5 - August 10
1985	May 20 - August 25		June 3 - July 31
1986a	May 19 - August 10	May 26 - July 20	June 2 - June 26
1987b	May 24 - July 27	May 24 - July 15	June 1 - June 30
1988	May 16 - August 26	May 16 - August 14	June 6 - July 6
1989	May 15 - August 20	May 29 - August 20	June 5 - June 30
1990	May 14 - July 22	May 22 - July 25	June 11 - July 6
1991	May 12 - July 27	May 26 - July 27	June 3 - June 28

a One trap net in 1986.
b Two trap nets in 1987 to 1991.

APPENDIX 6

Angling salmon landings from Restigouche River, 1951 to 1969. Data sources given in Appendix 7.

	New Brunswick			Quebec			
Year	1SW	MSW	Total	1SW	MSW	Total	Total
1951	0	3511	3511	25	160	185	3696
1952	0	5662	5662	104	373	477	6139
1953	0	2963	2963	75	111	186	3149
1954	0	2855	2855	127	374	501	3356
1955	0	2018	2018	99	232	331	2349
1956	125	2203	2328	107	227	334	2662
1957	750	2637	3387	124	259	383	3770
1958	0	9141	9141	220	350	570	9711
1959	0	3161	3161	108	209	317	3478
1960	621	2406	3027	6	21	27	3054
1961	117	3103	3220	8	32	40	3260
1962	202	3236	3438	1	0	1	3439
1963	1617	5788	7405	4	5	9	7414
1964	0	6480	6480	136	308	444	6924
1965	3860	3050	6910	211	476	687	7597
1966	1710	1687	3397	199	451	650	4047
1967	1084	2440	3524	257	580	837	4361
1968	408	617	1025	57	128	185	1210
1969	1352	1200	2552	137	312	449	3001

APPENDIX 7

Salmon landings for Baie des Chaleurs and Restigouche River are from the following sources:

1. Commercial data

New Brunswick: Districts 63, 64 and 65
Québec: Districts 12, 13, 14 and 15

New Brunswick commercial for 1970 to 1984 from Redbooks (compiled by Department of Fisheries and Oceans, Science Branch, Halifax).

Québec commercial for 1970 to 1981 from Bureau de la Statistique du Québec (G. Ouellet and J.P. Lebel, pers. comm.), and assume average weight and MSW/1SW ratio same as calculated from Redbooks.

Québec commercial for 1982 to 1983 from Ministère du Loisir, de la Chasse et de la Pêche, Québec (G. Ouellet and G. Landry, pers. comm.).

2. Angling data

New Brunswick angling data for 1951 to 1959 from O'Neil and Swetnam (1991); 1960 to 1969 from Swetnam and O'Neil (1985); 1970 to 1979 from O'Neil and Swetnam (1984); 1980 to 1983 from Swetnam and O'Neil (1984); 1984 from O'Neil et al. (1985); 1985 from O'Neil et al. (1986); 1986 from O'Neil et al. (1987); 1987 from O'Neil et al. (1989); 1988 from O'Neil et al. (1991); and 1989 to 1990 from O'Neil (pers. comm.).

Québec angling data for 1951 to 1969 from New Brunswick Department of Natural Resources and Energy files (A. Madden, pers. comm.); 1970 to 1990 from Ministère du Loisir, de la Chasse et de la Pêche, Québec (G. Ouellet, J.P. Lebel and G. Landry, pers. comm.).

3. Native data

New Brunswick Native data for 1975 to 1982 from Department of Fisheries and Oceans, Protection and Regulations Branch files (R. Roy and M. Sullivan, pers. comm.); 1983 to 1986 from Department of Fisheries and Oceans, Resource Allocation and Development Branch (K. Atwin, F. Ring and R. Hébert, pers. comm.); and 1987 to 1990 from Department of Fisheries and Oceans, Protection and Regulations Branch, (R. Roy, R. MacNair and R. Senechal, pers. comm.).

Québec Native data for 1976 to 1984 from Gaudreault (1984); 1985 to 1990 from Ministère du Loisir, de la Chasse et de la Pêche, Québec (G. Landry, pers. comm.).

4. All 1991 data are preliminary as described in text.