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Mortality Rates of Alewife in the Southern Gulf of St. Lawrence

by

G.J. Chaput
and
D.R. Alexander
Science Branch, Gulf Region
Department of Fisheries and Oceans
P.O. Box 5030
Moncton, NB E1C 9B6

ABSTRACT

A first estimate of 'natural mortality' of alewife (Alosa pseudoharengus) was calculated using upstream and downstream counts at a counting fence operated at South River, Nova Scotia in 1983 to 1987. There is no directed in-river fishery for gaspereau at South River although coastal fisheries undoubtedly exploit a variety of gaspereau stocks. Consequently, a composite mortality rate which excluded only in-river mortality was estimated and found to vary with frequency of spawning. Instantaneous mortality rate of alewife at South River over the first spawning year was estimated at 0.44 and over subsequent spawning intervals, mortality rate was 1.05. Mortality due to the spawning migration and the spawning act was a major component of this total mortality.

RESUME

On a estimé le taux de 'mortalité naturelle' du gaspareau en utilisant des comptes de gaspareau en amont et en aval prélevés d'une barrière de dénombrement à South River, Nouvelle-Ecosse depuis 1983 à 1987. Aucune pêche commerciale est effectuée dans la rivière, cependant, des pêches côtières sans doute exploitent ce stock. Par conséquence, on a estimé une valeur de taux de mortalité qui correspond à l'absence de pêche en rivière. Le taux de mortalité instantané augmentait avec le nombre de migrations entreprise, soit 0,44 pour une première et 1,05 pour migrations subséquentes. Une grande proportion de la mortalité totale est attribuable aux conséquences de migration des géniteurs et de la fraie.

MORTALITY RATES OF ALEWIFE IN THE GULF OF ST. LAWRENCE

INTRODUCTION

One of the weaknesses in the use of an age structured model in recent gaspereau (alewife Alosa pseudoharengus and blueback herring Alosa aestivalis) assessments (Alexander and Vromans 1988a,b) is the assumption that natural mortality (M) is 0.2 (i.e. 18% of the fish die during the year). In this paper, natural mortality is estimated for an unexploited alewife population spawning in South River, NS. Age distributions and sex ratios are also examined and compared to two exploited stocks in Margaree and Miramichi rivers.

BACKGROUND

For purposes of this discussion, the total instantaneous mortality formula as defined by Ricker (1975) will be used, i.e.

$$Z = F + M$$

where Z = total mortality
F = mortality due to fishing
M = mortality due to natural causes

Considering the life cycle pattern of alewife, the total instantaneous mortality formula can be subdivided into four components, namely:

$$Z = Fr + Fs + Mr + Ms$$

where Fr = fishing mortality in the directed inriver fisheries during the spawning migration,

F_s = fishing mortality at sea resulting from directed coastal fisheries and from by catch in other gear,

Mr = natural mortality during spawning migration and on the spawning grounds,

Ms = natural mortality at sea during the non-spawning phase of their life cycle.

The most direct method of estimating the natural mortality of alewife is to study an unexploited population, i.e. Fr = Fs = 0. However, this ideal situation probably does not exist in the Gulf of St. Lawrence. Practically all rivers in the Gulf ascended by gaspereau on their spawning migrations are exploited by a river fishery. One notable exception is South River, Nova Scotia. The Z estimated for the South River stock represents the sum of Fs, Mr and Ms since Fr = 0.

Tagging data indicate the extensive sea migration of gaspereau and confirm their potential to be intercepted in many fisheries. Gaspereau tagged in the Southwest Margaree were recaptured in these district 13 fisheries as well as along PEI (Table 1). Gaspereau from Pictou Harbour, NS, were recaptured in numerous locations in the gulf as well as along the Atlantic seaboard (Table 1). The South River alewife stock is undoubtedly captured in the coastal fisheries of district 13 (Figure 1). Landings from this district, which were obtained from data compiled by Statistics Branch of DFO, Moncton are presented in Table 2. Gaspereau are landed up into December in most years, almost exclusively from Ballantyne's Cove. In this report the sea fishing mortality component (Fs) is assumed to be greater than 0 but equal and constant for all stocks.

It shall be assumed that the two natural mortality components are present and constant for all stocks, all years although the Ms for non-maturing alewife may not equal the Ms of mature, spawned alewife. Consequently, the South River population of alewife suffers three components of mortality, namely: Fs + Ms + Mr. For convenience, these sources of mortality are estimated together and called Mc or composite mortality, which can be applied to exploited stocks for estimating the fishing mortality (Fr) from calculated values of Z, i.e. $F = Z - Mc$.

METHODS AND RESULTS

Mortality of alewife was estimated at South River where a counting fence was operated to monitor fish movements during 1981 to 1987. Details of the installation at South River are given in Chadwick et al. (1985). Upstream and downstream counts of gaspereau were not sampled consistently in early years and only the years 1983 to 1987 are considered in this report. For comparison with exploited stocks data were collected from Margaree River, Nova Scotia and from Miramichi River, New Brunswick. Study site descriptions for these two commercial fisheries and for South River are provided in Appendix A.

Gaspereau at South River were generally counted by dip net scoops when numbers at the fence were low. During peak run periods, the upstream trap at the fence was closed and gaspereau were visually counted through by removing a portion of the conduit pipe and enumerating the fish as they passed over a white concrete patio block positioned on the bottom. All downstream gaspereau counts were obtained by dip netting the fish out of the trap, number of fish equal to number of scoops times average number of fish per scoop.

In every year of fence operation, there were days when the fence was not operational due to high water conditions. In most of these instances, the fence conduit had been removed to reduce structural damage when water levels rose above a critical stage. The counts at the fence are therefore not complete counts and washout periods were inferred from patterns of daily counts at the fence (Table 3).

Sampling of upstream migrants was undertaken since 1983, although the sampling procedure varied from year to year. Effort to count gaspereau, as well as frequency and size of detailed samples were less in 1983 than in later years. Numbers of gaspereau sampled on any given day and the corresponding daily counts of upstream migrants are given in Table 3. Proportion of counts sampled in any year ranged from a low of 0.43% in 1986 to as high as 3.69% in 1983 (Table 3). The biological characteristics measured included species, fork length (cm), total weight (g), sex, maturity, weight of ovary, and scale samples from which total age, and age of first spawning were obtained.

Estimates of number of alewife at age were obtained by weighting the age and species distribution of the samples by the count of gaspereau for that day and summed for the year. Days on which no sacrificed samples were obtained were lumped with the next sacrifice sample day.

Estimation of Mortality

The between year mortality of an age group was calculated using Paloheimo's method (Ricker 1975), i.e.

$$Z = -\ln (X_{n,t} / X_{n+1, t+1})$$

where X = number of gaspereau (absolute or as CPUE)

n = age of fish as estimated from scales

t = year sample was collected

Recruitment to the spawning migration occurs at ages 2 to 5 although alewife at South River recruit primarily at ages 3 and 4. Consequently, mortality estimates were obtained for the two main recruitment groups thereby eliminating any bias in number at age associated with incomplete recruitment.

The calculated mortality estimates are dependent upon the reliability of the fence counts and subsequent estimation of numbers at age from subsamples of the counts. The estimation at age is further complicated by differences in timing between virgin and previous spawners. Cumulative counts of alewife at the fence by age group illustrate two modes of entry with previous spawners entering mostly in the first mode whereas virgin spawners enter in both, and over a longer time interval (Figure 2). The timing of 4 year old virgin spawners was variable for the years studied, in 1984 they entered in two distinct peaks in synchrony with the virgin 3 year olds whereas in 1986 and 1987, their entry was synchronised with the repeat spawners. The cumulative curves for 1985 are unimodal with virgin and previous spawner movements overlapped (Figure 2). The prognosis is that in 1985, a substantial portion of the virgin 3 year old spawners was not enumerated in the upstream migration, because of washouts in the latter part of the run when mostly first time spawning 3 year olds would enter, whereas 4 year old virgin spawner counts are representative. In years other than 1985, we inferred that washout periods were staggered throughout the run and did not cause bias in estimates of numbers at age.

Between year mortality estimates (Paloheimo) of alewife from South River are provided in Table 4. The 1983 estimates are shown but are not included in any further discussion because the numbers and level of sampling were very different from more recent years and were not considered to be representative of the migration. The 1985 estimate of virgin 3 year olds is also not considered to be valid, as discussed above. Age 4 recruits, however, were assumed to have been adequately counted and sampled. The instantaneous mortality rate estimates range between 0.20 to 2.58 for age 3 recruits and 0.23 to 1.34 for age 4 recruits. The calculated mean Z ($=Mc=F_{S+}M_{S+}M_{T}$) value of 3 and 4 year old recruits is:

Spawning Interval	Mean Mc	Std. Dev.	90% Conf. Int.
1	0.44	0.237	0.19 to 0.70
2	1.09	0.230	0.85 to 1.34
3	1.04	0.407	0.49 to 1.59

Ideally, a value for the spawning mortality (M_T) for each age class could have been obtained from upstream and downstream counts, however downstream migrants were not sampled for age structure. Discounting 1985 when total upstream counts are not reliable because of washouts, the global spawning mortality (Mr) is estimated at 0.79 (see table below). This value lends support to the premise that spawning mortality is high and probably is the dominant component of the composite mortality of mature, spawning alewife.

Year	Counts Upstream	Counts Downstream	Estimated Survival	Instantaneous Spawning Mortality (Mr)
1983	12400	14769		
1984	74592	29899	0.40	0.92
1985	88608	81206		
1986	145522	86119	0.59	0.52
1987	171558	66462	0.39	0.94
Mean				0.79

The sea mortality components (F_S, M_S) could not be quantified, however, the assumption that the sum of these was constant between years was examined. Assuming that the proportions of alewife which recruit at age 3

and at age 4 are constant, then a plot of 3 year old new recruits versus 4 year old new recruits of the same year class would be linear with minimal scatter around the line if the sea mortality of unrecruited 3 year olds was constant. The results are inconclusive because too few data points were available to properly evaluate the model. Regression of numbers at age was not significant (P=0.15, R-square=0.71) (Fig. 3).

We have assumed that the composite mortality of alewife at South River, is similar for males and females. Examination of the sex ratios at age indicates that male:female ratio is 1:1 for 3 year old recruited alewife, regardless of age whereas it is 40:60 for virgin 4 year olds and predominantly female in older age groups which suggests that mortality rate is probably higher for male alewife recruited at age 4 compared to females (Table 5).

COMPARISONS TO EXPLOITED STOCKS

Samples for detailed analysis were collected from one commercial tiptrap in the Southwest Margaree River from 1983 to 1987. Details of the sampling procedure are given in Appendix A. Catch and effort data, were available from logbooks for all years and an abundance index of age classes was calculated using the numbers at age in the 5% to 95% cumulative catch interval of the index trap. Results are presented as numbers per 10 hours of effort (Table 6).

Detailed analysis samples were obtained from the Millbank trapnet operated by DFO, on the Miramichi River in 1982 to 1987. Sampling details are provided in Appendix A. Abundance of age classes was calculated by weighting age distribution in daily samples by daily counts at the trap. The effort at the Millbank trap was considered constant among years since the trap was operational before the run of alewife commenced and was monitored in all years until the run was finished. Numbers at age from Millbank are presented as total counts of alewife for each year up to and including June 30 (Table 7).

Mortality rates calculated for 3 and 4 year old recruits for Margaree and Miramichi alewife varied from a low of 0.29 to as high as 6.12 (Tables 6, 7). Mean Z by spawning frequency for 3 and 4 year old recruited alewife are presented below (from Table 6, 7). The values of mortality are total Z and include a fishing mortality component (Fr). South River composite mortality values which do not include a fishing mortality component are included for comparison.

	South River	Margaree	Miramichi
First spawning	0.44	1.59	1.47
Second spawning	1.09	1.68	1.13

The assumption of constant sea mortality was also examined for the Miramichi and Margaree stocks. As with the case at South River, the results are inconclusive (Fig. 3). Neither of the linear regressions of number of 4 year old recruits on number of 3 year old recruits of the same age class was significant.

	R-square	P-value	Years Sampled
Margaree	0.01	0.9	1983 to 1987
Miramichi	0.04	0.76	1982 to 1987

South River, Margaree and Miramichi alewife stocks have similar age structures. However, proportions of first time spawners was lower at South River than in Margaree and Miramichi (Table 8). One would expect a larger proportion of previous spawners in a lightly exploited stock than in exploited fisheries.

Sex ratios at age were similar to that at South River. In both exploited stocks, sex ratio of alewife recruited at age 3 was approximately 1:1 whereas age 4 recruits and previous spawners were predominantly female as in South River (Table 5).

DISCUSSION

The high spawning mortality rate of South River alewife may in large part result from obstacles encountered during migration. The counting fence itself may increase mortality on weak postspawning alewife. Nevertheless migratory conditions in South River are not atypical of conditions at Margaree and in many other small Gulf rivers.

The oldest alewife sampled from any of these three river stocks was eleven years. Considering the concept presented by Hoenig (1983) wherein the mortality rate and longevity of a species should intuitively be inversely related and inserting the maximum age of alewife encountered (11 years) into the predictive equation of Hoenig gives a natural mortality estimate (M) of 0.40.

The South River data suggest that the composite mortality rate increases with frequency of spawning. The effect of sampling design, namely using small random samples to restructure age composition of a stock, has not been discussed, but the large newly recruited age classes impact negatively on the subsequent estimation of less abundant, older age groups when small samples (<100 fish) are collected. As a result, the estimate for the first spawning mortality is likely too low, and vice versa, the subsequent repeat spawning mortalities too high. In the absence of alternate, independently calculated mortality values, these estimates should be used, i.e.

0.44 for the first spawning interval

1.05 for subsequent spawning migrations

The Sequential Population Analysis (SPA) programs used in gaspereau assessments assume a Type II fishery. Ricker (1975) defines these fisheries/species relationships as ones in which the natural mortality occurs simultaneously with fishing mortality. Under the assumptions of the most widely used cohort analysis procedure (cohort method valid for $M < 0.3$ (Pope 1972)), small F/Z ratios, render the population simulation techniques unreliable because the simulations are best when the removals by fishery constitute the majority of losses (Jones 1981). The alewife values for Mc reported in this document make the SPA models unusable under Type II assumptions. Rather, the gaspereau fishery should be treated as a Type I fishery in which the natural mortality occurs at a time of year other than the fishing season and the population decreases during the fishing season as a result of catch removals only. For convenience, the biological year begins when fishing commences and natural mortality occurs after fish have passed through the fishery (Ricker 1975: p. 10-11). The gaspereau fishery occurs over a short time interval (three of four weeks maximum at Margaree and Miramichi) and exploits the fish on their migration upstream. Consequently the natural mortality during the fishing period and in the fishing zone can be considered negligible. Under Type I fishery conditions, absolute removals by each of the instantaeous mortality components are not equal to the direct F/Z and M/Z ratios. When $F = M$, absolute removals by the fishery always exceed natural mortality removals and as the ratio of catch to population increases, the ratio of fishing to natural removals also increases.

LITERATURE CITED

Alexander, D.R. and A.H. Vromans. 1985. Status of the Miramichi River estuary gaspereau fishery (1984). CAFSAC Res. Doc. 85/92.

Alexander, D.R. and A.H. Vromans. 1988a. Status of the Margaree River alewife (Alosa pseudoharengus) fishery 1987. CAFSAC Res. Doc. 88/25.

Alexander, D.R. and A.H. Vromans. 1988b. Status of the Miramichi River fishery (1987) for alewife (Alosa pseudoharengus) and blueback herring (Alosa aestivalis). CAFSAC Res. Doc. 88/27.

Chadwick, E.M.P., D.R. Alexander, R.W. Gray, T.G. Lutzac, J.L. Peppar and R.G. Randall. 1985. 1983 Research on anadromous fishes, Gulf Region. Can. Tech. Rep. Fish. Aquat. Sci. No. 1420: xi + 69 p.

Crawford, R. and D. Tully. 1989. The biology of gaspereau from Pictou Harbour, Nova Scotia. Nova Scotia Dept. of Fisheries. Manus. and Tech. Rep. Series. Project Rep. No. 89-01.

Hoenig, J.M. 1983. Empirical use of longevity data to estimate mortality rates. Fish. Bull. U.S. Vol. 81:898-902.

Jones, R. 1981. The use of length composition data in fish stock assessments (with notes on VPA and cohort analysis). FAO Fisheries Circular No. 734. 60 p.

Pope, J.G. 1972. An investigation of accuracy of virtual population analysis using cohort analysis. Res. Bull. Int. Comm. Northwest Atl. Fish., 9, 65-74. (In D.H. Cushing (Ed.). Key Papers on Fish Populations. IRL Press, Washington).

Ricker, W.E. 1975. Computation and interpretation of biological statistics in fish populations. Bull. Fish. Res. Board Can. No. 191:382 p.

APPENDIX 'A'

DESCRIPTION OF STUDY SITES

Situated in statistical district 13, Antigonish County, Nova Scotia, South River has a drainage area of approximately 200 sq. km and discharges into Antigonish Harbour leading into St. Georges Bay. Other rivers discharging into Antigonish Harbour include West River and Rights River. Lacustrine habitat, in the form of 20 lakes and ponds, provides spawning areas for gaspereau, although access is not available to all of these. Access to the upper watershed habitat is hampered by the presence of two water regulatory dams which have been accomodated with fishways. Alewife dominate the runs of gaspereau, blueback herring are few in number and arrive after the alewife component.

The Margaree River is situated in Cape Breton Island, statistical district 2, and discharges directly into the Gulf of St. Lawrence. The gaspereau fishery is directed primarily in the southwest branch of the Margaree which drains Lake Ainslie. There is no directed fishery for gaspereau in the northeast branch. All the fishing is conducted above tidal waters and effort is distributed along the entire length of the southwest branch. The Southwest Margaree is the only surface outlet of Lake Ainslie, with a surface area of 57 sq. km and a mean depth of less than 6 m. As at South River, alewife are the dominant species of gaspereau utilising the Margaree system.

The gaspereau fishery in the Miramichi drainage system occurs primarily in two specific areas, along the southern shores of the main stem (statistical district 71) and the southern shore of the Northwest Miramichi (statistical district 72). Both these fisheries are within the influence of tidal waters. The Department of Fisheries and Oceans has operated an index trap at Millbank since 1954 from which counts of gaspereau have been recorded since 1978. The trap is described in greater detail in Chadwick et al. (1985). In contrast to both South River and Margaree River, blueback are more abundant than alewife although oscillations in proportions exploited have been noted over the past several years.

SAMPLING METHODS

Miramichi River

Samples for detailed analysis have been collected from the DFO trapnet at Millbank since 1982. Details of the sampling procedure are outlined in Alexander and Vromans (1985). Proportion of numbers sampled ranged from a low of 1.7% to 3.5%.

Numbers of gaspereau at age were obtained using the counts at Millbank, and are thus considered as abundance indices of the year classes. This interpretation assumes that the catchability at Millbank has been constant

and that the Millbank trap effectively samples indiscriminately the gaspereau in the Miramichi River. Between year estimates of abundance were not weighted by days fished because Millbank fished before and after the spawning run of alewife in all years and the sample of alewife was thus considered complete. Samples up to and including June 30 were included in all years.

Southwest Margaree

Gaspereau were sampled from 1983 to 1987 from the same commercial tip trap in the Southwest Margaree. Between 25 and 100 fish were randomly selected by the trap crew and frozen for later analysis. Biological characteristics measured are similar to those from South River and Miramichi River. Logbook reports of catch and effort from the selected tip trap were also available for 1983 to 1987. As a consequence, it was considered more appropriate to use the catch and effort data from only this trap and estimate an abundance index of the year classes. Numbers at age were obtained using the age distribution of the detail sample weighted by daily catch, summed for all days. Days which did not have detailed sample information were lumped with the next detailed sample day.

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Table 1. Recaptures of gaspereau tagged at Margaree River and Pictou Harbour locations, 1980 to 1988. Place names are indicated in Figure 1. Numbers in parentheses refer to number of tags recovered.

Place Tagged	Date Tagged	Place Recaptured	Date Recaptured
Margaree River	May 1988	Ballantyne's Cove, NS (4)	June 1988
	June 1988	Savage Harbour, PEI (Mackerel Purse Seine)	July 1988
	May 1987	Ballantyne's Cove, NS (4)	May, June 1987
	May 1987	Havre Boucher, NS	June 1987
Pictou Harbour	May - June 1980	Chaleur Bay, NB	Summer 1980
		Chaleur Bay, NB (1)	Spring 1981
		Chaleur Bay, NB	Summer 1981
		North Cape, PEI	Summer 1980
		Pictou Harbour, NS (4)	Spring 1981
		Pictou Harbour, NS (1)	Spring 1983
		Ballantyne's Cove, NS (6)	Spring 1981
		St. Paul's Island, NS	Fall 1980
		Chedabucto Bay, NS (1)	Spring 1981
		Chedabucto Bay, NS (2)	Summer 1981
		Tancook Island, NS	Summer 1980

* Pictou Harbour tagging information from Crawford and Tully (1989).

Table 2. Landings (metric tons) of gaspereau by month from district 13 coastal fisheries 1983 to 1987.

Month	1983	1984	1985	1986	1987
May	1.1	6.4	10.1	98.7	27.1
June	1.3	6.4	10.4	4.3	23.1
July		17.3	22.8	104.7	12.2
August		24.7	13.2	4.9	10.2
September		10.6	10.5	5.1	4.9
October		4.6	32.3	3.7	1.3
November		0.1	0.1	0.1	1.2
December		0.0	0.0	14.6	47.6
Total	2.3	70.1	99.4	236.2	127.6

Table 3. Daily counts of gaspereau moving upstream through the South River counting fence and numbers sacrificed for biological characteristics, 1983 to 1987.

		1983		1984		1985		1986		1987	
			No.		No.		No.		No.		No.
mm	dd	Count	Sampl.	Count	Sampl.	Count	Sampl.	Count	Sampl.	Count	Sampl.
May	1	0	.	0		0	.	0	.	0	.
	2	0	.	0		0	.	2	.	0	.
	3	0	.	0		0	.	4	.	0	.
	4	0	.	0		0	.	0	.	0	.
	5	1	.	2		0	.	0	.	0	.
	6	11	7	1		0	.	6	5	0	.
	7	0	.	0		0	.	1	.	0	.
	8	8	.	1	1	0	.	4	.	0	.
	9	50	18	3	.	0	.	3	.	0	.
	10	1	.	3	2	0	.	3	.	0	.
	11	4	.	11	.	0	.	18	.	17	.
	12	0	.	10	.	0	.	2	.	64	.
	13	0	.	21	.	0	.	0	.	313	.
	14	0	.	3	.	0	.	0	.	9202	60
	15	0	.	0	.	0	.	4520	25	14460	50
	16	0	.	17	.	0	.	10053	50	1644	25
	17	11	.	18	.	0	.	225	.	194	.
	18	3	.	55	.	2	.	10466	49	132	.
	19	673	12	132	.	1	.	20760	41	43	.
	20	7165	147	106	4	1	.	16290	49	52	.
	21	818	.	452	10	36	.	4865	.	959	25
	22	1981	46	17701	59	47	.	37	.	29562	43
	23	19	.	4838	50	139	10	3030	50	7388	36
	24	1	.	13211	50	34	10	0	.	18846	15
	25	2	.	1284	10	2735	25	16490	46	30566	47
	26	0	.	211	9	4079	10	15670	34	20852	49
	27	2	.	1038	.	9419	50	16350	48	14989	.
	28	14	.	1073	25	1499	25	7450	50	991	70
	29	0	.	437	.	6879	50	3010	25	3838	50
	30	17	.	844	.	9207	111	8940	49	1911	24
	31	4	.	3581	59	11588	50	0	.	874	10
June	1	0	.	3136	19	19660	50	0	.	2319	25
	2	127	43	25910	99	0	.	0	.	1441	10
	3	925	49	232	.	72	.	3720	30	750	25
	4	108	.	6	.	18575	49	0	.	29	25
	5	170	33	6	1	919	10	14	.	1455	25
	6	50	.	19	.	317	10	0	.	7	.
	7	31	.	3	.	0	.	63	16	399	25
	8	40	20	9	.	145	10	67	.	1442	25
	9	20	18	67	.	156	10	2654	25	500	.
	10	1	.	71	2	2698	25	65	.	126	10
	11	2	.	7	5	53	.	159	.	8	.
	12	0	.	0	.	59	10	26	.	96	6
	13	3	3	0	.	24	10	64	.	5255	50
	14	2	2	5	.	2	.	7	.	23	.
	15	0	.	0	.	3	.	10	10	10	4
	16	42	.	0	.	3	.	46	.	396	25
	17	77	35	0	.	38	10	236	9	244	.
	18	30	24	4	.	5	.	64	10	32	10
	19	1	.	6	.	0	.	13	.	3	22
	20	0	.	69	38	10	.	24	.	21	.
	21	0	.	2	.	39	10	9	.	9	.
	22	9	.	0	.	94	10	6	.	10	.
	23	1	.	0	.	10	.	0	.	0	.
	24	0	.	0	.	11	10	5	.	1	1
	25	0	.	1	.	11	.	11	.	2	.
	26	0	.	1	.	0	.	17	10	7	.
	27	0	.	14	.	0	.	0	.	1	.
	28	0	.	1	.	6	.	8	.	24	10
	29	0	.	1	.	0	.	2	.	6	.
	30	0	.	1	.	5	.	2	.	29	7
	Totals	12424	457	74624	443	88581	565	145491	631	171542	809
	% of Count		3.68%		0.59%		0.64%		0.43%		0.47%

Table 4. Paloheimo 'Z' calculated on number at age of alewife enumerated at South River counting fence, 1983 to 1987. The first digit in the age description refers to total age whereas the second digit refers to age at recruitment.

Counts of gaspereau moving upstream at counting fence up to and including June 30 compared to number of gaspereau sampled for biological characteristics.

Count	12400	74585	88571	145491	171542
Sampled	457	447	575	631	809
%	3.69	0.60	0.65	0.43	0.47

	Sampling Year				
Age	1983	1984	1985	1986	1987
3.3	2416	63731	31356	82841	22014
	- -1.011	- 0.540	- -0.122	- 0.201	
4.3	6140	6637	37125	35421	67748
	- 2.296	- 1.056	- 1.373	- 0.848	
5.3	813	618	2309	9406	15172
	- 1.190	-	- 0.710	- 1.636	
6.3	63	0	188	1135	1832
				- 2.580	
7.3	0	0	0	0	86

	Sampling Year				
Age	1983	1984	1985	1986	1987
4.4	1675	2104	14634	10398	54847
	- 0.887	- 0.232	- 0.850	- 0.398	
5.4	650	690	1669	6254	6982
	- 0.409	- 1.344	-	- 0.845	
6.4	315	432	180	0	2687
		- 0.622			
7.4	47	0	232	0	0

	Sampling Year				
Age	1983	1984	1985	1986	1987
5.5	4	0	0	0	99
	- -1.792				
6.5	49	24	0	0	0
	- -1.870				
7.5	0	318	0	0	0

Table 5. Proportion female by age of alewife sampled from South River, Southwest Margaree River and at Millbank, 1982 to 1987.

South River

Age	Recruit at Age	Percent female at age					
		1983	1984	1985	1986	1987	Mean
2	2	.	.	.	.	.	.
3	2	.	.	.	.	.	.
	3	46	58	45	54	48	50
4	3	51	56	54	49	45	51
	4	51	60	47	65	59	56
5	3	42	67	67	69	52	59
	4	59	80	83	61	65	70
	5	50	.	.	.	100	75
6	3	33	.	.	50	63	49
	4	67	100	33	.	100	75
	5	50	100	.	.	.	75
7	3	.	.	.	.	.	.
	4	100	.	100	.	.	100
	5	.	100	.	.	.	.
10	3	100	.	.	.	.	.
	4	100	.	.	.	.	.

Southwest Margaree

Age	Recruit at Age	Percent female at age					
		1983	1984	1985	1986	1987	Mean
1	1	.	43	.	.	.	.
2	2	.	.	17	.	.	.
3	2	100	.	45	.	.	73
	3	34	40	35	43	39	38
4	2	.	.	.	.	.	.
	3	48	43	37	40	53	44
	4	65	64	58	72	63	64
5	3	43	66	50	57	33	50
	4	62	78	69	69	70	70
	5	100	100	33	100	.	83
6	3	25	81	56	100	33	59
	4	50	93	100	60	81	77
7	3	43	100	67	.	.	70
	4	.	33	100	100	.	78
8	3	.	100	.	.	.	.
	4	100	50	33	.	.	61
9	3	.	.	67	.	.	.
	4	.	100	.	.	.	.
10	4	.	100	.	.	.	.

Table 5 (Cont'd).

Millbank

Age	Recruit at Age	Percent female at age 1982	1983	1984	1985	1986	1987	Mean
2	2	50	.	36	.	.	.	43
3	2	.	100	.	.	.	.	.
	3	42	42	49	40	48	48	45
4	2	.	.	.	.	.	.	.
	3	45	42	35	50	42	46	43
	4	49	57	62	58	71	75	62
5	3	.	57	42	60	58	50	45
	4	67	66	44	44	78	71	62
	5	.	83	.	.	100	100	94
6	3	40	.	60	.	.	42	47
	4	55	33	57	.	50	71	53
	5	.	67	.	.	.	100	84
7	3	25	.	.	.	.	.	.
	4	40	67	.	.	.	50	52
	5	100	100	.	.	.	.	100
8	3	.	33	.	.	.	.	.
	4	100	43	.	.	.	.	72
	5	100	100	.	.	.	.	100
9	3	.	100	100	.	.	.	100
	4	100	50	.	.	.	.	75
	5	.	.	.	.	.	.	.
10	3	.	.	.	.	.	.	.
	4	.	100	.	.	.	.	.
	5	.	.	.	.	.	.	.
11	3	100	.	.	.	.	.	.

Table 6. Paloheimo 'Z' calculated on catch of alewife per 10 hours effort for index trap on the Southwest Margaree River. Numbers at age in catch and effort were calculated for the period encompassing 5% to 95% cumulative catch. The first digit in the age designation refers to total age whereas the second digit refers to age at recruitment.

Estimated number of alewife in catch compared to number of alewife sampled for biological characteristics.

Est. #	203528	68466	142970	229225	533444
Sampled	609	446	239	493	330
%	0.30	0.65	0.17	0.22	0.06

Alewife recruited at age 3

Age	1983		1984		1985		1986		1987
3	1653		1646		801		3592		20339
		~ 2.379909		~ -0.09938		~ 0.290599		~ 0.860656	
4	633		153		1818		599		1519
		~ 1.740940		~ 0.952900		~ 1.213923		~ 2.236378	
5	453		111		59		540		64
		~ 6.115892		~ 0.758286		~ 2.131627			
6	32		1		52		7		0
7	31		0		0		0		0
8	6		0		0		0		0
9	47		0		0		0		0

Alewife recruited at age 4

Age	1983		1984		1985		1986		1987
4	964		270		6476		878		1837
		~ 4.306141		~ -0.49740		~ 1.145882		~ 0.516154	
5	278		13		444		2059		524
		~ 3.325036		~ 1.466337		~ 1.105391		~ 1.360879	
6	37		10		3		147		528
		~ 2.917770				~ -1.09861			
7	0		2		0		9		0
8	6		3		0		0		0
9	0		29		0		0		0

Table 7. Paloheimo 'Z' calculated on catch of alewife at the Millbank trap. Numbers at age in catch determined for samples and counts at Millbank up to and including June 30, all years. The first digit in the age designation refers to total age whereas the second digit refers to age at recruitment.

Number of gaspereau (alewife and blueback) enumerated at Millbank (up to June 30) compared to number of gaspereau sampled for biological characteristics.

Count	34164	52831	37821	59361	39853	38631
Sampled	640	1552	1305	1008	1168	1129
%	1.87	2.94	3.45	1.70	2.93	2.92

	Sampling Year					
Age	1982	1983	1984	1985	1986	1987
3.3	3435	6743	7045	3656	10193	2380
	- 0.491	- 2.203	- 1.372	- 1.223	- 0.855	
4.3	1960	2101	744	1786	1075	4336
	- 1.764	- 1.776	- 0.823	- 1.317	- 0.623	
5.3	2	335	355	326	478	576
		- 1.847			- 0.475	
6.3	42	0	52	0	0	297
7.3	19	0	0	0	0	0
	- -1.459					
8.3	3	85	0	0	0	0
		- 2.152				
9.3	0	13	9	0	0	0
10.3	0	2	0	0	0	0
11.3	11	0	0	0	0	0

	Sampling Year					
Age	1982	1983	1984	1985	1986	1987
4.4	2651	6612	3190	3375	1165	3186
	- 1.266	- 3.259	- 1.773	- 1.873	- 0.427	
5.4	566	747	253	541	518	760
	- 0.286	- 1.319		- 1.375	- 0.253	
6.4	709	425	199	0	136	402
	- 1.097				- 1.365	
7.4	174	236	0	0	0	34
	- -0.229					
8.4	300	219	0	0	0	0
	- 1.063					
9.4	6	103	0	0	0	0
	- -0.827					
10.4	0	15	0	0	0	0
11.4	0	58	0	0	0	0

Table 8. Proportion at age of alewife number enumerated from South River, Southwest Margaree and at Millbank, 1982 to 1987. Numbers in parentheses are percent of age group which was composed of first time spawners.

South River alewife

Age	1983	1984	1985	1986	1987
2	.	.	0.01 (100)	.	.
3	0.20 (100)	0.86 (100)	0.36 (99)	0.57 (100)	0.14 (100)
4	0.63 (22)	0.12 (25)	0.58 (28)	0.31 (23)	0.71 (45)
5	0.12 (1)	0.02	0.05	0.11	0.13
6	0.04	0.01	<0.01	0.01	0.02
7	0.01	<0.01	<0.01	.	<0.01
8	.	.	.	.	.
9	.	.	.	.	.
10	<0.01	.	.	.	.
11	<0.01	.	.	.	.
% first time spawner	34	89	53	64	46

Southwest Margaree alewife

Age	1983	1984	1985	1986	1987
2	.	.	<.01 (100)	.	.
3	0.40 (99)	0.79 (100)	0.10 (77)	0.46 (99)	0.82 (100)
4	0.38 (60)	0.19 (65)	0.84 (78)	0.19 (59)	0.14 (55)
5	0.19 (6)	0.06	0.05	0.33 (1)	0.02
6	0.02	<.01	0.01	0.02	0.02
7	0.01	<.01	.	<.01	.
8	<.01	<.01	.	.	.
9	0.01	0.01	.	.	.
10	.	.	.	.	.
11	.	.	.	.	.
% first time spawner	63	86	74	57	89

Millbank alewife

Age	1982	1983	1984	1985	1986	1987
2	.	.	.	.	.	.
3	0.40 (100)	0.38 (100)	0.59 (100)	0.44 (100)	0.76 (100)	0.20 (100)
4	0.43 (67)	0.48 (76)	0.33 (81)	0.49 (66)	0.17 (52)	0.62 (42)
5	0.06	0.07 (10)	0.05	0.07	0.07 (2)	0.12 (5)
6	0.05	0.03	0.03	.	<.01	0.06
7	0.04	0.01	.	.	.	<.01
8	0.02	0.02	.	.	.	.
9	<.01	0.01	<.01	.	.	.
10	.	<.01	.	.	.	.
11	<.01	<.01	.	.	.	.
% first time spawner	69	75	86	76	85	47

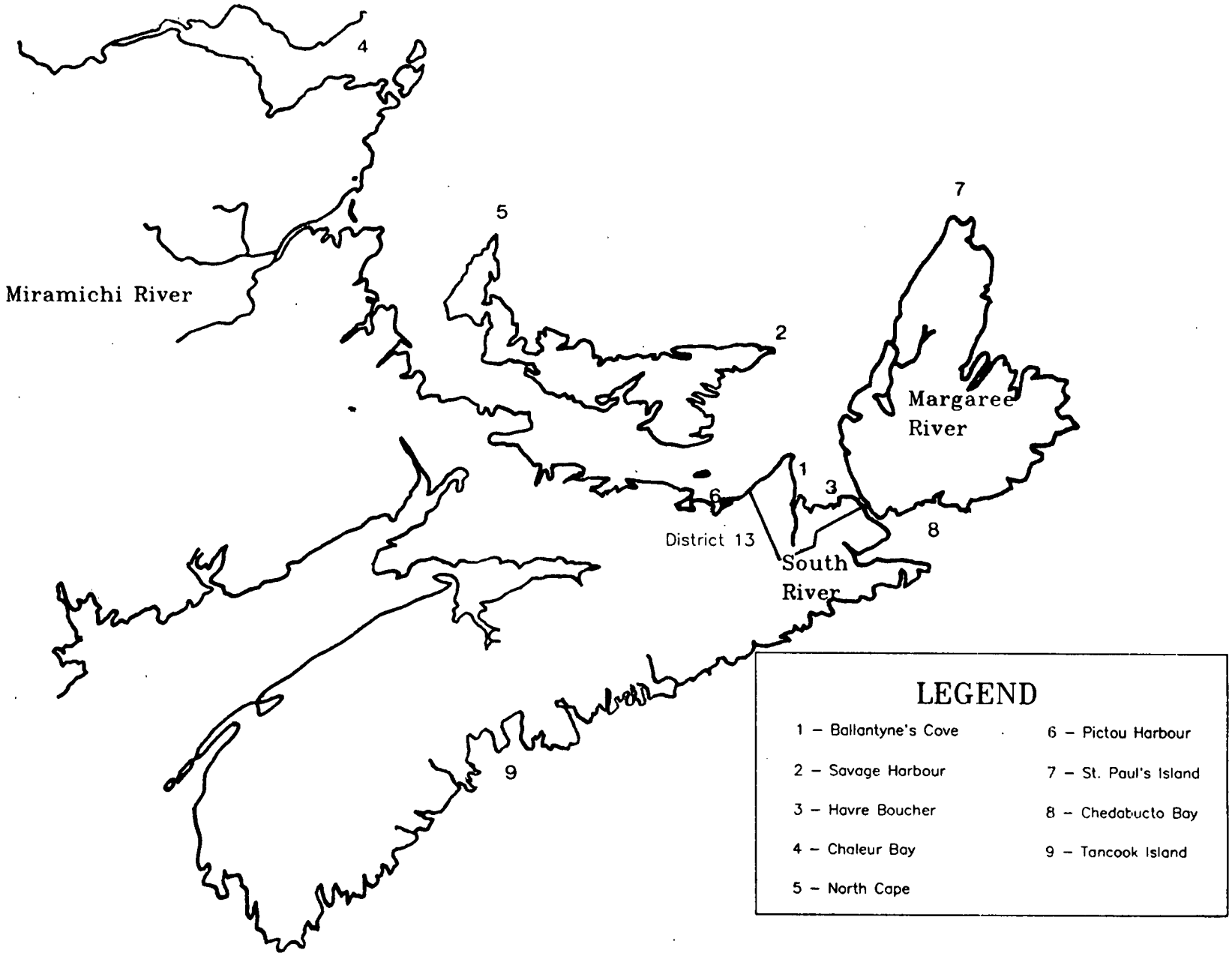

Figure 1. South River, Margaree River, Miramichi River and place names referred to in text and tables.

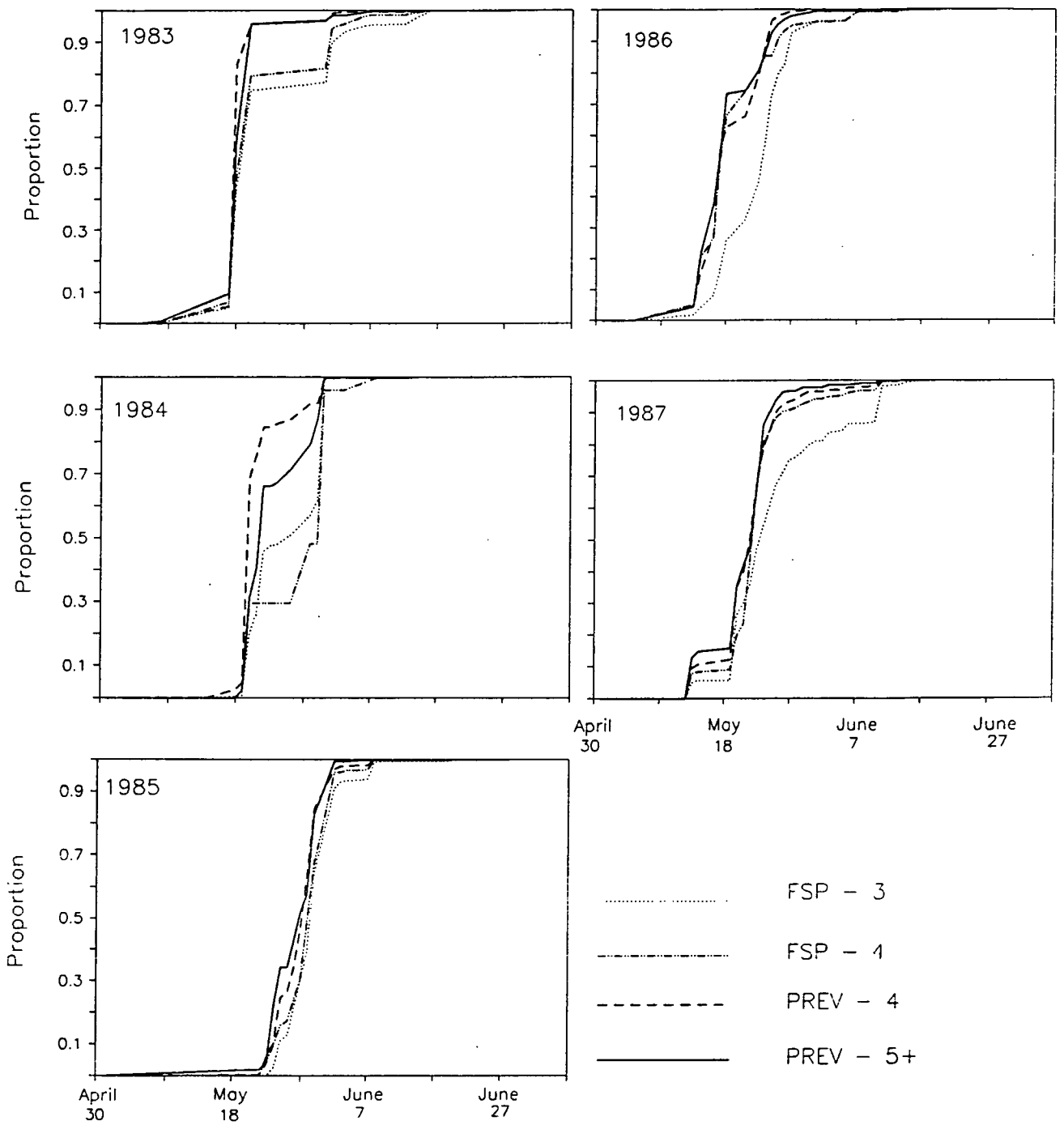

Figure 2. Cumulative counts of alewife, by age, at the South River counting fence, 1983 to 1987. Legend for curves is: FSP-3 = first time spawners, age 3; FSP-4 = first time spawners, age 4; PREV-4 = previous spawners, age 4; PREV-5+ = previous spawners, age 5 and older.

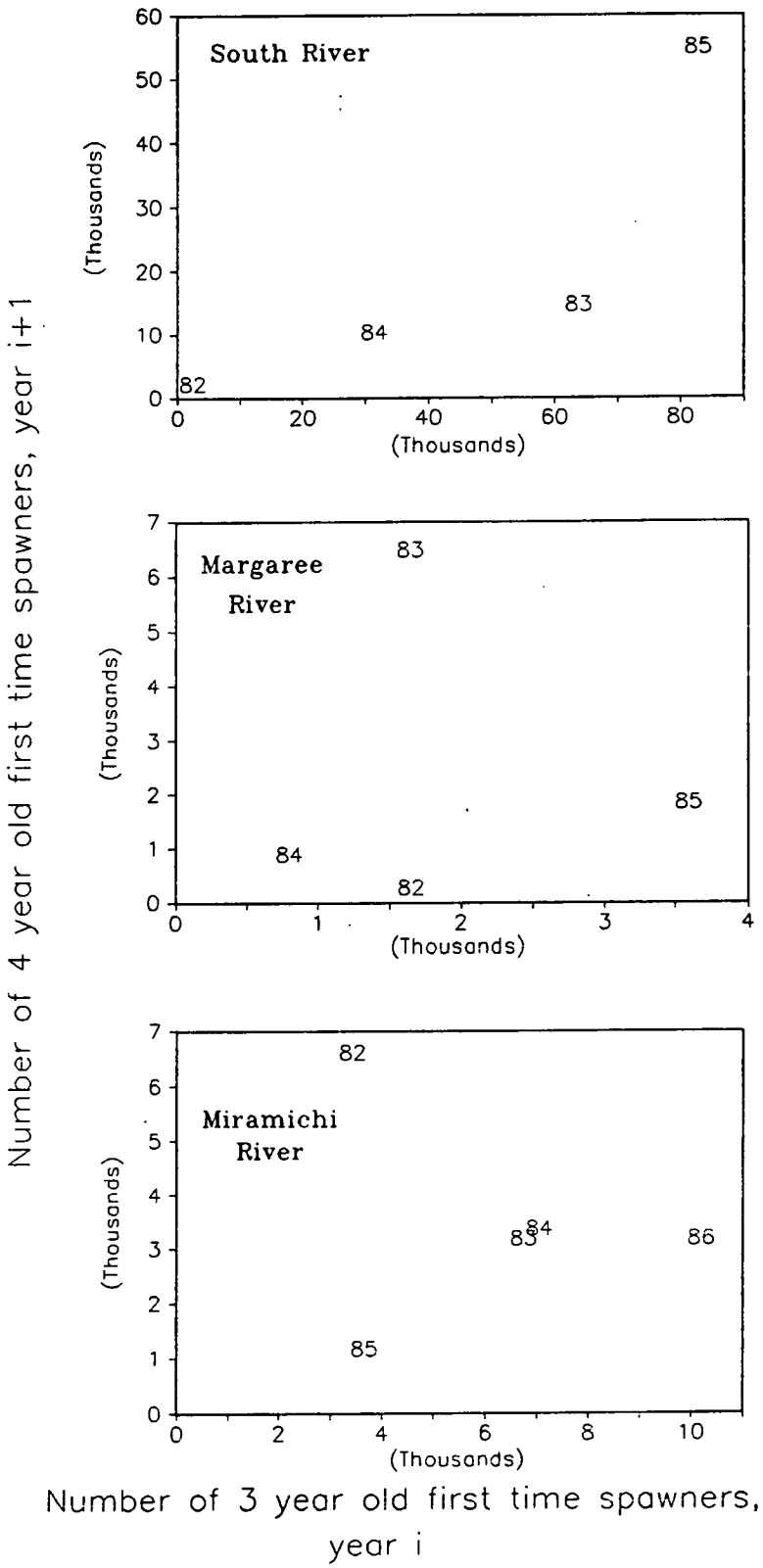

Figure 3. Number of 3 year old first time spawners in year i relative to number of 4 year old first time spawners in year i+1 from South River, Margaree River and Miramichi River.