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Status of the Miramichi River fishery (1987) for alewife (*Alosa pseudoharengus*) and blueback herring (*Alosa aestivalis*)

by

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ABSTRACT

The Miramichi River gaspereau fishery harvested 2,145 tonnes in 1987. This harvest is the highest since 1980 despite imposition of a weekly closed time to reduce the rate of exploitation. Alewives and bluebacks contributed about equally to the catch. The 1983 year-class of both species was shown to be the largest observed in seven years of study and provided 72% of the total harvest. Sequential population analysis produced estimates of fishing mortality for alewives (0.57) and for bluebacks (0.55) in 1986 which are much closer to $F_{0.1}$ (0.47 and 0.41 respectively) than previously thought. Estimates of fishing mortality for 1987 however, again suggest that exploitation was excessive, reaching 1.4 for alewives and 1.1 for bluebacks. At current rates of exploitation, harvest of survivors from the 1987 fishery should reach 1,200 tonnes in 1988. With moderate recruitment, 1988 harvest should reach 1,500 tonnes. To reach $F_{0.1}$, the estimated harvest for 1988 is only 700 tonnes. A comparison between samples from Millbank and an adjacent trap showed that gaspereau were similar in size-at-age for both sites but the Millbank sample included a higher proportion at smaller sizes. It was not determined if Millbank selectively captures smaller fish or if the comparative sample was selected for larger specimens.

RESUME

La pêcherie de gaspareaux de la rivière Miramichi a récolté 2 145 tonnes en 1987. Cette récolte est la plus forte depuis 1980 malgré l'imposition d'une période hebdomadaire de fermeture afin de réduire le taux d'exploitation. Le gaspareau et l'alsoe d'été ont été capturés à peu près également. La classe d'âge 1983 chez les deux espèces s'est révélée être la plus forte en sept ans d'étude et a contribué pour 72 % à la récolte totale. L'analyse séquentielle des populations a donné des évaluations de mortalité par la pêche chiffrées à 0,57 pour le gaspareau et à 0,55 pour l'alose, en 1986, ce qui se rapproche beaucoup plus de la $F_{0,1}$ (0,47 et 0,41), respectivement) qu'on ne l'avait cru jusqu'ici. Les évaluations de la mortalité par la pêche pour 1987 ont suggéré, cependant, que l'exploitation a atteint un niveau excessif, soit 1,4 pour la gaspareau et 1,1 pour l'alose. Au taux présent d'exploitation, la récolte des survivants de la pêche 1987 devrait se chiffrer à 1 200 tonnes en 1988. Avec un recrutement modéré, la récolte 1988 devrait atteindre 1 500 tonnes. Pour respecter la $F_{0,1}$, il faut une récolte en 1988 qui est évaluée à seulement 700 tonnes. Une comparaison entre des échantillons pris à Millbank et dans un piège adjacent a montré que le gaspareau n'était pas différent d'un site à l'autre en taille par rapport à l'âge, mais l'échantillon de Millbank comptait davantage de poissons de petite taille. Il n'a pas été déterminé si Millbank capture d'une manière sélective des poissons plus petits ou si l'échantillon de comparaison était constitué de plus gros spécimens.

INTRODUCTION

Annual assessments indicate that the Miramichi River gaspereau fishery has exploited mixed stocks of alewife (Alosa pseudoharengus) and blueback herring (Alosa aestivalis) at excessive levels every year since at least 1982 (Alexander and Vromans 1983, 1984, 1985, 1986, 1987). This occurred despite a reduction to only 36 trap nets fishing throughout that period. Consequently, in response to persistent recommendations by CAFSAC, an effort was made in 1987 to reduce the rate of exploitation by enforcing a weekly closed time from 12:00 hours Saturday till 18:00 hours on Sunday. Results of the 1987 assessment, using cohort analysis are provided in this paper.

The assessment procedure used on the Miramichi requires information on the catch of gaspereau at each age. Generation of those data has depended, in part, on age analysis using scale samples from fish collected at the Millbank trap. Since 1982, the analysis has included an annual average of 1,300 fish aged twice each. However, since Millbank is not a commercial gaspereau trap, the possibility that these data are not representative must be considered. Also, because of the substantial manpower requirements to process samples for complete analysis including age determination, consideration must be given to reducing that task possibly through use of length-age keys. The 1987 project included a comparison of length frequency and age frequency at Millbank to an adjacent commercial trap in order to address these issues.

METHODS

Gaspereau samples were collected daily from the Millbank trap site. These were processed to provide biological data (Alexander and Vromans 1985) which were weighted using logbook statistics (Alexander and Vromans 1986) to represent the commercical catch of each species. The method of calculating effort from logbooks was revised in 1987 to exclude effort recorded for days on which the catch was recorded as zero. In most of those cases, zero catch was the result of late arrival of fish in the fishing zone and was not a reflection of stock abundance. Similar revisions were made for data files from previous years. Comparable catch, effort and age data are available for each year since 1981 and were used for sequential population analysis (SPA). This analysis was performed using APL programs described by Rivard (1982) with revisions to provide rapid tuning (G. Nielsen, pers. comm., DFO, Gulf Region).

In the previous assessment (Alexander and Vromans 1987) partial recruitment was estimated from the proportion of virgin spawners in a form of historical averaging. For 1987, new partial recruitment rates were determined by dividing the proportion of catch-at-age for Millbank each year into that for the commercial catch. Extreme values were ignored and values were considered constant after reaching a peak. All values were then normalized. The age structure of the Millbank sample was weighted to reflect the daily catch at Millbank in the same manner that it is weighted to reflect the commercial catch. The matrix of partial recruitment values generated by cohort analysis was examined for possible use in further analysis.

In this assessment, weight was input to the initial SPA as the weight-at-age matrix and to the projections as the mean weight-at-age vector. Between-year total mortality (Z) for fully-recruited year-classes was calculated using the Paloheimo method (Ricker 1975). Consecutive year averages of the Paloheimo values, reduced by an assumed natural mortality rate of 0.2, were used as an estimate of annual fishing mortality (F). These were used as starting estimates of fishing mortality for the oldest age groups in the analysis. The average rate of fishing was used as the starting rate for the most recent year. New values of F, generated by SPA after convergence (AUTO F), were used for further analysis. Fishing mortality in the most recent year was then varied in an automatic tune program to determine the most appropriate value. Yield per recruit was calculated using the method of Thompson and Bell (Ricker 1975).

Projections of catch were made using the lowest and highest levels of recruitment observed during assessments as well as the geometric mean of recruitment. Projections include hypothetical fishing at $F_{0.1}$, "F" for 1987, derived from Tune programs, and at the mean annual Paloheimo value of fishing mortality.

A sample of approximately 30 gaspereau was collected daily from the commercial trap located about 500 meters downriver from Millbank. These fish were collected by the fisherman. Commercial samples were processed in the same manner as samples from Millbank and data from the two sites were compared to investigate potential sampling bias.

RESULTS

STOCK ASSESSMENT

Science Branch personnel estimated total gaspereau landings on the Miramichi at 2,144,891 kg, based on sales slips. This includes over-the-side sales of 654 tonnes. This harvest is the highest observed since 1980 and is well above the average of 1,160 tonnes recorded after 1954, (Table 1). Earlier harvest levels are exceptional and accuracy is suspect. Since the catch recorded in voluntary logbooks was only 1,075,059 kg, a factor of 1.9951 was used to convert logbook data to represent the fishery as a whole (Table 2). This conversion factor is the highest required in seven years of study, but the result is adequate to represent the fishery. Total fishing effort was estimated at 15,107 hours (logbook effort = 7,572 hours), extending from mid-May to late June (Table 3) with an overall catch rate of 142 kg/hr. This rate was achieved previously only with the good catch in 1985 and suggests a general increase in abundance.

Daily catch in 1987 greatly exceeded that from the previous year, reaching a peak of 211,554 kg on June 8. Assuming that catch on each day of the closure would have been approximately equal to the average catch on the first day preceeding and following, then weekly closed time resulted in a catch reduction of 308 tonnes. Only alewives were harvested during the first

two weeks of the season (Table 4; Fig. 1). Total catch by numbers consisted of 4.17 X 10^6 (43%) alewives and 5.41 X 10^6 (57%) bluebacks. Alewives averaged 243 g, which is an increase compared to 1986 but is among the lower values observed for the fishery (Table 5). Average weight of bluebacks was only 209 g and is the lowest value observed. Mean weight is unlikely to drop from observed levels since a further decrease would imply a heavy dependence on age 3 which is recruited only at low rates.

The proportion of catch at each age (Table 6) shows that age 4 alewives contributed 28% (Table 6) and age 4 bluebacks contributed 43% of the total catch. This is the highest dependence on a single year-class yet observed. No other year-class of either species contributed more than 7% in 1987. The catch-at-age matrices for alewives and bluebacks (Table 7 and Table 8, respectively) similarly show the great strength of the 1983 year-class at age 4. The 1981 year-class of bluebacks at age 6 which was previously shown to be strong, continued to provide substantial numbers as did the 1982 year-class of alewives at age 5. There is some indication of improved numbers at older ages compared to the last several years. Nevertheless the mean age reflects the large catch from 1983 year-class and is calculated at 4.09 for alewives and 4.36 for bluebacks.

The proportion of catch-at-age in the commercial fishery compared to Millbank provided starting estimates of partial recruitment. Those values (Table 9) show that bluebacks achieve full recruitment one year later than alewives. This is similar to the conclusion of previous assessments. However, for both species, that age of full recruitment was determined to be one year older than in previous assessments. This probably indicates that some younger fish on the spawning migration and previously assumed to be recruited, arrive after fishing ceases or otherwise selectively escape capture.

Estimates of cumulative catch per hour for age groups at or near full recruitment suggested that annual fishing mortality for alewives ranged from 0.66 to 1.50 (Table 10). These values were used as estimates of fishing mortality of the oldest age groups for cohort analysis. For bluebacks, the estimates of fishing mortality ranged from 0.22 to 1.21 (Table 10). These were also used in cohort analysis. The mean values of annual fishing mortality, 1.20 and 0.86 for alewives and bluebacks, respectively, were used as the initial estimates of fishing mortality for fully recruited age groups in 1987.

The initial cohort analysis for alewives, produced converged rates of fishing mortality in two iterations. The extremely high value of 9.75 for 1984 (Table 10) reflects the dissappearance of several remnant year-classes but other values differed less from the originals. Historical average partial recruitments were then calculated which suggest that the 1987 values are too high (Table 9). Substitution of the historical average partial recruitment value however caused no change in the calculated value of F for the oldest age group or to the weighted value of F in each year. Tuning of the 1987 fishing mortality produced few good indicators for revision but the maximum R^2 value of 0.89 for a regression of age 5+ population numbers on 5+ CPUE was produced at

F = 1.40 Cohort analysis re-run with this terminal F produced final minor changes in estimates of weighted fishing mortality (Table 10). These values ranged from 0.57 in 1986 to 9.78 in 1984. It must be noted that, if the 1986 estimate of 0.57 is correct, then the mean value of 1.20 used in the last assessment (Alexander and Vromans 1987) was much too high. The estimate for 1987 may be no better. Nevertheless, population numbers generated from this last run (Table 11) were used for subsequent projections of catch.

Yield per recruit analysis for alewives produced an $F_{0.1}$ fishing mortality of 0.47 at a yield per recruit of 173 g and a mean weight of 293 g. The current estimate of fishing mortality in 1987 exceeds $F_{0.1}$ but the 1986 fishing mortality may have been near that level.

Projections of harvest using the calculated 1987 population numbers include cases in which 1988 recruitment at age 3 equals the low value observed for 1981 (1.35×10^6); the high value observed for 1986; (8.17×10^6) and the geometric mean of annual recruitment since 1981 (2.63×10^6). In each case, recruitment for 1989 and 1990 was input as the geometric mean of the number at age 3. For each of the three levels of recruitment a projection was made for future exploitation at a fishing mortality of 0.47 ($F_{0.1}$); at the tuned 1987 rate of 1.40; and at the mean Paloheimo rate of 1.20.

Results of the forecasts (Table 12) suggest that the harvest of over 1,000 tonnes of alewives achieved in 1987 will not likely be equalled in 1988. In these projections, the best catch of survivors from the 1987 fishery would be 519 tonnes at the high exploitation rate of 1.40. Any additional harvest is dependent on new recruits. With poor recruitment and exploitation reduced to the $F_{0.1}$ level, harvest is estimated at only 284 tonnes but, if recruitment is high then, harvest could reach 1,102 tonnes at high exploitation. The recommended level of harvest would be achieved at $F_{0.1}$ and mean annual recruitment. That estimate of catch is 319 tonnes but, in the absence of new restrictions, catch would be expected to reach 706 tonnes. Given this same level of annual recruitment (2.63×10^6) and rate of exploitation (1.40), harvest would fall back to 557 tonnes by 1989 and 533 tonnes by 1990.

The projected improvement in catch of older fish resulting from reductions in rate of exploitation is disappointing (Table 12). The harvest from those year-classes at $F_{0.1}$ would modestly exceed the harvest at the other two levels in both 1989 and 1990 but the difference is not great. The cumulative future catch from these year-classes is estimated for F = 0.47; F = 1.20 and F = 1.40 to be: 497 tonnes; 677 tonnes; and 693 tonnes, respectively. Although fishing at the $F_{0.1}$ level provides a slight improvement in stability of the fishery by providing a more diverse age structure, it results in reduced total harvest. The suitability of managing to the $F_{0.1}$ level of exploitation is questioned unless there is also a strong relationship between spawner escapement and future year-class size.

The initial cohort analysis for bluebacks produced converged rates of fishing mortality in two iterations. Weighted values of F (Table 10) ranged from 0.55 for 1986 to 1.57 in 1985. Estimates from cohort analysis are substantially different from the Paloheimo estimates for 1985 and 1986 in particular. Historical average partial recruitment values were then calculated (Table 9) but these values were very low up to age 7 and suggested that recruitment was not complete until age 9. Recalculations of F using revised partial recruitment then required four iterations to converge and produced weighted estimates of F ranging from 1.07 in 1982 to 9.26 in 1984. Tune programs provided good correlations only with extremely high values of 1987 fishing mortality. Revised rates of partial recruitment were deemed unacceptable and the initial estimates were used for further analysis. Tune programs then provided maximum R^2 values of 0.925 and 0.976 for regressions of population numbers on catch per hour for ages 5+ and 6+, respectively, both at F = 1.1. Final estimates of fishing mortality for the oldest age groups (Table 10) ranged from 0.61 in 1984 to 1.65 in 1985. The estimate for 1986 is 0.62 and is well below the mean value of 1.13 used in the last assessment (Alexander and Vromans 1987). Population numbers generated by the last run of cohort analysis (Table 13) were used for subsequent projections of catch.

Yield per recruit analysis for bluebacks produced an $F_{0.1}$ fishing mortality of 0.41 at a yield per recruit of 130 g and a mean weight of 238 g. The current estimate of fishing mortality in 1987 exceeds $F_{0.1}$ but, the 1986 fishing mortality, as well as the 1984 mortality may have been close to $F_{0.1}$.

Projections of harvest using the 1987 population numbers include cases in which 1988 population at age 3 equals the low value observed in 1987 (0.76×10^6); the high value observed in 1986 (12.08×10^6); and the geometric mean of the annual population numbers observed, beginning in 1981 (3.06×10^6). In each case, recruitment for 1989 and 1990 was input as the geometric mean of the number at age 3. For each of the three levels of recruitment a projection was made for future exploitation at a fishing mortality of 0.41 ($F_{0.1}$); at the mean Paloheimo estimate of 0.86; and at the tuned 1987 rate of 1.10.

Results of the forecasts (Table 14) suggest that the 1987 harvest of bluebacks (1,131 tonnes) can be surpassed only if recruitment and exploitation remain high. The best catch of survivors from the 1987 fishery is estimated at 684 tonnes if exploitation remains high. At the recommended level of exploitation, those fish would contribute only 332 tonnes. However, if recruitment in 1988 is as bad as in 1987, (0.76×10^6) then new recruits would provide only 14 additional tonnes at the $F_{0.1}$ exploitation rate. The recommended level of harvest would be achieved at $F_{0.1}$ and mean annual recruitment. That estimate of catch is 385 tonnes but, in the absence of new restrictions, catch would be expected to reach 813 tonnes at that recruitment level. Given the same level of annual recruitment (3.06×10^6) and rate of exploitation (1.10), harvest would fall to 557 tonnes in 1989 and tonnes by 1990.

The projected improvement in catch of older bluebacks resulting from reductions in rate of exploitation is disappointing (Table 14), as it was for alewives. The harvest from those year-classes at $F_{0.1}$ would be less than the harvest at the other two levels in 1989 but would be modestly higher by

1990. The cumulative 3 year catch from these year-classes is estimated for F = 0.41; F = 0.86 and F = 1.10 to be: 893 tonnes; 982 tonnes; and 1035 tonnes, respectively. Fishing at the $F_{0.1}$ level provides a slight improvement in stability of the fishery by catching fish from more age groups but results in reduced harvest. The suitability of managing to the $F_{0.1}$ level of exploitation is again questioned.

MILLBANK:COMMERCIAL COMPARISON

A total of 544 gaspereau were collected on 18 sample days from the trap of Leslie E. Clarke adjacent to the Millbank trap. A sub-sample of 156 fish was aged. These were compared to the length and age distribution for 1,129 gaspereau measured and 1,121 aged at Millbank on 33 sample days.

The length-at-age for alewives (Table 15) was not significantly different (P = .7396) for the two sites. Length-at-age for bluebacks (Table 15) did show differences but when only the lengths for age groups represented by 7 or more samples were compared, this difference was not significant (P = .1660).

When the samples were seperated into eight size categories (Table 16) it was shown that a greater proportion of the Millbank samples was in the smaller size groups. It was also shown that the alewife:blueback ratio at the commercial trap (71:29) suggested a much higher catch of alewives than indicated by the ratio (46:54) for Millbank. However, these samples are not directly comparable because sampling at Millbank began earlier and continued longer. When samples were compared only for the same days and weighted to reflect numbers caught daily at Millbank (Table 16), proportions were revised somewhat but still showed a higher proportion of alewives (55:45) in the commercial sample compared to the Millbank sample (43:57). The distribution of the catch by size groups is significantly different between the two sample locations. The figures suggest that Millbank catches substantially more fish less than 250 mm in length and a correspondingly lower proportion at larger sizes compared to the commercial trap. If this is the case, then Millbank over-estimates the catch of smaller, younger fish and under-estimates the catch of larger, older fish. The catch-at-age matrix and the 1987 estimates of partial recruitment may require adjustment which would affect the results of SPA. However, it is difficult to see why Millbank would catch more young fish than the commercial trap since Millbank uses 5.1 cm mesh compared to 4.4 cm in the commercial trap. Another possible explanation is that samples collected by the commercial fisherman may have been inadvertently selected to provide us with the best specimens, which may have been larger. The difference is great enough to warrant further comparison between Millbank and the commercial catch in 1988.

SUMMARY

Using sequential population analysis, the best estimates of fishing mortality for 1987 are 1.4 for alewives and 1.1 for bluebacks. Despite the weekly closed time these values are much in excess of the $F_{0.1}$ values (0.47 and 0.41 respectively). However, the same SPA showed that mortality for 1986 was 0.57 for alewives and 0.55 for bluebacks. These values are much lower than previously estimated. Reduction to $F_{0.1}$ in 1988 would result in a projected harvest of only 704 tonnes but the estimate is based on only a few years of data. The estimate should be revised if biological samples used to generate SPA parameters are shown to be biased. The best estimate of 1988 harvest under current regulations is 1519 tonnes.

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Table 1. Annual catch statistics and number of fishing licences for the Miramichi River, New Brunswick, gaspereau fishery (Districts 71 and 72).

Year	Catch (mt)	Number of licences	Catch/licence
1950	4,952	220	22.51
1951	8,014	163	49.17
1952	11,381	180	63.23
1953	8,026	178	45.09
1954	4,649	231	20.13
1955	3,413	181	18.86
1956	3,009	166	18.13
1957	884	135	6.55
1958	816	120	6.80
1959	1,596	108	14.78
1960	716	120	5.97
1961	161	109	1.48
1962	733	67	10.94
1963	543	66	8.23
1964	119	37	3.22
1965	425	36	11.81
1966	746	41	18.20
1967	532	34	15.65
1968	436	27	16.15
1969	175	23	7.61
1970	874	28	31.21
1971	469	37	12.68
1972	468	26	18.00
1973	967	35	27.63
1974	271	351	7.74
1975	141	341	4.15
1976	406	341	11.94
1977	2,240	341	65.88
1978	1,434	341	42.18
1979	3,343 (694)2	341	98.32
1980	3,767 (398)2	341	110.79
1981	1,410	341	41.47
1982	1,278	36	35.50
1983	1,088	36	30.22
1984	665	36	18.47
1985	1,857	36	51.58
1986	1,154 (566)2	36	32.04
1987	2,145 (654)2	36	59.58

1 The number of traps may have been as high as 36 beginning in 1974.
2 "Over-the-side sales" for all gaspereau in New Brunswick.

Table 2. Miramichi River gaspereau catches reported through voluntary logbooks, total estimated catch for the river and resultant conversion factors used to convert logbook data to represent the whole fishery each year.

	Year						
	1981	1982	1983	1984	1985	1986	1987
Total catch (kg) A	1,410,241	1,277,639	1,087,899	664,774	1,857,386	1,153,542	2,144,891
Logbook catch (kg) B	1,320,172	1,106,124	848,869	610,906	1,492,829	608,365	1,075,059
Conversion factor A/B	1.0682	1.1551	1.2816	1.0882	1.2442	1.8961	1.9951
Total effort (hrs.)	13,147	15,187	19,088	9,638	13,073	14,126	15,107
CPUE (kg/hr.)	107.3	84.1	57.0	69.0	142.1	81.7	142.0
Blueback effort (hrs.)*	12,792	15,021	16,989	6,699	11,110	9,312	10,239
Alewife effort (hrs.)*	13,147	15,187	19,088	9,613	13,043	14,126	14,740

* This adjusted effort was calculated by summing effort only for days on which the species was caught.

Table 3. Daily catch (kg), effort (hours) and catch per unit effort (kg/hr) in the 1987 Miramichi River gaspereau fishery, as reported through catch-and-effort logbooks.

		Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Total
May 11-17	Catch	0	0	0	0	0	0	0	0
	Effort	0	0	0	0	0	0	0	0
	CPUE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May 18-24	Catch	8848	13912	7086	5243	6050	4417	0	45556
	Effort	207	219	183	137	230	124	0	1100
	CPUE	42.74	63.53	38.72	38.27	26.30	35.62	0.00	41.41
May 25-31	Catch	9982	18702	35263	61414	59697	23860	0	208918
	Effort	291	340	344	365	362	222	0	1924
	CPUE	34.30	55.01	102.51	168.26	164.91	107.48	0.00	108.59
June 1- 7	Catch	64629	59100	72388	73128	75206	53526	0	397977
	Effort	337	365	363	342	364	235	0	2006
	CPUE	191.78	161.92	199.42	213.82	206.61	227.77	0.00	198.39
June 8-14	Catch	106031	89826	63410	61737	40295	42482	0	403781
	Effort	357	363	364	363	342	171	0	1960
	CPUE	297.01	247.45	174.20	170.07	117.82	248.43	0.00	206.01
June 15-21	Catch	1486	2449	2291	1520	1420	567	0	9733
	Effort	64	69	69	69	69	12	0	352
	CPUE	23.22	35.49	33.20	22.03	20.58	47.25	0.00	27.65
June 22-28	Catch	2087	1678	1451	1882	1996	0	0	9094
	Effort	46	46	46	46	46	0	0	230
	CPUE	45.37	36.48	31.54	40.91	43.39	0.00	0.00	39.54
Total	Catch	193063	185667	181889	204924	184664	124852	0	1075059
	Effort	1302	1402	1369	1322	1413	764	0	7572
	CPUE	148.28	132.43	132.86	155.01	130.69	163.42	0.00	141.98

Table 4. Estimated daily catch (Districts 71 and 72 combined) in the 1987 Miramichi River gaspereau fishery.

	Alewife		Blueback		Catch (kg)			Number		
Date	Mean wt.	%	Mean wt.	%	Alewife	Blueback	Combined	Alewife	Blueback	Combined
Ma 18	.2679	100.0	.0000	0.0	17654	0	17654	65896	0	65896
Ma 19	.2679	100.0	.0000	0.0	27678	0	27678	103313	0	103313
Ma 20	.2680	100.0	.0000	0.0	14138	0	14138	52754	0	52754
Ma 21	.2639	100.0	.0000	0.0	10461	0	10461	39640	0	39640
Ma 22	.2585	100.0	.0000	0.0	12071	0	12071	46696	0	46696
Ma 23	.2610	100.0	.0000	0.0	8813	0	8813	33766	0	33766
Ma 24	.2704	100.0	.0000	0.0	0	0	0	0	0	0
Ma 25	.2631	100.0	.0000	0.0	19916	0	19916	75698	0	75698
Ma 26	.2541	100.0	.0000	0.0	37314	0	37314	146849	0	146849
Ma 27	.2471	100.0	.0000	0.0	70357	0	70357	284732	0	284732
Ma 28	.2605	100.0	.0000	0.0	122534	0	122534	470380	0	470380
Ma 29	.2612	90.0	.3120	10.0	105152	13956	119108	402574	44730	447304
Ma 30	.2440	100.0	.2709	0.0	47606	0	47606	195106	0	195106
Ma 31	.2756	100.0	.2709	0.0	0	0	0	0	0	0
Jn 1	.2502	55.0	.2618	45.0	69472	59476	128949	277677	227182	504849
Jn 2	.2370	25.0	.2521	75.0	28135	89782	117917	118713	356138	474850
Jn 3	.2417	83.7	.2548	16.3	119789	24640	144429	495611	96704	592315
Jn 4	.2399	58.0	.2404	42.0	84552	61354	145906	352445	255218	607663
Jn 5	.2332	36.0	.2188	64.0	56241	93811	150052	241172	428751	669923
Jn 6	.1965	33.3	.2267	66.7	32290	74506	106796	164326	328653	492979
Jn 7	.2287	18.0	.2097	82.0	0	0	0	0	0	0
Jn 8	.2250	25.7	.1982	74.3	59680	151874	211554	265246	766266	1031512
Jn 9	.2158	15.7	.1935	84.3	30851	148371	179222	142959	766777	909736
Jn 10	.2158	15.7	.1935	84.3	21778	104738	126516	100917	541284	642201
Jn 11	.1745	5.7	.1898	94.3	6501	116677	123178	37257	614737	651994
Jn 12	.2420	4.0	.1980	96.0	3896	76501	80397	16099	386369	402468
Jn 13	.1903	6.3	.1979	93.8	5106	79654	84761	26833	402498	429331
Jn 14	.1780	4.0	.1938	96.0	0	0	0	0	0	0
Jn 15	.2130	5.9	.1915	94.1	193	2772	2965	905	14476	15381
Jn 16	.2057	0.0	.1935	100.0	0	4886	4886	0	25252	25252
Jn 17	.2057	0.0	.1798	100.0	0	4571	4571	0	25423	25423
Jn 18	.2032	17.1	.1851	82.9	561	2471	3033	2762	13352	16114
Jn 19	.2128	12.9	.1800	87.1	421	2413	2833	1977	13403	15380
Jn 20	.2320	8.6	.1753	91.4	125	1006	1131	538	5741	6279
Jn 21	.2110	2.9	.1736	97.1	0	0	0	0	0	0
Jn 22	.1863	0.0	.1670	100.0	0	4164	4164	0	24934	24934
Jn 23	.1863	3.5	.1707	96.5	129	3219	3348	690	18860	19550
Jn 24	.1740	5.7	.1763	94.3	163	2732	2895	939	15494	16433
Jn 25	.1740	5.7	.1763	94.3	212	3543	3755	1218	20097	21315
Jn 26	.1740	5.7	.1763	94.3	225	3758	3982	1292	21314	22606
	.2433		.2089		1014014	1130877	2144891	4166970	5413653	9580622
% of combined total					48.66	51.34		43.49	56.51	

Table 5. Relative contribution by alewives and blueback herring to the Miramichi River gaspereau fishery, 1981-1987.

Year	Species	Number (X 1,000)	Percentage of total	Weight kg (X 1,000)	Percentage of total	Mean weight (g)
1981	Alewife	1,067.7	24.5	316.0	22.4	296
	Blueback	3,289.7	75.5	1,094.3	77.6	333
1982	Alewife	1,590.1	39.6	493.1	38.6	310
	Blueback	2,425.5	60.4	784.5	61.4	323
1983	Alewife	1,832.7	44.9	493.8	45.5	269
	Blueback	2,251.4	55.1	594.1	54.6	264
1984	Alewife	1,899.2	73.7	487.9	72.6	257
	Blueback	677.5	26.3	176.9	27.4	261
1985	Alewife	1,868.4	23.7	462.5	25.3	248
	Blueback	6,001.8	76.3	1,394.9	74.7	232
1986	Alewife	3,146.7	62.0	718.6	62.2	228
	Blueback	1,931.5	38.0	435.0	37.8	225
1987	Alewife	4,167.0	43.5	1,014.0	48.7	243
	Blueback	5,413.7	56.5	1,130.9	51.3	209

Table 6. Percentage contribution by each age of alewife and blueback herring to the Miramichi River gaspereau fishery, 1981-1987. Contribution is shown as a percentage of the species catch (S) and as a percentage of the total catch (T).

			Age							
Year	Species	Group	2	3	4	5	6	7	8	9
1981	Alewife	S	0.0	3.5	31.6	14.5	28.9	19.0	1.4	1.1
		T	0.0	0.9	7.7	3.5	7.1	4.7	0.3	0.3
	Blueback	S	0.0	0.3	6.0	14.3	55.8	10.5	8.7	4.2
		T	0.0	0.3	4.5	10.8	42.2	7.9	6.6	3.2
	Both	T	0.0	1.2	12.2	14.3	49.3	12.6	6.9	3.5
1982	Alewife	S	0.0	33.9	47.7	7.5	5.7	2.2	2.8	0.0
		T	0.0	12.3	17.3	2.7	2.1	0.8	1.0	0.0
	Blueback	S	0.0	1.5	20.3	29.9	12.1	30.0	2.7	3.5
		T	0.0	0.8	11.2	16.5	6.7	16.5	1.5	2.0
	Both	T	0.0	13.1	28.5	19.2	8.8	17.3	2.5	2.0
1983	Alewife	S	0.2	34.0	52.6	6.1	2.9	1.4	1.8	0.6
		T	0.1	15.2	23.6	2.7	1.3	0.6	0.8	0.3
	Blueback	S	0.0	2.5	46.6	27.8	11.0	3.0	7.0	1.3
		T	0.0	1.4	25.7	15.3	6.1	1.7	3.9	0.4
	Both	T	0.1	16.6	49.3	18.0	7.4	2.3	4.7	0.7
1984	Alewife	S	0.0	55.6	35.8	6.4	2.0	0.0	0.0	0.2
		T	0.0	41.0	26.4	4.7	1.5	0.0	0.0	0.1
	Blueback	S	0.0	7.6	48.0	21.7	11.3	5.0	3.8	1.9
		T	0.0	2.0	12.6	5.7	3.0	1.3	1.0	0.5
	Both	T	0.0	43.0	39.0	10.4	4.5	1.3	1.0	0.7
1985	Alewife	S	0.0	38.4	51.1	10.4	0.0	0.0	0.0	0.0
		T	0.0	9.1	12.1	2.5	0.0	0.0	0.0	0.0
	Blueback	S	0.0	6.1	62.8	20.1	6.7	1.8	0.1	1.9
		T	0.0	4.7	47.9	15.3	5.1	1.4	0.1	1.5
	Both	T	0.0	13.8	60.0	17.8	5.1	1.4	0.1	1.5
1986	Alewife	S	0.0	74.2	18.0	7.5	0.3	0.0	0.0	0.0
		T	0.4	46.0	11.2	4.7	0.2	0.0	0.0	0.0
	Blueback	S	0.4	28.9	16.7	42.4	9.5	0.8	0.9	0.0
		T	0.2	11.0	6.4	16.1	3.6	0.3	0.4	0.0
	Both	T	0.2	56.9	17.5	20.8	3.8	0.3	0.4	0.0
1987	Alewife	S	0.0	15.5	65.4	14.2	4.4	0.6	0.0	0.0
		T	0.0	6.7	28.4	6.2	1.9	0.3	0.0	0.0
	Blueback	S	0.0	3.6	76.7	5.0	10.2	3.8	0.8	0.0
		T	0.0	2.0	43.4	2.8	5.7	2.1	0.4	0.0
	Both	T	0.0	8.8	71.8	9.0	7.6	2.4	0.4	0.0

Table 7. Catch-at-age (numbers of fish) of alewife in the Miramichi River gaspereau fisheries, 1981 to 1987.

Age	1981	1982	1983	1984	1985	1986	1987
2	0	363	3,719	411	0	0	0
3	38,619	502,137	622,237	1,055,839	717,910	2,333,664	644,918
4	317,258	773,959	964,566	679,906	955,514	566,640	2,724,071
5	147,714	115,197	111,979	120,792	195,001	235,992	590,821
6	304,056	98,261	52,594	38,564	0	10,424	182,978
7	217,214	36,003	25,603	0	0	0	24,184
8	14,696	50,399	33,023	0	0	0	0
9	12,494	0	11,726	3,730	0	0	0
10	0	0	753	0	0	0	0
11	0	610	6,486	0	0	0	0
12	0	0	0	0	0	0	0
Mean age	5.42	4.08	3.92	3.56	3.72	3.34	4.09

Table 8. Catch-at-age (numbers of fish) of blueback herring in the Miramichi River gaspereau fisheries, 1981 to 1987.

Age	1981	1982	1983	1984	1985	1986	1987
2	0	0	163	0	0	8,304	0
3	10,586	40,283	55,462	51,341	368,098	557,669	195,061
4	194,411	506,240	1,049,216	324,828	3,766,743	322,453	4,154,554
5	476,165	746,833	625,558	146,937	1,205,880	819,141	269,125
6	1,830,828	302,795	247,459	76,348	403,914	183,970	549,253
7	344,686	686,484	68,468	33,907	110,187	15,956	203,716
8	289,803	69,135	159,626	25,476	8,423	17,923	41,946
9	136,676	86,227	15,283	12,932	113,740	743	0
10	0	1,547	29,906	3,629	0	5,376	0
11	19,287	0	291	0	0	0	0
12	0	0	0	2,074	24,844	0	0
Mean age	6.13	5.88	4.96	4.80	4.43	4.41	4.36

Table 9. Values of partial recruitment-at-age for alewives and blueback herring in the Miramichi River gaspereau fishery as determined: 1) for the 1985 fishery assessment, 2) for the 1986 fishery assessment, 3) by comparing the 1987 Millbank catch to the 1987 commercial catch, 4) by using average historical partial recruitment.

	Alewife (Method)				Blueback (Method)			
Age	(1)	(2)	(3)	(4)*	(1)	(2)	(3)*	(4)
2	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.5	0.53	0.70	0.31	0.04	0.11	0.30	0.03
4	1.0	1.00	0.87	0.74	0.60	0.88	0.60	0.24
5			1.00	1.00	1.00	1.00	0.90	0.43
6							1.00	0.48
7								0.55
8								0.92
9								1.00

* Denotes partial recruitment values selected for 1987 cohort analysis and for projections.

Table 10. Estimates of cumulative catch-per-hour (No./hr) for fully recruited alewife and blueback herring in each year, and the same year classes in the following year on the Miramichi River. Between year instantaneous mortality (Z) is shown and fishing mortality by year (F) is shown as determined from the Paloheimo method; from the first cohort analysis; from cohort analysis after revision to partial recruitment (PR); and from cohort after selection of the best PR and "tuned" to the best 1987 F.

		Year						
		1981	1982	1983	1984	1985	1986	1987
Alewife:	Catch/hr (4+)	77.09	70.75	63.22	87.46	88.01	57.56	233.14
	Catch/hr (5+)	52.96	19.79	12.69	16.92	14.92	17.45	52.82
	Z		1.36	1.70	1.33	1.77	1.62	0.09
	F (from Paloheimo)	1.20	1.33	1.32	1.35	1.50	0.66	1.20
	F (Cohort)	1.25	1.11	3.46	9.75	1.41	0.53	1.20
	F (Cohort-Revised PR)	1.25	1.11	3.46	9.75	1.41	0.53	1.20
	F (Tuned)	1.25	1.11	3.46	9.78	1.45	0.57	1.40
Blueback:	Catch/hr (5+)	235.60	124.65	60.07	31.26	142.81	73.84	70.43
	Catch/hr (6+)	199.38	75.47	27.30	16.02	50.57	15.86	52.26
	Z		1.14	1.50	1.32	-0.48	2.20	0.35
	F (from Paloheimo)	0.86	1.12	1.21	0.22	0.66	1.08	0.86
	F (Cohort)	1.12	1.06	1.26	0.61	1.57	0.55	0.86
	F (Cohort-Revised PR)	3.90	1.07	1.55	9.26	2.97	5.88	0.86
	F (Tuned)	1.12	1.07	1.27	0.61	1.65	0.62	1.10

Table 11. Number of alewives at each age in the Miramichi River as determined from Cohort analysis.

	Population Numbers						
Age	1981	1982	1983	1984	1985	1986	1987
3	1,349,707	2,056,136	2,025,021	3,323,205	2,820,434	8,174,233	2,006,489
4	592,848	1,070,103	1,229,069	1,094,924	1,765,448	1,659,584	4,580,910
5	338,105	198,316	175,819	133,501	281,243	580,841	846,036
6	446,024	143,160	58,133	42,626	5	53,818	262,018
7	331,209	90,052	28,299	6	5	3	34,631
8	16,244	74,628	41,152	3	4	3	1
9	20,279	2	15,497	3,812	1	3	2
3+	3,094,415	3,632,396	3,572,990	4,598,076	4,867,140	10,468,486	7,730,086
4+	1,744,708	1,576,260	1,547,969	1,274,871	2,046,706	2,294,252	5,723,597
5+	1,151,860	506,157	318,900	179,948	281,258	634,668	1,142,688
6+	813,755	307,841	143,081	46,446	15	53,827	296,652

Table 12. Summary of projected catch of alewives from Miramichi River assuming 1988 recruitment at high, medium and low levels followed by recruitment at medium levels and with future exploitation at three different levels. The future harvest of currently recruited year-classes is independent of future recruitment and is shown in parenthesis.

1988 Recruitment	Exploitation	CATCH (tonnes) 1988	1989	1990
low	0.47	284 (248)	302 (160)	356 (89)
low	1.20	562 (477)	436 (158)	478 (42)
low	1.40	615 (519)	447 (143)	490 (31)
mean	0.47	319 (248)	368 (160)	412 (89)
mean	1.20	642 (477)	542 (158)	527 (42)
mean	1.40	706 (519)	557 (143)	533 (31)
high	0.47	471 (248)	655 (160)	654 (89)
high	1.20	991 (477)	1,005 (158)	740 (42)
high	1.40	1,102 (519)	1,035 (143)	720 (31)

Notes: Low recruitment is the estimated number of fish at age three in 1981 (1.35×10^6).

Mean recruitment is the geometric mean of the number of fish at age three from 1981 to 1987 (2.63×10^6).

High recruitment is the estimated number of fish at age three in 1986 (8.17×10^6).

Exploitation rate of 0.47 is the $F0.1$ level.

Exploitation rate of 1.20 is the mean Paloheimo rate.

Exploitation rate of 1.40 is the 1987 rate estimated from Cohort analysis.

Table 13. Number of bluebacks at each age in the Miramichi River as determined from Cohort analysis.

	Population Numbers						
Age	1981	1982	1983	1984	1985	1986	1987
3	2,205,034	2,740,934	3,594,939	8,117,687	1,535,683	12,078,943	761,506
4	1,722,203	1,795,751	2,207,637	2,893,103	6,599,769	924,242	9,384,802
5	1,427,794	1,234,110	1,012,171	858,091	2,074,756	1,995,144	464,938
6	3,239,258	738,127	334,642	262,667	569,591	607,541	892,296
7	523,051	995,478	330,347	50,071	145,971	100,865	330,950
8	516,350	116,353	193,872	208,513	10,315	19,810	68,144
9	154,310	160,527	32,706	14,294	147,420	823	2
10	2	2,669	53,407	12,949	1	17,781	2
3+	9,788,002	7,783,949	7,759,721	12,417,374	11,083,506	15,745,149	11,902,639
4+	7,582,968	5,043,015	4,164,782	4,299,687	9,547,823	3,666,206	11,141,133
5+	5,860,765	3,247,265	1,957,145	1,406,585	2,948,054	2,741,965	1,756,331
6+	4,432,971	2,013,154	944,974	548,494	873,298	746,821	1,291,393

Table 14. Summary of projected catch of bluebacks from Miramichi River assuming 1988 recruitment at high, medium and low levels followed by recruitment at medium levels and with future exploitation at three different levels. The future harvest of currently recruited year-classes is independent of future recruitment and is shown in parenthesis.

1988 Recruitment	Exploitation	CATCH (tonnes) 1988	1989	1990
low	0.41	346 (332)	320 (244)	317 (151)
low	0.86	611 (585)	424 (284)	389 (113)
low	1.10	716 (684)	436 (267)	400 (84)
mean	0.41	385 (332)	386 (244)	388 (151)
mean	0.86	689 (585)	532 (284)	472 (113)
mean	1.10	813 (684)	557 (267)	479 (84)
high	0.41	542 (332)	648 (244)	668 (151)
high	0.86	997 (585)	957 (284)	800 (113)
high	1.10	1,195 (684)	1,032 (267)	788 (84)

Notes: Low recruitment is the estimated number of fish at age three in 1987 (0.76×10^6).

Mean recruitment is the geometric mean of the number of fish at age three from 1981 to 1987 (3.06×10^6).

High recruitment is the estimated number of fish at age three in 1986 (12.08×10^6).

Exploitation rate of 0.41 is the $F0.1$ level.

Exploitation rate of 0.86 is the mean Paloheimo rate.

Exploitation rate of 1.10 is the 1987 rate estimated from cohort analysis.

Table 15. Mean lengths (mm) at age of alewife and blueback herring determined from samples collected at the Millbank trap (MB) and a commercial trap (MC) near Millbank, NB., 1987.

	Alewife				Blueback herring			
	MB		MC		MB		MC	
Age	no.	length	no.	length	no.	length	no.	length
2	0	---	0	---	0	---	0	---
3	94	252	7	255	50	242	2	253
4	316	261	80	261	474	253	27	261
5	74	278	9	281	26	266	7	270
6	29	282	8	280	43	274	11	275
7	2	289	2	287	9	284	1	293
8	0	---	0	---	3	292	2	321
9	0	---	0	---	1	327	0	---
10	0	---	0	---	0	---	0	---
TOTAL	515		106		606		50	

Table 16. Number of alewives and bluebacks in each size group for gaspereau samples collected at Millbank and at an adjacent commercial trap, 1987. The proportion in each group after weighting to reflect daily catch at Millbank is also shown (M%).

		Millbank			Commercial		
Size (mm)		blueback	alewife	total	blueback	alewife	total
<240	n	59	6	65	0	1	1
	%	5.2	0.5	5.8	0.0	0.2	0.2
	M%	1.2	3.4	4.6	0.0	0.4	0.4
240-249	n	150	52	202	12	23	35
	%	13.3	4.6	17.9	2.2	4.2	6.3
	M%	14.2	12.5	26.7	4.6	4.2	8.8
250-259	n	211	176	387	48	119	167
	%	18.7	15.6	34.3	8.7	21.5	30.1
	M%	20.1	13.8	33.9	12.7	21.4	34.1
260-269	n	115	144	259	39	124	163
	%	10.2	12.8	22.9	7.0	22.4	29.4
	M%	12.2	8.2	20.4	9.6	15.8	25.4
270-279	n	47	91	138	26	69	95
	%	4.2	8.1	12.2	4.7	12.5	17.2
	M%	5.8	3.4	9.2	7.9	7.7	15.6
280-289	n	19	32	51	22	40	62
	%	1.7	2.8	4.5	4.0	7.2	11.2
	M%	2.2	1.4	3.6	6.4	4.4	10.8
290-299	n	6	12	18	7	14	21
	%	0.5	1.1	1.6	1.3	2.5	3.8
	M%	0.9	0.1	1.0	1.6	1.0	2.6
>299	n	4	5	9	8	2	10
	%	0.7	1.0	0.8	1.4	0.4	1.8
	M%	0.4	0.0	0.4	2.4	0.1	2.5
TOTAL	n	611	518	1129	162	392	554
	%	54.1	45.9		29.2	70.8	
	M%	57.1	42.9		45.1	54.9	

APPENDIX I. Mean weight-at-age matrix, determined from log length-log weight regression equations for alewives and blueback herring in the Miramichi River.

Age	1981	1982	1983	1984	1985	1986	1987	Mean*
Alewife								
2	127*	135	114	137	122	127*	127*	127
3	240	244	223	210	210	206	220	222
4	278	317	275	271	254	270	243	273
5	299	347	328	324	290	302	293	312
6	334	393	317	352	339*	334	306	339
7	340	398	404	368*	368*	368*	329	368
8	392	460	374	409*	409*	409*	409*	409
9	401	536	404	460	450*	450*	450*	450
Blueback herring								
2	112*	112*	100	112*	117	120	112*	112
3	169	169	171	154	165	166	164	165
4	220	213	208	192	193	202	189	202
5	257	238	256	228	233	230	222	238
6	313	333	297	275	275	255	245	285
7	341	367	359	311	307	308	275	324
8	349	341	359	347	389	385	300	353
9	345	325	374	320	389	373	433	366
10	360*	362	370	333	360*	373	360	360

* Values determined by averaging across years for which data are present.

APPENDIX II. Proportions of virgin spawning alewives and blueback herring at each age in the Miramichi River gaspereau fishery (1981-87).

Year	Age	Percentage of virgin spawners	
		Alewife	Blueback
1981	3	100	86
	4	100	95
	5	81	60
	6	15	12
1982	3	100	100
	4	63	90
	5	5	37
	6	0	
1983	3	100	100
	4	77	96
	5	12	44
	6	6	4
1984	3	100	95
	4	77	88
	5	0	31
	6	0	0
1985	3	99	78
	4	62	74
	5	0	18
	6	0	0
1986	3	100	96
	4	43	64
	5	4	4
	6	0	0
1987	3	100	98
	4	62	85
	5	3	23
	6	0	0

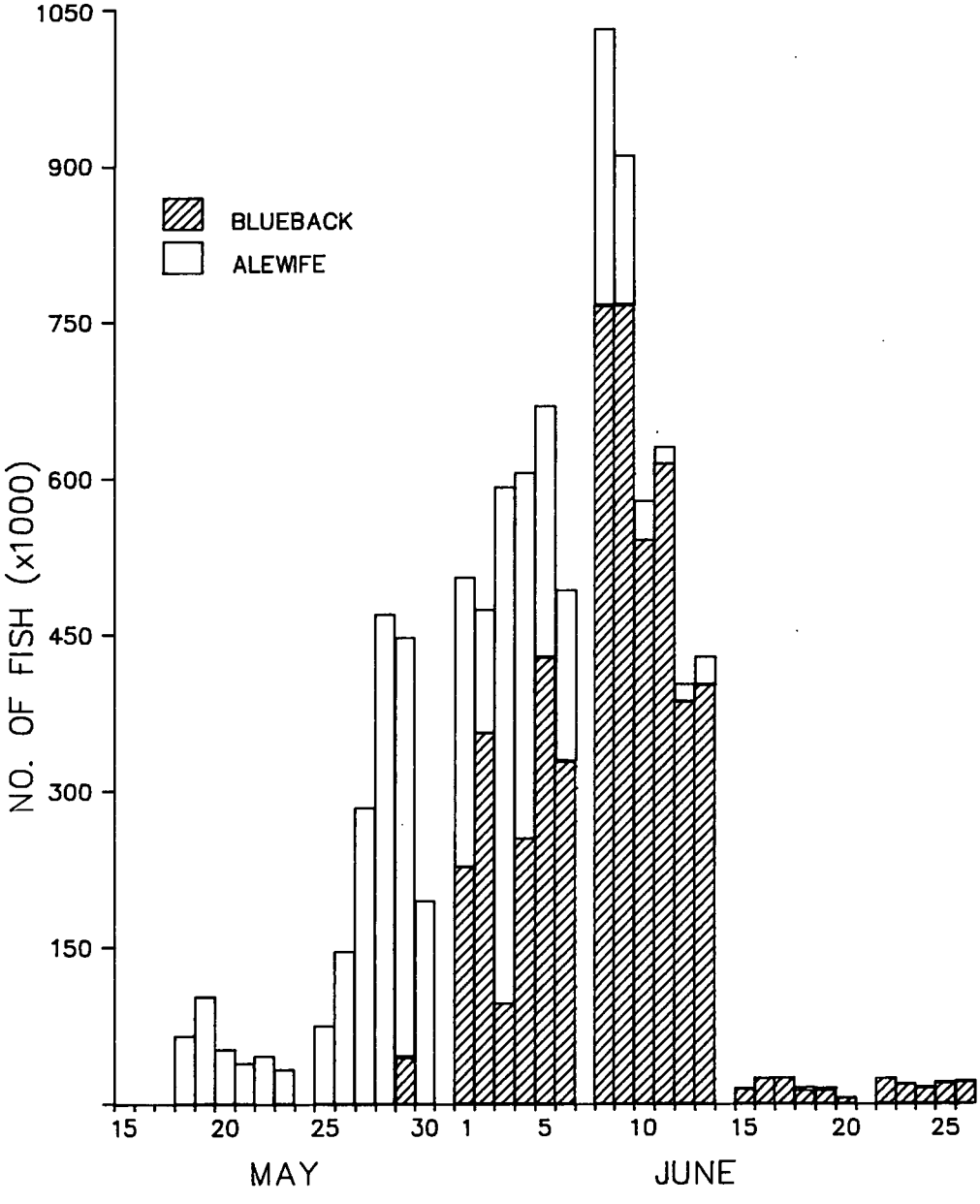

Figure 1. Numbers of alewife and blueback herring in the 1987 Miramichi River gaspereau fishery.

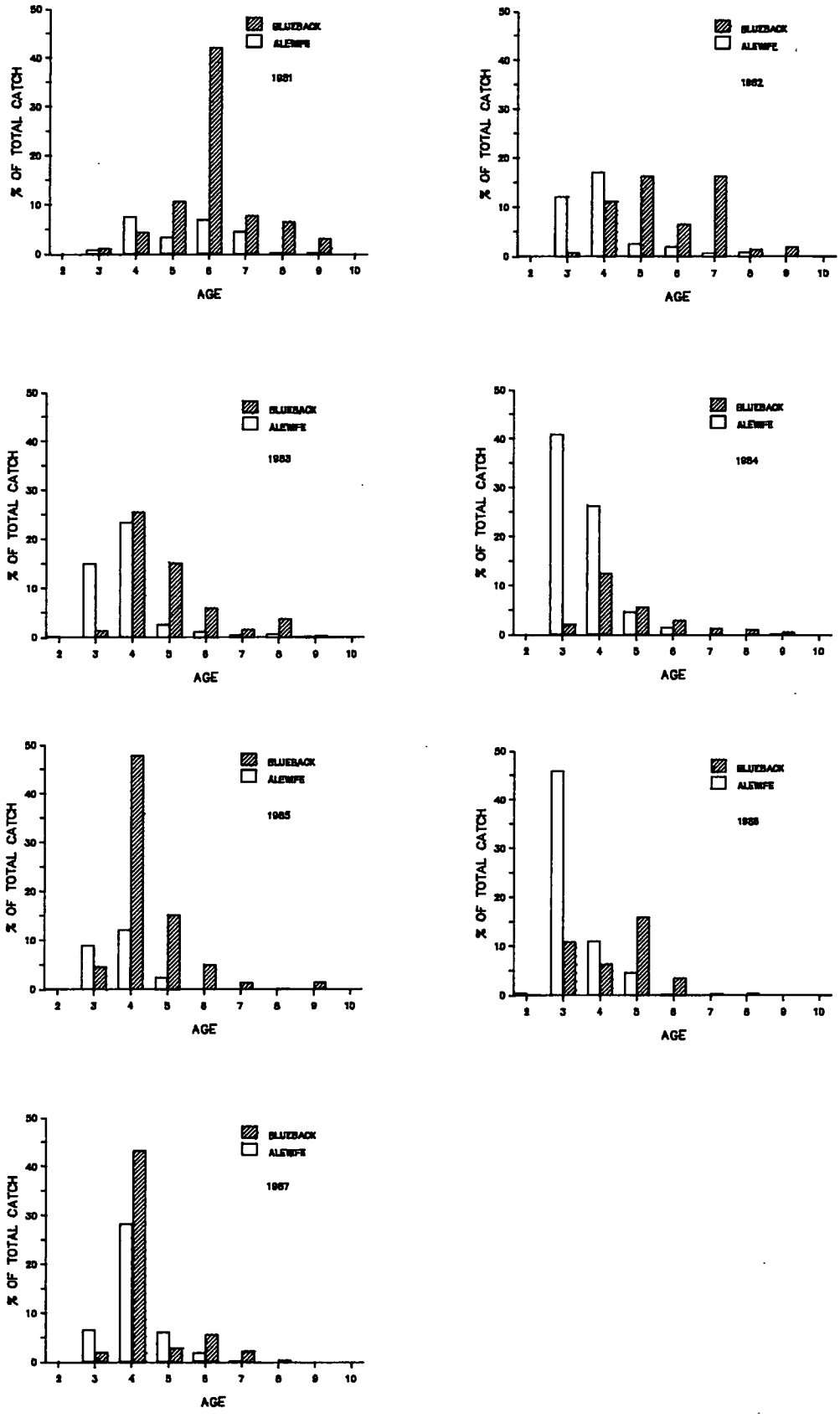

Figure 2. Percent at age of alewife and blueback herring in the Miramichi River gaspereau fishery, 1981–87.

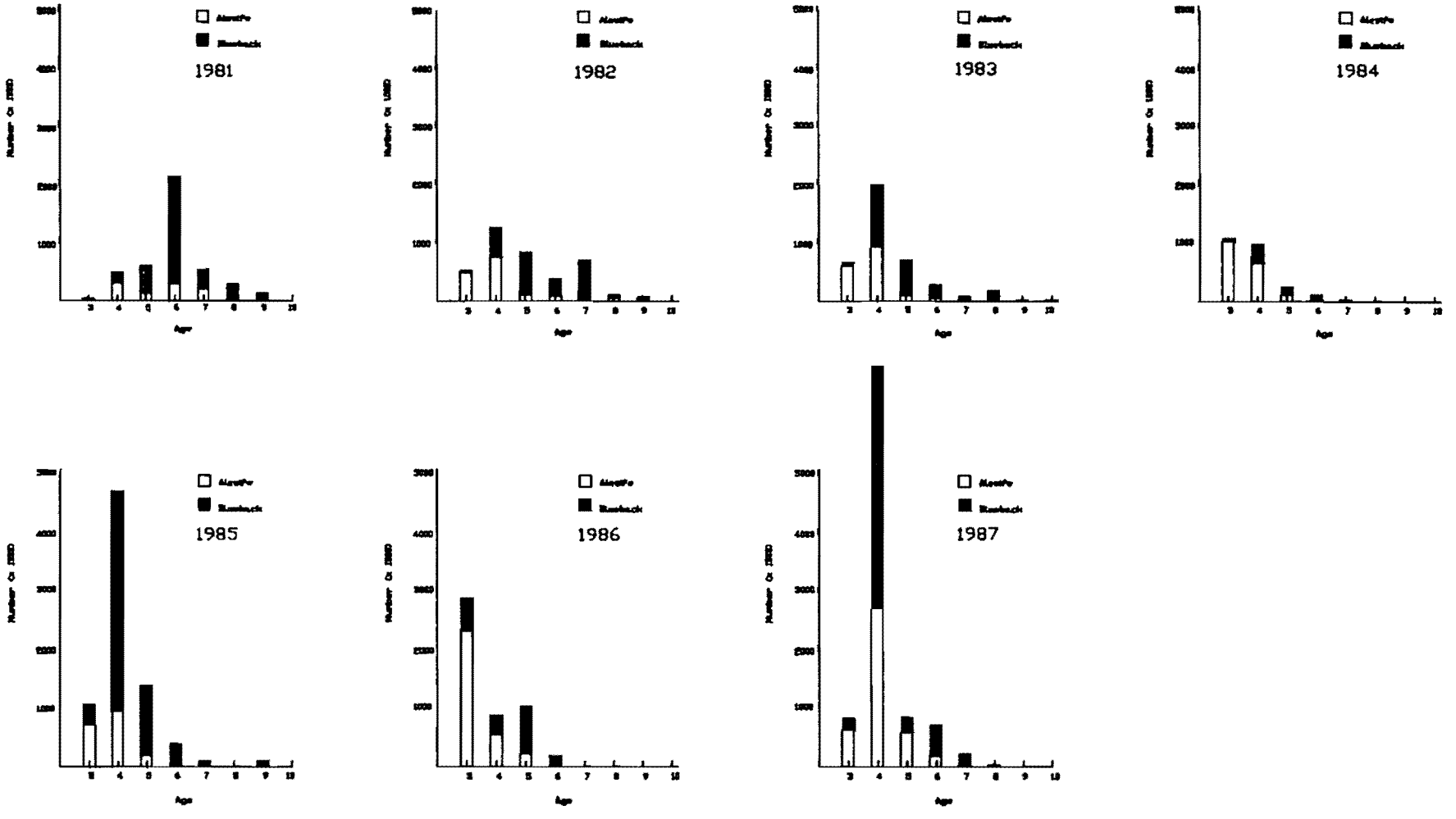

Figure 3. Numbers at age in catches of alewife and blueback herring in the Miramichi River gaspereau fishery, 1981-87.