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Assessment of Atlantic herring in NAFO Division 4T, 1988

by

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ABSTRACT

Reported herring landings in 1988 for the southern Gulf of St. Lawrence (NAFO Division 4T) were 71,400 t, which was the sixth largest catch in history. Landings were 10% below the TAC of 78,900 because of a strike in the fall gillnet fishery. Catch rates remained high in the spring and fall gillnet fisheries. Catch rates of index fishermen were also high in both fisheries. The biomass (164,000 t) of spring spawners was estimated from the 1988 acoustic survey in Chaleur Bay. The assessment of fall spawners indicated that the 1977-1982 year-classes were about 20% smaller and the 1983 and 1984 year-classes were about 50% larger than last year's estimates. As in the previous assessment, herring were not fully recruited until age 9. The results indicated a weighted age 5 and older fishing mortality of 0.26 in 1988. Projected landings at $F_{0.1}$ = 0.3 for 1990 were 16,000 t for spring spawners and about 50,000 t for fall spawners. Although there appears to be strong recruitment in the fishery, there was uncertainty in the partial recruitment values used in the projection.

RESUME

En 1988, on a déclaré des débarquements de hareng de 71 400 t dans le sud-est du golfe du Saint-Laurent (division 4T de l'OPANO). En importance, ces prises venaient au sixième rang de toutes celles obtenues jusque-là. Les débarquements ont été inférieurs de 10 % au TPA (78 900 t), cela en raison d'une grève ayant affecté la pêche d'automne au filet maillant. Les taux de prises sont demeurés élevés dans les pêches de printemps et d'automne au filet maillant. Les taux de prises des pêcheurs servant à établir l'indice ont également été élevés dans ces deux pêches. L'estimation de la biomasse (164 000 t) de reproducteurs du printemps était fondée sur le sondage acoustique réalisé dans la baie des Chaleurs en 1988. D'après les estimations établies pour les géniteurs d'automne, les classes d'âge 1977-1982 et 1983-1984 étaient respectivement inférieurs d'environ 20 % et supérieures d'environ 50 % aux estimations de l'année précédente. Comme le révélait aussi l'évaluation antérieure, le hareng n'était pas pleinement recruté avant d'avoir atteint neuf ans. D'après les résultats obtenus, l'âge pondéré était de cinq ans et la mortalité due à la pêche aux âges plus avancés de 0,26 en 1988. Les projections de débarquements pour 1990, à raison de $F_{0,1}$ = 0,3, sont de 16 000 t pour les géniteurs de printemps et d'environ 50 000 t pour les géniteurs d'automne. Quoique le recrutement à la pêche semble important, une incertitude existait au sujet des valeurs de recrutement partiel utilisées dans la projection.

1. INTRODUCTION

This assessment of the 1988 herring fishery marks the twelfth year that CAFSAC has provided biological advice on 4T herring. There have been thirteen previous assessments, including: Winters et al. (1977), Winters (1978), Winters and Moores (1979), (1980), Cleary (1981), (1982), (1983), Ahrens and Nielsen (1984), Ahrens (1985), Clay and Chouinard (1986), Chadwick and Nielsen (1986), (1987), and Chadwick and Cairns (1988).

There are two recognized spawning groups: spring and fall spawners. Prior to 1965, 4T herring were exploited primarily by gillnetters on spawning grounds; average landings for 1949-1964 were 32,000 t. In the mid 1960's, purse seines were introduced, which primarily harvested mixed stocks of spring and fall spawners. Landings by the seiner fleet peaked at 175,000 t in 1970. 4T herring were also fished on their wintering grounds in NAFO Division 3Pn from 1966-1972 (Figure 1). Purse seines were the major gear in the 1970's, but since 1981 over 80% of reported landings have been by gillnetters.

Total herring landings in 4T have followed a rising trend since 1981. In 1988, total reported landings were 71,366 t. The landings in 1987 were revised upwards to 77,606 t (Table 1). The largest fishery is that of gillnetters in the fall, whose landings accounted for 57% of total 4T harvest. Gillnets are primarily set on spawning grounds inshore, whereas the purse seine fishery since the early 1980's has been primarily prosecuted in October-December, after the fall spawning period. Most seine activity in 4T occurs in the Chaleur Bay area, principally on the north side of the bay in the general area of Shigawake-Chandler. 4T herring are also taken by seiners in winter in the Sydney Bight area of 4Vn.

Quotas or total allowable catches (TAC) have been established since 1972. From 1974-1981, the TAC ranged from 45,000 to 60,000 t but it was never achieved. From 1981 to 1984, TAC's ranged from 15,000 to 20,000 t but were exceeded each year by at least 30%. In 1985 reported landings were slightly lower than the TAC of 32,500 t, but a substantial portion of the catch was unreported and the TAC may have been exceeded by about 30% (Chadwick and Nielsen 1986). The 1986 TAC was 43,375 t, which was exceeded by 36%. The 1987 TAC was exceeded by 7%. Advice from the 1987 assessment for the 1988 fishery was 12,800 t for spring and 23,300 t for fall spawners. Revised $F_{0.1}$ catches from the 1988 assessment for fall spawners in the 1988 fishery was 59,700 t. The 1988 advice for the 1989 fishery was 21,000 t for spring spawners and 53,700 t for fall spawners.

In 1988, the total quota for 4T was 78,900 t. The quota was divided as follows:

a) spring spawners	-	gillnets 10,240
	-	purse seines 2,560
b) fall spawners	-	gillnets 52,854
	-	purse seines 13,214

The quotas for spring spawners caught in fixed gear was divided into fishing areas (Fig. 2) as follows:

Area	Season	Quota (t)	Catch (t)
Escuminac (16C)	January 1 - May 31	3,600	3,451
Remainder of 4T (16A to G)	January 1 - May 31	5,400	8,745
All Area 16	June 1 - June 30	1,240	

The quotas for fall spawners caught in fixed gear was divided as follows:

Area	Season	Quota (t)	Weekend Closure	Vessel Limit (lb)	Catch (t)
Isle Verte 16A	July 7 - Dec 31	375	No	20,000	193
Chaleur 16B	Test Fishery	854	No	20,000	22,271
16B	Test Fishery	28,500	Yes	20,000	
Escuminac 16C	Test Fishery	900	No	20,000	1,249
Magdalen 16D	Aug 1 - Dec 31	125	No	15,000	-
West PEI 16E	Test Fishery	2,100	No	20,000	2,716
Pictou 16F	Test Fishery	10,000	Yes	20,000	10,029
Fisherman's Bank 16G	Test Fishery	10,000	Yes	15,000	6,603

The combined quota of 15,774 t in the purse seine fishery was fished in the fall, after the gillnet fishery was over.

The 1988 catch was 10% below the quota. The shortfall was most pronounced in Chaleur Bay and Fisherman's Bank. The shortfall was because of a fisherman's strike, which delayed the opening of the fishery in many areas until after September 1.

	1980	1981	1982	1983	1984	1985	1986	1987	1988
TAC	55	16	15	20	19	32.2	43.4	72.8	78.9
Catch	40	21	24	26	27	31	59	77.6	71.4[a]
CAFSAC advice	55	16	20	13	18	30	32	44	

a Provisional

2. INPUT DATA

2.1 Catch-at-Age Matrices

The 4T fishery was divided into cells according to stock area, fishing season, gear type and spawning group. Stock areas were defined by NAFO unit areas 431-435, 436, and 437-439. Table 2 lists the landings and spawning-group affinity of herring for each cell, including updated values for 1987. July 1 was the date used to divide the fishing season into spring and fall components. Fixed gear consists mostly of gillnets, with some traps, and mobile gear is mainly purse seines, with some otter trawls.

Spring spawners include spring and early-summer spawners, and fall spawners consist of late-summer and fall-spawning fish. Fish were designated as spring spawners if they were caught before June 1 and their gonad maturity was at stage 5, 6 or 7. Fish caught after July 31 with similar maturity stages were assigned to the fall-spawning group. Fish not meeting the above criteria were assigned to a spawning group by visual inspection of their otoliths by an experienced ager. The merits and assumptions of our current methodology will be compared to those of alternate methods before the 1989 assessment.

The fixed-gear landings consist almost exclusively of ripe fish, which results in a very high correlation between spawning-group affinity and fishing season for this fishery. On the other hand, the mobile-gear fishery captures a mixture of spring and fall-spawners: in 1988 for example, 48% of the purse-seine catch consisted of spring spawners (Table 2).

Since 1981, catches of both spawning groups have been dominated by the gillnet fishery.

Year	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88
Spring Spawners															
GN Catch (kt)	8	8	7	5	9	9	9	6	8	8	5	8	11	13	13
PS Catch (kt)	7	17	15	18	15	10	11	3	1	2	2	2	7	7	8
Fall Spawners															
GN Catch (kt)	5	4	3	3	4	5	4	11	10	14	18	19	38	51	40
PS Catch (kt)	16	16	15	19	25	25	17	2	2	2	1	2	4	7	9

Table 3 presents the matrices of catch-at-age with fixed, mobile, and all gears combined, of spring spawners. Table 4 lists the equivalent data for fall spawners. The mean weights-at-age for both spawning groups are in Table 5. The 1988 catch-and weight-at-age have been appended to equivalent data from previous years. As well, the 1987 data have been recomputed using updated landings and age-length keys. The new values differ from last year's results in only minor ways.

2.2 Gillnet catch rates

2.2.1 Methods:

Catch rates were defined as catch per net per day. Catch per day information was calculated using purchase slips in the gillnet fishery. Daily purchase slip data were available 1978-1988, and as in the previous assessment they were standardized for season and area effects using a multiplicative model. Season effects were examined using three models: a two quartile model, a four quartile model, and a fixed-week model. The two quartile model combined data in the first and fourth quartiles and second and third quartiles of a cumulative catch distribution and assumed that catch rates at the center of the distribution were more representative of stock abundance. This model was used in the last assessment. The four quartile model was a slight modification of the two quartile model and treated data in each quartile separately. The fixed week model assumed that there was little annual variation in the timing of the fishery. Each month was divided into three 'weeks' of 10 days each. It was shown by Chadwick (1989) that there was no significant annual variation in the timing of the spring and fall fisheries and therefore seasonal effects in the fixed week model should be similar to those in the quartile models.

Area effects were examined by treating data in each Statistical District separately. In the previous assessment, the 10 most important S.D. in the fall fishery and the 11 most important S.D. in the spring fishery, which comprised 99% of 1987 landings, were used in the analysis. If the 1978-1987 mean

landings are used as a basis for assessing importance, only seven S.D. in each fishery contribute more than 3% of the total catch (Fig. 3).

The 1988 fall fishery was interrupted by a fishermen's strike and its effect on the catch rate was examined. The dates of 25%, 50% and 75% cummulative catches were summarized for the important S.D. 1978-1988 (Table 6). In the fall fishery, the first quartile and median were significantly later in S.D. 65, 66, and 67 than in previous years; there was no significant difference in timing of 1988 catches either in other S.D. of the fall fishery or in any S.D. of the spring fishery. It was possible therefore, that the strike had an influence on the timing of catches in Chaleur Bay, but not in other areas.

The number of nets was determined from a phone questionnaire. The survey indicated that there had been no change in the number of nets used in the peak period of the spring fishery, 1986-1988, except in S.D. 82 and 92 where there was a decline in the number of nets from 1987. There was no change in the number of nets used in the non-peak period. In the fall fishery during the peak period, there was a slight increase from 1987 in the number of nets in 5 of 6 S.D., most notably all S.D. in Chaleur Bay. There was no change in the non-peak period. See Nielsen (1989) for further details.

2.2.2 Results

a) Spring fishery

Two abundance indices were calculated for spring spawners. The first index was calculated using the two quartile model with all S.D. (Chadwick and Cairns 1988). This model explained only 33% of the total variance in CPUE, however the overall fit of the model was good. There was no improvement when S.D. 11, 13, 66, and 67, which had low catches, were removed from the analysis and therefore they were included as in the previous assessment. The four quartile model also explained only 33% of the variance but because it had an additional two parameters it was discarded.

The second index was calculated with a fixed-week model. This model explained 41% of the variance but had four more parameters than last year's model (Table 7 and Fig. 4). More importantly, its time series of catch rates was different than the historical series. This difference was most pronounced in 1984: the fixed week model indicated a large increase in catch rate, whereas the other models showed an increase in 1985. The reason for the divergence could be related to the significantly later timing of the fishery in this year, particularily in S.D. 75, 78, and 82. These latter S.D., which had lower catch rates in 1984, were

given less emphasis in the fixed week model. The fixed week model also indicated an increase in catch rate from 1987 to 1988 in contrast to the other models, which indicated no change in abundance over these two years (Fig. 5). Because it was not possible to calibrate last year's assessment with the two-quartile abundance index, it was decided that it would be worthwhile to examine the calibration fits using both catch rate series.

An error in last year's catch rate was corrected. The error resulted from analyzing the 1986 and 1987 purchase slip data without removing the Supplementary 'B' slips from the data base. Catches not sold to plants are estimated by fishery officers and recorded on Supplementary 'B' slips, which are normally added to the data base at the first day of each month. Failure to delete these slips resulted in overestimating the catch rates in the first quartile and consequently overestimating the abundance index in these two years.

Data on index fishermen were available 1987 and 1988. The analysis indicated (R^2 = 0.43) that there were significant area and season effects, but not year effects. Catch rates were highest in Chaleur Bay area, followed by Escuminac, Pictou, Alberton and Southeast N.B. Catch rates were higher in 1988, but this difference was not significant, which indicated that there was no real change in stock abundance over these years.

An analysis of effort indicated that the number of nets did not change from 1987 to 1988 (R^2 = 0.74). Although there were significant area effects, year effects and year-area interactions and season effects were not significant. The analysis indicated that most nets were used in Southeast N.B., followed by Escuminac, Alberton, Chaleur Bay and Pictou. These results were consistent with the gillnetter's telephone survey.

b) Fall fishery

In general, the survey of index fishermen indicated that there had been no consistent change in catch rate or number, length or surface area of nets used from 1986 to 1988. There was an indication that mesh size had changed from 1986, but not from 1987 to 1988 (Table 8). A first analysis that included all fishermen in the survey indicated that catch rates in 1986 were significantly greater than 1987 and 1988, which were equal. By contrast when the analysis was restricted to the eight fishermen present during all three years of the survey, there was no significant change in catch rates over the time period. A further analysis, which was restricted to weeks during September in order to compare catch rates unaffected by the 1988 strike, indicated that there had been no significant change in catch rates during these three years.

Catch rates also had significant area and season effects. Catch rates were higher in Chaleur Bay than the other three areas, which were equal. Catch rates were also lowest during August and did not change over time during September.

Fishing effort was estimated from the number and size of nets. The analysis of all fishermen indicated that the number of nets had significant area, season and year effects: more nets were used in 1988 than the other two years. The interaction between area and year was not significant, however, which indicated that the number of nets did not change within an area. In addition, when the analysis was restricted to the eight fishermen, it indicated that significantly fewer nets were used in 1987, which corroborated the results of the gillnetter's telephone survey. The length and surface area (number*length*width) of nets did not have significant year effects and it was concluded that fishing effort did not change significantly over the three years.

Fishing effort also had significant area and season effects. Chaleur Bay stood out as having the fewest and smallest nets of the other three areas. Fewer nets were fished during the last week of the season, whereas net number did not vary among the other weeks. There was no season effect for net length.

Finally, mesh size had significant year and area effects. Results from both the survey of all fishermen and the selected eight individuals indicated that mesh size was significantly smaller in 1986, but it was not different between 1987 and 1988. Mesh sizes were larger in Pictou that the other three areas, which were not different. There was no significant change in mesh size during the season.

Catch per fisherman per day was also examined because it would be comparable to the purchase slip data. The analysis of all fishermen indicated that catches were equal in 1986 and 1988 but greater than 1987. On the other hand, catches of the eight fishermen were equal in all years. Interestingly, there were no significant area effects, which indicated that despite the large variation in effort, all areas had approximately the same daily catches.

A total of 12 multiplicative models were analyzed to estimate the appropriate fall abundance index. One important criterion for selecting a catch rate index was its synchrony with the index fishermen catch rates. The 12 models could be divided into three groups: 2-quartile, 4-quartile, and fixed-week. Each group was divided into four models, each containing a different number of S.D.: all 10 S.D., 7 important S.D., 7 important S.D. excluding Chaleur Bay (S.D. 65, 66 and 67) in 1988, and 4 important S.D. from southern Gulf that excluded Chaleur Bay in all years.

The following reasoning was made to select the best model (Table 9 and Fig. 6). The 10 S.D. models were discarded because there were trends in the residuals for S.D. 73, 78 and 82, which indicated that these areas were poorly fitted by the model. The 4 S.D. models were discarded because these catch rate series were different from the historical series and suggested that there had been a significant increase in catch rates during 1984 and from 1987 to 1988. Thus it was felt that southern areas could not be used to predict catch rates for the entire Gulf.

The 7 S.D. models that excluded Chaleur Bay in 1988 were also rejected. It was felt that the fixed week model already accounted for differences in run timing that may have occurred because of the fishermen's strike and it was unnecessary to removed the affected districts. Secondly, the fit of the model was better when Chaleur Bay was included in all years. The second reason also applied to the 2-quartile model. In the latter case, there was also a dramatic, but not significant, increase from 1987 to 1988, which was not supported by the index fishermen. Except for the 4 S.D. models, all catch rate series indicated that there had been no significant change in abundance since 1985 (Figs. 7 and 8).

There were subtle differences between the 7 S.D. fixed-week and 2-quartile models and therefore they were both brought forward for the calibration of fall spawners (Fig. 9). The fixed-week model showed a slightly higher catch rate in 1978 and a slightly lower catch rate in 1988 when compared to the 2-quartile model. In 1978, migrations were earlier than expected. If the delay was caused by fishery-related factors when the fixed-week model would be more appropriate because it would adjust catch rates to their normal time period. If the delay was because of biological factors, however, then the quartile model would be more appropriate. In 1988, we knew the delay in Chaleur Bay was fishery-related, and therefore the fixed-week model was more accurate. The delay in season would have artificially elevated catch rates in the first quartile and consequently overestimated catch rates in this year. The residual plot for 1988 showed large positive residuals for the first quartile. In summary, the fixed-week model was the preferred abundance index, but because the 2-quartile model was used in the previous assessment both models were used in the calibration (Table 10).

2.3 Research survey data:

The fall acoustic survey for 4T herring was conducted for a fifth year in 1988. The survey was modified to a random-stratified design following the recommendations of a meeting on the statistical design of acoustic surveys in 1988 (O'Boyle 1989). Normally, this survey covers the Chaleur and Sydney Bight areas in the first and second halves of

November, respectively. Because of vessel problems, the survey was delayed and the Chaleur area was completed in mid-November. Surveys of the Sydney Bight area could not be completed in November because of weather and time constraints. An additional acoustic survey covered the Chaleur and Sydney Bight areas in early and mid-December, respectively. Results of the survey in comparison to other years are given in Table 11. The improved survey design resulted in much lower variance estimates.

The biomass estimate of spring and fall spawners in Chaleur Bay was probably a minimum because of the late timing of the survey and the possibility that herring may have been distributed in other areas of the Gulf. The December survey in Chaleur Bay was probably not comparable to other years because fish had already migrated out of the area and the proportion of fall spawners was very low.

Because ther was no confidence in the Chaleur Bay December survey, the November Chaleur survey and the December Sydney Bight survey were used to estimate biomass. The sampling may have been inadequate (only 4 sets in Chaleur); however, three of these sets were made in strata which contained 95% of the biomass. Using Foote's target strength value, biomass estimates (t) for spring and fall spawners 1984-88 are as follows:

	Chaleur				Sydney Bight			
Year	Spring spawners	Fall spawners	Total	C.V.*	Spring spawners	Fall spawners	Total	C.V.*
1984	-	-	95000	-	-	-	73100	-
1985	-	-	63000	-	-	-	125000	-
1986	112560	88440	201000	-	-	-	109000	-
1987	141572	532580	674152	-	176214	233586	409800	-
1988	163867	76407	240274	20%	47543	125342	172885	29%

* C.V. for total biomass

3. ESTIMATION OF STOCK SIZE

3.1 Fall Spawners

The last year F was estimated using the same technique as last year, a non-linear least squares regression analysis called ADAPT (Gavaris 1988). Because the calculation of F's on oldest age groups is influential on calculation of F's in the body of the matrix, two models were evaluated in this assessment: one assumed that the age 10+ F was equivalent to age 9, the CALC-F function from McQuinn

(1987); the other assumed age 10 F's were equivalent to the average of ages 7-9, the AUTO-F function from Rivard (1982). ADAPT runs under these two formulations indicated an overall better fit to the first model. Initial formulations indicated that the intercepts were not significant. The final formulation is in Table 12. ADAPT was also run using the new (fixed-week) and old (quartile) catch rates. It was initiated using the final F's from last year's assessment.

3.2 Spring Spawners

For spring spawners, several different formulations of ADAPT were tried. First, models of gillnet catch rate against total exploitable numbers, with and without intercepts and with dome-shaped and flat-topped PR's were attempted but rejected because of poor fit. Second, an eight parameter model (population numbers for ages 3 to 6+ and slopes of regressions between ln catch rate and ln SPA numbers at age) was tried. Age 6+ F's were calculated by assuming that they were equal to F's on 5-year-old herring for all formulations. This formulation was rejected because population parameters were insignificant.

Because the catch rate index could not be used to calibrate the spring spawners, information from the 1988 acoustic survey in Chaleur Bay was used to estimate population numbers in 1988. Two methods were used. Partial recruitment was calculated by comparing the 1988 catch-at-age in the fishery to the acoustic survey.

	%		
Age	Acoustic	Catch	PR
1	15	-	0
2	35	0.5	0.001
3	17	6	0.003
4	15	19	0.13
5	5	8	0.36
6	9	27	0.30
7	4	14	0.35
8	1	10	1.0
9	-	3	1.0
10	-	0.5	1.0
11	-	2	1.0

The biomass (163,856 t) of spring spawners estimated from the 1988 acoustic survey in Chaleur Bay was a minimum estimate of population biomass. Using the PR vector from above, age specific F's were calculated for 1988 to produce a SPA consistent with the population biomass in the 1988 survey. The major weakness of this method was the unpredictability in the proportion of spring spawners in Chaleur Bay.

4. ASSESSMENT RESULTS:

4.1 Fall Spawners

The fixed-week and quartile catch rate indices gave very similar results. The best model fit was found for the fixed-week model using the CALC-F (Fig. 10) formulation and it was used for the assessment. Age-by-age calibration plots are presented in Fig. 11. The C.V.'s around population numbers in 1988 ranged from 20% for ages 6 to 10 to 35% for age 4 (Table 13). The formulation using AUTO-F estimated almost identical population numbers in 1988 (Fig. 10).

The ADAPT results using CALC-F estimated a weighted 5+ F in 1988 of 0.30 which compared to last year's F of 0.21. The 1983 year-class dominated (Table 14). A comparison of last year's projected catch biomass-at-age and observed values is given in Fig. 12. Again it was clear that the size of the 1983 year-class (age 5 in 1988) was under estimated in last year's assessment, but the size of the 1980 year-class was overestimated.

		78	79	80	81	82	83	84	85	86	87	88
This year	Age 2 Recruit nos. (x106)	88	285	261	379	564	372	457	590	354	43	36
	Age 5+ Biomass (kt)	38	30	20	15	26	54	86	153	168	166	188
	5+ F	.65	1.01	.92	.26	.34	.19	.15	.10	.21	.30	.26
Last year	Age 2 Recruit nos. (x106)	97	350	341	458	767	493	534	397	201	220	
	Age 5+ Biomass (kt)	39	22	20	25	37	77	116	213	227	217	
	5+ F	.66	1.09	.69	.16	.23	.13	.10	.07	.14	.21	

The current assessment indicates that the 1977-82 year-classes were about 20% smaller than estimated last year but the 1983 and 1984 year-classes were estimated to be 50% larger than last year's estimates (Fig. 13). Trends in mature biomass are given in Fig. 14. Biomass levels in 1988 are equivalent to those seen in 1974.

A comparison of partial recruitment vectors indicated that in 1987 ages 4-8 were less recruited to the fishery than previously believed. Fish continued to be fully recruited at age 9.

Age	Last year	This year	
	1987	1987	1988
2	.003	.002	.001
3	.17	.06	.02
4	.54	.19	.34
5	.49	.30	.55
6	.58	.40	.53
7	.80	.64	.71
8	.94	.67	.74
9	1.0	1.0	1.0
10	1.0	1.0	1.0
11+	1.0	1.0	1.0

Examination of the 1988 mean population numbers may indicate a somewhat more pessimistic view of the stock compared to last year's assessment. In general, the perception of the size of the resource has declined by about 25%. ADAPT provides variances of the population estimates. The coefficients of variation ranged from 20 to 40% and therefore the change from 1987 to 1988 is within this variation. The relative strength of year-classes did not change between the two assessments.

4.2 Spring Spawners

The results of the SPA using the biomass estimate from Chaleur Bay is given below:

	Year										
	78	79	80	81	82	83	84	85	86	87	88
Age 2 Recruit nos. (x106)	55	155	92	210	228	342	524	222	460	511	1150
Age 4+ Biomass (kt)	50	31	16	16	15	28	44	82	131	125	162
Age 4+ F	.47	.50	.70	.39	.15	.31	.14	.09	.12	.16	.12

These results indicate that the biomass from the 1988 acoustic survey in Chaleur Bay provided a view of the resource, similar to last year's assessment.

5. PROGNOSIS

5.1 Fall Spawners

The following input parameters were used to run the projection. Population numbers at ages 2 and 3 were geometric mean numbers 1978-86. Mean weights and partial recruitment were average values (1986-88).

	Fall spawners			
Age	Nos. ($x10^3$)	Catch ($x10^3$)	Wt. (kg)	PR
2	344411	33	.135	.003
3	258272	1556	.232	.084
4	228787	27153	.250	.398
5	284273	52521	.287	.561
6	146447	26093	.321	.651
7	82975	19250	.354	.895
8	76208	18352	.365	.908
9	34723	10186	.394	1.000
10+	17812	5225	.408	1.000

In assessments prior to Chadwick and Cairns (1988), herring were estimated to be fully recruited at ages 5 or 6. Last year, a change in the way the partial recruitment was calculated resulted in full recruitment at age 9. The same method was used this year and the age of full recruitment was again age 9. Theoretical calculations based on the mesh sizes used in the gillnet fishery have indicated younger ages of full recruitment (Chadwick and Nielsen 1986). In this assessment, it was not possible to calculate a partial recruitment vector independent of the calibration, because there was inadequate sampling of fall spawners in the acoustic survey. In previous years, a PR vector was calculated by comparing age structure in the acoustic survey to age structure in landings of the gillnet fishery. It is generally accepted that F = 0.3 is an appropriate target fishing mortality for fully recruited herring. Therefore, changes in the partial recruitment values have implications on catch projections.

Using the partial recruitment above, if the 1989 TAC of 53,700 t is caught, it will result in a fishing mortality of 0.40 on ages 9 and older and an average fishing mortality of F = 0.30 on ages 5 and older. Fishing at $F_{0.1}$ in 1990 (Scenario A, see below), that is F = 0.30 on ages 9 and older, would then produce a catch of 39,000 t. By contrast, maintaining the 1989 TAC for 1990 would result in fishing mortalities on ages 9 and older of F = 0.44, with the average fishing mortality on age 5 and older being F = 0.33 (Scenario B, see below). However, if the age of full recruitment was age 5 rather than age 9 and the exploitation pattern was more typical of a gillnet fishery, the $F_{0.1}$ catch in 1990 would be close to the current TAC.

These projections are summarized below:

		A	B
The results are:	1989	1990	1990
Catch (t)	53,700	39,000	53,700
5+ Biomass (t)	145,002	128,627	123,916
Fully recruited F	0.40	0.30	0.44
5+ F	0.30	0.23	0.33

For spring spawners, an estimate of stock status in 1990 was made using the population biomass from the 1988 survey. Assuming the same PR values and GM mean (1978-86) population numbers at age 2 of 206,749 and at age 3 of 120,889 the $F_{0.1}$ catch in 1990 would be 16,180 t.

Results of these analyses indicate that fishing mortality in 1988 was close to $F_{0.1}$. The projection provided yield estimates which were similar to catches in the last 3 years.

6. CAFSAC RECOMMENDATIONS FROM 1988

6.1 Under-reporting of landings

In February 1989 meeting, CAFSAC requested Gulf Region to investigate the extent and pattern of misreporting of herring landings in 4T. There are three principal factors which may contribute to incorrect landing statistics for 4T herring. Firstly, a substantial portion of spring catches is used for bait, and is not recorded on official purchase slips. Secondly, the fall gillnet fishery has been regulated since 1987 by daily boat quotas, leading to the possibility that some fishermen underreport catches to hide quota overruns. Finally, the fall seine fishery operates under seasonal boat quotas, which provide motivation for underreporting daily catches.

We investigated misreporting of herring catches by interviewing those close to the industry, and by examining landing statistics and catch data from index fishermen.

Official landing statistics used in assessments include estimates by fishery officers of fish landed, but not sold commercially. These estimates are recorded on a monthly basis by statistical district on Supplementary B forms. It is not possible to identify Supplementary B records from computerized landing files for 1983 and previous years. Since 1984, Gulf Region has been responsible for collecting 4T landing data, and Supplementary B records can be identified by a special buyer code.

Reported Supplementary B landings for the spring fishery were 43% in 1984, and varied from 18.3 to 10.6% in 1985-1988 (Table 15). However, Gulf Region Statistics Branch has advised us that coding errors may have occurred when the landing record system was being set up, and that the 1984 figure for Supplementary B's may be erroneous. Other Supplementary B totals depend on subjective estimnates by fishery officers of the volume of catch destined for non-commercial purposes (primarily lobster bait). Conservation and Protection Branch personnel indicated that fishery officers would be able to make reasonably accurate estimates fo bait catches on the basis of the daily, per boat, bait requirements of the lobster fishery. However, we were also told that some officers may be conservative in their judgements.

We have also calculated the percentage of herring caught in spring by index fishermen which are not sold to plants. These percentages (15.1 in 1987, 7.1 in 1988; Table 15) are roughly similar to those calculated from Supplementary B records. However, we do not view our index fishermen as necessarily representative of the spring herring fishery with respect to catch proportions allocated to non-commercial purposes, because index fishermen have been chosen for their involvement in the commercial herring fishery.

In view of the above it is clear that landing statistics for the spring herring fishery are subject to some error. However, major overestimates of bait landings will produce only modest errors in overall landing figures, because the bait fishery is a minority component of the overall fishery. For the years 1985-1988, when mean percent of Supplementary B's was 15% (Table 15), if true non-commercial landings were double those estimated on Supplementary B's, landing totals would change by 15%. In our subjective opinion official statistics may understate true landings of spring-caught herring by 10% in the last five years, but we caution that this estimate is subject to a wide margin of uncertainty. No evaluation of underreporting can be made for years previous to 1984 because of the lack of identifiable Supplementary B records. However, it can be noted that lobster fishing effort has remained relatively constant in the southern Gulf for the past decade, so that demand for bait herring presumably does not vary greatly from year to year.

Boat quotas imposed on the fall gillnet fishery since 1987 have limited daily catches to 9.07 tonnes in the Chaleur, Western P.E.I. and Pictou areas, and to 6.80 tonnes on Fisherman's Bank. These quotas changed the frequency distributions of daily catches, so that very large catches were no longer recorded (Cairns et al. 1988). However, some fishermen may continue to exceed daily quotas. Interviews with Conservation and Protection personnel yielded a wide variety of views on the extent of underreporting in this fishery, with estimates of underreporting ranging from 0 to 30%. Those who felt that underreporting was common referred to difficulties in simultaneously monitoring the unloading of fish from many boats at

many wharves, and pointed to the inability of the Department to obtain convictions on what were felt to be clear cases of quota violation. Others held the view that the power of an officer to order the weighing of a catch was ample deterrent to quota overruns, because such weighings absorb much valuable time during a short and intense fishing season.

To obtain an independent view of underreporting in the fall gillnet fishery, we compared raw and adjusted landings by index fishermen. Our analysis depends on three assumptions: i) index fishermen are representative of the fishery as a whole, ii) index fishermen provide us with accurate records of their daily landings, and iii) when a sale by a fisherman to a plant exceeds the daily quota, the weight of fish marked on the purchase slip is the daily quota, rather than the true amount of fish sold.

To make the comparison, we first summed the landings reported by the index fishermen. Then we reduced to the daily limit any landings that exceeded that limit, and recalculated the summed landings. Differences between raw and adjusted landings were 3.6% in 1987 and 7.6% in 1988 (Table 16).

We view the differences between raw and adjusted landings by index fishermen to be conservative estimates of underreporting in the fall gillnet fishery, because index fishermen closely cooperate with Department staff, and are likely to be more conscientious than average in observing fishery regulations. In addition, it is possible that some index fishermen were reluctant to report quota overruns, even though they were assured that information from individual fishermen would be kept confidential. Both these factors might downwardly bias the differences between reported and adjusted catches in Table 17.

In our opinion, official statistics likely underreport fall gillnet catches by 10-15% for 1987-1988. Official statistics were probably relatively unbiased before the introduction of boat quotas in 1987.

The fall seiner fishery in the southern Gulf, which has been prosecuted primarily in the Bay of Chaleur since the early 1980's, is regulated by seasonal vessel quotas. These quotas are administrated through running tallies of landings by each vessel during the season. This system depends on fishery officers being present at the unloading site at all times when a vessel might land, and on accurate records being made of weight landed. We interviewed a number of people close to this industry, and found no concensus on the presence and extent of underreporting by the seiner fleet. We are unaware of any objective way to separate fact from fiction in this matter. We do know that surveillance of the 1987 fishery was limited to regular office hours, but that landings in 1988 were monitored on a near 24 h basis. Our interpretation of underreporting trends, which we emphasize has a very high margin of uncertainty, is as follows. During the period

1981-1985, when reported landings were 2800 - 3700 tonnes, we consider that unreported landings equaled reported landings. In 1986 and 1987 we estimate unreported landings to be 30% of reported landings, and in 1988 we estimate that unreported landings were 10% of reported landings.

6.2 Effect of timing on catch-at-age

In May 1988, CAFSAC requested Gulf Region to investigate the potential influence of seasonal changes in fish size on the catch-at-age.

It has previously been pointed out that larger fish of some species tend to spawn first, and consequently there may be season changes in the size of herring within spawning areas. This phenomenon might distort the catch-at-age and hence biomass estimates of biological sampling does not cover the entire spawning season or is not proportional to the temporal abundance of the spawners. First, there is little (and not overwhelming) published evidence that such shifts in spawner size with time occur in 4T herring (Jean 1956 and Day 1957 reworked in Lambert 1987). Second, the recent commercial sampling makes every effort to cover the entire period of a fishery, and proportionally to its intensity. The samples therefore seem adequately weighted when the catch-at-age is calculated, to the extent that a fishery covers the entire spawning season. There is no reason to inspect sampling records in further detail until the data base is thoroughly checked and ridden of all errors, in preparation for the revision of catch-at-age matrices.

6.3 Effect of season on catch rates:

The effect of season regulations in the herring fishery was examined for its potential influence on catch rates. Season regulations since 1978 are summarized in Table 17. In general, the opening data of seasons has not been restricted, but the closing dates has been restricted since 1981. In Fig. 15, the timing and duration of the fisheries in the important S.D. are summarized 1978-1987. It is clear that season regulations have not affected the timing of catches, except perhaps in 1985. During this year, catches in the third quartile occurred after the official closure date in many districts. It appeared therefore that fishermen continued to fish despite regulations.

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Table 1. Catches (t) of herring by gear and by season in NAFO Division 4T 1971-1987. Spring fishery occurs from January to June; the fall fishery from July to December.

	GILLNETS (and other inshore)		SEINES (and other offshore)		
YEAR	SPRING	FALL	SPRING	FALL	TOTAL
1971	14074	10327	13316	97129	134846
1972	8137	9585	948	34910	53580
1973	11713	7920	7185	13539	40357
1974	8285	4199	8681	13988	35153
1975	7119	4741	18566	14139	44565
1976	6611	3419	17217	12206	39453
1977	4926	3285	19887	16726	44824
1978	8484	4853	8048	31756	53141
1979	7444	5780	13899	20620	47743
1980	6443	6784	13330	13886	40443
1981	6545	10926	20	3663	21154
1982	6742	14130	0	3109	23981
1983	8545	13858	0	3470	25873
1984	5269	15902	0	2809	23980
1985	7098	23654	0	3685	34437
1986	7828	39956	0	11247	59031
1987	11745	52129	0	13732	77606
1988	12630	41085	1	17650	71366

Table 2. Landings and spawning affinity of herring in 4T, 1978-1987, by year, stock area, season, and gear. Landing tonnage (t), percent (by number) of spring spawners among sampled fish (%), and the number of fish used in spawning affinity determinations (N) are shown for each year. The spring season is January to June; the fall season is July to December. Fixed gear landings are primarily gillnet, but also include landings from traps and miscellaneous gears. Mobile gear is primarily purse seine, but also includes Danish seines and otter trawls.

Year		Areas 431-435				Area 436				Areas 437-439			
		Spring		Fall		Spring		Fall		Spring		Fall	
		Fixed	Mobile	Fixed	Mobile	Fixed	Mobile	Fixed	Mobile	Fixed	Mobile	Fixed	Mobile
1978	t	2317	5762	560	3619	3796	0	322	1106	2352	2256	4568	19218
	%	96	8	0	10	85	—	2	28	72	—	2	53
	N	3076	1514	*	370	527	—	*	371	134	*	1041	1428
1979	t	836	13777	1234	39	3532	118	572	672	3034	4	3929	19585
	%	90	22	0	0	86	—	2	17	89	—	12	51
	N	4171	1323	727	96	485	*	188	344	*	*	287	2269
1980	t	2353	13332	1618	8254	1730	10	1059	82	3354	0	4574	5232
	%	96	24	0	5	100	—	2	11	100	—	12	72
	N	4275	1196	*	*	941	*	194	96	190	*	390	1709
1981	t	2010	21	2224	167	1974	0	1618	1	2540	0	7087	3020
	%	100	100	0	5	100	—	0	—	85	—	0	16
	N	2827	86	106	*	302	—	489	*	919	—	1968	537
1982	t	1417	0	3526	0	2604	0	1021	0	1418	62	7820	2579
	%	98	—	0	—	100	—	0	—	99	—	2	53
	N	3075	—	299	—	371	—	*	—	6234	*	1134	*
1983	t	1584	0	4726	0	4771	0	1440	0	2088	0	7552	3470
	%	92	—	0	—	93	—	4	—	96	—	1	51
	N	*	—	1102	—	681	—	188	—	113	—	1133	1031
1984	t	536	0	7295	0	3670	0	1222	0	1063	0	7385	2809
	%	72	—	0	—	91	—	1	—	85	—	4	62
	N	127	—	447	—	*	—	404	—	139	—	878	867
1985	t	1893	0	8483	0	3489	0	1297	0	1716	0	13874	3685
	%	100	—	0	—	99	—	0	—	89	—	10	68
	N	115	—	*	—	236	—	*	—	*	—	*	277
1986	t	2855	0	12253	0	3297	0	1267	0	1676	0	26163	11247
	%	84	—	1	—	83	—	0	—	88	—	17	49
	N	163	—	683	—	204	—	*	—	272	—	595	668
1987	t	3492	0	18210	78	3737	0	1971	13	4516	0	31948	13641
	%	90	—	0	11	100	—	0	23	93	—	6	52
	N	328	—	1727	*	232	—	132	*	328	—	1368	561
1988	t	1917	0	14992	226	3924	1	3776	1	6789	0	22317	17423
	%	94	—	1	10	94	—	0	—	71	—	13	48
	N	577	—	698	*	401	—	95	—	559	—	805	553

* Sample size is inadequate to indicate percent of spring spawners. Percent of spring spawners is estimated from samples taken in other years from the same area.

Table 3. Catch-at-age matrices for spring and fall spawners all gears combined. Numbers are thousands of fish.

SPRING SPAWNERS: THOUSANDS CAUGHT BY ALL GEARS 22/ 4/89

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
2	14434	21741	21382	6141	924	424	207	125	315	272	438
3	14121	13689	42580	17775	33383	10821	3476	8473	5021	2285	4752
4	65301	5856	5689	8250	6201	31206	11033	11330	17265	8416	14748
5	4692	33954	3096	1304	1476	3934	13838	11707	20651	29101	14094
6	6956	2130	15768	868	337	1104	1509	5368	16048	17481	20533
7	1277	3072	3269	4444	217	70	116	2036	5797	15010	10682
8	1182	707	2033	755	339	50	11	364	1667	5831	8128
9	191	203	740	756	114	17	11	249	538	731	2073
10	3584	718	320	108	2	2	22	1	117	458	434
11	1992	3488	2910	1198	110	10	34	1	461	196	1591

FALL SPAWNERS: THOUSANDS CAUGHT BY ALL GEARS 22/ 4/89

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
2	1514	2906	1369	109	184	35	9	30	331	57	33
3	19348	6217	32429	10075	9273	4782	1135	3736	4372	9362	1556
4	27378	35031	9995	33204	21526	23879	27519	17694	35927	39632	27153
5	14092	27629	23278	5971	26147	10971	16248	24072	26265	33182	52521
6	3973	11109	8343	2606	5663	13643	12972	12625	35034	25825	26093
7	3465	2323	4130	978	2344	2409	6718	5798	20078	41477	19250
8	13853	3128	637	977	1004	1867	1386	2144	10143	19047	18352
9	1606	5242	848	216	641	623	480	431	3308	10650	10186
10	890	702	320	108	132	114	154	203	535	4654	3011
11	16259	10386	2966	872	162	309	174	1	667	1755	2214

Table 4a). Catch-at-age matrices for spring and fall spawning herring caught in gillnets. Numbers are in thousands of fish.

SPRING SPAWNERS: THOUSANDS CAUGHT BY GILLNETS 22/ 4/89

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
2	39	55	541	45	69	2	13	2	8	124	420
3	6459	7667	22220	13031	32598	5160	1877	6602	3882	1283	3407
4	27333	3056	3568	7527	6048	29195	7932	9341	12248	6801	8937
5	1386	20895	1406	1270	1475	3647	11970	9663	14241	21792	9489
6	1902	557	9528	786	326	1020	1195	4543	9205	11206	13624
7	316	1405	217	3197	177	37	52	1655	1961	9869	8749
8	262	111	1075	80	333	2	0	257	284	3617	6011
9	97	64	105	285	114	2	0	197	8	655	1308
10	1361	362	141	39	2	2	0	0	63	424	159
11	1165	1673	2135	1010	109	2	0	0	425	175	1331

FALL SPAWNERS: THOUSANDS CAUGHT BY GILLNETS 22/ 4/89

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
2	6	2	25	2	2	2	0	0	258	20	0
3	352	129	7254	6852	3543	793	931	2755	3605	8378	1454
4	4389	7809	3293	28863	18645	21648	26518	16301	34220	38571	21152
5	3105	3822	4027	5538	23281	10465	14918	21838	23241	30592	41811
6	594	1883	929	2472	5308	12545	12214	11787	30308	20146	21699
7	614	402	837	975	2251	2223	6236	5473	17661	36324	14531
8	3441	484	185	830	960	1783	1308	1993	9361	14745	14936
9	83	695	210	105	492	590	446	332	2961	9498	7931
10	179	11	140	54	131	81	154	197	518	4456	2415
11	1785	1418	621	866	61	260	171	0	614	1740	1545

Table 4b). Catch-at-age matrices for spring and fall spawning herring caught in purse seines. Numbers are in thousands of fish.

SPRING SPAWNERS: THOUSANDS CAUGHT BY PURSE SEINES 22/ 4/89

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
2	14395	21686	20841	6096	855	422	194	123	307	148	18
3	7662	6022	20360	4744	785	5661	1599	1871	1139	1002	1345
4	37968	2800	2121	723	153	2011	3101	1989	5017	1615	5811
5	3306	13059	1690	34	1	287	1868	2044	6410	7309	4605
6	5054	1573	6240	82	11	84	314	825	6843	6275	6909
7	961	1667	3052	1247	40	33	64	381	3836	5141	1933
8	920	596	958	675	6	48	11	107	1383	2214	2117
9	94	139	635	471	0	15	11	52	530	76	765
10	2223	356	179	69	0	0	22	1	54	34	275
11	827	1815	775	188	1	8	34	1	36	21	260

FALL SPAWNERS: THOUSANDS CAUGHT BY PURSE SEINES 22/ 4/89

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
2	1508	2904	1344	107	182	33	9	30	73	37	33
3	18996	6088	25175	3223	5730	3989	204	981	767	984	102
4	22989	27222	6702	4341	2881	2231	1001	1393	1707	1061	6001
5	10987	23807	19251	433	2866	506	1330	2234	3024	2590	10710
6	3379	9226	7414	134	355	1098	758	838	4726	5679	4394
7	2851	1921	3293	3	93	186	482	325	2417	5153	4719
8	10412	2644	452	147	44	84	78	151	782	4302	3416
9	1523	4547	638	111	149	33	34	99	347	1152	2255
10	711	691	180	54	1	33	0	6	17	198	596
11	14474	8968	2345	6	101	49	3	1	53	15	669

Table 5. Mean weights at age for spring and fall spawning herring in 4T.

SPRING SPAWNERS: MEAN WEIGHTS (KG) AT AGE 22/ 4/89

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
2	.133	.133	.133	.124	.117	.146	.144	.103	.101	.143	.081
3	.172	.172	.172	.173	.170	.178	.168	.160	.159	.203	.184
4	.213	.213	.213	.232	.202	.214	.202	.210	.213	.202	.230
5	.247	.247	.247	.277	.247	.242	.220	.244	.251	.237	.250
6	.287	.287	.287	.318	.295	.252	.281	.288	.284	.274	.278
7	.291	.291	.291	.346	.285	.310	.224	.359	.325	.292	.299
8	.310	.310	.310	.366	.299	.254	.320	.409	.309	.304	.310
9	.348	.348	.348	.376	.305	.398	.312	.428	.331	.313	.359
10	.324	.324	.324	.369	.312	.375	.241	.324	.279	.314	.432
11	.359	.359	.359	.413	.420	.385	.216	.359	.299	.418	.293

FALL SPAWNERS: MEAN WEIGHTS (KG) AT AGE 22/ 4/89

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
2	.119	.119	.119	.076	.094	.143	.137	.119	.167	.143	.095
3	.177	.177	.177	.143	.151	.174	.214	.249	.221	.231	.243
4	.245	.245	.245	.242	.155	.249	.244	.279	.242	.247	.260
5	.283	.283	.283	.273	.189	.285	.290	.312	.294	.279	.289
6	.313	.313	.313	.317	.237	.317	.306	.355	.331	.311	.322
7	.338	.338	.338	.326	.324	.343	.344	.384	.374	.340	.349
8	.359	.359	.359	.348	.237	.362	.367	.404	.386	.332	.377
9	.380	.380	.380	.394	.285	.365	.380	.405	.404	.376	.402
10	.364	.364	.364	.328	.380	.348	.416	.423	.436	.385	.402
11	.395	.395	.395	.427	.389	.398	.361	.395	.424	.425	.439

Table 6. Timing of herring catches in major spring and fall herring fisheries. Q_1 indicates date when 25% of catch was taken. MED indicates the date when 50% of catch was taken. Catches are divided into Statistical Districts where over 90% of catch was taken. The top two tables are for spring fisheries. The bottom two tables for fall fisheries. Dates are expressed in Julian Days.

	DIST										
	11	13	65	66	67	73	75	78	80	82	92
	Q1	Q1	Q1	Q1	Q1	Q1	Q1	Q1	Q1	Q1	Q1
	SUM	SUM	SUM	SUM	SUM	SUM	SUM	SUM	SUM	SUM	SUM
YEAR											
1978	.	114	133	.	.	132	.	133	129	134	137
1979	.	136	138	144	134	128	125	139	121	132	132
1980	.	157	133	131	127	126	150	128	129	128	140
1981	160	121	132	143	113	121	132	138	135	134	116
1982	139	148	121	136	167	137	137	128	135	143	130
1983	130	130	141	136	137	139	140	141	138	133	135
1984	.	129	138	124	.	134	135	170	137	163	130
1985	93	141	127	134	137	130	129	139	132	136	141
1986	.	123	124	99	108	126	124	127	127	142	142
1987	.	140	132	124	135	128	128	138	139	144	146
1988	.	126	140	142	143	130	133	146	145	144	145

	DIST										
	11	13	65	66	67	73	75	78	80	82	92
	MED	MED	MED	MED	MED	MED	MED	MED	MED	MED	MED
	SUM	SUM	SUM	SUM	SUM	SUM	SUM	SUM	SUM	SUM	SUM
YEAR											
1978	.	114	135	.	.	133	.	136	133	137	142
1979	.	139	141	163	174	130	125	150	129	134	134
1980	.	157	140	138	129	129	154	136	138	130	140
1981	164	121	142	176	128	124	135	143	143	139	118
1982	139	149	135	136	170	138	144	146	155	146	137
1983	133	133	148	141	144	141	144	144	146	136	137
1984	.	135	155	134	.	136	136	175	142	168	158
1985	93	145	135	136	140	131	131	140	136	140	144
1986	.	125	128	125	109	127	126	130	130	147	143
1987	.	145	137	126	138	131	128	141	142	146	156
1988	.	130	142	145	145	132	135	148	151	147	159

	DIST									
	11	13	65	66	67	73	78	82	87	92
	Q1	Q1	Q1	Q1	Q1	Q1	Q1	Q1	Q1	Q1
	SUM	SUM	SUM	SUM	SUM	SUM	SUM	SUM	SUM	SUM
YEAR										
1978	215	258	224	225	233	257	186	188	244	221
1979	223	200	240	244	248	241	193	254	241	248
1980	219	236	208	235	236	243	191	235	234	246
1981	216	240	240	229	230	243	183	240	236	234
1982	228	245	239	240	243	251	191	256	235	245
1983	236	241	239	232	236	190	189	228	232	232
1984	262	261	243	236	235	186	184	185	237	237
1985	256	261	236	233	235	212	183	255	246	243
1986	245	244	231	231	233	244	195	251	239	244
1987	254	252	240	239	239	257	239	192	233	243
1988	253	259	250	250	253	245	186	249	237	244

	DIST									
	11	13	65	66	67	73	78	82	87	92
	MED	MED	MED	MED	MED	MED	MED	MED	MED	MED
	SUM	SUM	SUM	SUM	SUM	SUM	SUM	SUM	SUM	SUM
YEAR										
1978	226	271	235	235	235	258	187	285	244	249
1979	230	269	277	256	248	253	193	273	257	260
1980	229	236	258	240	251	246	193	235	246	250
1981	238	243	247	241	237	244	184	242	241	241
1982	243	250	254	245	247	251	311	258	252	254
1983	240	243	241	238	238	194	189	244	238	240
1984	268	263	250	242	237	192	185	186	244	244
1985	262	266	250	236	249	247	184	257	249	250
1986	252	251	251	251	251	252	196	252	244	251
1987	260	259	245	244	244	260	239	259	240	250
1988	259	264	256	259	263	257	187	249	249	246

Table 7. Results of multiplicative model for analysis of catch rates in spring fishery: fixed-week model.

SPRING 1978-88 20:18 FRIDAY, APRIL 14, 1989 2

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: CPUE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	25	679.17051348	27.16682054	37.44	0.0	0.409472	11.4791
ERROR	1350	979.47990671	0.72554067		ROOT MSE		CPUE MEAN
CORRECTED TOTAL	1375	1658.65042019			0.85178675		7.42030163

SOURCE	DF	TYPE III SS	F VALUE	PR > F
DIST	10	211.57294251	29.16	0.0
WEEK	5	187.83443679	51.78	0.0
YR	10	225.79690926	31.12	0.0

PARAMETER		ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT		7.00942020 B	60.45	0.0	0.11595762
DIST	11	-1.48691849 B	-4.40	0.0001	0.33764655
	13	-1.07857455 B	-6.04	0.0001	0.17866080
	65	-0.08522088 B	-0.84	0.3999	0.10120399
	66	-0.14636842 B	-0.99	0.3208	0.14737521
	67	0.93966285 B	5.45	0.0001	0.17241916
	73	0.61199233 B	6.45	0.0001	0.09491777
	75	0.31116965 B	2.44	0.0150	0.12776169
	78	0.26207348 B	2.59	0.0096	0.10106267
	80	0.35146609 B	3.67	0.0003	0.09586583
	82	-0.36986164 B	-3.69	0.0002	0.10010478
	92	0.00000000 B	.	.	.
WEEK	1	0.71767280 B	4.62	0.0001	0.15530000
	2	0.95025490 B	10.78	0.0001	0.08817070
	3	1.12955490 B	14.72	0.0	0.07671521
	4	1.04590353 B	13.47	0.0001	0.07767537
	5	0.56640980 B	5.82	0.0001	0.09729798
	6	0.00000000 B	.	.	.
YR	1978	-0.79702236 B	-6.87	0.0001	0.11605268
	1979	-1.07167645 B	-9.21	0.0001	0.11641062
	1980	-1.33454107 B	-11.85	0.0001	0.11263645
	1981	-1.18870772 B	-10.76	0.0001	0.11050940
	1982	-0.57032722 B	-5.31	0.0001	0.10741148
	1983	-0.60641725 B	-6.33	0.0001	0.09573886
	1984	-0.31284642 B	-2.49	0.0129	0.12564996
	1985	-0.32636046 B	-3.01	0.0027	0.10843281
	1986	-0.08111899 B	-0.72	0.4741	0.11328942
	1987	-0.13231208 B	-1.28	0.2009	0.10339827
	1988	0.00000000 B	.	.	.

Table 8. Summary of analysis of catch rate data from index fishermen in fall fishery.

EFFECT	FACTOR	ALL FISHERMEN	FISHERMEN	CONTROL OTHER
YEAR	1. CPUE	1986 > 1987 = 1988	N.S.	SEPTEMBER ONLY 1986 = 1987 = 1988
	2. CATCH	1987 < 1986 = 1988	N.S.	
	3. NETS	1988 > 1987 = 1986	1987 < 1986 = 1988	
	4. LENGTH	N.S.	-	
	5. SURFACE AREA	N.S.	-	
	6. MESH	1986 < 1987 = 1988	1986 < 1987 = 1988	
AREA	1. CPUE	C > F = A = P	-	
	2. CATCH	N.S.	-	
	3. NETS	C < P < F = A	-	
	4. LENGTH	C < F = A = P	-	
	5. SURFACE AREA	C < F = P < A	-	
	6. MESH	P > C = F = A	-	
WEEK	1. CPUE	2 = 3 < 4 = 5 = 6	-	
	2. CATCH	2 = 3 < 4 = 5 = 6	-	
	3. NETS	6 < 2 = 3 = 4 = 5	-	
	4. LENGTH	N.S.	-	
	5. SURFACE AREA	2 = 3 = 4 > 5 = 6	-	
	6. MESH	N.S.	-	
F	1. CPUE	8.8	8.4	11.5
	2. CATCH	3.9	1.9	
	3. NETS	56.6	65.3	
	4. LENGTH	5.8		
	5. SURFACE AREA	13.9		
	6. MESH	7.5	7.8	

AREAS

A = Alberton (S.D. 92)
C = Chaleur (S.D. 65 - 67)
F = Fishermen's Bank (S.D. 87)
P = Pictou (S.D. 1)

N.S. = Non Significant

WEEKS

1 - August 1 - 10
2 - August 11 - 20
3 - August 21 - 31
4 - September 1 - 10
5 - September 11 - 20
6 - September 21 - 30

Table 9. Results of multiplicative model for analysis of catch rates in fall fishery for fixed-week model.

HARENG, 1978-88 11:54 TUESDAY, APRIL 11, 1989 2

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: CPUE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	21	1573.57768391	74.93227066	73.18	0.0	0.477278	12.4154
ERROR	1683	1723.40519030	1.02400784		ROOT MSE		CPUE MEAN
CORRECTED TOTAL	1704	3296.98287421			1.01193272		8.15064616

SOURCE	DF	TYPE III SS	F VALUE	PR > F
DIST	6	403.19815464	65.62	0.0
WEEK	5	342.08751451	66.81	0.0
YR	10	394.52074689	38.53	0.0

PARAMETER		ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT		8.48342044 B	57.69	0.0	0.14704731
DIST	11	-0.26989196 B	-2.51	0.0122	0.10759776
	13	-0.31062500 B	-2.28	0.0229	0.13638269
	65	-0.62747638 B	-5.95	0.0001	0.10547686
	66	0.70759926 B	6.51	0.0001	0.10861871
	67	0.37178435 B	3.16	0.0016	0.11747424
	87	0.50541818 B	4.54	0.0001	0.11133919
	92	0.00000000 B	.	.	.
WEEK	1	-0.35471312 B	-3.14	0.0017	0.11300304
	2	0.54321215 B	4.67	0.0001	0.11630148
	3	0.73976830 B	6.45	0.0001	0.11463899
	4	0.76492911 B	6.68	0.0001	0.11449576
	5	0.66794528 B	5.56	0.0001	0.12011794
	6	0.00000000 B	.	.	.
YR	1978	-0.60298061 B	-3.52	0.0004	0.17110603
	1979	-1.31270114 B	-9.80	0.0001	0.13401122
	1980	-1.67241783 B	-12.36	0.0001	0.13533013
	1981	-0.96824837 B	-8.44	0.0001	0.11472464
	1982	-1.09390236 B	-9.35	0.0001	0.11694758
	1983	-0.97320988 B	-8.17	0.0001	0.11905940
	1984	-0.68920002 B	-5.83	0.0001	0.11819000
	1985	-0.10017908 B	-0.83	0.4092	0.12134561
	1986	-0.02884127 B	-0.23	0.8165	0.12428513
	1987	-0.07971109 B	-0.67	0.5010	0.11842335
	1988	0.00000000 B	.	.	.

NOTE: THE X'X MATRIX HAS BEEN DEEMED SINGULAR AND A GENERALIZED INVERSE HAS BEEN EMPLOYED TO SOLVE THE NORMAL EQUATIONS. THE ABOVE ESTIMATES REPRESENT ONLY ONE OF MANY POSSIBLE SOLUTIONS TO THE NORMAL EQUATIONS. ESTIMATES FOLLOWED BY THE LETTER B ARE BIASED AND DO NOT ESTIMATE THE PARAMETER BUT ARE BLUE FOR SOME LINEAR COMBINATION OF PARAMETERS (OR ARE ZERO). THE EXPECTED VALUE OF THE BIASED ESTIMATORS MAY BE OBTAINED FROM THE GENERAL FORM OF ESTIMABLE FUNCTIONS. FOR THE BIASED ESTIMATORS, THE STD ERR IS THAT OF THE BIASED ESTIMATOR AND THE T VALUE TESTS H0: E(BIASED ESTIMATOR) = 0. ESTIMATES NOT FOLLOWED BY THE LETTER B ARE BLUE FOR THE PARAMETER.

Table 10a). Catch rates at age for spring spawners using quartile and fixed-week models.

SPRING SPAWNERS: CPUE INDEX FOR QUARTILE MODEL 22/ 4/89

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
2	0	0	1	0	0	0	0	0	0	1	3
3	20	16	57	60	218	27	19	42	23	6	21
4	83	6	9	35	41	151	81	59	73	34	56
5	4	44	4	6	10	19	122	61	84	110	60
6	6	1	24	4	2	5	12	29	55	57	86
7	1	3	1	15	1	0	1	10	12	50	55
8	1	0	3	0	2	0	0	2	2	18	38
9	0	0	0	1	1	0	0	1	0	3	8
10	4	1	0	0	0	0	0	0	0	2	1
11	4	4	5	5	1	0	0	0	3	1	8

SPRING SPAWNERS: CPUE INDEX FOR WEEK MODEL 22/ 4/89

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
2	0	0	2	0	0	0	0	0	0	1	2
3	22	18	64	60	201	27	14	43	24	7	20
4	92	7	10	35	37	151	60	61	75	38	53
5	5	49	4	6	9	19	90	63	87	121	56
6	6	1	28	4	2	5	9	30	56	62	81
7	1	3	1	15	1	0	0	11	12	55	52
8	1	0	3	0	2	0	0	2	2	20	36
9	0	0	0	1	1	0	0	1	0	4	8
10	5	1	0	0	0	0	0	0	0	2	1
11	4	4	6	5	1	0	0	0	3	1	8

Table 10b). Catch rates at age for fall spawners using quartile and fixed-week models.

FALL SPAWNERS: CPUE INDEX FOR QUARTILE MODEL 22/ 4/89

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
2	0	0	0	0	0	0	0	0	3	0	0
3	6	1	50	45	26	5	10	57	40	73	17
4	71	69	22	189	135	146	297	339	378	336	254
5	50	34	27	36	168	71	167	454	257	267	502
6	10	17	6	16	38	85	137	245	335	176	261
7	10	4	6	6	16	15	70	114	195	317	175
8	56	4	1	5	7	12	15	41	104	129	179
9	1	6	1	1	4	4	5	7	33	83	95
10	3	0	1	0	1	1	2	4	6	39	29
11	29	13	4	6	0	2	2	0	7	15	19

FALL SPAWNERS: CPUE INDEX FOR WEEK MODEL 22/ 4/89

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
2	0	0	0	0	0	0	0	0	3	0	0
3	8	1	61	47	26	6	10	49	35	64	15
4	94	74	28	199	135	157	281	290	333	297	211
5	66	36	34	38	168	76	158	388	226	235	417
6	13	18	8	17	38	91	129	209	295	155	217
7	13	4	7	7	16	16	66	97	172	279	145
8	73	5	2	6	7	13	14	35	91	113	149
9	2	7	2	1	4	4	5	6	29	73	79
10	4	0	1	0	1	1	2	4	5	34	24
11	38	13	5	6	0	2	2	0	6	13	15

Table 11a. Total area backscatter estimates of herring surveyed in 4T and 4VN, 1984-1987. N means the number of transects run. A dash (-) indicates that the stratum was not surveyed in the indicated year. Data for 1984 from Shotton et al. 1987a, for 1985 from Shotton 1986, for 1986 from Shotton et al. 1987b, and for 1987 from Cairns et al. 1988. Data for 1988 are from the November survey of the Bay of Chaleur and the December survey of Sydney Bight.

Stratum	Total area backscatter (m^2 sr^{-1})									
	1984	1985		1986		1987		1988		
	Mean	Mean	N	Mean	N	Mean	N	Mean	SE	N
Chaleur										
Cap Bon Ami		0@	2	0*	3	0*	2	0*	0	3
Baie de Gaspé		0@	2	23*	3	11*	2	0*	0	3
Gaspé Offshore				0#	4	0*	3	0*	0	4
American Bank		-		-		115*	3	0*	0	4
La Malbaie		0@	3	0#	4	61*	3	0*	0	4
Anse-à-Beaufils		1807@	3	535#	7	0*	4	0*	0	6
Grande Rivière				25731*	7	3667*	9	101*	32	12
Newport		4814	2	16275*	3	2713*	8	0*	0	13
Shigawake				18600*	3	8142*	8	48272*	11069	23
New Carlisle		-		-		0*	3	218*	225	5
New Richmond		-		-		258*	3	3209*	1720	14
Central Chaleur		-		-		-		54	42	12
Maisonnette		-		-		-		12290	6716	12
West Miscou		7964*	2	59*	3	141885*	3	558*	329	20
North Miscou		0@	3	0*	3	1389*	3	0*	0	4
East Miscou		4464*	4	20*	4	28000*	2	4*	4	15
Total Chaleur	28700	19048	21	61243	44	186241	56	64706	13067	154
Prince Edward Island										
North Point	-	16	1	-		-		-		
Northeast P.E.I.	-	-		2346*	3	0*	2	-		
Beyond East Pt. (BP)	-	0	1	-		-		-		
East Point (EP)	-	0	1	-		-		-		
Cardigan Bay (CB)	-	0	1	-		-		-		
Total P.E.I.	-	16	4	2346	3	0	2	-		
West Cape Breton	10787	-		-		-		-		
Sydney Bight										
Aspy Bay		642*	1	174*	2	3484*	7	0*	0	5
Neil Harbour		3630@	1	16310*	1	54672*	8	16122*	7841	23
Wreck Cove		17246@	9	16755#	3	10066*	9	32994*	12082	14
St. Ann's Bay		-		-		3257*	7	857*	787	14
Haddock Bank		1133@	5	12*	4	412*	7	0*	0	2
Sydney		2956*	4	0*	3	3970*	7	78*	77	9
New Waterford		4572*	6	-		43268*	8	0*	0	15
Donkin		703*	4	-		8080*	7	0*	0	4
Total Sydney Bight	22318	30882	30	33251	13	127209	60	50051	14425	86
Total all areas	61805	49946	55	96840	60	313450	118	114757		240

@,#,* Years with similar symbols have the same stratum boundaries. Years with different symbols have different stratum boundaries.

Table 11b. Acoustic biomass estimates for herring in the Southern Gulf of St. Lawrence and Sydney Bight, 1984-1988. All estimates are based on Foote's (1987) value for target strength. A dash (-) means that no estimate is available.

Area and spawning affinity	Biomass estimate (tonnes)				
	1984	1985	1986	1987	1988
Chaleur					
Spring	-	-	143179	153381	163881
Fall	-	-	112498	563352	76413
Total	104709	73599	255677	716733	240294
Survey dates	7-12 Nov	7-13 Nov	17-28 Nov	4-11 Nov	12-18 Nov
P.E.I.					
Total	-	62	9794	0	-
Survey dates		8-27 Nov	1-12 Dec	16-17 Nov	
West Cape Breton					
Total	36600	-	-	-	-
Survey dates	17 Nov				
Sydney Bight					
Spring	-	-	-	191844	47544
Fall	-	-	-	251214	125342
Total	75724	106865	127708	443058	172886
Survey dates	18-27 Nov	21-25 Nov	1-12 Dec	17-24 Nov	9-13 Dec
All areas					
Spring	-	-	-	345225	211424
Fall	-	-	-	814566	201756
Total	217033	180464	383385	1159791	413180
Survey dates	7-27 Nov	7-28 Nov	17 Nov-12 Dec	4-24 Nov	12 Nov-13 Dec

Table 12. ADAPT input summary for 4T herring.

Parameters:

- year-class estimates: $N_{i,1988}$ i = 4-10+
- calibration constants for gillnet catch rates population at age: k_i i = 4-10+

Structure:

- F for oldest age group calculated as an average F for ages 7-9 (AUTO-F)
- F for oldest age group (10+) assumed to equal F at age 9 (CALC-F)
- model did not include an intercept term

Objective Function:

- log transformation

Input:

- $C_{i,t}$ i = 4-10+; t = 1978-88
- $CPUE_{i,t}$ (numbers) i = 4-10+; t = 1978-88

Summary:

- number of observations = 99
- number of parameters = 14

Table 13. Results of calibration using ADAPT. Top table indicates estimates of population numbers and slopes of model of SPA numbers versus catch rate index. Bottom table gives correlation matrix among parameters.

ESTIMATED PARAMETERS AND STANDARD ERRORS
APPROXIMATE STATISTICS ASSUMING LINEARITY NEAR SOLUTION

ORTHOGONALITY OFFSET..... 0.000000
MEAN SQUARE RESIDUALS 0.151602

PAR. EST.	STD. ERR.	T-STATISTIC
2.29236E0005	8.21976E0004	2.78884E0000
2.86161E0005	7.39080E0004	3.87185E0000
1.47348E0005	3.40953E0004	4.32165E0000
8.34087E0004	1.77564E0004	4.69739E0000
7.67804E0004	1.64363E0004	4.67140E0000
3.31908E0004	6.72426E0003	4.93597E0000
1.79610E0004	3.65735E0003	4.91095E0000
1.29994E²003	1.72399E²004	7.54032E0000
1.88391E²003	2.43858E²004	7.72542E0000
2.21505E²003	2.84927E²004	7.77410E0000
2.63368E²003	3.41141E²004	7.72021E0000
3.66543E²003	4.82309E²004	7.59976E0000
3.40311E²003	4.66661E²004	7.29247E0000
3.84752E²003	5.59771E²004	6.87337E0000

Parameter Correlation Matrix 5/ 5/89

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	1.000	.075	.064	.053	.046	.041	.057	-.321	-.047	-.039	-.034	-.032	-.032	-.033
2	.075	1.000	.094	.078	.066	.060	.087	-.235	-.273	-.057	-.051	-.048	-.049	-.051
3	.064	.094	1.000	.102	.086	.077	.117	-.198	-.223	-.254	-.067	-.063	-.065	-.069
4	.053	.078	.102	1.000	.110	.094	.149	-.166	-.186	-.216	-.260	-.079	-.082	-.087
5	.046	.066	.086	.110	1.000	.118	.186	-.143	-.156	-.177	-.225	-.273	-.102	-.109
6	.041	.060	.077	.094	.118	1.000	.237	-.129	-.142	-.157	-.184	-.235	-.304	-.139
7	.057	.087	.117	.149	.186	.237	1.000	-.177	-.213	-.257	-.302	-.366	-.470	-.585
8	-.321	-.235	-.198	-.166	-.143	-.129	-.177	1.000	.148	.120	.106	.099	.101	.104
9	-.047	-.273	-.223	-.186	-.156	-.142	-.213	.148	1.000	.137	.121	.114	.118	.124
10	-.039	-.057	-.254	-.216	-.177	-.157	-.257	.120	.137	1.000	.142	.134	.140	.150
11	-.034	-.051	-.067	-.260	-.225	-.184	-.302	.106	.121	.142	1.000	.160	.165	.177
12	-.032	-.048	-.063	-.079	-.273	-.235	-.366	.099	.114	.134	.160	1.000	.202	.214
13	-.032	-.049	-.065	-.082	-.102	-.304	-.470	.101	.118	.140	.165	.202	1.000	.275
14	-.033	-.051	-.069	-.087	-.109	-.139	-.585	.104	.124	.150	.177	.214	.275	1.000

Table 14. Population numbers, biomass and fishing mortality for fall spawners.

FALL SPAWNERS POPULATION NUMBERS 18/ 5/89

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
2	87528	285197	260836	379438	564481	372400	457307	589870	353617	43022	36428
3	131770	70292	230870	212316	310559	461991	304864	374403	482918	289218	35172
4	90868	90378	51925	159677	164714	245874	373920	248575	303155	391424	228320
5	43267	49624	42298	33468	100689	115378	179698	281239	187505	215694	284610
6	9325	22673	15629	13568	21999	58778	84537	132422	208478	129751	146571
7	10105	4040	8511	5247	8750	12887	35779	57475	96995	138987	82864
8	24721	5138	1205	3232	3411	5043	8371	23214	41811	61245	76263
9	3433	7705	1377	411	1762	1884	2440	5600	17066	25054	32909
10	36660	16299	5334	1862	808	1279	1667	2650	6201	15077	17816
2+	437678	551345	617985	809219	1177171	1275515	1448582	1715450	1697746	1309472	940953
3+	350151	266148	357149	429781	612690	903115	991275	1125579	1344129	1266450	904525
4+	218380	195857	126279	217465	302132	441123	686411	751176	861211	977232	869354
5+	127512	105479	74354	57787	137418	195250	312491	502601	558056	585808	641033

MID-YR POPULATION BIOMASS (t) 18/ 5/89

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
2	9425	30709	28086	26093	48012	48186	56689	63515	53434	5567	3131
3	21104	11258	36975	27472	42432	72737	59032	84355	96569	60452	7733
4	20144	20035	11511	34965	23101	55396	82554	62753	66362	87481	53714
5	11079	12707	10831	8267	17219	29754	47153	79396	49881	54452	74425
6	2641	6421	4426	3892	4718	16860	23407	42536	62439	36512	42705
7	3091	1235	2603	1548	2565	4000	11137	19970	32824	42759	26167
8	8030	1669	392	1018	731	1652	2780	8486	14603	18398	26015
9	1180	2649	473	146	454	622	839	2052	6239	8524	11970
10	12074	5368	1757	553	278	403	628	1014	2446	5252	6481
2+	88769	92052	97054	103953	139510	229608	284218	364078	384817	319397	252342
3+	79344	61344	68969	77860	91498	181423	227529	300563	331383	313830	249211
4+	58240	50086	31993	50388	49067	108686	168497	216208	234814	253379	241477
5+	38096	30051	20482	15423	25966	53290	85943	153456	168432	165898	187763

FISHING MORTALITY 18/ 5/89

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
2	.019	.011	.006	.000	.000	.000	.000	.000	.001	.001	.001
3	.177	.103	.169	.054	.034	.012	.004	.011	.010	.036	.050
4	.405	.559	.239	.261	.156	.114	.085	.082	.140	.119	.140
5	.446	.955	.937	.220	.338	.111	.105	.099	.168	.186	.227
6	.637	.780	.892	.239	.335	.296	.186	.111	.205	.248	.218
7	.476	1.009	.768	.231	.351	.231	.233	.118	.260	.400	.294
8	.966	1.117	.877	.407	.394	.526	.202	.108	.312	.421	.307
9	.714	1.327	1.101	.850	.508	.450	.244	.089	.240	.624	.414
10	.714	1.327	1.101	.850	.508	.450	.244	.089	.240	.624	.388
5+	.647	1.012	.922	.260	.343	.191	.146	.105	.212	.305	.257

Table 15. Herring landings (tonnes) reported on purchase slip files and by index fishermen in NAFO District 4T, 1984-1988. Supplementary B (Supp B) landings represent estimates by fisheries officers of fish caught but not commercially sold.

Area	Purchase slip data files										Index fishermen			
	1984[a]		1985		1986		1987		1988		1987		1988	
	Total catch	% Supp B	Total catch	% Supp B	Total catch	% Supp B	Total catch	% Supp B	Total catch	% Supp B	Total catch	% bait & dumped	Total catch	% bait & dumped
16B (Chaleur)	504	31.7	914	27.9	1071	6.7	3593	9.5	5318	3.7	209	12.3	388	2.7
16C (Escuminac)	3272	40.0	2924	1.4	2742	3.5	3392	12.7	3677	11.8	64	16.4	237	5.9
16E (SE New Brunswick, W P.E.I.)	496	57.2	2075	24.1	3253	27.7	3586	17.1	1844	18.5	288	16.4	1026	8.9
16F (Pictou)	182	61.6	153	61.5	67	40.8	138	48.8	153	53.6	6	35.5	3	82.5
16G (E Northumberland Strait)	107	92.3	252	97.6	268	97.7	39	70.0	124	98.3	0	-	0	-
Total	4562	43.0	6319	18.0	7401	18.3	10749	13.8	11115	10.6	567	15.1	1654	7.1

[a]Percentage allocation of Supplementary B's may be unreliable. See text.

Table 16. Reported and adjusted landings (tonnes) by index fishermen in the fall herring fishery of NAFO District 4T, 1987 and 1988. Reported landings are the sum of landings indicated by index fishermen. Adjusted landings have been altered so that reported landings which exceed the daily trip limit (6.80 tonnes on Fisherman's Bank, 9.07 tonnes elsewhere) have been reduced to that limit.

Area	1987				1988			
	Reported landings	Adjusted landings	% difference	N	Reported landings	Adjusted landings	% difference	N
Chaleur	1026.0	974.1	5.1	178	271.2	247.9	8.6	38
Pictou	222.8	222.8	0	45	120.0	117.3	2.3	18
West P.E.I.	188.8	188.0	0.4	27	161.8	161.8	0	24
Fisherman's Bank	353.7	341.2	3.5	62	198.6	167.5	15.7	31
Total	1791.3	1726.1	3.6	312	751.6	694.5	7.6	111

Table 17. Summary of closures in the southern Gulf of St. Lawrence herring gillnet fishery.

Fishery	Year	Statistical Districts	Julian day of closure
Spring	1978	All	None
	1979	All	None
	1980	All	None
	1981	All	None
	1982	All	None
	1983	All	None
	1984	All	138
	1985	65-67	142
		73-75	132
		78-82	143
		Others	None
	1986	73-75	131
		Others	None
	1987	All	179
Fall	1978	All	None
	1979	All	None
	1980	All	None
	1981	All	290
	1982	All	262
	1983	All	250
	1984*	All	276
	1985	11-13	270
		65-80	251**
		87-92	258
	1986	All	264
	1987	65-67	259
		Others	None

* Several mid-season closures.
** Fishing continued for seven more days in spite of closure.

Figure 1 Landings of herring in NAFO Division 4T.

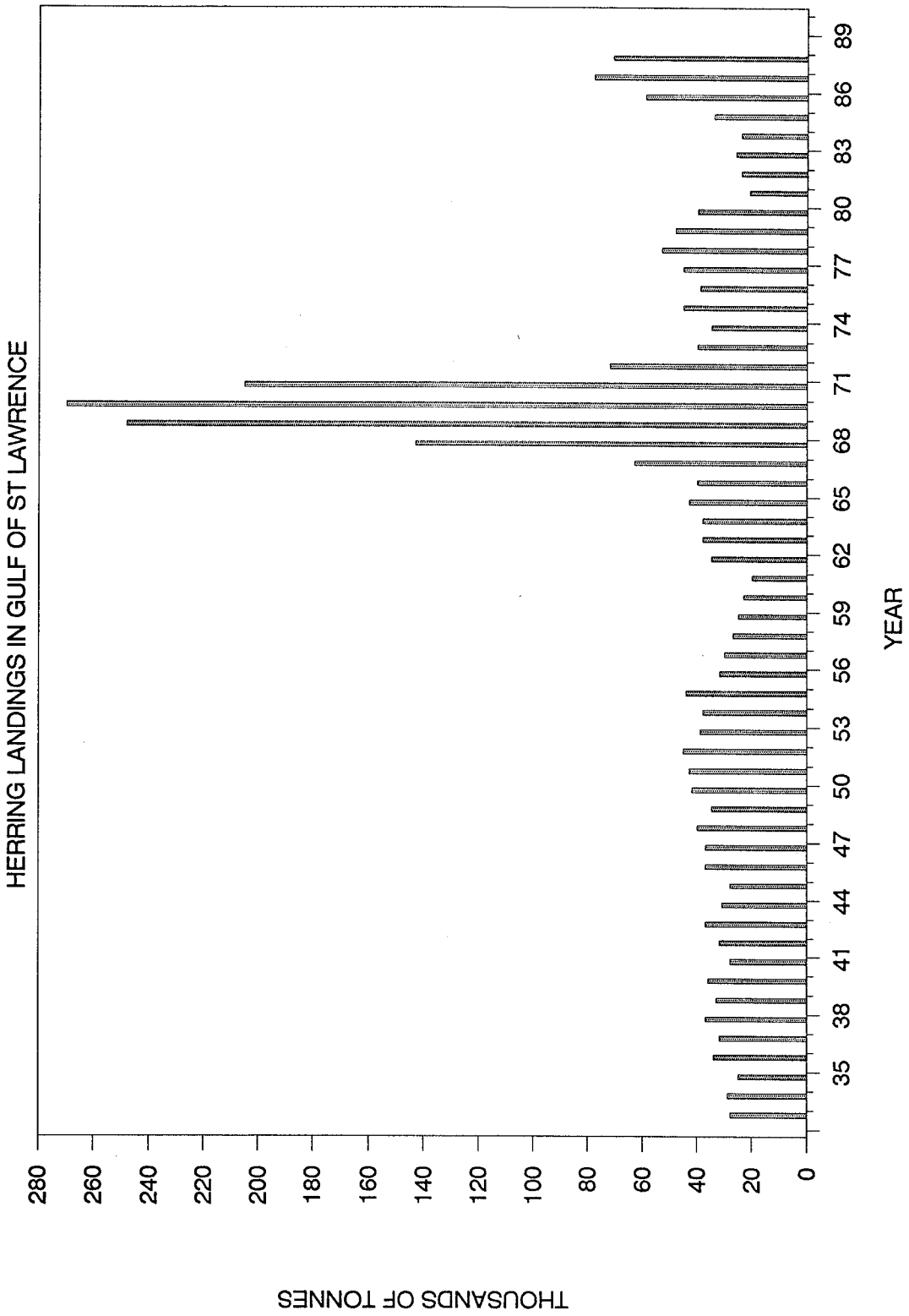


Figure 2 Location of herring management zones in eastern Canada.

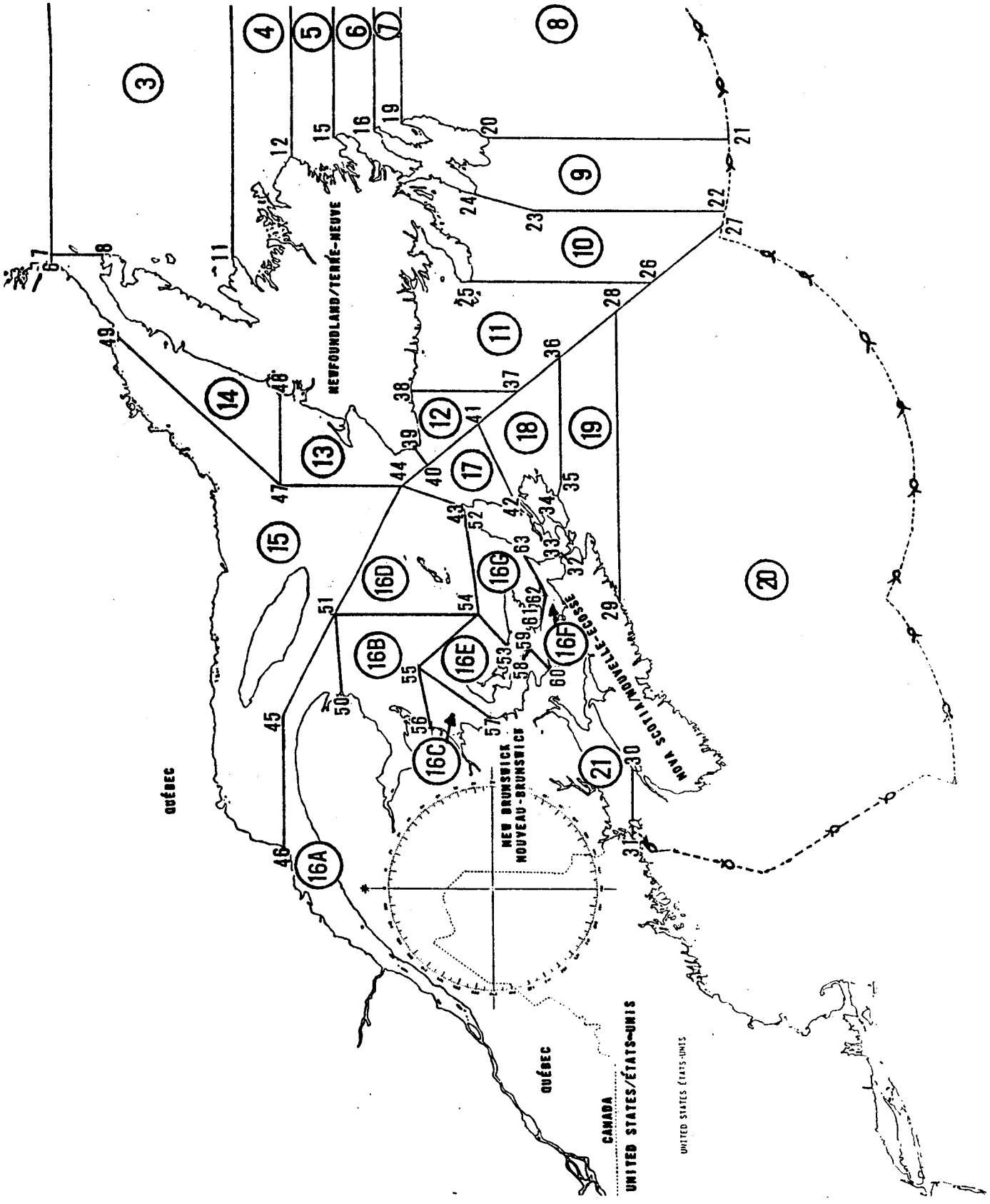


Figure 3 Distribution of mean 1978-1987 landings by Statistical District in spring and fall herring fisheries.

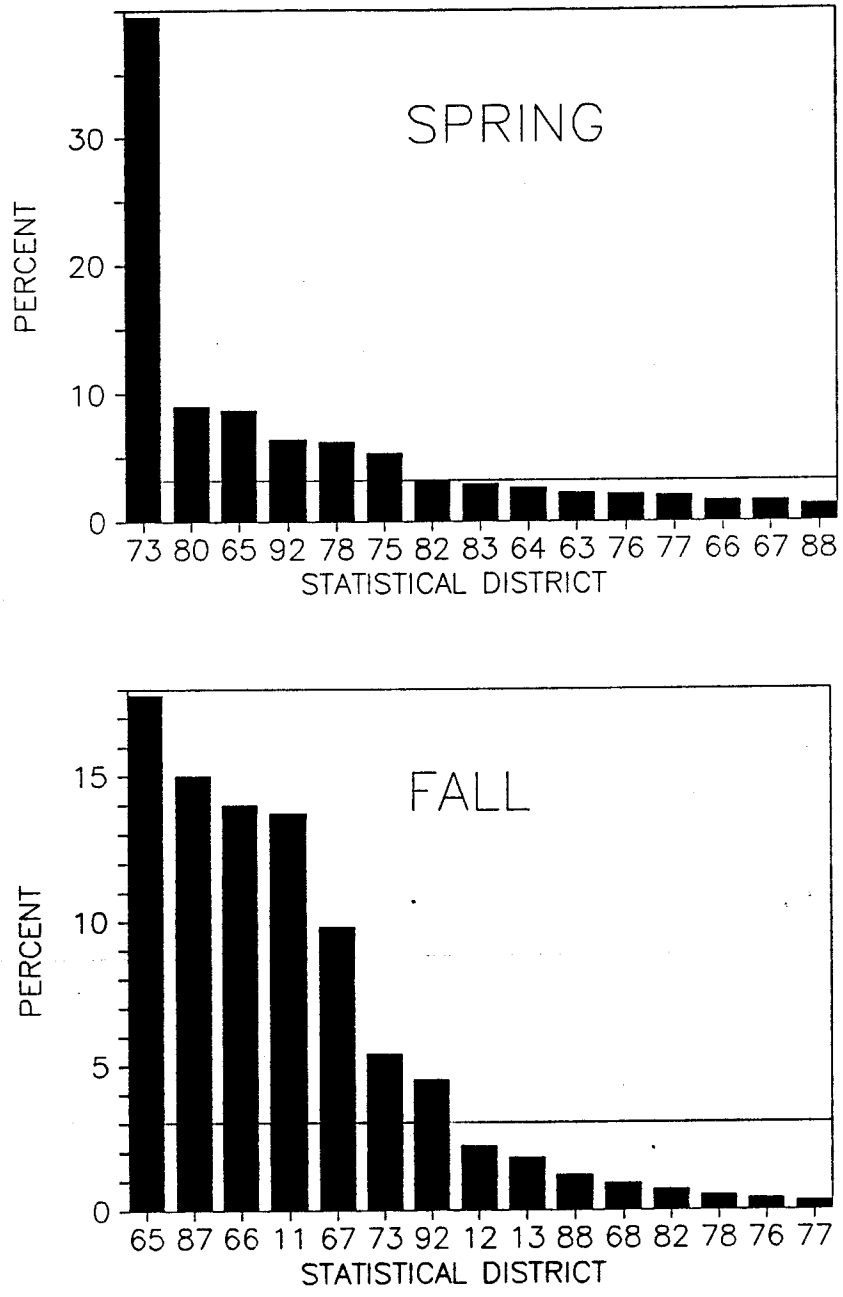
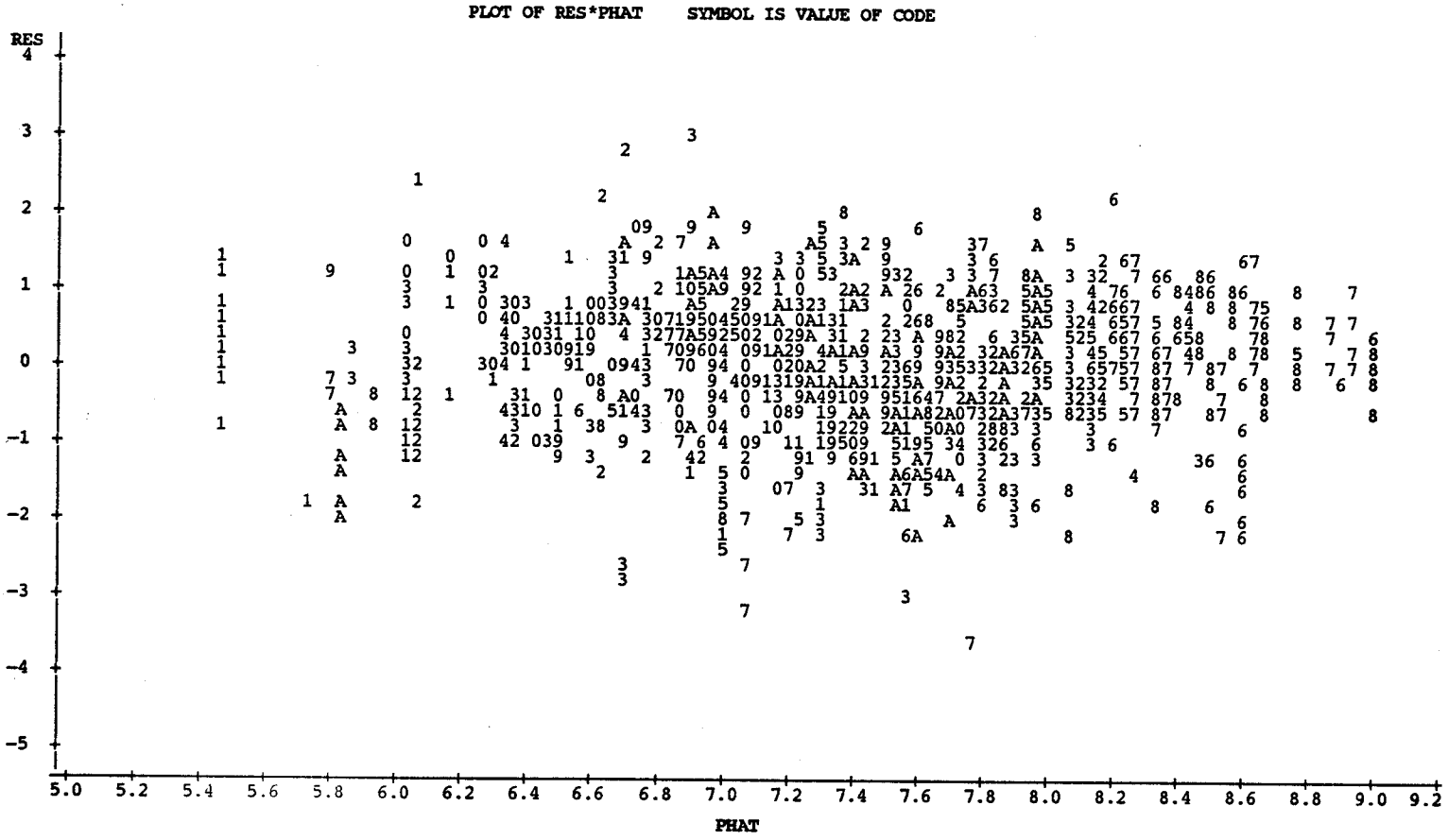
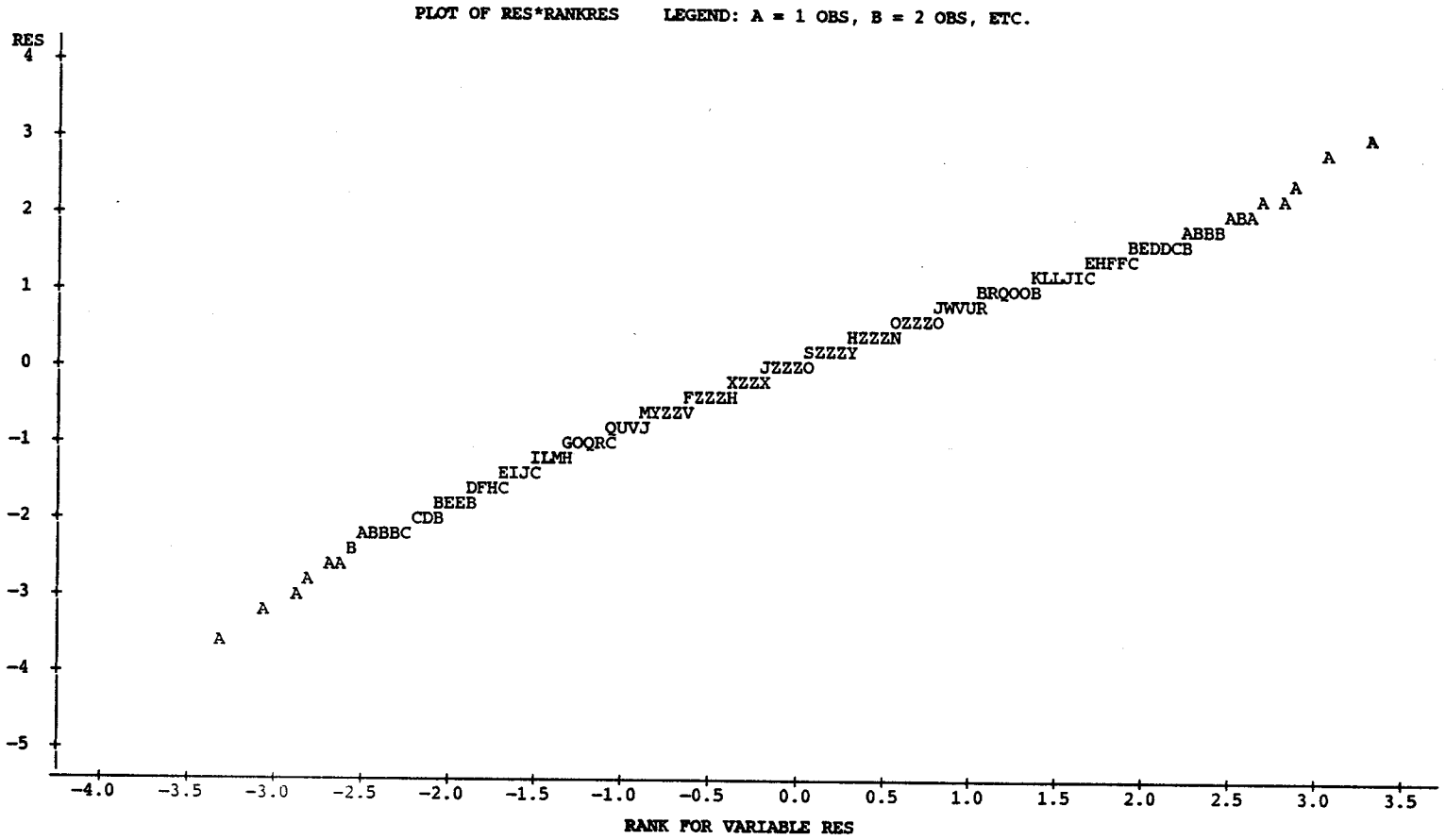


Figure 4a) Plot of residuals versus predicted values for fixed-week model in spring fishery.



NOTE: 683 OBS HIDDEN

Figure 4b) Plot of normalized residuals for fixed-week model in spring fishery.



NOTE: 94 OBS HIDDEN

Figure 5 Abundance indices in spring herring fishery.

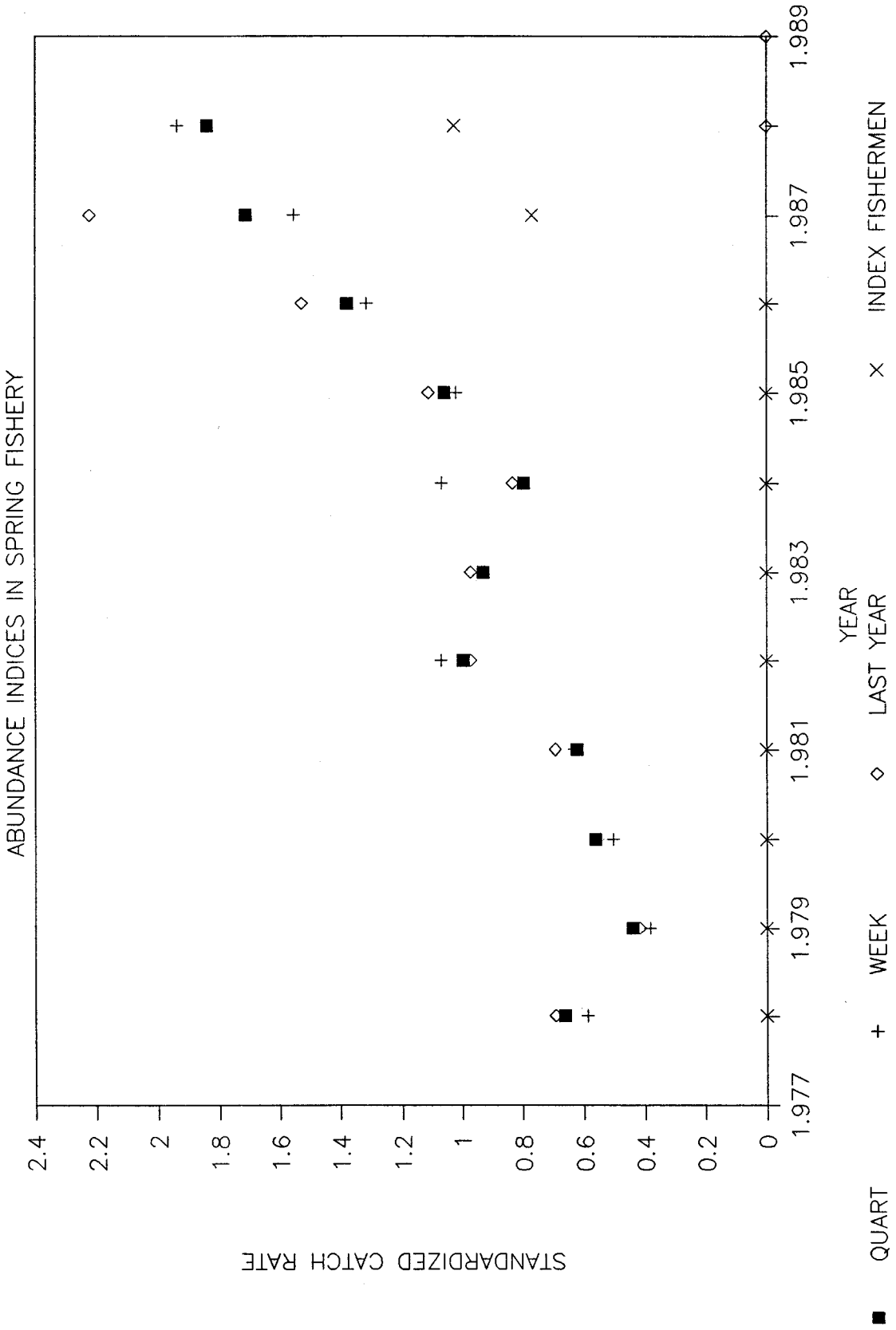


Figure 6a) Plot of residuals versus predicted values for fixed-week model in fall fishery.

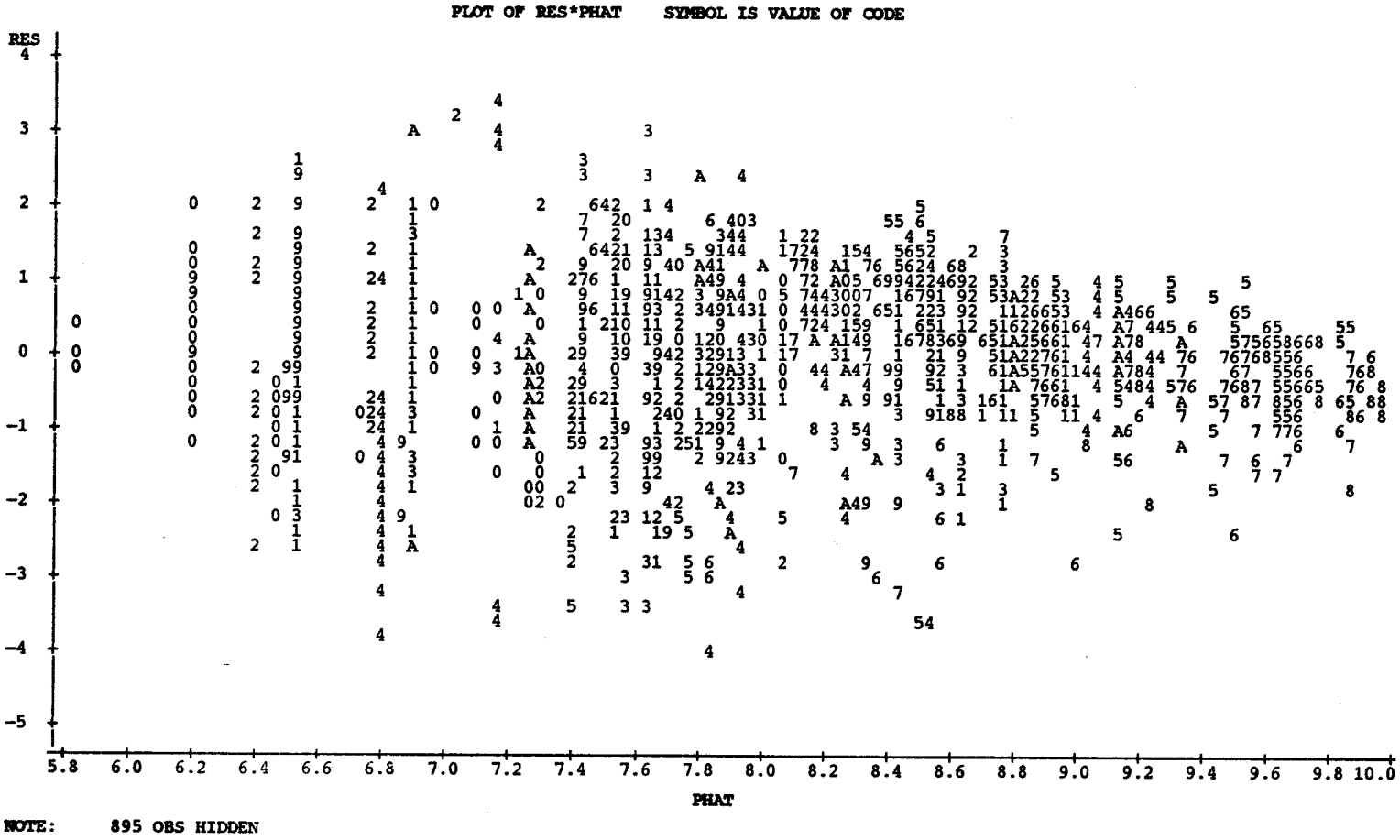


Figure 6b) Plot of normalized residuals for fixed-week model in fall fishery.

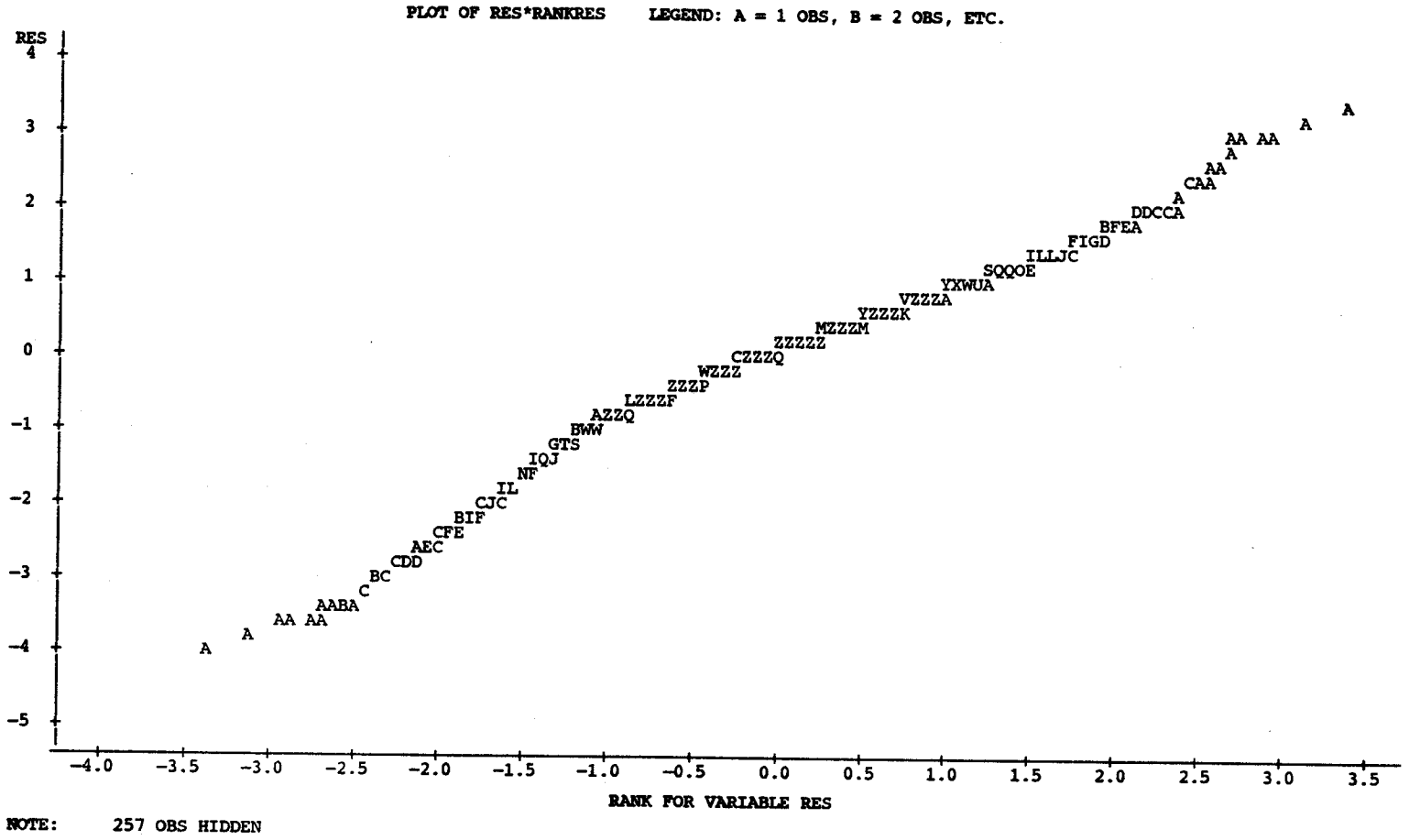


Figure 7 Summary of various abundance indices using two quartile model: ALL - 10 Statistical Districts; REV+88 - 7 Statistical Districts; REV-88 - 7 Statistical Districts without 1988 values in Chaleur Bay; SOUTH 4 S.D. in south eastern Gulf only.

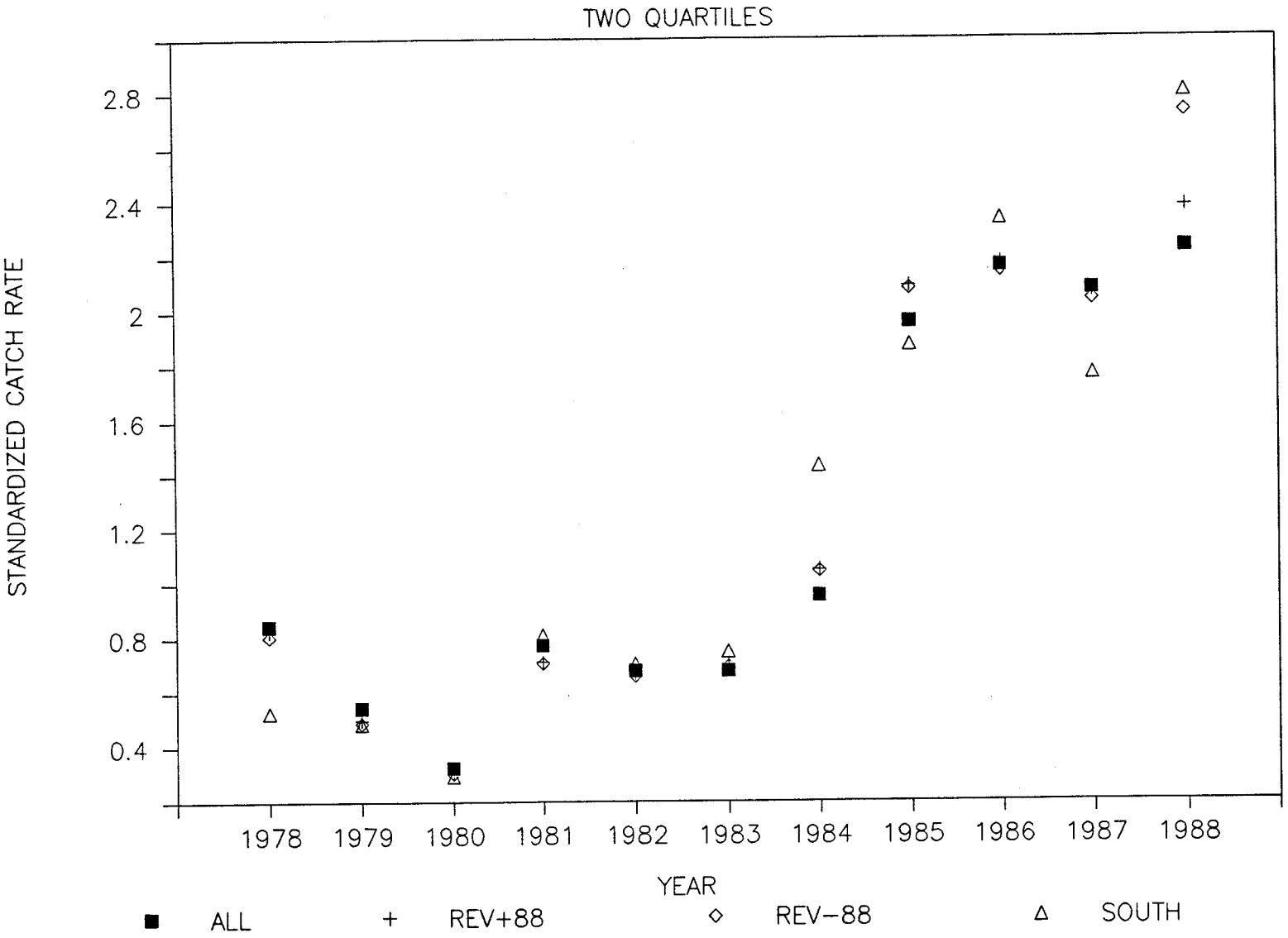


Figure 8 Summary of various abundance indices using fixed-week model: ALL - 10 Statistical Districts (S.D.); REV+88 = 7 S.D.; REV-88 - 7 S.D. without 1988 values in Chaleur Bay; SOUTH 4 S.D. in south eastern Gulf; OLD last year's index.

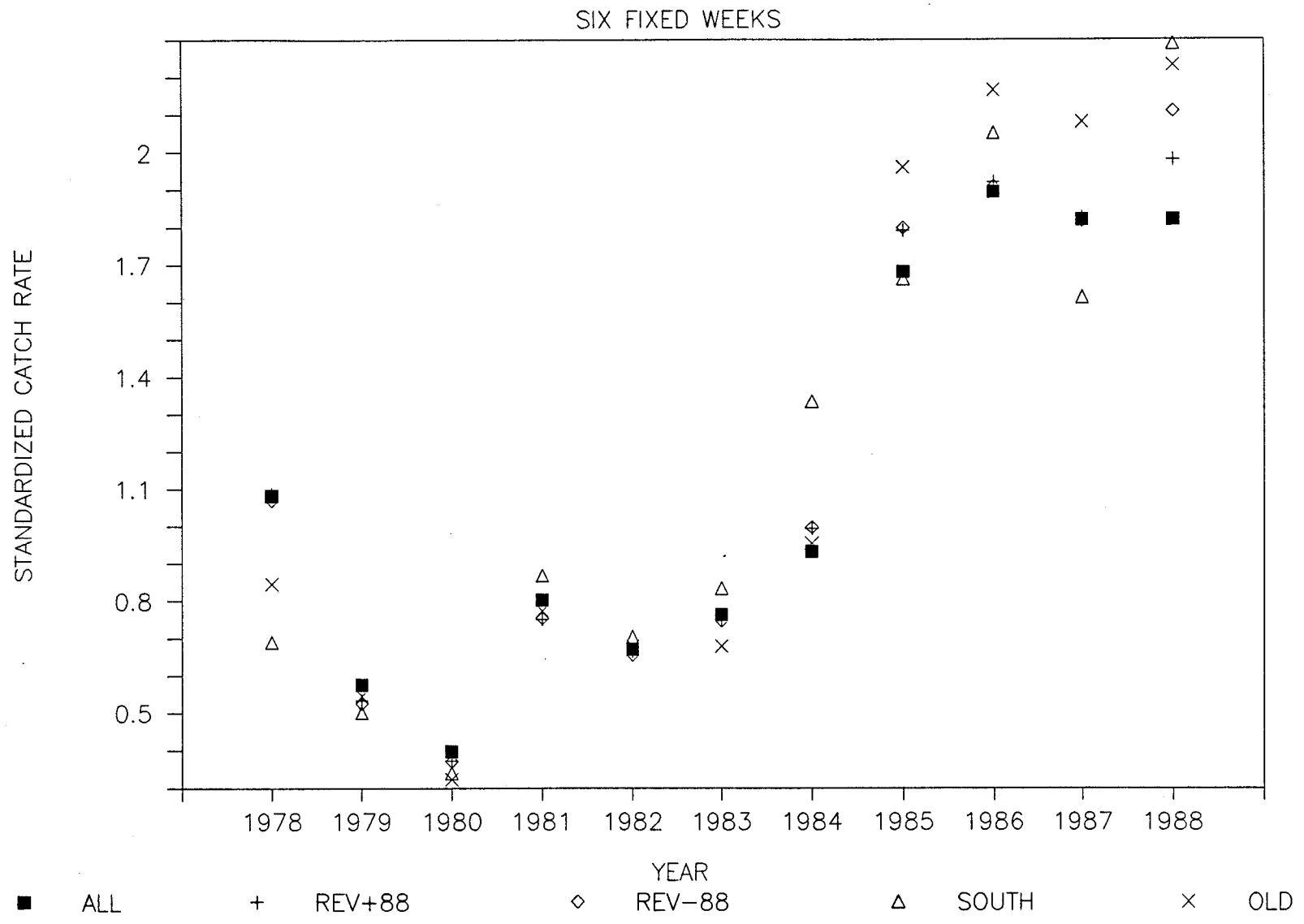


Figure 9 Comparison of three abundance indices in fall fishery.

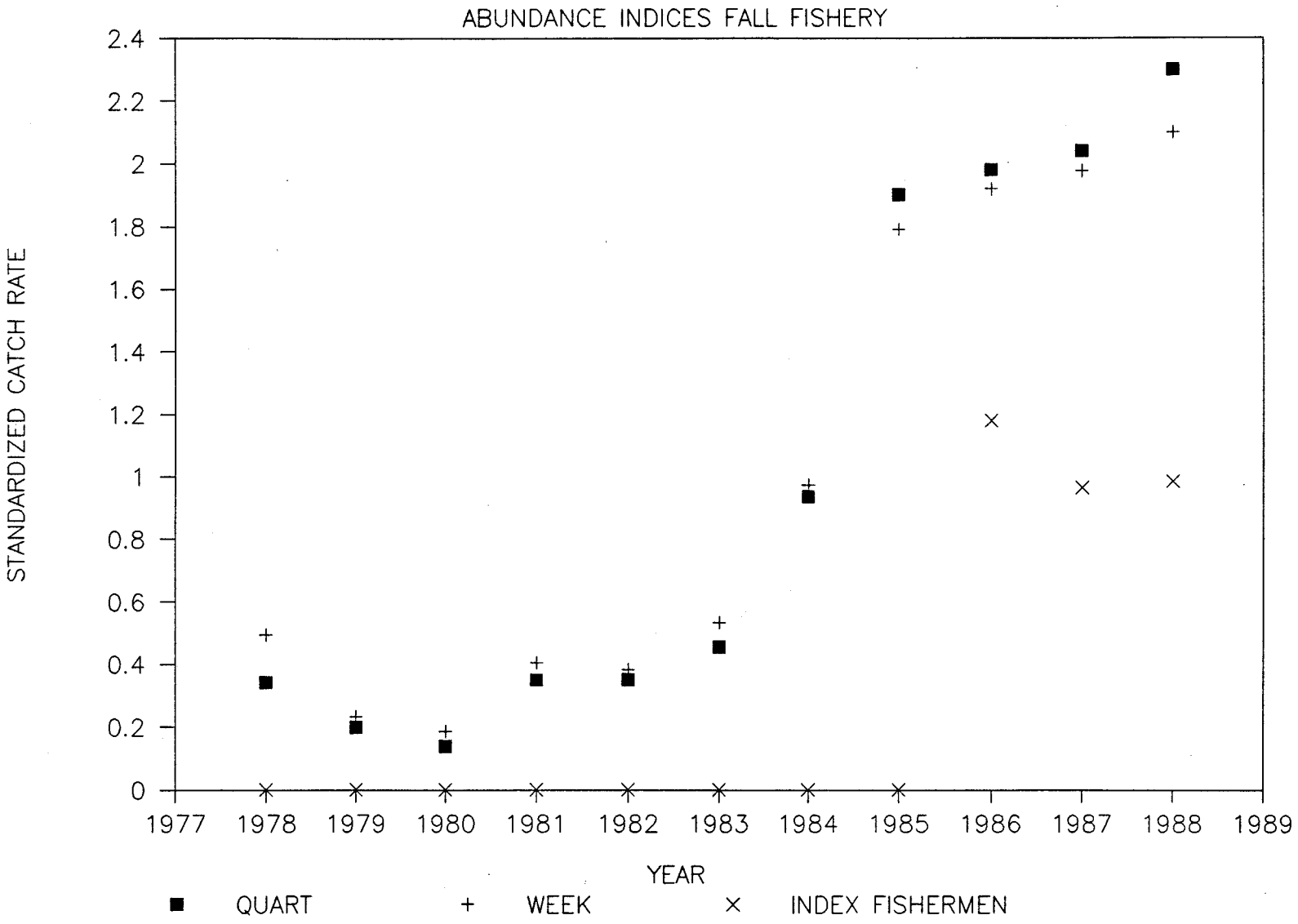


Figure 10 Age 4 population numbers using two calibration models (AUTO-F and CALC-F) compared to last year's assessment.

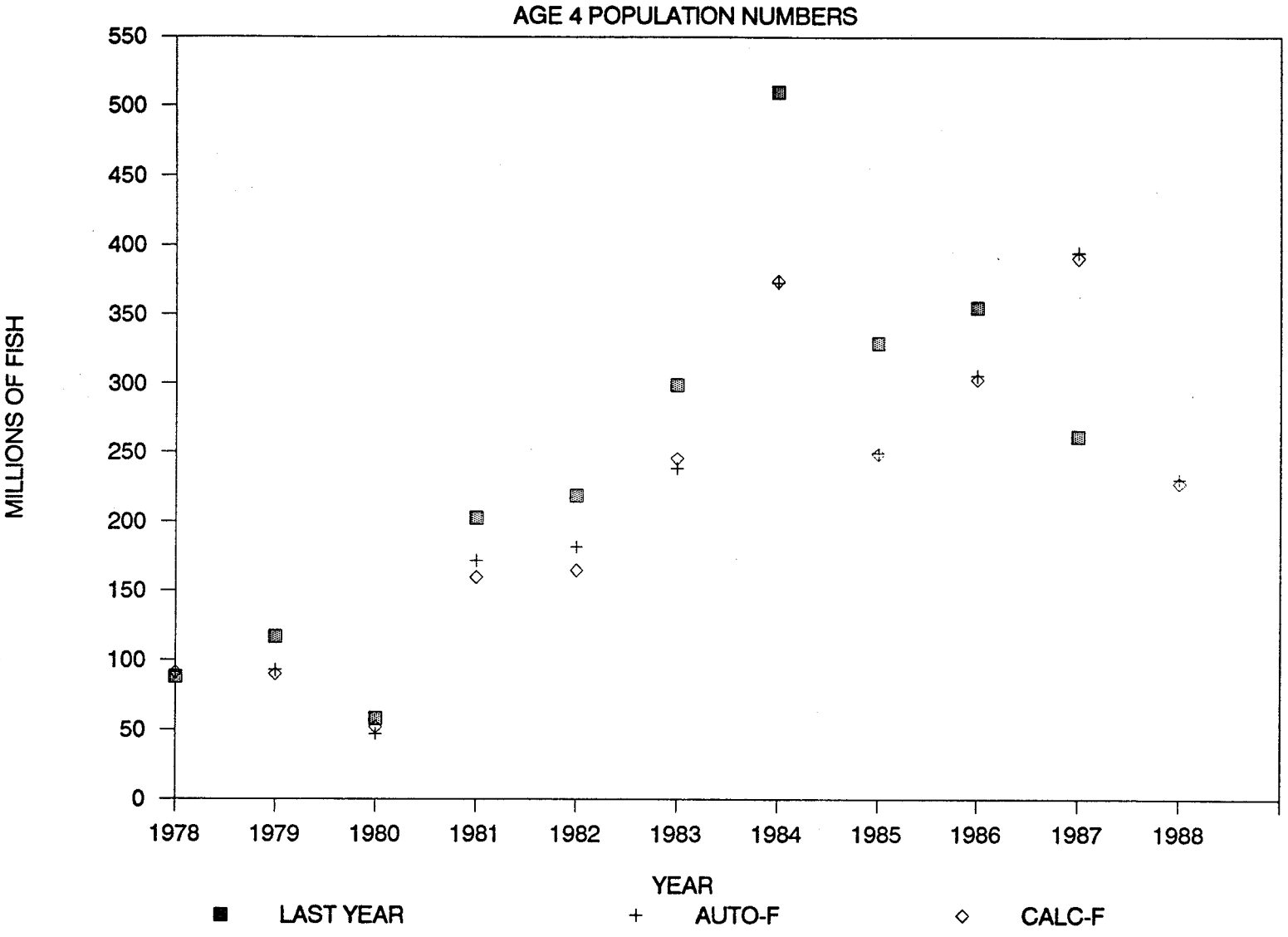
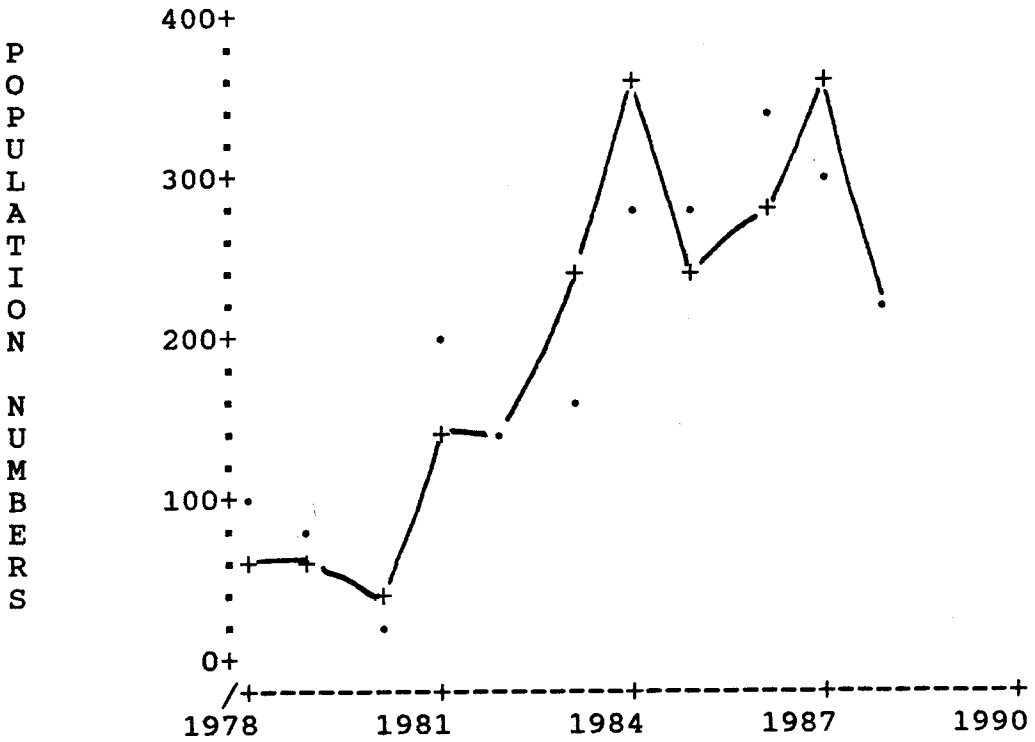


Figure 11a) Calibration plots using CALC-F model for ages 4 to 10+. The plots show trends in fishable biomass over time: + - predicted values, . - observed values.

AGE 4



AGE 5

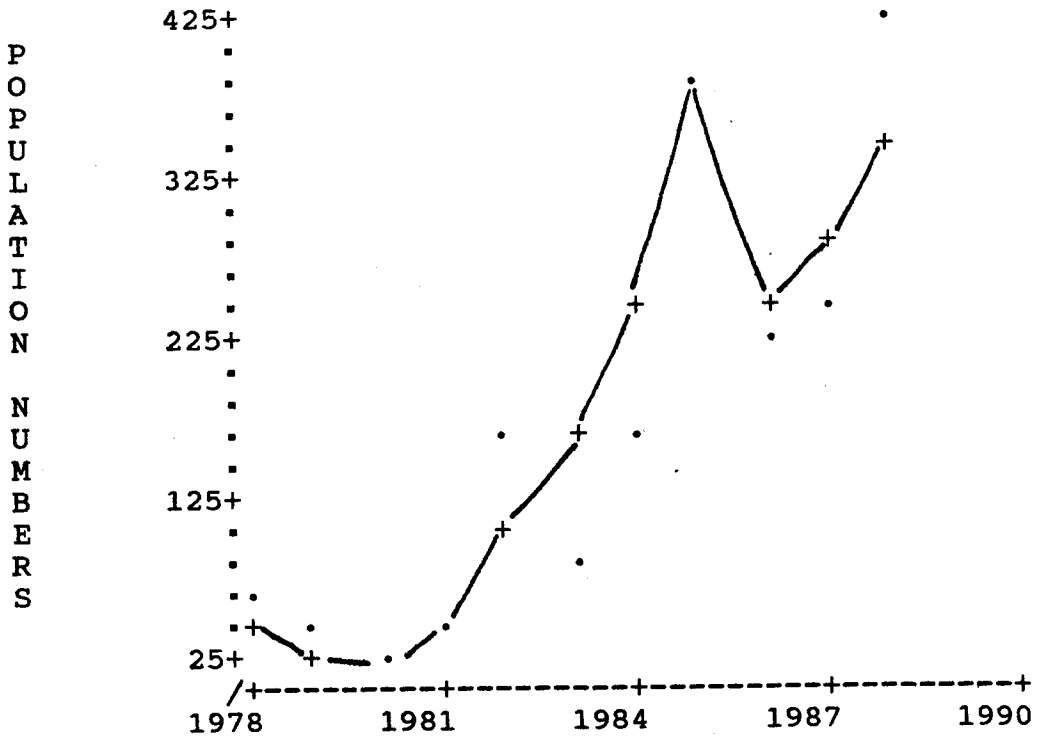
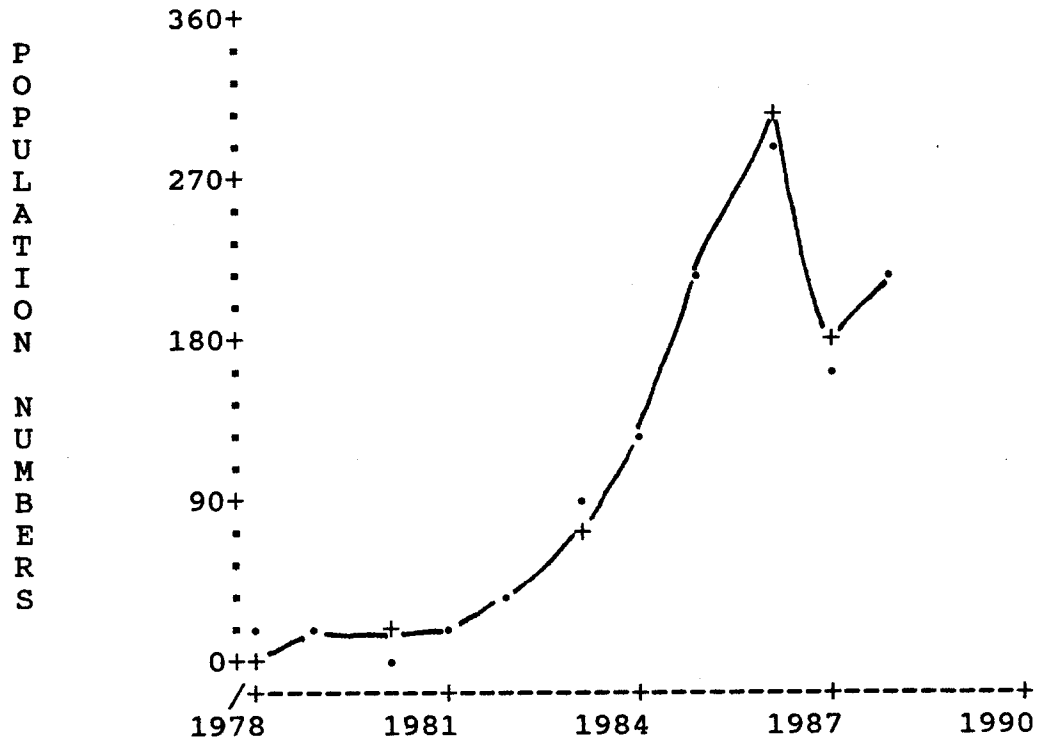


Figure 11b)

AGE 6



AGE 7

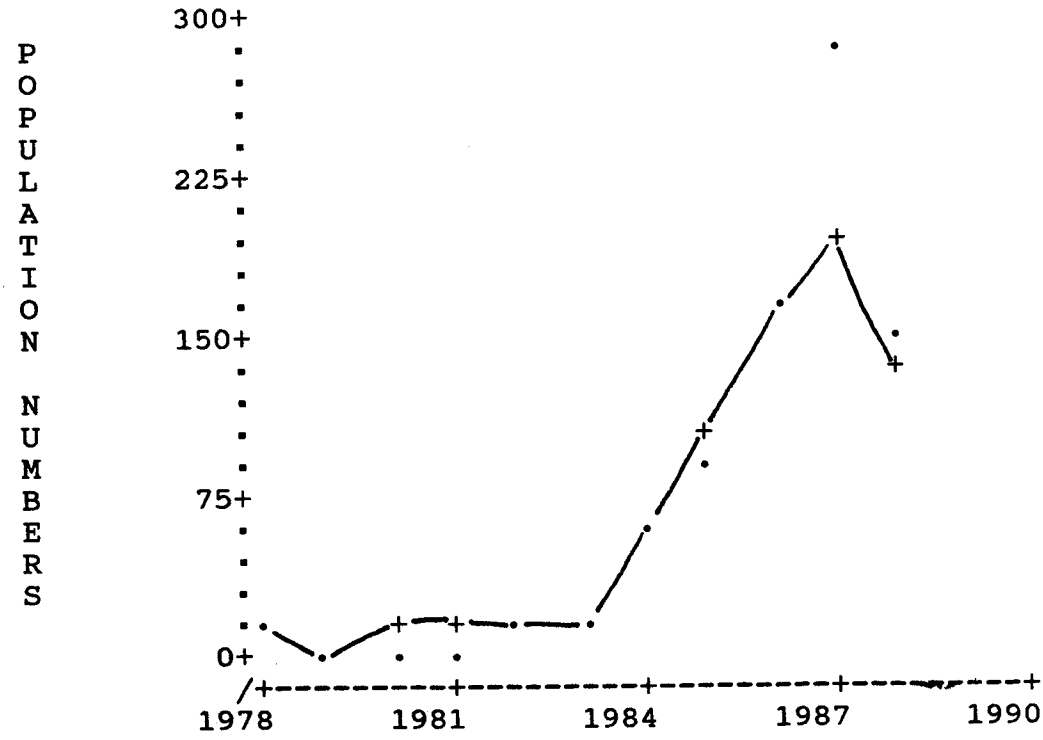
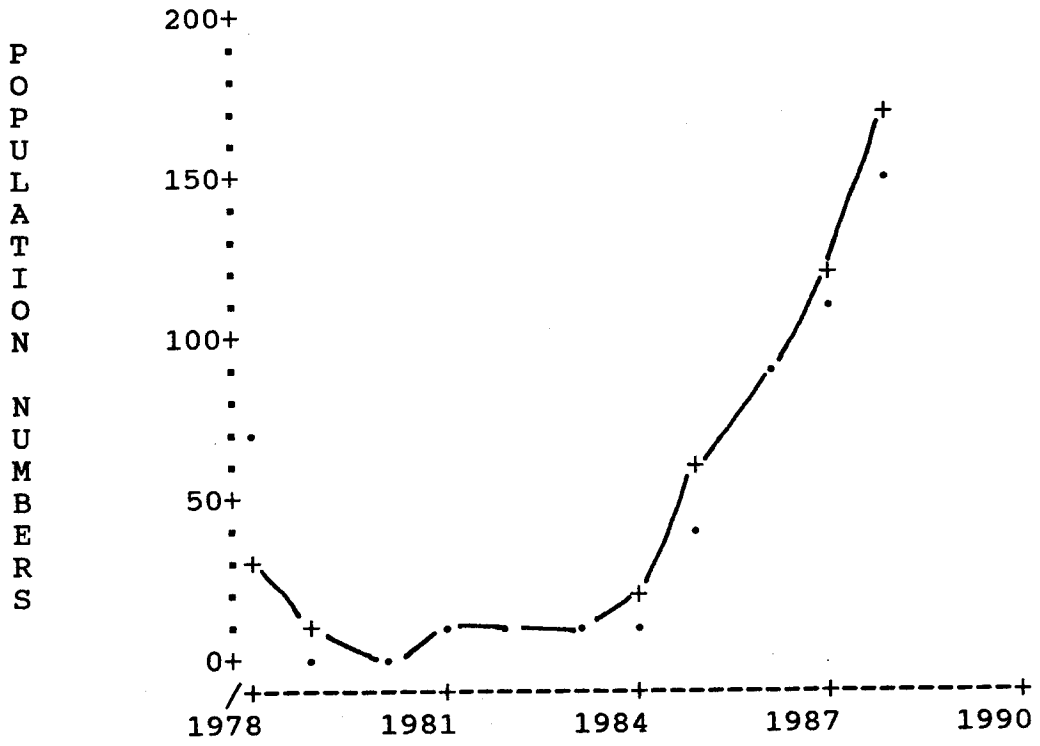


Figure 11c)

AGE 8



AGE 9

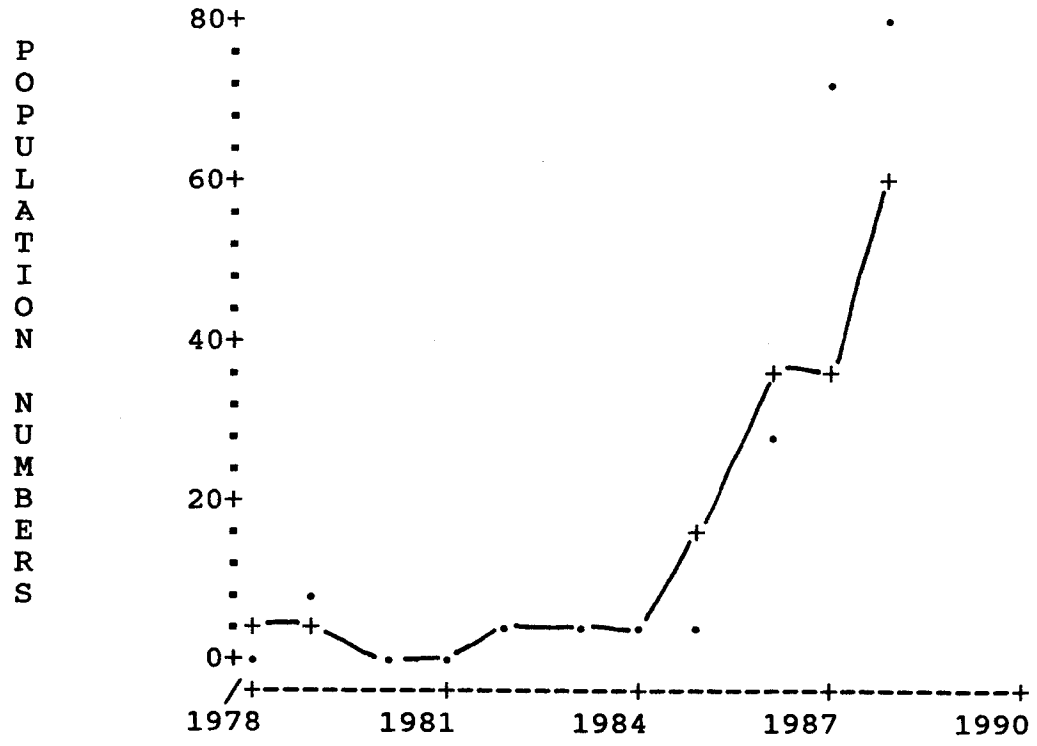


Figure 11d)

AGE 10+ PLOTS

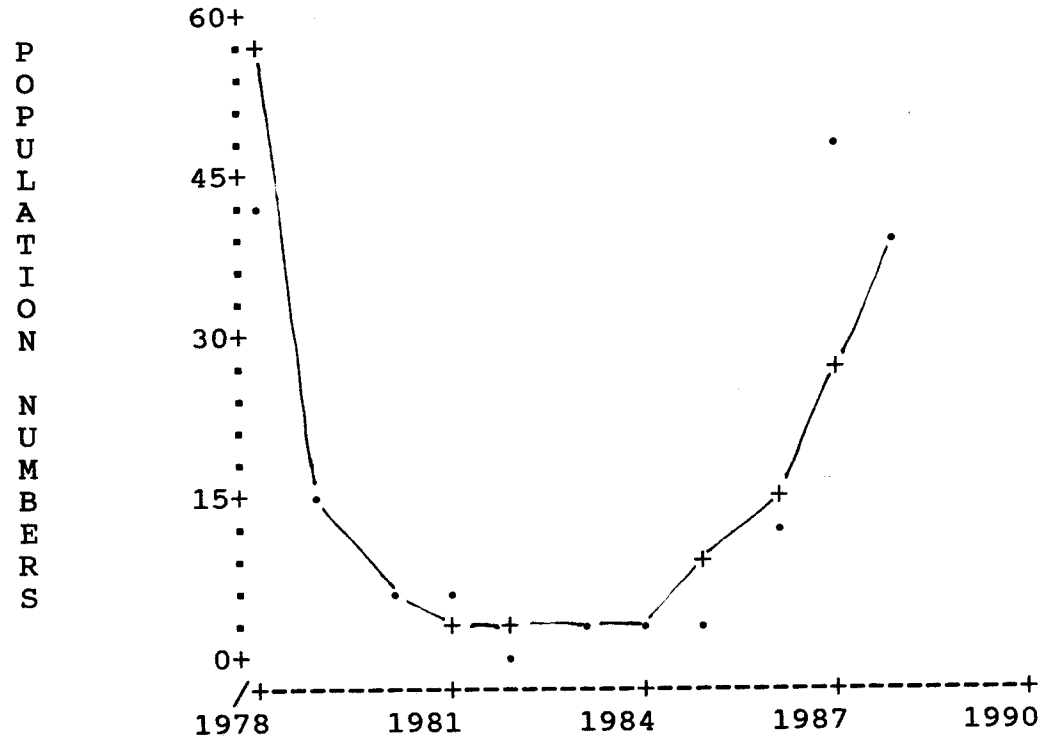


Figure 12 Catch biomass at age for fall spawners in 1988 fishery. Predicted values were estimated from last year's assessment.

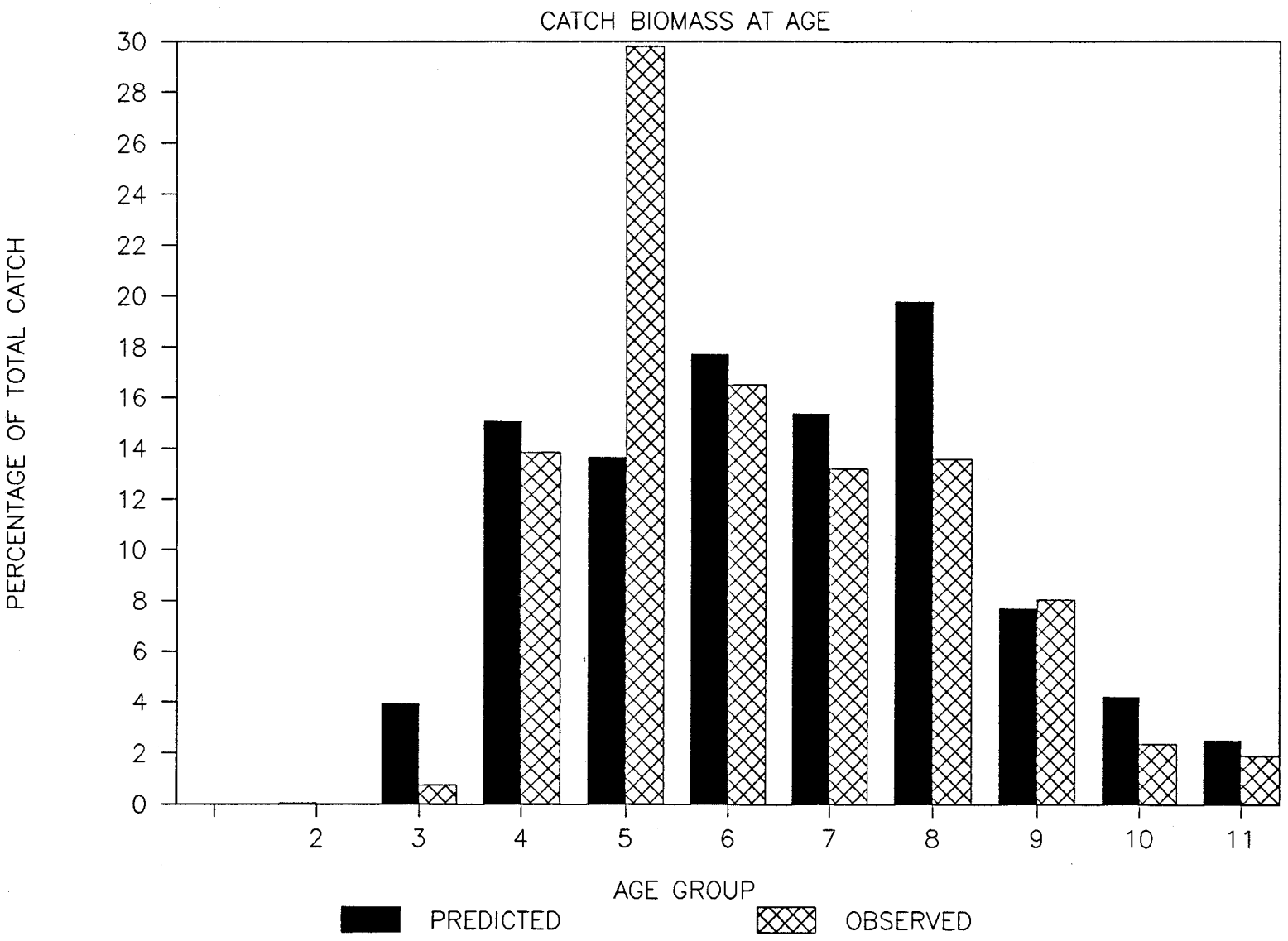


Figure 13 Trends over time of population numbers of fall spawners at age compared between last year's and this year's assessment.

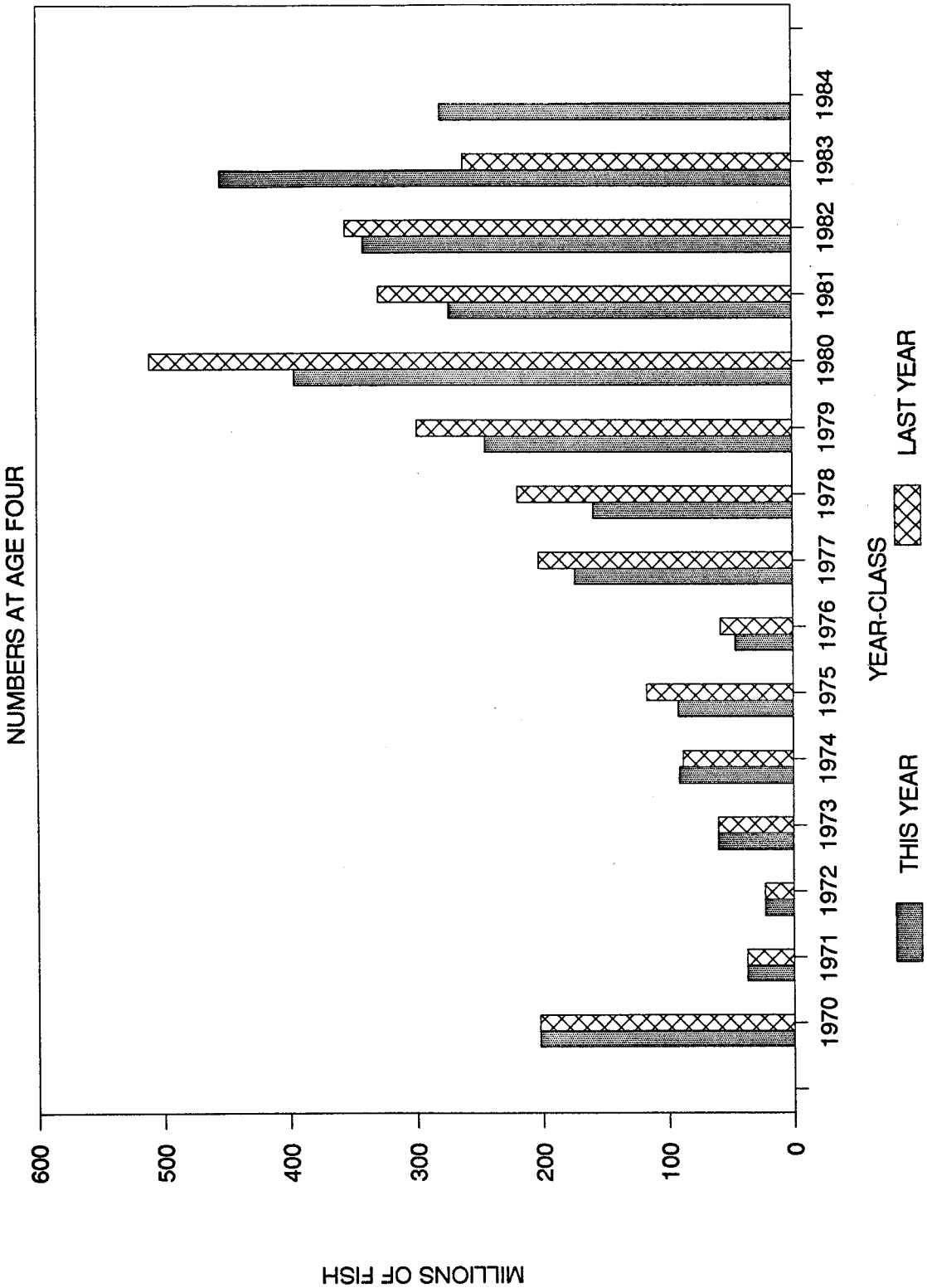


Figure 14 Trends over time of mature population biomass of fall spawners, 1974 - 1988.

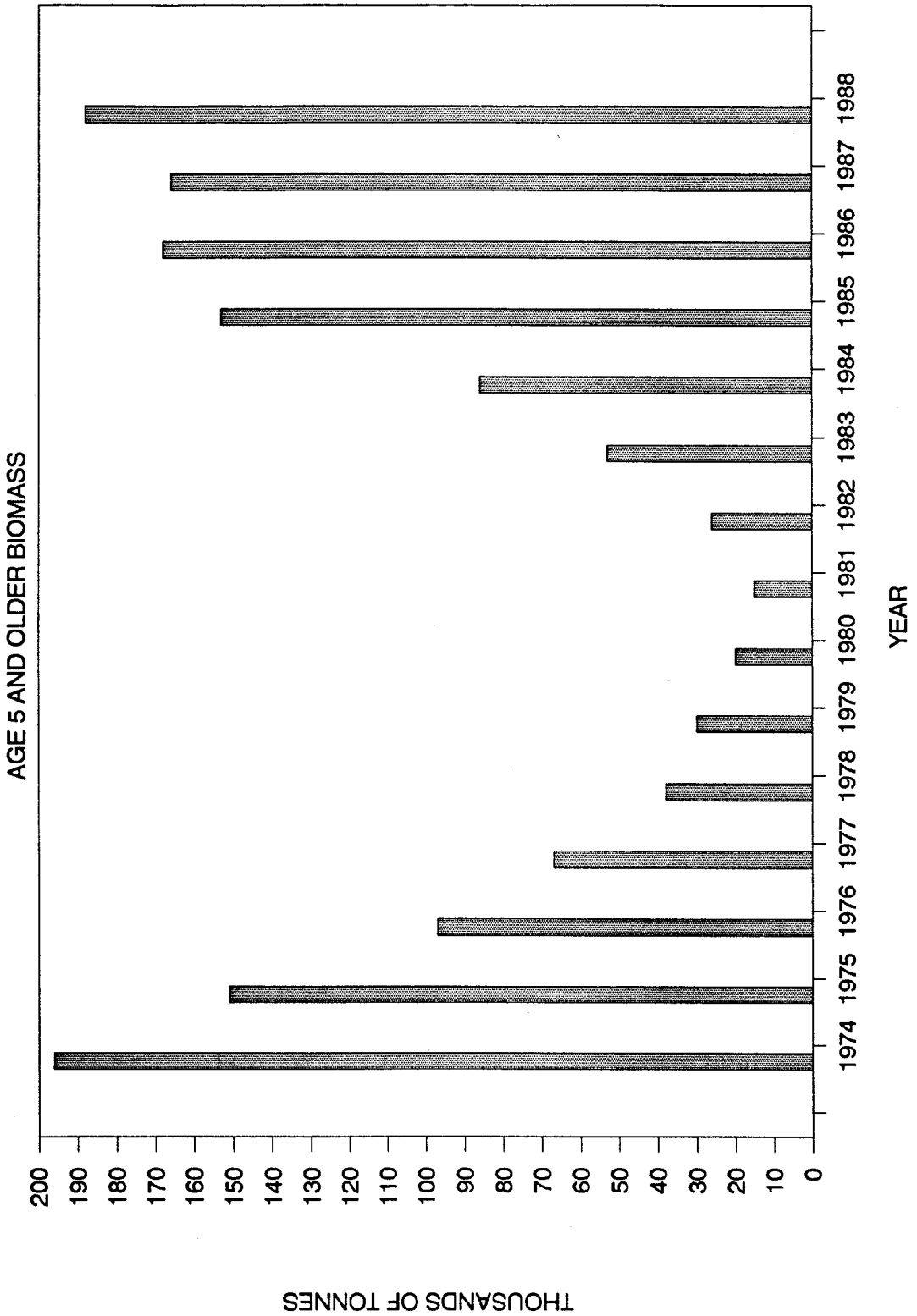


Figure 15 Variation in median date of catches of herring taken in the inshore gillnet fishery in the seven most important Statistical Districts in the southern Gulf of St. Lawrence spring fishery and the six most important Statistical Districts in the fall fishery. The vertical lines indicated dates when 25% and 75% of the catch was taken.