Canadian Atlantic Fisheries
Scientific Advisory Committee

CAFSAC Research Document 87/80

Comité scientifique consultatif des
pêches canadiennes dans l'Atlantique

CSCPCA Document de recherche 87/80

Assessment of Atlantic herring in NAFO Division 4T, 1987

by

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ABSTRACT

Reported herring landings in 1986 in the southern Gulf of St. Lawrence (NAFO Division 4T) were 59,031 t; 70% of the catch was taken in the fall gillnet fishery which had its largest catch since 1971 and probably the largest in history. The prognosis is more optimistic than the previous year because of large numbers of 1980 and 1982 year-classes occurring in the catch as well as high catch rates. Catch rates in the spring and fall gillnet fisheries were the highest since 1974. Fishing mortality on fully recruited age groups was estimated to be 0.40 for spring spawners and 0.36 for fall spawners. Projected landings at $F_{0.1} = 0.3$ for 1988, assuming the 1987 catch is 50,000 t, are 12,800 t for spring spawners and 23,300 t for fall spawners.

RÉSUMÉ

Les débarquements de hareng signalés en 1986 dans le sud du golfe du Saint-Laurent (Division 4T de l'OPANO) ont été de 59 031 t; 70 % des prises proviennent de la pêche au filet maillant pratiquée à l'automne, ce qui constitue la prise la plus importante de ce type de pêche depuis 1971 et, probablement la plus importante de l'histoire. Le pronostic est plus favorable que l'année précédente, parce qu'on observe dans les prises un grand nombre de poissons des classes d'âge 1980 et 1982 et que les taux de prise sont élevés. Les taux de prise pour la pêche au filet maillant au printemps et à l'automne ont été les plus élevés depuis 1974. La mortalité par pêche dans les groupes d'âge pleinement recrutés a été estimée à: 0,40 pour les reproducteurs de printemps et à 0,36 pour les reproducteurs d'automne. En supposant que les prises pour 1987 seront de 50 000 t, les débarquements prévus en 1988, pour une $F_{0,1} = 0,3$, sont de 12 800 t pour les reproducteurs de printemps et de 23 300 t pour les reproducteurs d'automne.

INTRODUCTION

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

The current assessment was conducted using the same procedures as used by Chadwick and Nielsen (1986). Nevertheless the prognosis is considerably more optimistic on the size of incoming year-classes, both for spring and fall spawners. This is due to both large numbers of the 1980 and 1982 year-classes occurring in the catch as well as significantly enhanced gillnet catch rates for both resources.

There are two recognized spawning groups: spring and fall spawners. Prior to 1965, the fishery was exploited primarily by gillnetters on spawning grounds; average landings for 1949-64 were 32,000 t. In the mid 1960's, purse seines were introduced which primarily harvested mixed stocks; landings increased to a peak of 175,000 t in 1970. 4T herring were also fished in NAFO Division 3Pn from 1966-72. Purse seines were the major gear throughout the 1970's. Since 1981, over 80% of reported landings were caught by gillnetters.

In 1986, about 87% of the catch was taken in gillnets, of which 60% was taken in fixed gillnets; the remaining 40% was taken in drift gillnets. Gillnets are set inshore, primarily on the spawning grounds. By contrast, purse seines, which took the remaining 13% of the 1986 catch, are fished offshore. Purse seines capture a mixture of stocks and generally catch younger and smaller fish than gillnets. A small precentage of herring was caught in traps and miscellaneous gears, but because these gears are set inshore their landings have been included with gillnets.

Quotas or total allowable catches (TAC) have been established since 1972. From 1974-81, the TAC ranged from 45,000 to 60,000 t but it was never achieved. From 1981-85, the TAC ranged from 15,000 to 20,000 t but was exceeded each year by at least 30%, except in 1985 when the TAC of 32,500 t was almost achieved; however, unreported landings indicate that the 1985 TAC may have been exceeded by about 30% (Chadwick and Nielsen 1986). In 1986 CAFSAC adjusted the original scientific advice of 9,100 t for spring spawners and 16,000 t for fall spawners (Anon. 1986a) to 7,900 t for spring spawners and 23,400 t for fall spawners (Anon. 1986b).

The 1986 TAC was established at 43,375 t and partitioned as follows: 7,200 t for the spring gillnet fishery, 27,500 t for the fall gillnet fishery, and 8,675 t for the purse seine fishery. The spring gillnet fishery was managed by seasonal quotas, i.e. 4,000 t of herring could be caught between January 1 and May 21; 2,200 t between May 22 and May 31; and, 1,000 t between June 1 and June 30. The fall fishery was managed by a global quota and weekly closures in order to ensure an equitable distribution of catch.

The 1987 TAC of 60,250 t, has been divided as follows: spring fishery - 8,200 t for gillnets and 2,050 t for purse seines; fall fishery - 40,000 t for gillnets and 10,000 t for purse seines.

INPUT DATA

1986 Landings

Preliminary 1986 landings were available from the Gulf Region purchase slip file: total landings were 59,031 tonnes which was 36% greater than the TAC and nearly twofold the CAFSAC advice. The 1986 landings were the fifth highest on record for Area 4T, excluding Magdalen Islands (Figure 1).

The landings have been divided into the spring and fall spawning groups in the table below:

Year	1979	1980	1981	1982	1983	1984	1985	1986	1987
TAC	55	55	16	15	20	19	32.3	43.4	60.3
Catch									
Spring	18	20	9	8	10	6	9	17	-
Fall	30	21	13	12	16	19	22	42	-
Total	48	40	21	24	26	27	31	59	-

The following general points can be made with reference to the 1986 nominal catches. First, the largest monthly catch was taken in September (Table 1): in 1986, 50% of the annual catch was taken in this month; in 1985, it was also 50%. Second, 70% of the catch was taken in the fall gillnet fishery which had its largest catch since 1971 and probably the largest in history (Table 2). Third, the fall 1986 purse seine catch was the largest since 1980. Fourth, about 5% of the 4T catch was landed in Quebec.

It is also worth noting the very clumped distribution of catches in the purse seine fishery. The location of sets for the 1985 fishery is indicated in Figure 2, and for the 1986 fishery in Figures 3 and 4. In both years, almost all sets were within several kilometers of Grande Rivière.

In 1986, slightly more than 1% of total landings were officially recorded on Supplementary-B slips (slips filled out monthly by fishery officers to estimate landings not sold to plants): 654 t from the spring fishery (January-June), and 64 t from the fall fishery (July-December). About 4% of catch was recorded on Supplementary-B slips in 1985.

In 1986, unreported landings were again estimated from a survey of gillnet fishermen (Nielsen 1987). The greatest fraction of unreported landings occurred in the Acadian Peninsula and Escuminac areas. Unreported landings comprise catch used for bait or personal use and not sold to plants. Supplementary B slips are supposed to estimate this part of the catch. As in 1985, unreported catches would increase the landings in the spring fishery by almost twofold. There would be only a slight increase of landings in the fall fishery because 99% of the landings were sold to plants.

The assessment was not calculated using an estimate of unreported gillnet landings because it was not possible to adjust years before 1985.

Based on antecdotal information from the fall purse seine fishery, it is possible that landings in this fishery have been under reported by 40% since 1981.

Tagging studies have shown that 4T herring are caught in Sydney Bight (NAFO Subdiv. 4Vn), where a late fall purse seine fishery occurs. It is not possible to estimate accurately the quantity of 4T herring caught in that fishery because herring from other stocks may also be present.

ABUNDANCE INDEX

Gillnet fishery catch rates:

The abundance index was calculated from the catch per net per trip in the gillnet fishery. Catch per trip data were aggregated across areas and months, 1973-86, for five areas for the spring and fall fisheries. The spring fishery occurs up to June 30 and the fall fishery during the last half of the year.

The five areas were (Figure 5): Caraquet (Statistical Districts (S.D.) - 65, 66, 67), Escuminac (S.D. - 73, 75), Shediac (S.D. - 78, 80), Pictou (S.D. - 11), and North P.E.I. (S.D. - 82, 92). These areas were selected because they are areas of major gillnet landings and because most of their catch is from discrete spawning aggregations (Messieh 1984). From 1983-86, 80% of spring catches and 50% of fall catches were from these areas (Table 3).

The annual catch per trip for each area is summarized in Table 4; 1973-83 data were taken from Messieh (1984). There were no correlations over time of catch rates among areas within the spring, and fall fisheries. This result suggested that, within fishing season, stock abundance was independent in each of the five areas. There were several significant correlations between fishing seasons, however, which suggested that factors which affect abundance may not be independent among areas. For example, the spring Escuminac fishery was positively correlated with the fall Pictou fishery ($p=0.01$); and the spring Shediac fishery was positively correlated with the fall P.E.I. ($p=0.01$) fisheries.

The monthly catch rate data were analyzed by area, month and year, separately for the spring and fall fisheries, using the multiplicative model of Gavaris (1980) in a revised STSC APL version written by D. Gascon, Quebec Region (STANDARD.WS Version 1.0). For the spring fishery, 58% of the standardized catch rate could be explained by the model, due to variation among areas and months (Table 5). There was no significant annual variation or trend in the standardized catch rate. Similar results were obtained for the fall fishery (Table 5) and the standardized catch rates were not used as an index of abundance for either fishery.

The number of nets was estimated from a series of five questionnaires which were sent to fishermen in recent years:

Years Surveyed	Year of Survey	Reference
1971-79	1978-79	O'Boyle and Cleary (1981)
1980-82	1983	Cleary and Hamel 1986
1983	1984	Ahrens, unpublished
1983-85	1985	Nielsen (1986)
1986	1986	Nielsen (1987)

The number of nets used in the spring and fall fisheries was calculated using a number of assumptions. First, the number of nets used per fishing trip in the spring fishery was estimated from the average number of nets in the Chaleur area (S.D. 63-68) and Escuminac area (S.D. 70, 73, 75-78, 80, 82, 83, 92), weighted by the proportion of catch in the two areas.

There has been a dramatic decline in the number of nets in the fall fishery since 1982. It is believed that the variation in nets fished per trip is inversely related to stock abundance. The influence of other factors, such as the recent change towards a roe fishery and the imposition of boat quotas and perhaps an emphasis towards catching mature fish on the spawning grounds, was not known. However, the use of boat quotas has been localized and not felt to have greatly affected aggregate catch rates.

Second, although questionnaires cover a broader area and more Statistical Districts than included in the time series of catch rates taken from Messieh (1984), they were assumed to be equivalent because there was considerable overlap of Statistical Districts in both data sets.

Third, the time series from 1980-86 was adjusted to be consistent with the years 1971-79 by including only fishermen who sold more than 50% of their catch to plants. The adjustment was necessary because fishermen who sell their catch to plants use twice as many nets as fishermen who keep their catch. The 1986 survey indicated that the number of nets used in the fishery had not changed since 1984:

The abundance indices for the spring and fall fisheries, are presented in Table 6. It is clear that the 1986 catch rates were the highest since 1974. Values in the fall fishery were significantly correlated ($p < 0.01$) with results from the multiplicative model (monthly purchase slip data). The spring catch rate showed a similar trend to the multiplicative model but they were not correlated.

Purse seine fishery catch rates:

Catch rates (tonnes per set) in the purse seine fishery were available from logbooks sent annually to Statistics Branch by the fishermen. These

data were summarized by month 1971-79 by Winters and Moores (1980) who used an unweighted mean to calculate an annual catch rate. Logbooks from 1980-85 were summarized and the unweighted means were calculated as before (Table 7). The unweighted means were significantly correlated ($P < 0.01$) to the catch per net per trip in the fall gillnet fishery (Table 6). Because only about 20% of landings are taken by this fishery, this catch rate series was not used as an abundance index.

Index fishermen:

In the fall of 1986 an independent abundance index was initiated with the assistance of 15 index fishermen. The fishermen were distributed as follows: five in Area 438 (Caraquet), three in Area 436 (Nortwest P.E.I.), three - Area 432 (Fishermen's Bank), and four - Area 433 (Pictou). The following statistics were available:

Statistic	Mean	S.D.
No. of trips	11.1	4.2
No. of days fished	11.1	4.2
No. of nets/trip	6.0	
Catch/net/trip	1.12	0.61

It is noteworthy that the catch rate is very similar to the fall catch rate of 1.14 from the purchase slip file. Variation in daily catch rates and variation among areas are shown in Figure 6. It is evident in Figure 6 that there are pronounced patterns in the daily variation in catch tables which should be examined in greater detail next year.

Catch and Weight at Age

Spawning groups for each sample collected in 1986 were assigned in the following manner: 1) in the gillnet fishery, fish in maturity stage 5-7 were assumed to spawn during the season of capture; 2) in the fall purse seine fishery, fish in maturity stage 4 were assumed to spawn in the spring; and 3) for all other maturity stages, a discriminant function based on otolith morphometry was used if the probability of correct classification was higher than 75%. All remaining fish (<10%) were not used. Samples taken 1971-86 are summarized in Table 8.

Although the above technique is consistent with previous years, it is different from the technique currently used in 4R and 4S. A blind test of spawning assignment showed 78% agreement between the ager and the discriminant function, but there is concern about assigning spawning groups by using otoliths for maturity stages other than stages 5-7.

The macroscopic method of assigning maturity stages was compared to that used in 4R and 4S (McQuinn 1987). Generally our technique tended to assign earlier maturity stages, whereas, McQuinn's technique assigned more stages 3 and 8 (Table 9).

Catch and weight at age matrices were calculated using stratified samples for 1984, 1985, and 1986 and random samples in previous years. Gillnet fisheries in NAFO Division 4T were divided into three groups for each spawning group, including: NAFO Unit Areas 431-4, Area 436, and Areas 437-9. These areas were further subdivided into the spring (Jan.-June) and fall (July-Dec.) fisheries. A seventh group included all fish taken by purse seines. Landings in three areas for 1985 and 1986 are given in Table 10. A computer program called HERCTA was used to combine the age-length keys and length-frequency data within each group and to weight the numbers at age by the landings. In 1986, HERCTA was modified slightly to weight length frequencies by trip weights. It was also necessary to redo the catch at age for 1985 samples. Prior to 1985 samples were collected randomly and no changes were required.

The percentage of the catch by spawning group in the spring and fall fisheries, 1980-86 are summarized in Table 11. The percentage of spring spawners in the fall purse seine fishery for areas 437-439 was 61% in 1986.

The mean weight-at-age matrix for spring and fall spawners, 1974-86 is shown in Table 12.

The catch-at-age matrix was calculated separately for spring and fall spawners in the gillnet and purse seine fisheries (Tables 13 and 14). It was truncated at age 11+ to be consistent with previous assessments (Clay and Chouinard 1986). The cross products of the 1986 mean weights and catches at age were within 1% of the reported catch.

The landings in the gillnet fishery by spawning group (cross products of Tables 13 and 14) were divided by the catch rate (catch/net/trip of Table 6) to obtain an effort index (Table 15). This effort index, in numbers of net-trips, was used to calibrate the VPA.

It is interesting to note that the size and age distribution of herring caught in the fall fisheries of areas 4Th (Pictou) and 4Tn (Chaleur Bay) were quite different in 1986. The length-frequency distributions are shown in Figure 7 for fish taken by the same size of gillnet (2 5/8"). There were fewer small fish taken in Chaleur Bay. The age distributions for the two areas is compared for the years 1984 to 1986 in Table 16. Again, it is clear that in 1986, more younger herring especially the 1982 year-class, were caught in the Pictou area. There appeared to be little difference between the two areas in 1984.

Partial Recruitment

Partial recruitment for the spring fishery was calculated using selectivity curves for the gillnet fishery and the assumption that all mature herring were available to the purse seine fishery. The mesh selectivity at age was updated using results of mesh size distribution from the 1986 survey. Spring spawners were considered to be fully recruited at ages 4, 5, and 6.

The essential steps are as follows: selectivity curves were known for mesh sizes of 2.25, 2.50, 2.63, and 2.75 inches (Ahrens 1985a); curves for eight other mesh sizes, ranging from 1.63 to 3.25 inches, were interpolated and extrapolated using the average variance, skewness and kurtosis of Ahren's curves and the Gram Charlier series; selectivity at age was obtained by multiplying the selectivity at length by the age-length key; 1986 gill net landings were separated according to mesh size (Table 17) using Nielsen's (1987) survey of fishermen; the combined selectivity at age was weighted by landings at each mesh size for the spring and fall fisheries; immature fish were assumed to be not on the spawning grounds; and, maturities at age in the gillnet fishery were taken from samples from the fall purse seine fishery. The maturities at age are shown below:

	2	3	4	5	6
Spring	0.24	0.84	0.97	1.00	1.00
Fall	0.14	0.21	0.96	1.00	1.00

Selectivity at age for the purse seine fishery was assumed to be 1.0 for age 3 and older; 61% of purse seine catches were assumed to be spring spawners; and finally, purse seine and gillnet catches at age were combined and normalized at the age with the highest catch.

These partial recruitment patterns were consistent with an age-structured analysis which was based on the calculation of historical PR's and the selection of terminal F's on the basis of minimizing residuals along a cohort.

There was no basis for changing the PR for fall spawners. An analysis of selectivity of gillnet and purse seine fisheries indicated that it had not changed in 1985 and 1986. The flat-topped PR was also consistent with results of the age-structured analysis described above.

The partial recruitment values selected for this assessment and those used in the previous three assessments are summarized in Table 18.

Natural Mortality

As in previous assessments natural mortality was assumed to be 0.2.

Fishing Mortality

F (11+): Fishing mortality rates at older ages were calculated by assuming the F's on the 11+ were equal to the F's on the 10 year olds as described for 4R herring.

F (1986): The gillnet catch rate was broken down across ages by using the gillnet sampling data. Fully recruited F was chosen on the basis of regressions between spawning group gillnet catch numbers at age per unit effort and estimated beginning of year VPA spawning group population numbers at age for the converged part of the matrix (1974-82). The VPA was calculated using the APL workspace FISH, Version 1.0 written in STSC APL (Rivard 1982). Unlike last year, preliminary regressions indicated an intercept of zero. Consequently the tuning regressions were forced through the origin. The selection criteria were based upon maximizing the correlation coefficient and minimizing the sum of squared standardized residuals of the last four years (1983, 1984, 1985, and 1986). This was repeated individually for the fully recruited ages-4, 5, and 6 for spring spawners and 5, 6, and 7 for fall spawners.

ASSESSMENT RESULTS

Spring Spawners

The optimization changed slowly with fishing mortality:

		F		
Age	Criterion	0.3	0.4	0.5
4	R^2	0.685	0.720	0.725
	SS Residual	1.7	1.2	0.9
5	R^2	0.756	0.704	0.635
	SS Residual	0.7	0.6	0.5
6	R^2	0.913	0.899	0.867
	SS Residual	0.4	0.2	0.2

A fishing mortality which was selected from the middle of the optimal range.

The fully recruited F in 1986 was estimated to be 0.40. This analysis generated a fully-recruited F in 1985 of 0.28, consistent with last year's estimate of 0.3. The resulting cohort analysis indicated that the 1979, 1980 and 1981 year-classes were dominant and the 1982 year-class was average. Together, the 1979 and 1980 year-classes comprised over 50% of the catch biomass. The population estimates, compared to those derived last year, are:

		Year										
		76	77	78	79	80	81	82	83	84	85	86
This year	Age 2 Recruit Nos. (x10^6)	330	50	52	116	109	240	176	149	97	118	118
	Age 4-10 Biomass (kt)	32	24	44	25	14	10	12	34	42	56	55
Last year	Age 2 Recruit Nos. (x10^6)	291	38	45	93	97	228	110	64	34	96	-
	Age 4-10 Biomass (kt)	37	24	36	20	11	8	13	33	35	36	-

The beginning of year population numbers, fishing mortality and mean population biomass are shown in Table 19. The current assessment is predicting much stronger 1980, 1981 and 1982 year-classes.

Fall Spawners

Again, the optimization changed slowly with fishing mortality, with a slight increase in R^2 at F=0.36:

		F		
Age	Criterion	0.32	0.36	0.38
5	R^2	0.622	0.626	0.626
	SS Residual	1.27	1.19	1.16
6	R^2	0.902	0.903	0.901
	SS Residual	0.24	0.21	0.20
7	R^2	0.824	0.829	0.828
	SS Residual	0.32	0.27	0.25

The fully recruited F in 1986 was estimated to be 0.36. This analysis generated a fully-recruited F in 1985 of 0.18 which compares to last year's F of 0.25. The 1980 and 1982 year-classes dominated. Together they comprised 48% of the catch biomass. The population estimates, compared to those derived last year, are:

		Year										
		76	77	78	79	80	81	82	83	84	85	86
This year	Age 2 Recruit Nos. ($x10^6$)	136	169	76	265	244	314	383	204	318	159	159
	Age 5-10 Biomass (kt)	74	50	32	20	14	13	20	43	65	103	91
Last year	Age 2 Recruit Nos. ($x10^6$)	137	159	72	260	197	216	280	211	86	139	-
	Age 5-10 Biomass (kt)	55	42	29	20	14	12	18	35	44	64	-

The beginning of year population numbers, fishing mortality and mean population biomass are shown in Table 20. Trends over time for some of the population parameters is shown in Figure 8. The current assessment is predicting much larger 1979, 1980 and 1982 year-classes. The age specific calibration plots are given in Figure 9. The four regression lines fit the data fairly well; that for age 4 was not used in the calibration but, nevertheless, illustrates the fit of the 1986 point (1982 year-class) to the line. The time trends (Figure 10) for ages 4 and 5 present evidence for a trend in the residuals. It is also evident in Figure 9 that the model for these two age groups may not be linear.

PROGNOSIS

As in previous assessments the 1986 numbers at ages 2 and 3 were set by the age 2 geometric mean population numbers for the period 1974 to 1983. Projections were made using: 1974-83 geometric mean population numbers at age 2, catch in 1986, and fully recruited F. The catch in 1987 was assumed to be 10,000 t of spring spawners and 50,000 t of fall spawners. Partial recruitment and mean weights in the period 1987 to 1989 were assumed to be as estimated for the 1986 fishery.

The following input parameters were used to run the projections:

	Spring Spawners				Fall Spawners			
Age	Nos.	Catch	Wt.	PR	Nos.	Catch	Wt.	PR
2	118,223	315	.101	.05	158,700	331	.167	.001
3	96,680	5,021	.159	.53	129,905	4,372	.221	.17
4	57,398	17,265	.213	1.0	209,624	35,927	.242	.58
5	68,655	20,651	.251	1.0	95,283	26,265	.294	1.0
6	53,352	16,048	.284	1.0	127,095	35,034	.331	1.0
7	35,167	5,797	.325	.5	72,838	20,078	.374	1.0
8	10,113	1,667	.309	.5	36,796	10,143	.386	1.0
9	3,264	538	.331	.5	12,001	3,308	.404	1.0
10	710	117	.279	.5	1,941	535	.436	1.0
11	2,797	461	.299	.5	2,420	667	.424	1.0

The results are:

	Year			
Spring Spawners	1987	1988	1989	1990
Catch (t)	10,000	12,800	12,400	12,000
4+ biomass (t)	45,077	44,660	42,100	40,200
Fully recruited F	0.23	0.30	0.30	0.30
Recruitment ('000s)	118,223	118,223	118,223	118,223
Fall Spawners				
Catch (t)	50,000	23,300	21,500	20,200
5+ biomass (t)	81,500	61,900	55,500	51,100
Fully recruited F	0.52	0.30	0.30	0.30
Recruitment ('000s)	158,700	158,700	158,700	158,700
Fall Spawners (50% rule)				
Catch (t)	50,000	30,900	23,100	19,900
5+ biomass (t)	81,354	58,300	48,500	44,200
Fully recruited F	0.52	0.42	0.36	0.33
Recruitment ('000s)	158,700	158,700	158,700	158,700

The projected catch at $F_{0.1}$ level in 1987 is 31,300 for the fall spawners. The 1987 TAC is 50,000 for this fishery. This catch will reduce the 1988 projected catch at $F_{0.1}$ by 16%.

Compared to the 1985 projections, 1987 catches at $F_{0.1}$ have increased by 30% for both spawning groups.

As noted above, the age 2 and 3 population estimates in 1986 are based on geometric mean recruitment. The impact of these year-class size estimates on projected yield is:

	Percent of Projected yield				
	1986	1987	1988	1989	1990
Spring Spawners	5	46	67	81	87
Fall Spawners	2	16	39	58	74

ACKNOWLEDGEMENTS

We would like to thank Clarence Bourque and Colin MacDougall for collection of samples and ageing; Robert O'Boyle for his many suggestions; and Shirley Gauthier and Rita Gautreau for typing the manuscript.

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Table 1. Herring landings in NAFO Division 4T, 1967 to 1986 (t).

YEAR	Jan.	Feb.	Mar.	Apr.	May.	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	TOTAL
1967	1742	--	--	409	25220	8764	5679	10718	4620	1358	3095	1131	62736
1968	546	442	806	6455	24239	2566	15847	19768	22350	5284	13057	770	112130
1969	--	--	73	9329	17701	6568	35476	46987	22448	4169	11543	121	154415
1970	--	55	--	21211	15782	2545	51002	36860	24959	18506	3831	746	175497
1971	--	--	42	10644	11895	4809	41521	23067	36282	5163	1053	370	134846
1972	--	--	--	400	6102	2583	11034	9092	14453	7777	2108	41	53590
1973	--	--	--	1876	12801	4221	2135	7737	9436	2079	69	3	40357
1974	--	--	--	1302	14474	1190	2958	3143	7282	3081	1714	9	35153
1975	--	--	--	4028	20229	1428	289	2398	4646	8986	2256	305	44565
1976	--	--	--	8461	14406	961	193	1082	1807	5244	6973	326	39453
1977	--	--	--	7625	8338	8850	244	2125	1148	7166	8726	602	44824
1978	240	--	--	2046	13363	883	526	2487	10095	13672	6981	2848	53141
1979	--	--	--	14072	6158	1113	680	1766	6381	5071	9904	2598	47743
1980	80	--	15	10458	9220	1032	910	2224	1952	9011	5001	540	40443
1981	--	--	13	1736	4566	729	1588	5119	3986	2171	1246	--	21154
1982	--	--	--	199	5667	876	442	5592	8047	3122	36	--	23981
1983	--	--	--	263	7282	1000	851	10291	2735	2160	1291	--	25873
1984*	--	--	--	188	5998	531	964	5747	8182	5433	184	--	27227
1985*	--	1	6	204	5237	577	776	5775	14675	3476	561	--	31288
1986*	--	--	--	610	5955	299	38	12240	28635	7203	4051	--	59031

*preliminary

Table 2. Catches (t) of herring by gear and by season in NAFO Division 4T 1971-1986. 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*	6717	17701	0	2809	27227
1985*	6037	21566	0	3685	31288
1986	7828	39956	0	11247	59031

*preliminary

Table 3. Combined landings in Statistical Districts 11, 65, 66, 67, 73, 75, 78, 80, 82 and 92 as a percentage of landings in gillnets and other inshore gears and of total landings in NAFO Division 4T. Spring fishery includes landings from January to June; fall fishery includes landings from July to December.

YEAR	Percent of Gillnets and other inshore gears		Percent of Total landings in Division 4T	
	Spring	Fall	Spring	Fall
1973	48	69	30	26
1974	46	65	23	15
1975	33	70	9	18
1976	45	63	12	14
1977	40	66	7	11
1978	53	47	27	6
1979	51	41	18	9
1980	41	43	13	14
1981	35	59	35	42
1982	58	50	58	41
1983	77	59	77	47
1984	87	56	87	47
1985	71	68	71	59
1986	80	71	80	56

Table 4. Catch-per-unit-effort (tons per purchase slip, or per successful fishing trip) in spring and fall inshore gillnet fisheries of five selected areas of NAFO Division 4T 1973-1986. The Statistical Districts represented by each area are given in the table heading.

YEAR	SPRING					FALL				
	Caraquet 65,66,67	Escuminac 73,75	Shediac 78,80	Pictou 11	PEI 82,92	Caraquet 65,66,67	Escuminac 73,75	Shediac 78,80	Pictou 11	PEI 82.92
1973	3.25	2.01	0.85	--	0.95	2.78	3.21	--	1.55	--
1974	2.15	1.58	0.45	--	0.36	6.20	3.71	--	0.97	0.21
1975	0.82	1.60	0.71	--	0.99	6.76	4.59	0.09	1.27	0.25
1976	1.52	1.83	0.24	--	0.49	5.18	7.44	--	1.04	0.44
1977	3.91	2.28	0.92	--	0.54	4.93	3.55	--	1.23	0.22
1978	4.33	2.67	1.22	--	0.96	4.18	4.30	--	1.05	0.38
1979	1.90	1.68	0.59	--	1.36	2.57	7.34	0.06	0.98	0.99
1980	2.56	1.17	0.63	--	0.92	1.78	5.37	--	0.85	2.69
1981	0.75	0.87	1.19	6.81	0.82	2.27	4.95	--	1.15	3.24
1982	1.49	2.33	1.28	9.46	1.61	4.00	1.25	--	0.74	5.28
1983	1.51	2.60	0.96	0.63	1.76	4.76	0.77	--	1.34	3.77
1984	1.33	2.92	0.62	--	0.44	3.52	0.77	0.75	2.83	2.46
1985	1.20	2.95	1.52	0.92	0.76	5.30	0.25	8.59	3.02	5.65
1986	1.51	3.40	3.10	--	1.00	6.40	6.20	0.25	4.04	5.14

Table 5. Monthly catch rate (catch/trip) analyzed by area, month and year for the spring and fall fisheries.

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R..... .764
MULTIPLE R SQUARED..... .583

SPRING

ANALYSIS OF VARIANCE

Source of Variation	DF	Sums of Square	Mean Squares	F-Value
Intercept	1	2.575E0003	2.575E0003	
Regression	20	3.661E0002	1.831E0001	9.232
Type 1	4	1.426E0002	3.565E0001	17.977
Type 2	3	1.654E0002	5.514E0001	27.809
Type 3	13	4.638E0001	3.568E0000	1.799
Residuals	132	2.617E0002	1.983E0000	
Total	153	3.203E0003		

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R..... .520
MULTIPLE R SQUARED..... .271

FALL

ANALYSIS OF VARIANCE

Source of Variation	DF	Sums of Squares	Mean Squares	F-Value
Intercept	1	2.939E0003	2.939E0003	
Regression	21	1.792E0002	8.533E0000	3.307
Type 1	4	5.677E0001	1.419E0001	5.500
Type 2	4	8.971E0001	2.243E0001	8.692
Type 3	13	5.652E0001	4.348E0000	1.685
Residuals	187	4.825E0002	2.580E0000	
Total	209	3.601E0003		

Table 6. Catch (t) per successful trip, number of nets fished per trip and CPUE index for spring and fall inshore gillnet fisheries of NAFO Division 4T.

YEAR	Spring Fishery			Fall Fishery		
	Catch (t) per successful trip[1]	Number of nets fished per trip[2]	CPUE index tons per net per trip	Catch (t) per successful trip[1]	Number of nets fished per trip[3]	CPUE index tons per net per trip
1974	1.23	20.6	0.060	2.99	7.6	0.39
1975	1.29	30.1	0.043	3.63	7.2	0.50
1976	1.34	29.9	0.045	3.13	8.9	0.35
1977	1.89	27.9	0.068	3.56	9.3	0.38
1978	2.22	29.4	0.076	3.21	11.4	0.28
1979	1.49	34.4	0.043	1.78	11.9	0.15
1980	1.09	39.2	0.028	1.45	18.4	0.079
1981	0.92	41.4	0.022	2.15	19.3	0.11
1982	1.73	39.7	0.044	2.33	18.6	0.13
1983	1.79	22.5	0.080	3.45	7.3	0.47
1984	1.90	26.5	0.072	3.02	5.3	0.57
1985	1.81	27.2	0.067	4.59	5.2	0.88
1986	2.47	27.1	0.091	5.91	5.2	1.14

1 - For combined Statistical Districts 11, 65, 66, 67, 73, 75, 78, 80, 82, and 92.
2 - For combined Statistical Districts 63, 64, 65, 66, 67, 68, 70, 73, 75, 76, 77, 78, 80, 82, 83, and 92.
3 - For combined Statistical Districts 63, 64, 65, 66, 67, 68

Table 7. Catch (t) per set for purse seiners in Areas 433-439 of NAFO Division 4T 1971-85. The 1971-79 data are taken from Winters and Moores (1980), recent data were summarized directly from logbooks.

YEAR	Catch (t) per set			Unweighted mean
	Sept.	Oct.	Nov.	
1971	47.2	59.4	63.6	56.7
1972	37.1	53.9	44.3	45.1
1973	49.1	--	--	--
1974	28.3	35.4	50.0	37.9
1975	32.1	37.8	33.5	34.5
1976	27.3	44.5	50.6	40.6
1977	39.5	53.1	40.6	44.4
1978	44.1	33.1	55.7	44.3
1979	31.3	19.9	22.2	24.5
1980	28.3	26.8	18.1	24.4
1981	--	22.2	46.2	34.2
1982	23.6	45.8	--	34.7
1983	--	33.4	71.0	52.2
1984	--	42.6	2.5	22.6
1985	--	53.6	101.5	77.6
1986	--	75.7	97.0	86.3

Table 8. Summary of samples taken for ageing of herring in NAFO Division 4T.

YEAR	Gillnet		Purse Seine	
	Spring	Fall	Spring	Fall
1971	2266	549	547	1046
1972	350	396	--	419
1973	1209	997	151	800
1974	1541	670	1074	1225
1975	3988	907	1934	621
1976	3067	696	1605	838
1977	1612	379	1559	2127
1978	5186	1462	896	2403
1979	7408	2258	1154	4204
1980	4850	194	1746	299
1981	2601	2245	95	549
1982	5240	1520	--	--
1983	878	2361	--	1102
1984	861	4077	--	2186
1985	457	999	--	437
1986	599	1107	--	680

Table 9. 1986 Comparison of Gulf and Quebec maturity assignments.

Areas 431-435

male	Jan-June					July-Dec				
	Que	3	4	5	8	Que	3	4	5	8
Gulf	3	0	0	0	4	3	0	0	0	0
	4	3	22	15	0	4	0	0	4	0
	5	0	2	3	0	5	0	0	17	0
	8	0	0	0	13	8	1	0	0	17

Areas 431-435

female	Jan-June					July-Dec				
	Que	3	4	5	8	Que	3	4	5	8
Gulf	3	1	0	0	4	3	0	0	0	1
	4	1	8	22	0	4	1	2	3	0
	5	0	1	17	0	5	0	1	19	0
	8	0	0	0	5	8	3	0	0	9

Areas 436

male	Jan-June					July-Dec				
	Que	3	4	5	8	Que	3	4	5	8
Gulf	3	0	0	0	1	3	0	0	0	0
	4	2	8	2	0	4	0	0	0	0
	5	0	0	1	0	5	0	0	0	0
	8	3	0	0	3	8	0	0	0	0

Areas 436

female	Jan-June					July-Dec				
	Que	3	4	5	8	Que	3	4	5	8
Gulf	3	1	1	0	0	3	0	0	0	0
	4	0	4	5	0	4	0	0	0	0
	5	0	0	9	0	5	0	0	0	0
	8	1	0	0	2	8	0	0	0	0

Areas 437-439

male	Jan-June					July-Dec				
	Que	3	4	5	8	Que	3	4	5	8
Gulf	3	4	0	0	15	3	17	10	1	24
	4	3	5	4	1	4	29	86	59	3
	5	0	0	2	0	5	0	0	20	0
	8	0	0	0	21	8	3	0	0	93

Areas 437-439

female	Jan-June					July-Dec				
	Que	3	4	5	8	Que	3	4	5	8
Gulf	3	15	1	0	15	3	121	3	1	62
	4	1	5	10	0	4	79	23	16	0
	5	0	1	13	0	5	0	1	14	0
	8	0	0	0	12	8	15	0	0	72

Table 10. 1986 Landings divided into seven areas with separate age - length keys.

Gear	Area	Season	LANDINGS		
			Maritimes	Quebec	Total
Gillnet	431-435	Jan - Jun	2,527	328	2,855
		Jul - Dec	12,253	0	12,253
	436	Jan - Jun	3,297	0	3,297
		Jul - Dec	1,267**	0	1,267
	437-439	Jan - Jun	1,041	635	1,676
		Jul - Dec	23,906	2257	26,163
	Unknown*	Jul - Dec	273		273
Seine	437-439	Jul - Dec	11,247		11,247
Total					59,031

* Unknown included in areas 437-439 fall
** Put 436 Jul - Dec into 431-435 fall

Table 11. Proportion of spring (S) and fall (F) spawners sampled in the spring (prior to July 1) and fall fisheries in Areas 431-435, 436 and 437-439 of NAFO Division 4T, 1980-86.

Spring fishery (gillnet)

	Area 431-435				Area 436				Area 437-439			
	numbers		%		numbers		%		numbers		%	
Year	S	F	S	F	S	F	S	F	S	F	S	F
80	4208	163	96	4	941	0	100	0	94	0	100	0
81	2755	73	97	3	382	74	84	16	911	0	100	0
82	3069	1	100	0	369	0	100	0	625	0	100	0
83	0	0	0	0	590	48	92	8	94	4	96	4
84	91	33	73	27	18	2	90	10	116	20	85	15
85	114	0	100	0	233	2	99	1	67	2	97	3
86	135	25	84	16	169	35	83	17	235	53	82	18

Fall fishery

	Area 431-435 Gillnet				Area 437-439 Gillnet				Area 437-439 Purse			
	numbers		%		numbers		%		numbers		%	
Year	S	F	S	F	S	F	S	F	S	F	S	F
80	0	0	0	0	46	344	12	88	1235	474	72	29
81	0	293	0	100	7	1931	0	100	84	443	16	84
82	0	290	0	100	28	1097	2	98	0	0	0	0
83	0	879	0	100	12	1074	1	99	507	488	51	49
84	1	434	0	100	37	812	4	96	521	318	62	38
85	6	576	1	99	47	298	14	86	185	143	56	44
86	4	659	1	99	98	488	17	83	405	263	61	39

Table 12. Weight (g)-at-age matrices for spring and fall fisheries of herring in NAFO Division 4T.

SPRING WEIGHTS AT AGE 28/ 4/87

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
2	95	90	104	133	133	133	133	124	117	146	144	103	101
3	160	154	177	172	172	172	172	173	170	178	168	160	159
4	202	185	210	213	213	213	213	232	202	214	202	210	213
5	238	229	247	247	247	247	247	277	247	242	220	244	251
6	275	266	275	287	287	287	287	318	295	252	281	288	284
7	291	298	271	291	291	291	291	346	285	310	224	359	325
8	319	304	304	310	310	310	310	366	299	254	320	409	309
9	320	316	310	348	348	348	348	376	305	398	312	428	331
10	328	329	333	324	324	324	324	369	312	375	241	324	279
11+	348	357	353	359	359	359	359	413	420	385	216	359	299

FALL WEIGHTS AT AGE 28/ 4/87

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
2	47	40	35	119	119	119	119	76	94	143	137	119	167
3	126	115	111	177	177	177	177	143	151	174	214	249	221
4	190	169	184	245	245	245	245	242	155	249	244	279	242
5	235	215	217	283	283	283	283	273	189	285	290	312	294
6	255	248	253	313	313	313	313	317	237	317	306	355	331
7	283	272	276	338	338	338	338	326	324	343	344	384	374
8	314	288	283	359	359	359	359	348	237	262	367	404	386
9	327	314	300	380	380	380	380	394	285	365	380	405	404
10	331	325	323	364	364	364	364	328	380	348	416	423	436
11+	354	362	349	395	395	395	395	427	389	398	361	395	424

Table 13. a) Catch-at-age matrices for spring spawning groups in the gillnet and purse seine fisheries of NAFO Division 4T.

	SPRING SPAWNERS CATCH AT AGE												1/ 5/87
	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
2	5260	1521	15931	3351	14434	21741	21382	6141	924	424	207	125	315
3	8736	27837	8498	58673	14121	13689	42580	17775	33383	10821	3476	8473	5021
4	3285	18829	27893	6874	65301	5856	5689	8250	6201	31206	11033	11330	17265
5	1647	3260	6746	10264	4692	33954	3096	1304	1476	3934	13838	11707	20651
6	21560	16243	2237	3563	6956	2130	15768	868	337	1104	1509	5368	16048
7	3699	20158	465	604	1277	3072	3269	4444	217	70	116	2036	5797
8	4128	2683	8805	498	1182	707	2033	755	339	50	11	364	1667
9	6245	3395	1034	6513	191	203	740	756	114	17	11	249	538
10	947	5457	1488	510	3584	718	320	108	2	2	22	1	117
11 +	2529	6157	19853	13472	1992	3488	2910	1198	110	10	34	1	461

	SPRING GILLNET CATCH AT AGE												1/ 5/87
	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
2	108	8	1	86	38	55	541	45	68	1	13	2	8
3	4911	14874	2338	13965	6459	7667	22219	13031	32597	5160	1877	6602	3882
4	1974	3710	18058	3301	27332	3056	3567	7527	6047	29194	7932	9341	12248
5	1191	1377	2307	3691	1386	20895	1406	1270	1475	3646	11970	9663	14241
6	14032	1793	535	540	1902	556	9528	785	326	1019	1195	4543	9205
7	2600	6672	97	42	315	1404	216	3197	177	36	52	1655	1961
8	2272	1925	2946	59	262	110	1074	79	332	1	0	257	284
9	2532	1628	419	1084	96	63	104	285	113	1	0	197	8
10	338	2640	292	1	1361	362	140	38	1	1	0	0	63
11 +	469	1660	2894	1497	1164	1672	2134	1009	109	1	0	0	425

	SPRING PURSE SEINE CATCH AT AGE												28/ 4/87
	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
2	5152	1513	15930	3265	14396	21686	20841	6096	856	423	194	123	307
3	3825	12963	6160	44708	7662	6022	20361	4744	786	5661	1599	1871	1139
4	1311	15119	9835	3573	37969	2800	2122	723	154	2012	3101	1989	5017
5	456	1883	4439	6573	3306	13059	1690	34	1	288	1868	2044	6410
6	7528	14450	1702	3023	5054	1574	6240	83	11	85	314	825	6843
7	1099	13486	368	562	962	1668	3053	1247	40	34	64	381	3836
8	1856	758	5859	439	920	597	959	676	7	49	11	107	1383
9	3713	1767	615	5429	95	140	636	471	1	16	11	52	530
10	609	2817	1196	509	2223	356	180	70	1	1	22	0	54
11 +	2060	4497	16959	11975	828	1816	776	189	1	9	34	0	36

Table 14. Catch-at-age matrices for fall spawners.

	FALL SPAWNERS CATCH AT AGE												1/ 5/87
	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
2	5403	96	93	205	1514	2906	1369	109	184	35	9	30	331
3	5715	2090	277	3037	19348	6217	32429	10075	9273	4782	1135	3736	4372
4	17524	4169	1758	7676	27378	35031	9995	33204	21526	23879	27519	17694	35927
5	6097	25621	5034	3604	14092	27629	23278	5971	26147	10971	16248	24072	26265
6	4235	6860	28944	3622	3973	11109	8343	2606	5663	13643	12972	12625	35034
7	10666	3262	4154	22200	3465	2323	4130	978	2344	2409	6718	5798	20078
8	2827	4854	1849	2219	13853	3128	637	977	1004	1867	1386	2144	10143
9	5444	2159	3510	1412	1606	5242	848	216	641	623	480	431	3308
10	4295	3568	737	2761	890	702	320	108	132	114	154	203	535
11+	19110	20635	16451	16704	16259	10386	2966	872	162	309	174	1	667

	FALL GILLNET CATCH AT AGE												1/ 5/87
	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
2	1	1	1	1	5	1	25	1	1	1	0	0	258
3	125	1	39	122	351	128	7254	6851	3542	792	931	2755	3605
4	4258	1602	276	1879	4389	7809	3293	28863	18645	21648	26518	16301	34220
5	1765	8163	1455	340	3104	3821	4027	5537	23280	10465	14918	21838	23241
6	515	1227	5839	253	593	1883	929	2471	5308	12544	12214	11787	30308
7	1876	742	465	3215	614	402	836	974	2250	2223	6236	5473	17661
8	180	616	243	133	3440	484	185	830	960	1782	1308	1993	9361
9	2070	403	419	81	83	694	210	104	491	589	446	332	2961
10	730	315	50	468	178	11	139	53	131	81	154	197	518
11+	4813	1800	2143	1162	1785	1418	620	866	61	260	171	0	614

	SPRING PURSE SEINE CATCH AT AGE												28/ 4/87
	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
2	5402	95	92	204	1509	2905	1344	108	183	34	9	30	73
3	5590	2089	238	2915	18997	6089	25175	3224	5731	3990	204	981	767
4	13266	2567	1482	5797	22989	27222	6702	4341	2881	2231	1001	1393	1707
5	4332	17458	3579	3264	10988	23808	19251	434	2867	506	1330	2234	3024
6	3720	5633	23105	3369	3380	9226	7414	135	355	1099	758	838	4726
7	8790	2520	3689	18985	2851	1921	3294	4	94	186	482	325	2417
8	2647	4238	1606	2086	10413	2644	452	147	44	85	78	151	782
9	3374	1756	3091	1331	1523	4548	638	112	150	34	34	99	347
10	3565	3253	687	2293	712	691	181	55	1	33	0	6	17
11+	14297	18835	14308	15542	14474	8968	2346	6	101	49	3	0	53

Table 15. An index of effort used to estimate terminal fishing mortalities for the spring and fall spawning groups of herring in NAFO Division 4T.

YEAR	EFFORT INDEX* Thousands of Net-Trips	
	Spring	Fall
1974	132	12
1975	194	7
1976	158	8
1977	76	6
1978	118	16
1979	196	32
1980	323	54
1981	283	101
1982	171	82
1983	105	30
1984	68	31
1985	112	22
1986	113	33

*Landings in the gillnet fishery (cross products of Tables 12, 13 and 14) of each spawning group divided by CPUE index (Table 6) X 1000.

Table 16. Catch at age in thousands of fish from the fall gillnet fishery in Northern and Southern parts of 4T. These numbers are for fall spawners only.

	South Areas 431-435			North Areas 437-539		
Age	1984	1985	1986	1984	1985	1986
2	0	0	234	0	0	24
3	244	944	1852	611	1471	1645
4	14875	6788	22950	10021	8139	9489
5	5117	11659	6532	7795	8893	13993
6	3737	4567	11608	3405	6685	17423
7	2196	1805	2971	2705	3533	14424
8	562	560	1561	506	1377	7772
9	302	285	317	75	47	2644
10	108	77	107	33	120	402
11+	22	0	177	140	0	407

Table 17. 1986 gillnet landings (t) by mesh size in NAFO Div. 4T.

Mesh size (inches)	Spring Fishery		Fall Fishery	
	Tonnes	Percent	Tonnes	Percent
≤ 2.000	107	1.4	226	0.5
2.125	72	0.9	135	0.3
2.250	3439	44.0	0	0.0
2.310	187	2.4	0	0.0
2.375	1191	15.2	227	0.5
2.500	1394	17.8	938	1.8
2.625	1242	15.9	40030	79.1
2.750	183	2.3	7786	15.4
2.875	38	0.5	986	2.0
3.000	0	0.0	288	0.6
3.250	13	0.2	0	0.0

Table 18. Partial recruitment for the spring and fall components of the NAFO Division 4T herring fishery used in the current and past two assessments.

	Spring				Fall			
AGE	Ahrens 1985 a	Clay & Chouinard 1986	Chadwick & Nielsen 1986	Current	Ahrens 1985 a	Clay & Chouinard 1986	Chadwick & Nielsen 1986	Current
1	0	0	0	0	0	0	0	0
2	0	0	0.001	0.005	0	0	0.001	0.001
3	0.47	0.77	0.87	0.53	0.03	0.11	0.17	0.17
4	1.00	1.00	1.00	1.00	0.50	0.53	0.58	0.58
5	1.00	0.82	1.00	1.00	1.00	1.00	1.00	1.00
6	0.50	0.58	0.51	1.00	0.85	0.73	1.00	1.00
7	0.34	0.51	0.46	0.50	0.63	0.54	1.00	1.00
8	0.20	0.40	0.46	0.50	0.53	0.31	1.00	1.00
9	0.15	0.40	0.45	0.50	0.50	0.22	1.00	1.00
10	0.15	0.40	0.45	0.50	0.50	0.18	1.00	1.00
11+	0.15	0.38	0.45	0.50	0.50	0.19	1.00	1.00

Table 19. Spring spawners results of virtual population analysis using a terminal F of 0.40: a) Population numbers in thousands at beginning of year, b) Fishing mortality and c) Mean population in biomass in kg.

a) POPULATION NUMBERS 12/ 8/87

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
2	155300	60150	336741	58598	52147	115714	109174	239964	176131	148939	97295	35433	173943
3	70324	122389	47871	261285	44944	29634	75066	70037	190909	143368	121557	79471	28897
4	30649	49671	75016	31504	160832	24020	11876	22931	41258	126097	107589	96377	57398
5	50277	22121	23630	36179	19573	72592	14367	4575	11309	28168	75003	78103	68655
6	116058	39673	15161	13243	20334	11780	28710	8961	2566	7924	19503	48886	53352
7	25426	75512	17785	10389	7618	10354	7717	9238	6552	1796	5489	14602	35167
8	52388	17470	43584	14140	7959	5082	5697	3360	3543	5168	1407	4389	10113
9	84108	39156	11875	27717	11126	5447	3521	2825	2068	2594	4186	1142	3264
10	46155	63211	28987	8787	16799	8937	4276	2213	1629	1590	2108	3417	710
11 +	35506	36931	46815	22386	6733	10511	6667	3211	1714	1332	1300	1706	2797
2+	666190	526286	647465	484228	348066	294069	267072	367317	437679	466975	435436	363526	434296
3+	510891	466136	310724	425630	295920	178356	157898	127353	261548	318036	338141	328093	260354
4+	440567	343746	262854	164345	250976	148722	82831	57316	70639	174668	216584	248623	231457
5+	409918	294075	187838	132841	90143	124702	70956	34385	29381	48571	108995	152245	174058

b) FISHING MORTALITY 12/ 8/87

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
2	.038	.028	.054	.065	.365	.233	.244	.029	.006	.003	.002	.004	.002
3	.148	.290	.218	.285	.427	.714	.986	.329	.215	.087	.032	.125	.212
4	.126	.543	.529	.276	.596	.314	.754	.507	.182	.320	.120	.139	.400
5	.037	.178	.379	.376	.308	.728	.272	.378	.156	.168	.228	.181	.400
6	.230	.602	.178	.353	.475	.223	.934	.113	.157	.167	.089	.129	.400
7	.175	.350	.029	.066	.205	.397	.631	.758	.037	.044	.024	.167	.200
8	.091	.186	.253	.040	.179	.167	.501	.285	.112	.011	.009	.096	.200
9	.086	.101	.101	.301	.019	.042	.264	.351	.063	.007	.003	.276	.200
10	.023	.100	.058	.066	.269	.093	.086	.055	.001	.001	.012	.000	.200
11 +	.082	.203	.622	1.057	.392	.452	.647	.524	.073	.008	.029	.001	.200
4+	.120	.297	.361	.370	.485	.496	.640	.438	.149	.266	.148	.149	.355

Table 19. Spring spawners results of virtual population analysis using a terminal F of 0.40: a) Population numbers in thousands at beginning of year, b) Fishing mortality and c) Mean population in biomass in kg.

c) MEAN POPULATION BIOMASS (KG) 12/ 8/87

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
2	13128249	4839924	30931594	6845448	5298138	12492496	11725612	26598284	18625021	19678589	12683844	3301557	15907500
3	9504050	14903791	6923922	35606149	5744194	3340252	7561677	9408477	26565782	22182987	18224762	10853943	3765750
4	5283075	6484866	11184228	5339300	23626627	4000523	1630292	3814371	6928159	21046436	18596161	17164213	9193613
5	10654382	4218795	4430708	6792465	3790991	11684724	2828727	962433	2350560	5704070	13423490	15846235	12958503
6	25942799	7256726	3471945	2919585	4243795	2756832	4928562	2446577	636681	1671216	4758529	11995469	11394080
7	6169025	17311814	4306927	2654000	1823058	2268399	1524931	2056087	1662182	494044	1101657	4387085	9420125
8	14499087	4405867	1065447	3897633	2053417	1318690	1269351	974342	910044	1183480	406407	1553585	2575515
9	23412023	10686202	3178675	7587958	3477033	1683579	980200	816818	554671	932363	1181948	388998	890390
10	13569938	17964472	8506253	2499462	4345007	2509853	1204713	720700	460324	540069	457926	1003250	163215
11+	10768152	10853919	11267510	4573597	1824119	2772749	1614270	943616	629979	462872	250937	554974	689195

2+	132930781	98926378	94858210	78715597	56226379	44828097	35268335	48741705	59323403	73896115	71085660	67049307	66957885
3+	119802532	94086453	63926617	71870149	50928241	32335601	23542723	22143420	40698382	54217526	58401816	63747750	51050385
4+	110298482	79182663	57002694	36264000	45184047	28995349	15981045	12734943	14132600	32034540	40177054	52893807	47284635
5+	105015407	72697796	45818466	30924701	21557420	24994825	14350754	8920572	7204440	10988103	21580894	35729594	38091023

Table 20. Fall spawners – results of virtual population analysis using a terminal F of 0.36: a) Population numbers in thousands at beginning of year; b) Fishing mortality and c) Mean population in biomass in kg.

a) POPULATION NUMBERS 12/ 8/87

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
2	42778	89497	135851	169179	76365	264654	244189	313775	383360	204361	317775	99179	1014628
3	51598	30135	73187	111141	138327	61152	214051	198686	256798	313703	167285	260164	81173
4	203435	37073	22781	59670	88247	95745	44442	145907	153554	201858	252511	135934	209624
5	49415	150702	26581	17061	41908	47477	46692	27342	89415	106242	143661	181838	95283
6	62480	34941	100202	17208	10707	21560	13872	17166	16983	49548	77057	102918	127095
7	111610	47322	22400	55849	10811	5171	7600	3808	11696	8780	28222	51351	72838
8	110350	81727	35793	14581	25638	5716	2132	2486	2233	7455	5009	17027	36796
9	135917	87789	62521	27631	9930	8456	1850	1169	1151	920	4414	2847	12001
10	138504	106353	69922	48012	21345	6677	2180	747	762	362	189	3180	1941
11 +	129733	109511	83846	56581	36810	16671	4831	1495	514	504	193	16	2420
2+	1035819	775051	633083	576911	460087	533280	581839	712581	916466	893733	996316	854453	1653800
3+	993042	685555	497232	407732	383722	268626	337650	398806	533106	689372	678541	755275	639172
4+	941444	655420	424045	296591	245396	207474	123598	200120	276307	375669	511256	495111	557999
5+	738009	618347	401264	236922	157149	111728	79157	54212	122753	173811	258745	359177	348375

b) FISHING MORTALITY 12/ 8/87

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
2	.150	.001	.001	.001	.022	.012	.006	.000	.001	.000	.000	.000	.000
3	.131	.080	.004	.031	.168	.119	.183	.058	.041	.017	.008	.016	.061
4	.100	.133	.089	.153	.420	.518	.286	.290	.168	.140	.128	.155	.209
5	.147	.208	.235	.266	.465	1.030	.801	.276	.390	.121	.134	.158	.360
6	.078	.245	.385	.265	.528	.843	1.093	.184	.460	.363	.206	.146	.360
7	.112	.079	.229	.579	.437	.686	.918	.334	.250	.361	.305	.133	.360
8	.029	.068	.059	.184	.909	.928	.401	.570	.687	.324	.365	.150	.360
9	.945	.028	.064	.058	.197	1.156	.707	.228	.956	1.381	.128	.183	.360
10	.035	.038	.012	.066	.047	.124	.177	.174	.213	.427	2.299	.073	.360
11 +	.177	.232	.243	.391	.658	1.124	1.095	1.003	.424	1.091	3.000	.074	.360
5+	.084	.131	.192	.300	.511	.942	.851	.282	.396	.221	.182	.150	.360

Table 20. Fall spawners – results of virtual population analysis using a terminal F of 0.36: a) Population numbers in thousands at beginning of year; b) Fishing mortality and c) Mean population in biomass in kg.

c) MEAN POPULATION BIOMASS (KG) 12/ 8/87

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
2	1696123	3242735	4307893	18235031	8148753	28376572	26258077	21609520	32652615	26484292	39457322	10695196	153547222
3	5535964	3022953	7348010	17567964	20484817	9266511	31472064	25046762	34462314	49068196	32328518	58262209	1578778
4	33392946	5329726	3640114	12315353	16113498	16735556	8624573	27918285	19909626	42607204	52519632	31919759	41639531
5	9813767	26603961	4677592	3859605	8664118	7729481	8350476	5938535	12763391	25897823	35426122	47684930	21449750
6	13910368	6995404	1919876	4307679	2380815	4190643	2436603	4519293	2946840	12010993	19381083	30889727	32211817
7	27137940	11230718	5026369	13115269	2702270	1159386	1546720	961909	3051077	2304677	7621310	16769399	20858811
8	30973017	20648358	8924735	4346363	5560935	1230237	575356	603238	350847	2100495	1404390	5804534	10875550
9	39413724	24654411	16484153	9254197	3114494	1759215	462149	374682	194458	168605	1430081	957834	3712311
10	40858922	30762594	20354237	15347413	6883825	2076389	661003	204425	237191	93657	28907	1176991	647944
11+	38264806	32189990	23642271	16874512	9761262	3650412	1070074	371369	148743	112692	20937	5373	785578
2+	240997578	164680849	113602250	11522385	83814785	76174402	81457097	87548018	106717102	160848634	189618303	204165951	301516292
3+	239301455	161438114	109294357	96988355	75666033	47797830	55199019	65938497	74064487	134364343	150160980	193470755	147969070
4+	233765490	158415162	101946347	79420391	55181216	38531319	23726955	40891736	39602174	85296147	117832462	135208547	132181292
5+	200372545	153084435	98306232	67105038	39067718	21795763	15102382	12973451	19692547	42688943	65312831	103288788	90541761

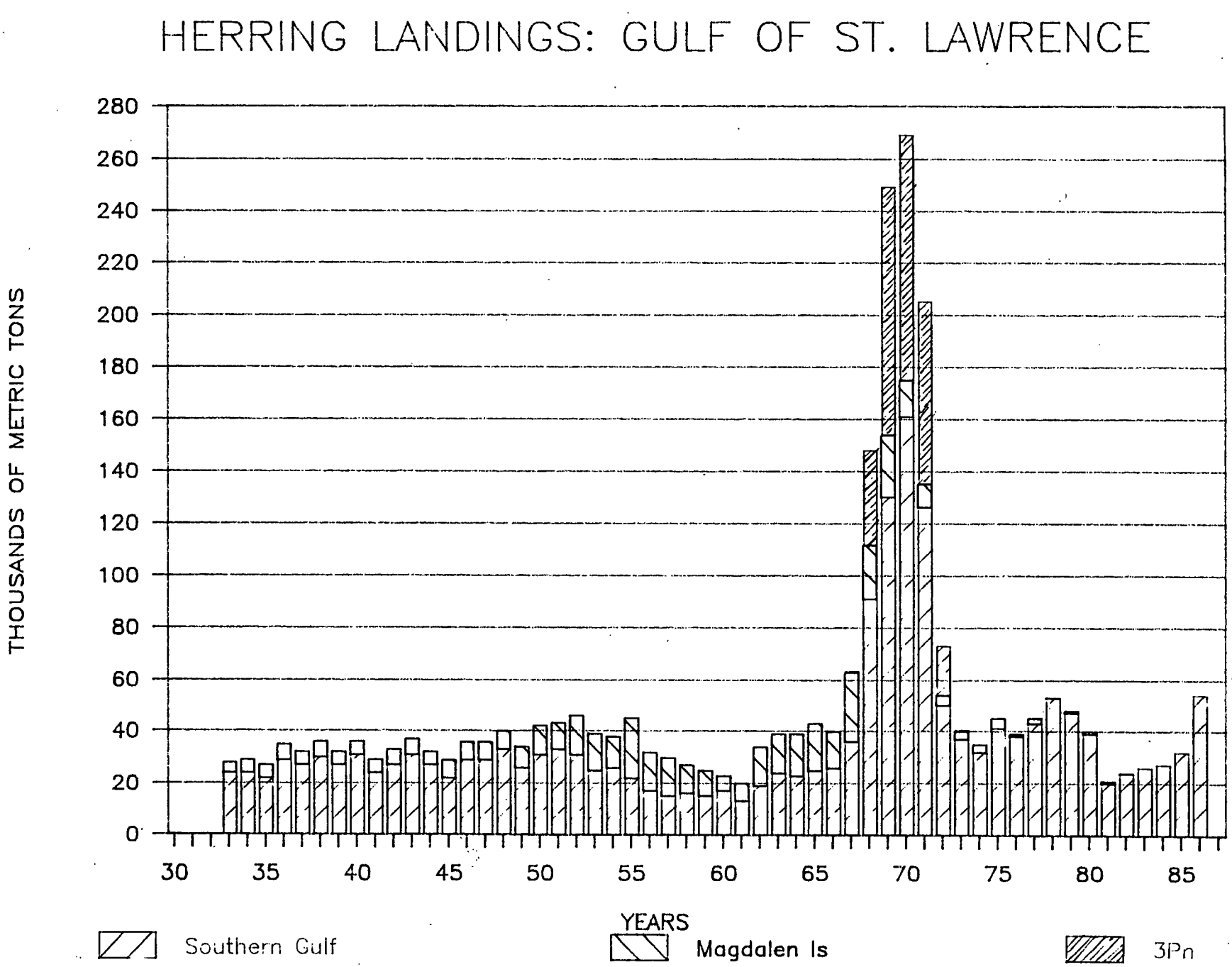


Figure 1 Landings of herring in NAFO Division 4T.

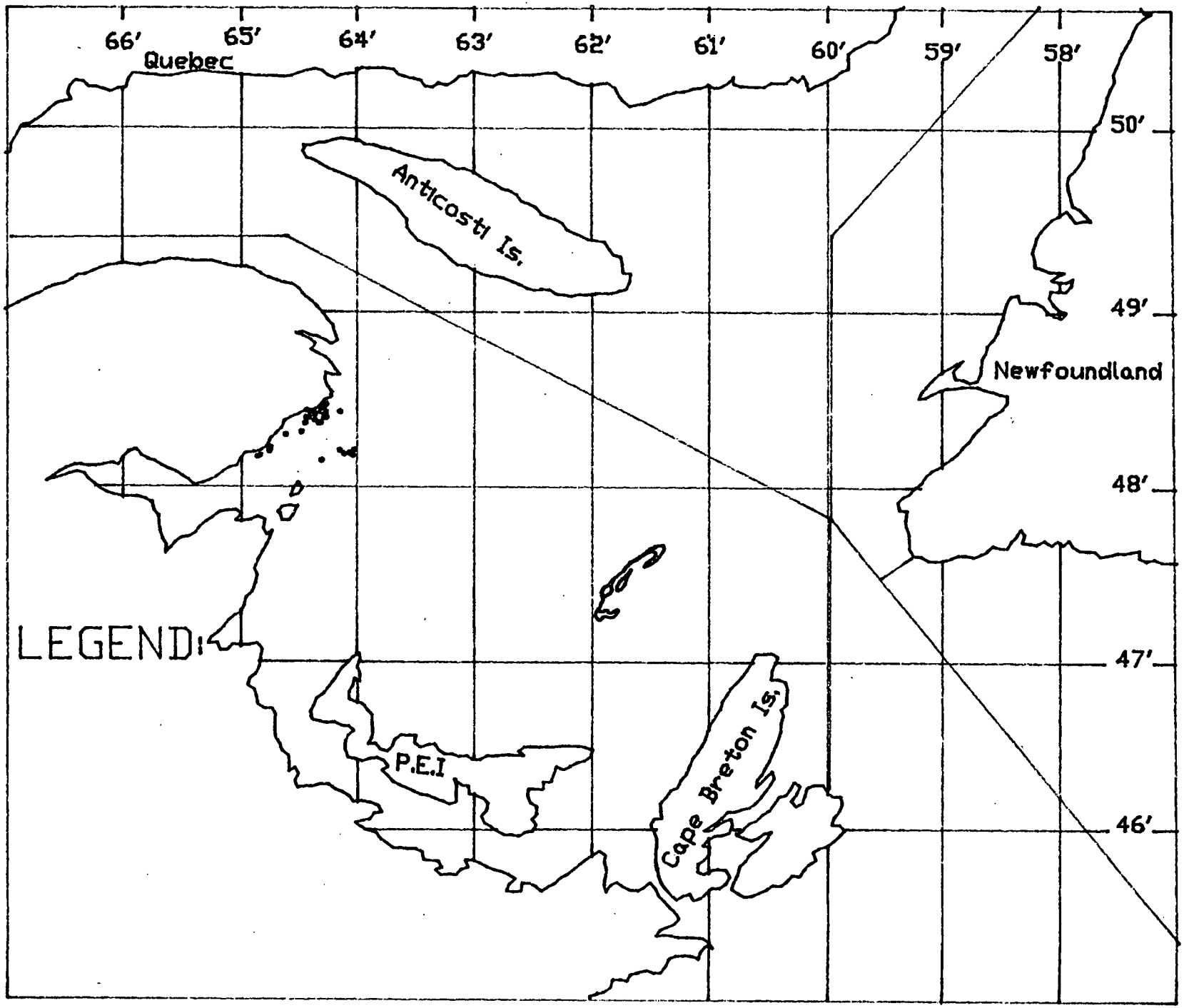


Figure 2 Location of Purse Seine Sets in 1985.

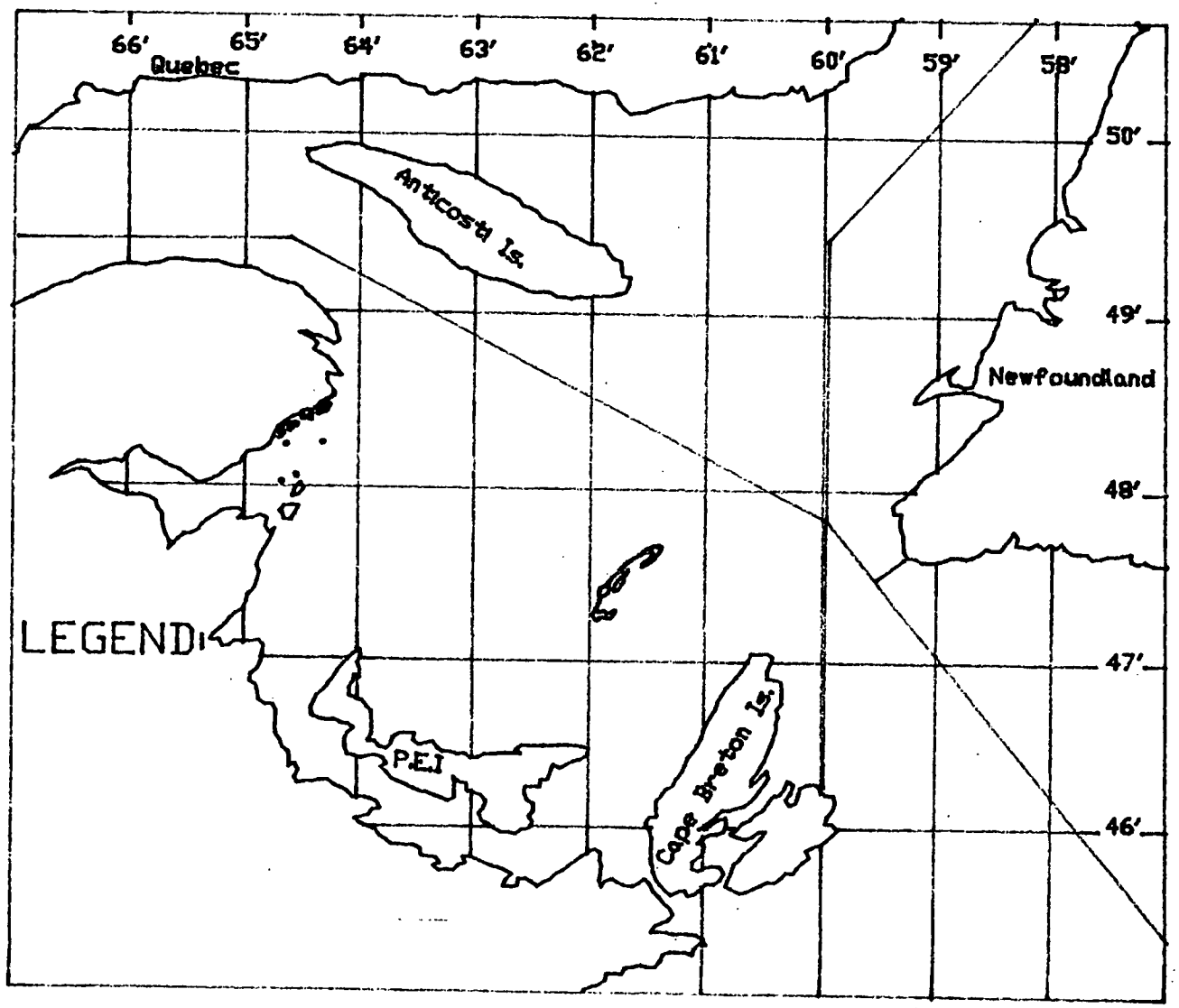


Figure 3 Location of Purse Seine Sets in 1986.

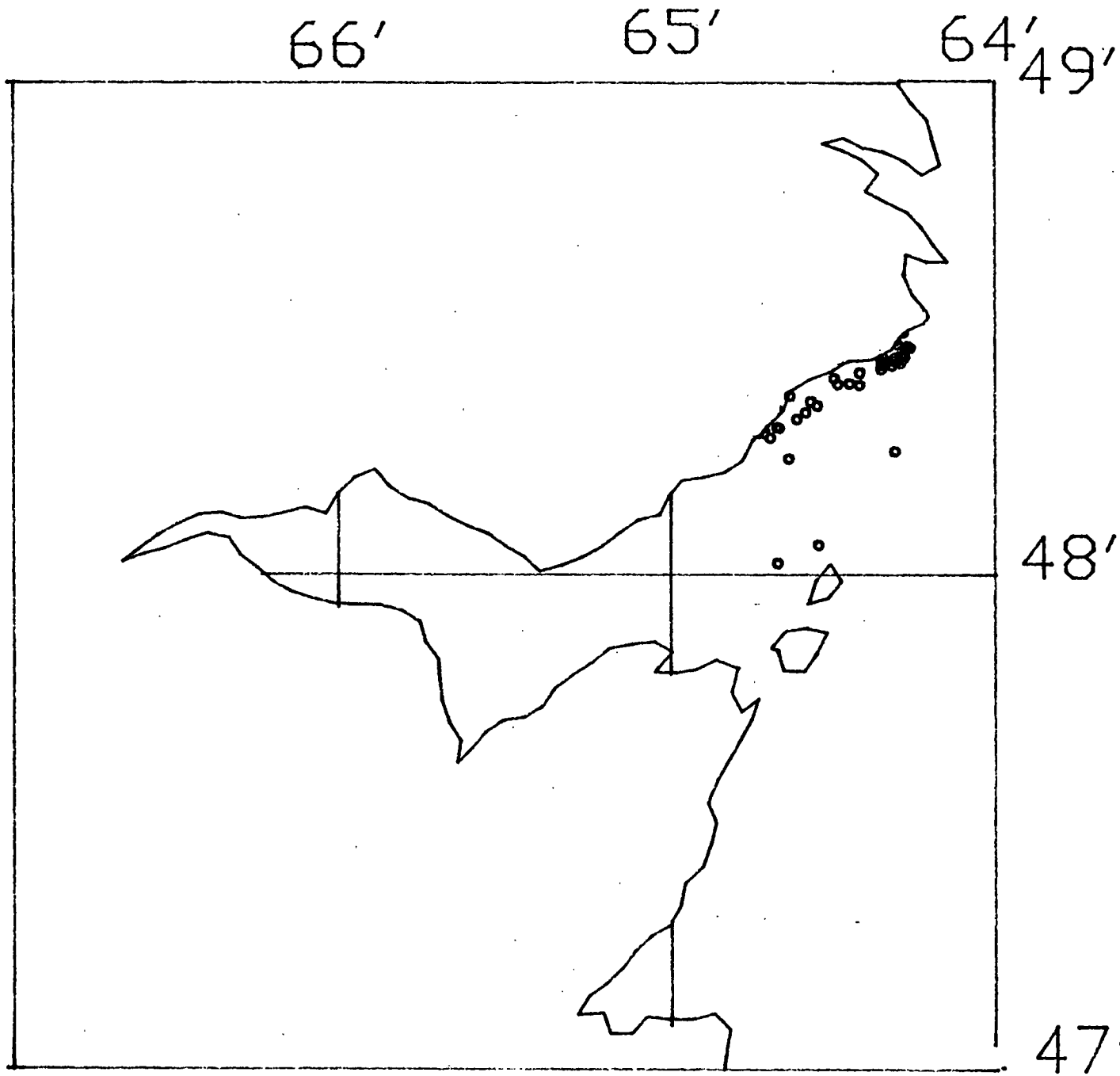
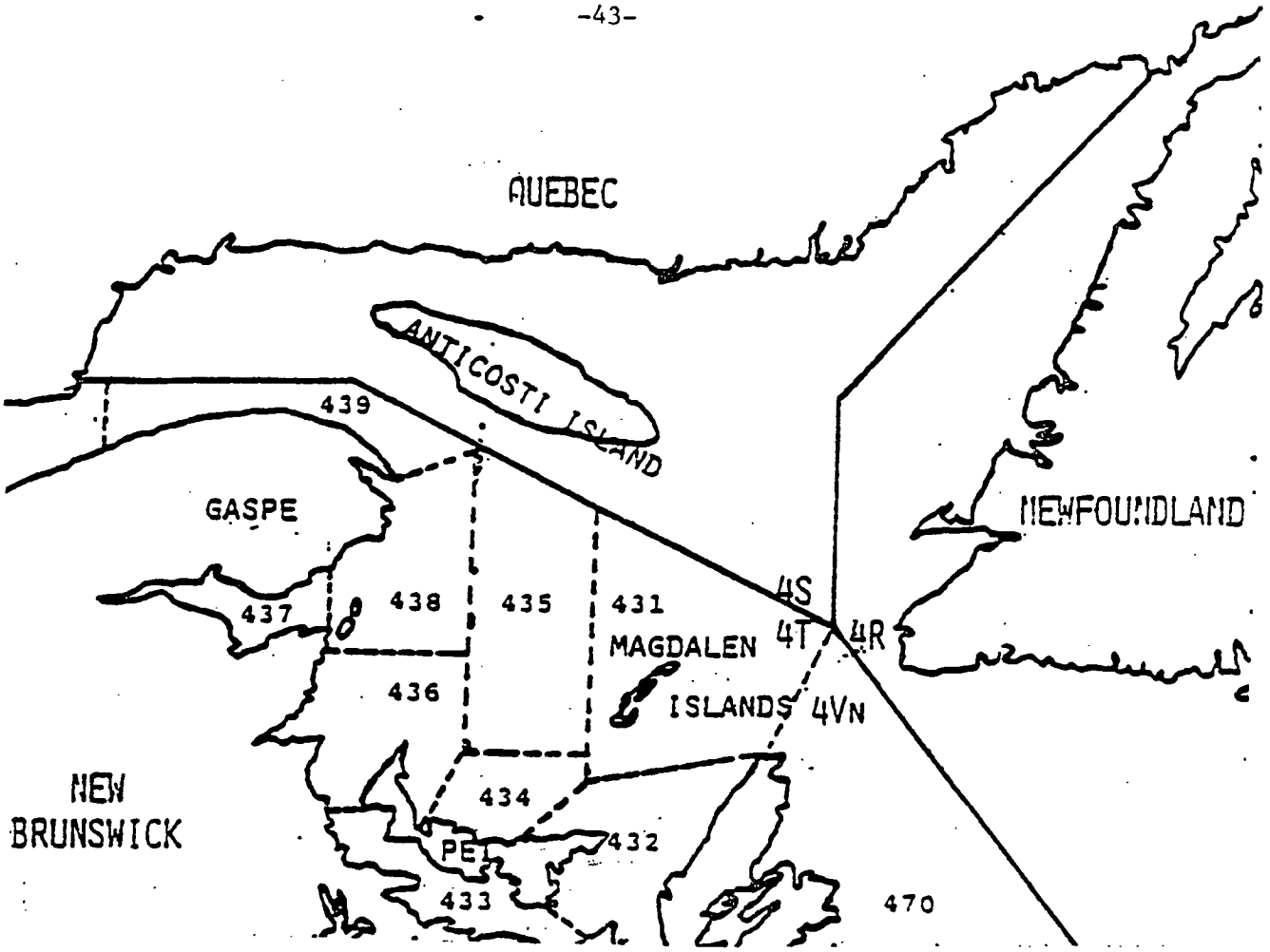


Figure 4 Location of Purse Seine Sets in 1986.



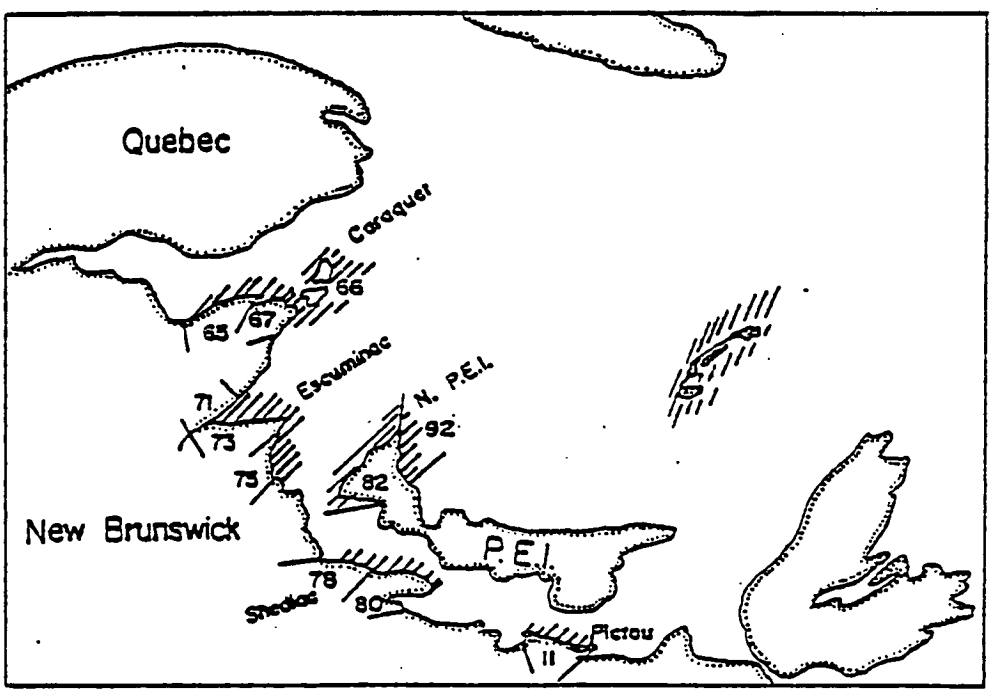


Figure 5 Map at top indicates NAFO Areas in 4T. At bottom, Map of Southern Gulf of St. Lawrence showing the areas where the major gillnet landings are made each year, and for which catch rates were calculated.

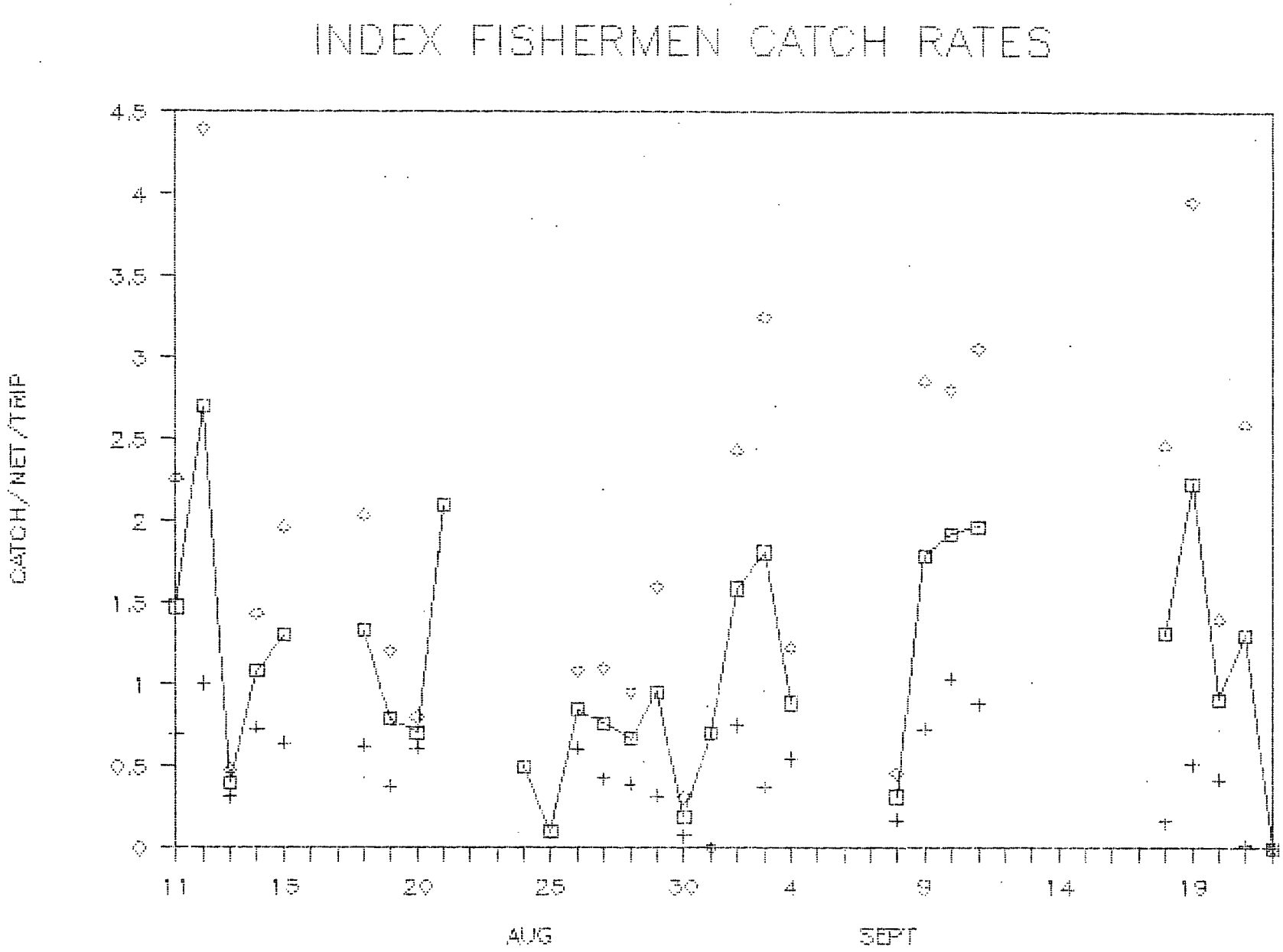
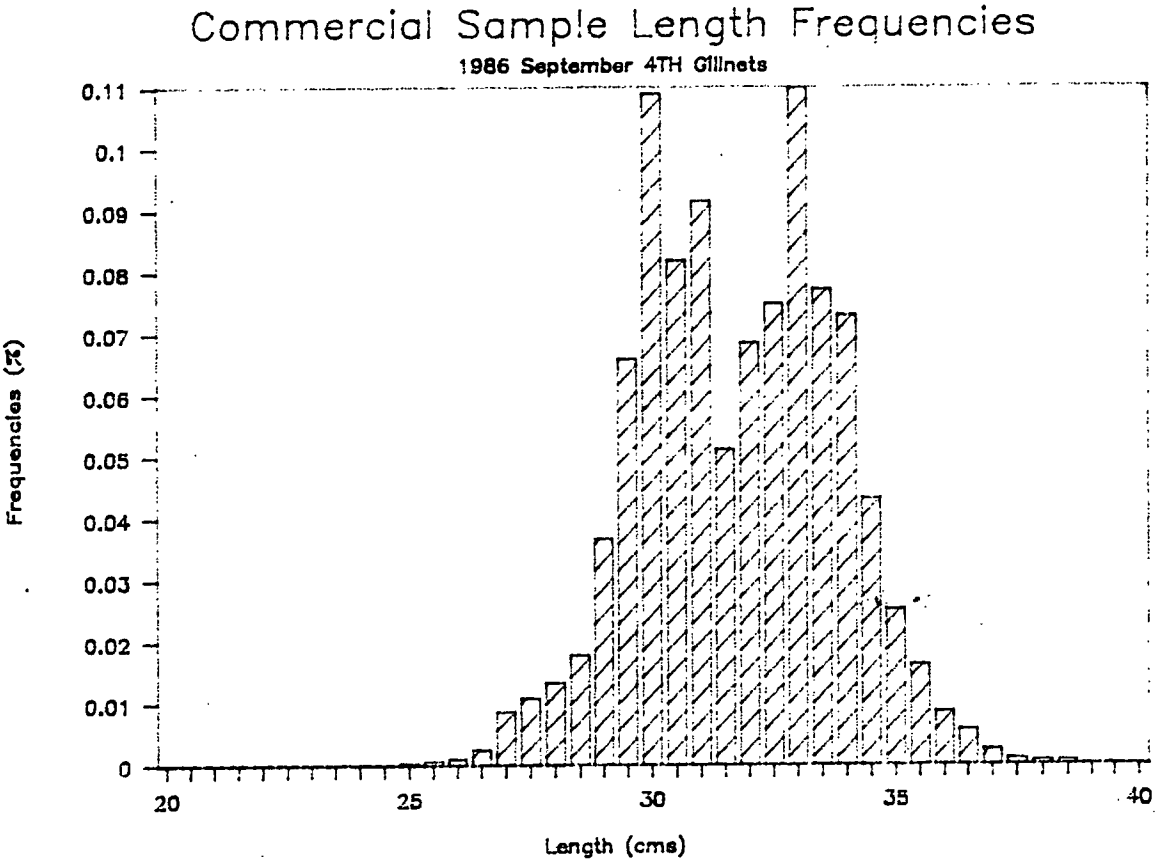


Figure 6 Mean daily catch rate and its standard deviation for 15 index fishermen in the fall gillnet fishery.



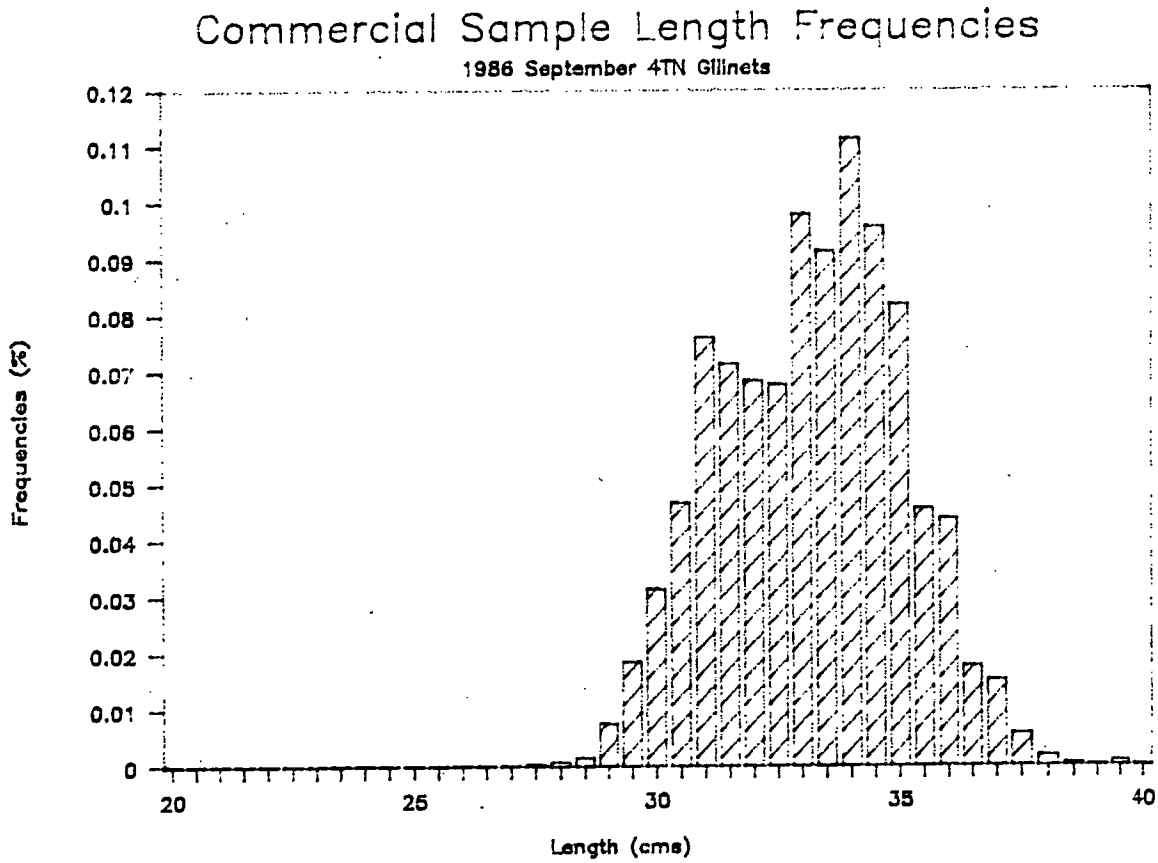
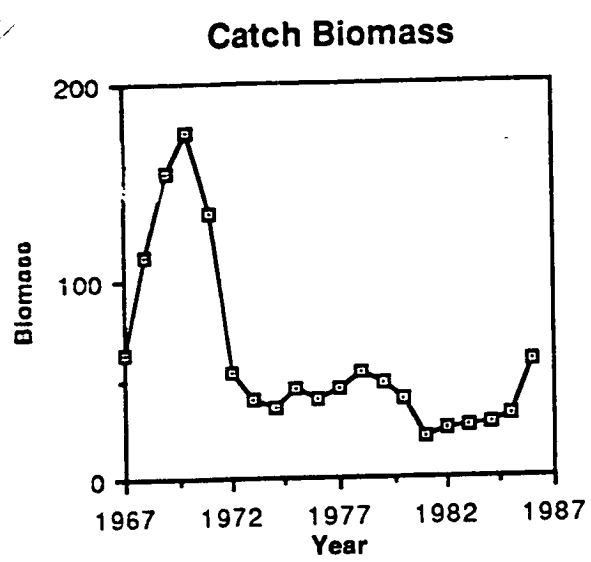
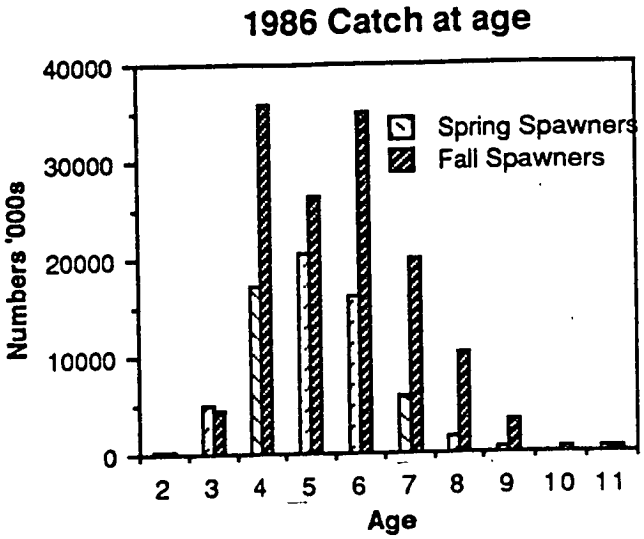
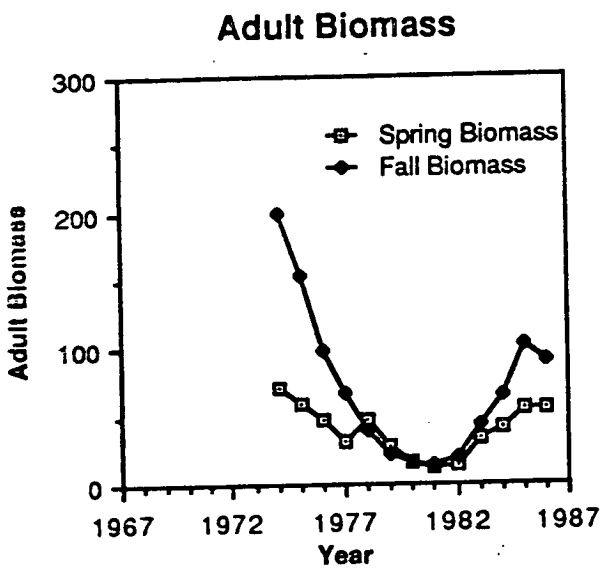
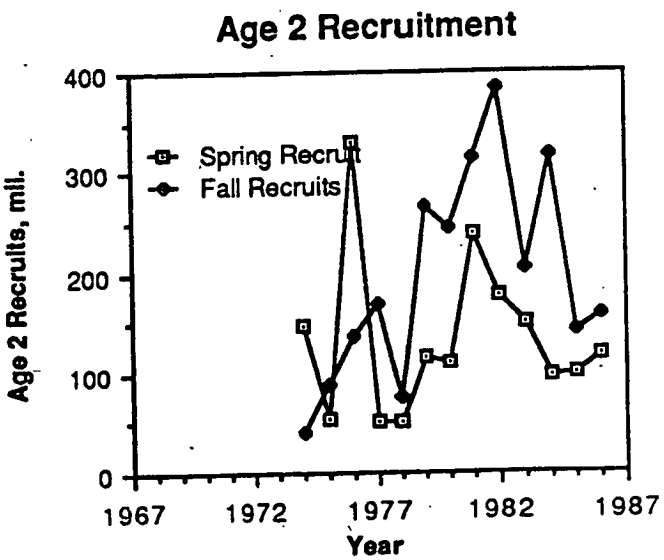


Figure 7 Length frequency distribution of herring caught in Pictou (Area 4Th) and Chaleur Bay (Area 4Tn) in 2 5/8" mesh gillnets in the 1986 fall fishery.









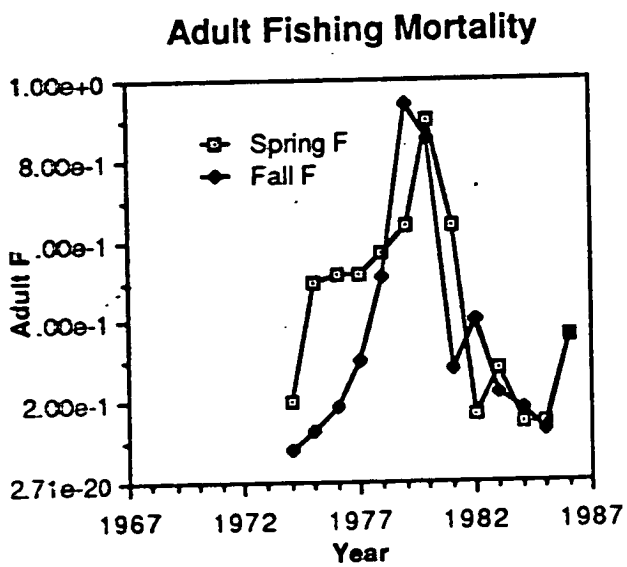


Figure 8 Herring in 4T -- population parameters.

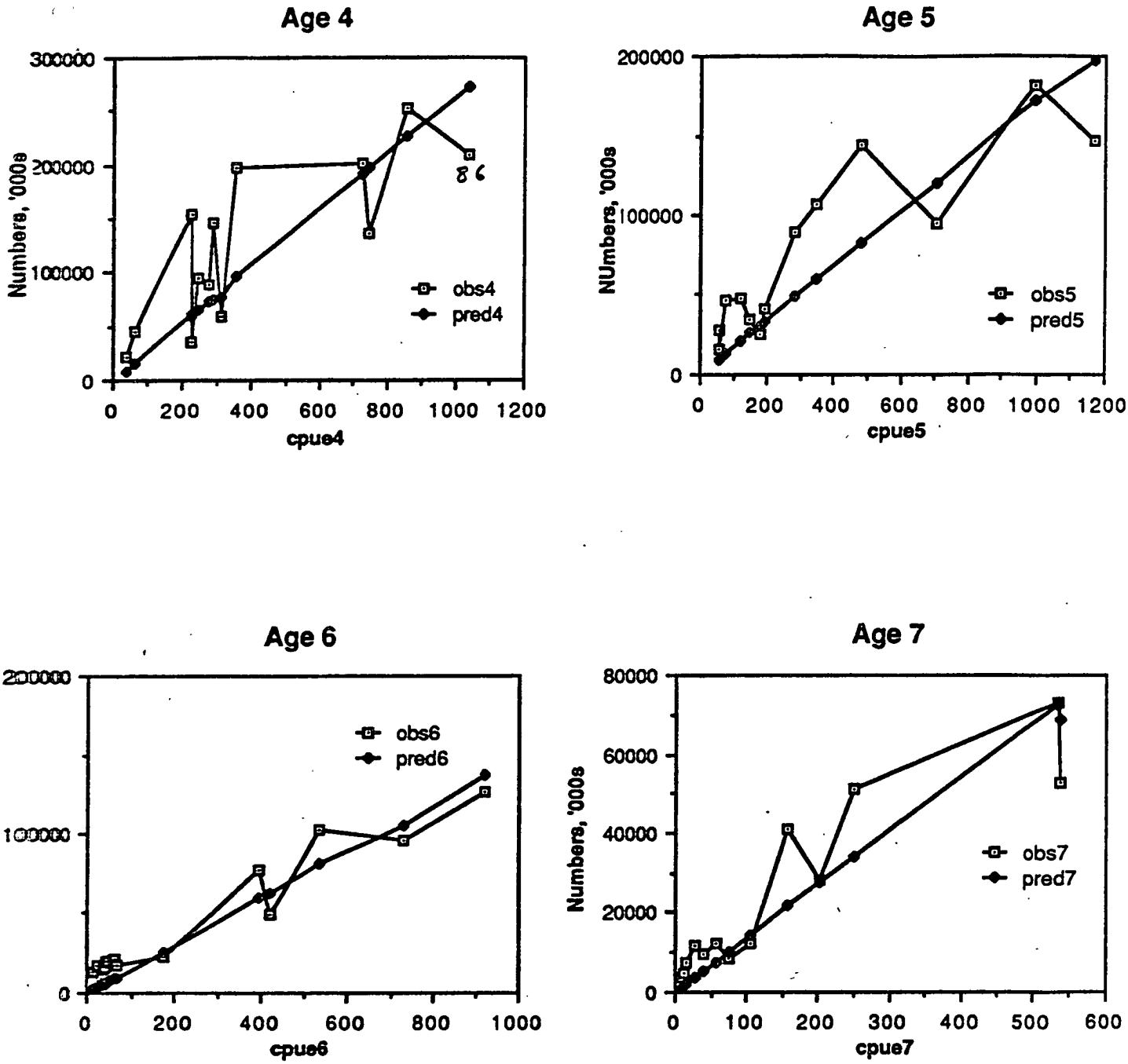


Figure 9 . Age specific relationships used in calibration of Fall spawner 4T herring SPA.

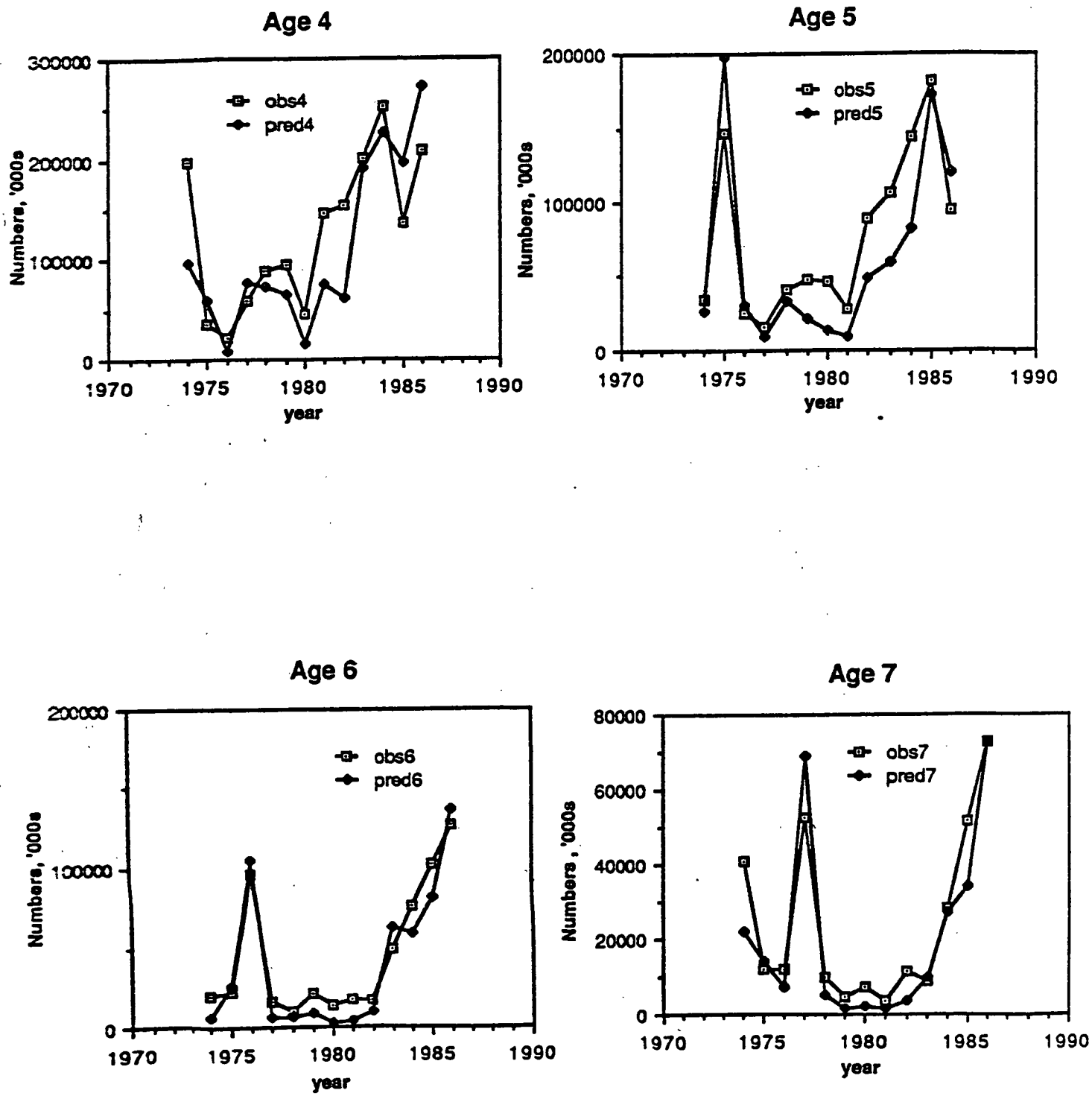


Figure 10 . Age specific trends of observed and predicted 4T herring Fall spawner population numbers.