Canadian Atlantic Fisheries
Scientific Advisory Committee

CAFSAC Research Document 85/69

Comité scientifique consultatif des
pêches canadiennes dans l'Atlantique

CSCPCA Document de recherche 85/69

STATUS OF THE WEST COAST OF NEWFOUNDLAND HERRING STOCKS IN 1984

by

I.H. McQuinn and L. Cleary

Direction de la Recherche sur les Pêches
Ministère des Pêches et des Océans
C.P. 15 000
901 Cap Diamant
Québec, Québec G1K 7Y7

[1] This series documents the scientific basis for fisheries management advice in Atlantic Canada. As such, it addresses the issues of the day in the time frames required and the Research Documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

Research Documents are produced in the official language in which they are provided to the Secretariat by the author.

[1] Cette série documente les bases scientifiques des conseils de gestion des pêches sur la côte atlantique du Canada. Comme telle, elle couvre les problèmes actuels selon les échéanciers voulus et les Documents de recherche qu'elle contient ne doivent pas être considérés comme des énoncés finals sur les sujets traités mais plutôt comme des rapports d'étape sur les études en cours.

Les Documents de recherche sont publiés dans la langue officielle utilisée par les auteurs dans le manuscrit envoyé au secrétariat.

ABSTRACT

Total herring landings in NAFO Division 4R have ranged from a peak of 26,984 t in 1973 to a low of 4,794 t in 1975. In 1984, 7,766 t were landed. TACs have been in effect since 1977 and have been exceeded every year except 1981, 1983 and 1984. In recent years, 55% of the TAC has been allocated to mobile gears (mainly purse seines) and 45% to fixed gears (mainly gillnets).

Gillnet catch rates for both the spring and fall spawners had shown a decreasing trend from 1978 to 1981 at which time they began to level off. Both catch rate series increased in 1984.

Spring spawners have almost always dominated the catch since 1966 and from 1974 to 1983 averaged 77% of the catch in numbers. The spring spawners have historically been dominated by the 1968 and 1974 year-classes. More recently however, the 1979 and 1980 year-classes have contributed significantly, representing 56% of the catch in numbers in 1984. The fall spawners had been dominated by the 11+ age groups from 1966 to 1983. In 1984, the 1979 year-class dominated at 45% of the catch in numbers.

Cohort analyses showed that the spring spawner population has decreased from 1.39×10^9 fish in 1971 to $.25 \times 10^9$ fish in 1984 while the fall spawners have suffered a 12.5 fold decrease in numbers from 1966 to 1984. The decline of these stocks was most certainly due to poor recruitment as the fishing mortalities have been kept below $F_{0.1}$ throughtout the history of the fisheries. Moreover, the only significant recruitment since 1972 has been the 1974, 1979 and 1980 year-classes for the spring spawners and the 1973 and 1979 year-classes for the fall spawners.

Projections using the expected catch of 5,670 t of spring spawners in 1985 show $F_T=0.12$. Only a slight decrease in population biomass is forecast, from 61,416 t in 1984 to 60,427 t in 1985. The 1986 $F_{0.1}$ catch would be 13,300 t. The expected 1985 fall spawner catch of 4,330 t should result in $F_T=0.39$. The population biomass is expected to drop from 22,650 t in 1984 to 19,916 t in 1985. The $F_{0.1}$ catch in 1986 would then be 3,400 t.

RESUME

Les débarquements de hareng dans la Division 4R de l'OPANO sont passes d'un maximum historique de 26,984 t en 1973 à un minimum de 4,794 t en 1975. En 1984, les captures rapportées étaient de 7,766 t. Les TPA imposés depuis 1977 ont été dépassés chaque année sauf 1981, 1983 et 1984. Récemment, 55% du TPA a été alloués aux engins mobiles (principalement des seineurs) et 45% aux engins fixes (en majorité des filets maillants).

Les taux de captures calculés à partir des données de la pêche côtière montrent une baisse de biomasse des reproducteurs de printemps et d'automne entre 1978 et 1981. Par la suite, les biomasses seraient demeurées stables jusqu'en 1983 et auraient augmenté en 1984.

Selon la matrice des captures à l'âge, les reproducteurs de printemps sont généralement dominants dans la capture depuis 1966. Ils représentaient environ 77% des captures totale en nombre entre 1974 et 1983. Ce sont les classes d'âge de 1968 et 1974 qui ont dominé les captures historiques des reproducteurs de printemps. En 1984, les classes d'âge de 1979 et 1980 représentaient 56% des captures en nombre. Les captures de reproducteurs d'automne ont compris une forte proportion de poissons de plus de 11 ans entre 1966 et 1983. Cependant, en 1984 la classe d'âge de 1979 était dominante et représentait 45% de la capture en nombre.

Les analyses de cohorte ont démontré que les reproducteurs de printemps sont passés de 1.39×10^9 harengs en 1971 à 0.25×10^9 harengs en 1984 alors que la population des reproducteurs d'automne a décliné par une facteur de 12.5 entre 1966 et 1984. La cause des déclins observés est attribuée à l'insuffisance du recrutement, étant donnée que les taux de mortalité par la pêche étaient inférieurs à $F_{0.1}$. De plus, seules les classes d'âge de 1974, 1979 et 1980 chez les reproducteurs de printemps et les classes d'âge de 1973 et 1979 chez les reproducteurs d'automne ont contribué de façon notable à la capture depuis 1972.

Les projections de captures et biomasses résiduelles montrent que la capture de 5,670 t des reproducteurs de printemps en 1985 résulterait en un taux de mortalité de F_T= 0.12. La biomasse totale passerait alors de 61,416 t en 1984 à 60,427 t en 1985. Une mortalité par la pêches de $F_{0.1}$ en 1986 permettrait de capturer 13,300 t de hareng. La capture de 4,330 t des reproducteurs d'automne prevue pour 1985 occasionnerait un taux de mortalité de F_T= 0.39 et une légère baisse de biomasse de 22,650 t en 1984 à 19,916 t en 1985. En pêchant à un taux $F_{0.1}$ en 1986, on récolterait 3,400 t de hareng.

INTRODUCTION

Total landings from the west coast of Newfoundland (NAFO division 4R) peaked in 1973, decreased sharply a year later when the number of seiners in the commercial fleet was greatly reduced, increased again until 1980 and have dropped continuously thereafter (Table 1, Figure 1). Total allowable catches (TACs) have been in effect since 1977, when the west coast of Newfoundland was defined as a herring management unit. In order to prevent overexploitation of local stocks, the TAC was broken down into quotas for three areas (Moores and Winters, 1978) : (1) St. George's Bay (area K), (2) Cape St. George to Cape St. Gregory (area L) and (3) Cape St. Gregory to Cape Norman (areas M + N) (Figure 2). TACs set since 1977 have been exceeded every year except in 1981, 1983 and 1984.

The fishing pattern of the herring fleet has varied greatly over time. Before 1971 most of the catch was reported in area M, while from 1971 to 1978 landings from area K were the most important (Figure 3). More recently, the proportion of the total catch reported in the latter area has slowly diminished while increasing in area L and again in area M.

These herring stocks have been exploited by fixed gears, mainly anchored gillnets, and mobile gears, mainly purse seines. However the proportion of the total catch taken by each gear component in each fishing area has been extremely variable, and complete disappearance of one or the other fishery has occured in some years (Table 2, Figure 4).

HISTORICAL TRENDS

The purse seine fleet, being very mobile, can direct its fishing effort wherever success is expected to be optimum. Therefore the fishing pattern of the fleet has fluctuated considerably over time (Figure 5). For instance, in the southern fishery (areas K + L) during the 70's, most of the catch was reported in area K. As the proportion of market size fish decreased in St. George's Bay in the early 80's, more and more catches were reported from area L. Finally in 1983 and 1984, catches were taken almost exclusively in area L. In the northern fishery (areas M + N), Moores and Winters (1980) noted that in 1979, the bulk of the catch, which previously came from St. John's Bay (area N), was now being reported from south of Pointe Riche (area M). Since then, this shift in fishing pattern has become more and more pronounced resulting in catches from area M being 4 times higher than in area N in 1983. In 1984, there was no purse seine catch taken in area N. As a result of these changes in fishing patterns, more and more of the total purse

seine catch is being taken in the central part of the west coast (areas L + M) rather than at the extremities which was the case in the mid 1970's.

The nearshore fishery, made up of all gears other than purse seines (mostly gillnets), has also gone through remarkable changes since 1966. In the late sixties, the predominance of this fishery in the southern areas rapidly declined (Figure 6). From 1971 to 1978, most of the catch was reported from area N. After 1975, the development of a major spring gillnet fishery south of Cape St. Gregory (Moores and Winters, 1980) resulted in more catches being reported from areas K and L. Consequently, since 1979, almost equal proportions of the total catch have been taken from the southern and the northern zones.

THE 1982, 1983 AND 1984 FISHERIES

Total allowable catches (TAC) of 10,000 t were set in 1982, 1983 and 1984. While the TAC was slightly overrun in 1982, total catches were less than 9,000 t in 1983 and 8,000 t in 1984 (Table 3). In 1982 and 1983, purse seine catches in St. George's Bay were below the area allocations, (no catches at all were reported in 1983) due to the dominance of fish below market size. During the same period, all other purse seine area allocations were overrun. In 1984, area allocations were not set, but the fishing pattern was very similar to the previous years with little catch in St. George's Bay and over 3,000 t reported from Cape St. Gregory North (areas M + N).

The fixed gear allocations were overrun in all areas in 1982 but were not reached in 1983 nor in 1984. In 1984, the gillnet catches in areas K and L were taken almost exclusively in April and May (Table 4). The decrease in importance of the summer and fall fisheries in the south was mainly the result of poor market conditions and the abundance of so-called "black herring" which are reported to be too soft for processing. The April fishery in the Port-au-Port area (area K) was temporarily closed because of a high incidence of dumping as fishermen were unable to sell their catch. Spring catches in area M were also considerably more than fall catches, which was not the case in 1982 nor in 1983.

POPULATION ABUNDANCE INDICES

Catch rate indices have been calculated for the gillnet and purse seine fisheries for both the spring and fall season. An index was also derived from the January bottom trawl survey in

Division 4R.

Gillnet Fishery:

Monthly gillnet catch rates (t/slip) were calculated using landings from all purchase slips available since 1977. Two catch rate indices were selected as representative of the two spawning stock components; from areas K and L in April and May for the spring spawners, and from area N in August for the fall spawners (Table 5). The geometric mean of t/slip, weighted by the corresponding gillnet catches, was calculated for each series (Table 6). These indices were adjusted for gang size, as they did not take into account changes in the number of nets fished per trip. The number of nets per gang for 1977 to 1981 were based on surveys carried out on the Newfoundland east coast. For 1982 to 1984, the gang size was obtained from a written survey conducted on the west coast in 1984. The number of nets fished from 1981 to 1983, recorded on the licence applications, was used to standardize the two series of data. The adjusted catch rates were used to fine tune cohort analyses on the two spawning stocks.

Gillnet abundance indices were higher for the spring spawners than for the fall spawners (Figure 7). The catch rates for the spring fishery in areas K and L showed a generally declining trend in abundance from 1978 to 1981, while decreasing only slightly between 1981 and 1983. In the area N fall fishery, the catch rates followed a rapid decline between 1979 and 1981. Between 1981 and 1983, the gillnet CPUE was stable, increasing only slightly in 1983. Both the spring and fall catch rates increased in 1984.

Purse Seine Fishery:

Catch and effort data from purse seine log-books have been analysed for trends in abundance. Historical catch and effort data were more consistently available for the months of April and May in areas K and L for the spring fishing season and for the months of November and December in areas M and N for the fall fishing season. Consequently, catch rates, weighted by the corresponding purse seine catches, were calculated for those selected months and areas.

Historical trends in c/set and c/night are very similar (Table 7, Figure 8). From 1980 to 1983, the spring catch rates were generally much higher than the fall catch rates; the weighted average c/set and c/night being 2.5 and 2 times higher, respectively. In 1984, c/night was still higher in the spring, but c/set was similar for the two seasons.

In the spring fishery, catch rates were more or less stable between 1975 and 1980, but have fluctuated since then. In

the fall fishery, catch rates dropped steadily between 1978 and 1981 (similar to the decrease in the gillnet abundance index for the fall spawners between 1978 and 1981), increased sharply in 1982 and have decreased thereafter. If we assume that the spring catch is mainly comprised of spring spawners and the fall catch is of both spring and fall spawners (Table 8), the more or less constant decline in catch rate, most evident in the fall fishery between 1978 and 1981, could indicate a decrease in the fall spawner fishable biomass.

The validity of seiner catch rates as representative of pelagic fish population abundance has often been discussed (Powles, 1981; Pope, 1978; Ulltang, 1978; Cleary, 1982) and generally they are considered to be difficult to interpret. Besides, log-book coverage was rather limited in 1982, 1983 and 1984. Consequently the data were not used to fine tune the cohort analyses, but are presented here as additional information on trends in abundance.

Bottom Trawl Survey:

Data from the January groundfish survey were available for 1983, 1984 and 1985. The catch rate has gone from 1.28 herring/tow in 1983 to 0.89 herring/tow in 1984 and 4.25 herring/tow in 1985.

This trawl survey is designed to obtain basic data on groundfish stocks. Any catch of herring is incidental and catch rates should be regarded with caution.

AGE COMPOSITION OF THE COMMERCIAL CATCH

Catch-at-age data from 1966 to 1981 were taken from Tremblay et al. (1983). The 1983 catch at age was updated with the final 1983 landing statistics. As official landings were not available at the time of the assessment, the 1984 catch at age was calculated using landings partially provided from the Newfoundland Statistics Branch, from the inshore fishery purchase slips and from the purse seine supplementary purchase slips. The total landings from these sources were similar to estimates made by the fisheries protection officers. They are believed to include approximately 90% of the reported catch based on a comparison between the available purchase slips and the DFO landings from January to May.

Spring Spawner Catch:

Spring spawners (SS) have almost always dominated the catch (Table 9), and from 1974 to 1983, averaged 77% of the catch in numbers. The 1968 year-class was the largest ever observed in the spring spawner catch and completely dominated the catch from 1970 to 1978 (Table 10). Between 1971 and 1982, the only significant recruitment to the spring spawner fishery came from the 1974 year-class. In 1983 about 39% of the catch consisted of the 1979 and 1980 year-classes. These same year-classes also dominated the 1984 fishery, representing 56% of the catch in numbers. Consequently, the mean age of the spring spawners in the catch dropped to 7 years old in 1983 and 1984 (the lowest average seen since 1975). After a sudden increase in the proportion of fish younger than 4 years old in 1983 due to the presence of the 1980 year-class, this proportion dropped back to 1.8% in 1984.

Fall Spawner Catch:

Herring of the 11+ age group have dominated the fall spawner (FS) catch since 1966, except in 1984 when the 1979 year-class contributed to more than 45% of the catch in numbers. The mean age of fall spawners in the catch has therefore decreased in recent years, from 10 years old in 1976 to 7 years old in 1984. The proportion of fish younger than 4 years old was negligible (less then 1%).

LENGTH FREQUENCIES OF THE COMMERCIAL AND RESEARCH CATCHES

In 1982, 1983 and 1984, commercial purse seine catches from the fall fishery were sampled by observers on board the vessels. Length frequencies of herring landed, as well as discarded, are shown on Figure 9. Sets were released if the percentage of small fish was judged to be too high.

In 1982 and 1983, the dominant lengths of landed fish were between 360 and 380 cm. In 1984 the modal length group was much smaller, from 300 to 320 cm. The length distributions of fish discarded in 1982 and 1983 were bimodal with peak lengths below 280 cm. In 1984, the situation was quite different. The dominant length group of discarded fish was the same as in the landed catch. Moreover, very few fish less than 220 cm were observed in 1984 in either the landed or discarded samples.

Length frequencies of herring caught during the bottom trawl survey in 1982 and 1983 also demonstrated that herring smaller than 280 cm were available (Figure 9). The modes observed corresponded very closely to those found in the landed catch and

discarded sets from the commercial purse seine fishery. In January 1985, the proportion of fish smaller than 300 cm in the research catch was negligible.

These data indicate that the length distribution of herring available to the commercial fishery has changed considerably over the last few years. The proportion of "bigger" fish, which are preferred for commercial purposes and, according to the catch-at-age data, have dominated the fishery for many years, has decreased. The absence of "smaller" fish in the discarded sets and research samples could indicate a drop in recruitment.

The comparison of the commercial and research length frequency data has shown very clearly that the purse seine fishery has been very selective towards the larger fish. However, in 1984, it seems that this situation has changed. The abundance of four and five year old fish mixed with the older age groups has prevented the seiner operators from selecting sets with only large fish. The declining proportion of older fish has also meant that they must land a higher proportion of smaller, less marketable fish.

NATURAL MORTALITY RATE

An estimate of 0.2 for the instantaneous natural mortality rate (M) was assumed for the present analyses. This value was used in the previous assessment (Cleary and McQuinn, 1984) and is consistent with that for other herring stocks (Lea, 1930; Runnstrom, 1936; Beverton, 1963).

PARTIAL RECRUITMENT

Partial recruitment vectors were estimated for the two spawning stocks from purse seine selectivity coefficients. These coefficients were derived from the ratio of the proportion-at-age from the commercial landings and the discarded sets (Table 11). Samples from the discarded sets were assumed to be representive of the population for the younger ages due to the non-selectivity for length of purse seines. Fish seven years and older were considered to be fully recruited as this fishery is directed towards older fish. The resulting partial recruitment vectors were as follows:

AGE	2	3	4	5	6	7+
SS	.023	.24	.63	.90	.64	1
FS	--	.10	.41	.40	.57	1

The partial recruitment vectors obtained differ from the previous assessment (Cleary and McQuinn, 1984) because of the dominance of the 1979 and 1980 year-classes. This has led to a concentration of fishing effort on these cohorts even though they are below the desirable length for the market and therefore would normally have lower partial recruitments.

WEIGHT AT AGE

Mean weight at age was calculated as the average weights for the 1^{st} and 2^{nd} quarters of the year for spring spawners and the 3^{rd} and 4^{th} quarters for fall spawners (Table 12).

COHORT ANALYSES

Cohort analysis was run separately for spring and fall spawners. Average F's for ages 8 to 10 were input as the last age F for each run. Population biomass was calculated for the beginning of the year for spring spawners and mid-year for fall spawners as these would represent the biomass available at the onset of the greatest effort exerted on each stock component.

A series of cohort analyses was run at various values of terminal F. Least squares regression of fishable biomass on gillnet catch rates was used to tune the cohort analyses for the two spawning stocks. Terminal F for fall spawners was determined by choosing the regression line with the best combination of correlation coefficient and intercept (Table 13). Because the cohort analysis for spring spawners did not converge, the criteria used for the selection of F_T were (a) the closeness of the 1984 point to the regression line and (b) the smallest sum of residuals for the 1982 to 1984 points to the regression line. These analyses indicated terminal F's in 1984 of 0.1 and 0.3 for spring and fall spawners, respectively (Figure 10 a,b).

According to the present analysis, the spring spawner population numbers reached an historical low of $.25 \times 10^9$ fish in 1984 after a decline from 1.39×10^9 fish in 1971 (Table 14a). This drop in abundance was observed even though fully recruited fishing mortality rates have been kept below the long term average $F_{0.1}$=.3 throughout the history of the fishery (Table

14b). The decline of this stock is most certainly due to the poor recruitment seen in the last decade. Since 1972, only the 1974 and, more recently, the 1979 and 1980 year-classes have contributed significantly to the stock. During this period, recruitment at age 2 has been substantially below the historical average (1966-1971: 270,116 x 10^3 fish vs 1972-1983: 50,823 x 10^3).

The results of the cohort analysis run for the fall spawners indicated a 12.5 fold decrease in population numbers from the historical high in 1966 to 1984 (Table 15a). Fully recruited fishing mortality rates were below $F_{0.1}$ until 1983 and 1984 when they reached their highest observed value of .3 (Table 15b). Again, the lack of recruitment appears to be the dominant reason for the drop in biomass as only the 1973 and 1979 year-classes have been of significance since 1972.

CATCH AND BIOMASS PROJECTIONS

Projections for 1985 and 1986 were run using population numbers obtained from the cohort analyses and recruitment at age 2 for 1983 and 1984 set to the geometric mean of the estimated recruitment from 1966 to 1982. It was assumed that the 1985 TAC would be taken and that the proportion of spring and fall spawners in the catch would be the same as was observed in the 1984 catch. Projections for 1986 were calculated using the long term fully recruited $F_{0.1}$ value of 0.3.

Spring Spawners:

According to the present projections, the expected catch of 5,670 t in 1985 will result in a fishing mortality of F=.12 (Table 16a). Only a slight decrease in population biomass is expected, from 61,416 t in 1984 to 60,427 t in 1985. The 1986 $F_{0.1}$ catch would be 13,300 t and the population biomass would be expected to drop to 54,996 t. Recruitment of the 1980 year-class should produce a slight increase in the mature biomass to 43,341 t in 1985 although this will still be well below the historical high of 169,766 t in 1974 (Figure 11).

Fall Spawners:

Assuming the expected 1985 catch of 4,330 t is taken, the projected fishing mortality will be F=.39 on fully recruited ages and will result in a catch of 3,400 t in 1986 at F=0.3. The population biomass is expected to drop from 22,650 t in 1984 to 19,916 t in 1985 and 17,304 t in 1986 at these levels of

exploitation (Table 16b). This stock has shown a constant decline in mature biomass since the historical high of 170,607 in 1968 (Figure 11). Recruitment of the 1979 year-class in 1984 increased the 5+ biomass to 18,420 t from 11,124 t in 1983. However, the mature biomass is expected to decrease to 11,548 t in 1986, which will be 7% of the 1968 value.

CONCLUSIONS

It appears from the foregoing analyses that the spring spawning stock is being exploited at a level lower than the long term $F_{0.1}$ value of 0.3. This stock has shown, however, a constant decline in biomass since 1974 even though it has never been fished above $F_{0.1}$ and has rarely been fished above F=.2 (Figure 11).

The fall spawning stock is presently being fished at $F_{0.1}$ but only due to shortfalls in the TAC. Projections showed that the terminal F will increase to 0.4 on this stock in 1985 at the present TAC. The biomass has declined continuously since 1968. During this period, a dominant year-class has not been produced which could support the fishery, as was seen in the late '50s. A slight increase in biomass was observed in 1984 due to the 1979 year-class, but not in the proportions seen in past decades (Figure 11).

The imbalance in the exploitation rates on the two stocks is partially due to the concentration of effort in the fall of the year in the mixed fishery in areas L and M. Even though this is a mixed fishery, the percent of fall spawners in the catch is disproportionate to its overall abundance. Consideration should therefore be given to the protection of the fall spawning component by concentrating more fishing effort in the spring in areas K and L when catches are dominated by spring spawners.

Herring stocks in the Gulf of St. Lawrence have been highly dependent upon the occasional appearance of extremely large year-classes for population resurgence. This was seen in Division 4R with the massive recruitment of fall spawners which occurred in 1958 and spring spawners in 1968. These were the dominant year-classes for these stocks for over a decade. This phenomenon was also observed in Division 4T with the 1958 and 1959 year-classes (Winters and Hodder, 1975). Between the rare occurrences of large year-classes, recruitment is neither strong enough nor regular enough to sustain high biomass levels even at low exploitation rates. For this reason and in order to prolong these fisheries during periods of poor recruitment, such as that being experienced at present, conservative management strategies should be adopted.

ACKKNOWLEDGMENTS

The authors would like to gratefully acknowledge the contributions made to this manuscript by Joanne Hamel and Roberta Miller for their diligent and expert assistance with the compulation and processing of the data and Lionel Corriveau for the graphics, which speak for themselves. We would also like to thank Alain Fréchet and Patrick Ouellet for critically reviewing the manucript.

REFERENCES

Beverton, R. J. H. 1963. Maturation, growth and mortality of clupeid and engraulid stocks in relation to fishing. Rapp. P.-V. Reun. Cons. int. Explor. Mer 154: 44-67.

Cleary, L. 1982. Assessment of the 4T herring stock. CAFSAC Res. Doc. 82/47.

Cleary, L. and I. H. McQuinn. 1984. Status of the west coast of Newfoundland herring stock in 1983. CAFSAC Res. Doc. 84/60.

Lea, E. 1930. Report on age and growth of the herring in Canadian waters. Rapp. Cons. Explor. Mer 65: 100.

Moores, J. A. and G. H. Winters. 1978. The Newfoundland west coast herring stocks. CAFSAC Res. Doc. 78/2.

Moores, J. A. and G. H. Winters. 1980. An assessment of the status of the Newfoundland west coast herring stock(s). CAFSAC Res. Doc. 80/51.

Pope, J. G. 1978. Some consequences for fisheries management of the aspects of the behaviour of pelagic fish. ICES Symp. Biol. Basis Pel. Fish Stock Management, No. 12: 1-27.

Powles, H. 1981. What does purse seine catch per unit effort measure? A simple fishery model. CAFSAC Res. Doc. 81/36.

Runnstrom, S. 1936. A study of the life history and migrations of the Norwegian spring herring based on an anaylsis of the winter rings and summer zones on the scale. Fiskeridir. Skr. Havunders. 5(2): 1-103.

Tremblay, D., H. Powles and J. A. Moores. 1983. Status of the 4R herring stock in 1982. CAFSAC Res. Doc. 83/33.

Ulltang, O. 1978. Catch per unit of effort in the purse seine fishery for Atlanto-Scandian (Norwegian spring spawning) herring. FAO Fish. Tech. Pap. 155: 91-101.

Winters, G. H. and V. W. Hodder. 1975. Analysis of the southern Gulf of St. Lawrence herring stock and implications concerning its future management. ICNAF Res. Bull. No. 11: 43-59.

Table 1. Total herring catches (t) from NAFO division 4R by fishing area, 1966-1984.

Year	Areas				Total catch	TAC
	K	L	M	N		
1966	216	103	5530	18	5867	
1967	215	66	5540	13	5834	
1968	945	59	3979	11	4994	
1969	280	46	2549	69	2944	
1970	441	110	3469	855	4875	
1971	4138	2596	1151	2619	10504	
1972	5960	925	1544	4765	13194	
1973	12540	2862	2067	9515	26984	
1974	2624	856	942	3035	7457	
1975	3341	113	242	1098	4794	
1976	6566	2069	227	1801	10663	
1977	5569	2205	156	4766	12696	12000
1978	6808	1984	365	5959	15116	12500
1979	6031	5043	3998	3254	18326	12500
1980	5097	6944	2968	4114	19123	18000
1981	3638	4900	3089	1969	13596	16000
1982	2399	4345	2463	1676	10883	10000
1983	1411	3157	2240	1920	8728	10000
1984	1194	1918	3853	801	7766	10000

Table 2. Herring catches (t) by fishing area and gear type for NAFO division 4R, 1966-1984.

	K			L			M			N			COMBINED			
YEAR	PURSE SEINE	GILLNET	OTHER[1] GEARS	PURSE SEINE	GILLNET	OTHER GEARS	PURSE SEINE	GILLNET	OTHER GEARS	PURSE SEINE	GILLNET	OTHER GEARS	PURSE SEINE	GILLNET	OTHER GEARS	TOTAL
1966	0	216	0	0	103	0	5491	39	0	0	18	0	5491	376	0	5867
1967	0	215	0	0	66	0	5464	76	0	0	13	0	5464	370	0	5834
1968	0	156	789	0	59	0	3776	67	136	0	11	0	3776	293	925	4994
1969	241	33	6	0	46	0	2344	201	4	0	68	1	2585	348	11	2944
1970	28	410	3	12	81	17	2939	526	4	0	763	92	2979	1780	116	4875
1971	3287	424	427	2239	333	24	725	405	21	356	2252	11	6607	3414	483	10504
1972	4743	351	866	727	134	64	1330	214	0	0	4619	146	6800	5318	1076	13194
1973	12112	428	0	2740	122	0	1763	302	2	3453	6047	15	20068	6899	17	26984
1974	2465	159	0	756	96	4	439	456	47	1071	1959	5	4731	2670	56	7457
1975	3221	117	3	0	97	16	0	216	26	0	1076	22	3221	1506	67	4794
1976	6067	496	3	1956	111	2	0	207	20	184	1477	140	8207	2291	165	10663
1977	5289	273	7	2009	193	3	0	125	31	2155	2428	183	9453	3019	224	12696
1978	6252	523	33	1037	931	16	0	284	81	1834	4103	22	9123	5841	152	15116
1979	4387	1641	3	2774	2267	2	2829	1048	121	0	3247	7	9990	8203	133	18326
1980	3499	1557	41	3703	3224	17	2002	878	88	428	3681	5	9632	9340	151	19123
1981	2269	1367	2	3277	1623	0	2037	912	140	342	1600	27	7925	5502	169	13596
1982	934	1462	3	2762	1572	11	1888	517	58	0	1675	1	5584	5226	73	10883
1983	0	1409	2	2240	871	46	1906	226	108	465	1421	34	4611	3927	190	8728
1984	63	1129	2	1321	597	0	3312	521	20	0	801	0	4696	3048	22	7766

[1] Includes shrimp trawl, bar seine, trap, midwater trawl and otter trawl.

Table 3. A comparison of catch (t) and quotas for NAFO division 4R herring stocks in 1982, 1983 and 1984 (allocations in brackets*).

1982

Fishing area		Purse seine		Other		Total	
St.George's Bay	(K)	934	(2200)	1465	(1000)	2399	(3200)
Port-au-Port	(L)	2762	(1650)	1493	(1500)	4255	(3150)
Cape St.Gregory North	(M + N)	1888	(1650)	2136	(2000)	4024	(3650)
Total		5584	(5500)	5094	(4500)	10678	(10000)

1983

Fishing area		Purse seine		Other		Total	
St.George's Bay	(K)	0	(1925)	1411	(2250)	1411	(6100)
Port-au-Port	(L)	2240	(1925)	917		3157	
Cape St.Gregory North	(M + N)	2371	(1650)	1789	(2250)	4160	(3900)
Total		4611	(5500)	4117	(4500)	8728	(10000)

1984

Fishing area		Purse seine		Other		Total	
St.George's Bay	(K)	63		1131	(2250)	1194	
Port-au-Port	(L)	1321		597		1918	
Cape St.Gregory North	(M + N)	3312		1342	(2250)	4654	
Total		4696	(5500)	3070	(4500)	7766	(10000)

* Allocations are officially established for "mobile" and "fixed" gears.

TABLE 4. Herring catches(t) from NAFO division 4R by month, gear type and fishing area in 1982, 1983 and 1984

	K			L			M			N		
1982	PURSE SEINE	GILLNET	OTHER GEARS	PURSE SEINE	GILLNET	OTHER GEARS	PURSE SEINE	GILLNET	OTHER GEARS	PURSE SEINE	GILLNET	OTHER GEARS
J												
F												
M												
A		12		1364	38				10			1
M	8	1319	3	1291	1135	1		44	1		2	
J		44		107	133			29	9		28	
J		33			3			55	9		532	
A		15			5			12	1		350	
S	323	20			29			49			51	
O	603	16			227	10	1455	249	28		621	
N		3			2		433	80			83	
D											8	
T	934	1462	3	2762	1572	11	1888	518	58	--	1675	1
1983												
J		1			2							
F		2			1				1			
M		15			5				54			4
A		887	1	1585	393	46		29	52		9	3
M		429	1	590	358			48			5	
J		29		65	44			9	1		43	
J		25			36			23			233	10
A		12			26			6			540	3
S		3						6			233	
O		5			1		284	23			74	
N					2		1338	29		357	159	16
D		1			1		284	39		108	137	
T		1409	2	2240	869	46	1906	212	108	465	1433	36
1984												
J					1		183					
F					1							
M		1										
A	8	469		1024	218		472	119	18		1	
M	55	648	2	297	237		423	207			15	
J		7			1			29	2		44	
J								1			99	
A											175	
S											129	
O		4			5		567	75			221	
N					134		1009	78			97	
D							658	12			20	
T	63	1129	2	1321	597	--	3312	521	20	--	801	--

Table 5. Proportion (%) of spring and fall spawner herring in the gillnet catch, NAFO division 4R. 1965-1984.

SPRING

	FISHING AREA																			
	K			L				M							N							
	APR	MAY	OCT	APR	MAY	SEPT	OCT	MAY	JUNE	JULY	SEPT	OCT	NOV	DEC	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1965													26.0									
1966							56.0					81.2										
1967		100.0				30.8			100.0			62.6							18.0			
1968			100.0																			
1969														64.0								
1970													72.0	76.7			3.0			49.5		
1971													37.8			9.0						
1972		100.0								26.0			73.5				4.0		15.0		77.0	
1973										30.9		29.0	80.9				30.0				63.1	
1974									100.0					86.7				18.0			50.0	88.0
1975		88.0							50.0	15.0												
1976		100.0			100.0				100.0								8.0				75.3	
1977									95.6	98.0				86.0		70.0	32.8	2.0	28.3	57.4	79.0	
1978		100.0						100.0	100.0							12.0	34.4				79.1	
1979	83.6			93.0				96.0					84.0				39.7	11.2	39.0	53.2		
1980	96.4			92.0				100.0					76.8		62.7	46.2	33.0	0.0	46.0	76.0	63.3	
1981	96.0			96.3	100.0			100.0	100.0							4.0	24.3	0.3			46.9	
1982		100.0			99.4								51.9				2.7					
1983		60.7									73.3	32.1	33.3	58.2			30.2	1.8	32.1	31.1	40.1	67.3
1984					92.1		22.0					19.4	24.0	42.9				6.2	27.0	19.0	28.0	45.2

FALL

	FISHING AREA																			
	K			L				M							N							
	APR	MAY	OCT	APR	MAY	SEPT	OCT	MAY	JUNE	JULY	SEPT	OCT	NOV	DEC	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1965													74.0									
1966							44.0					18.8										
1967		0.0				69.2			0.0			37.4							82.0			
1968			0.0																			
1969														36.0								
1970													28.0	23.3			97.0			50.5		
1971													62.2			91.0						
1972		0.0								74.0			26.5				96.0		85.0		23.0	
1973										69.1		71.0	19.1				70.0				36.9	
1974									0.0					13.3				82.0			50.0	12.0
1975		12.0							50.0	85.0												
1976		0.0			0.0				0.0								92.0				24.7	
1977									4.4	2.0				14.0		30.0	67.2	98.0	71.7	42.6	21.0	
1978		0.0						0.0	0.0							88.0	65.6				20.9	
1979	16.4			7.0				4.0					16.0				60.3	88.8	61.0	46.8		
1980	3.6			8.0				0.0					23.2		37.3	53.8	67.0	100.0	54.0	24.0	36.7	
1981	4.0			3.7	0.0			0.0	0.0							96.0	75.7	99.7			53.1	
1982		0.0			0.6								48.1				97.3					
1983		39.3									26.7	67.9	66.7	41.8			69.8	98.2	67.9	68.9	59.9	32.7
1984					7.9		78.0					80.6	76.0	57.1				93.8	73.0	81.0	72.0	54.8

Table 6. Fixed gillnet catches, catch rates * (t/landing) and catch rates adjusted for gang size used as the spring and fall spawning herring abundance indices.

YEAR	SPRING											FALL			STANDARDIZED GANG SIZE
	K				L				K + L **			N			
	APRIL		MAY		APRIL		MAY		APRIL + MAY			AUGUST			
	C	C/E	C	C/E	C	C/E	C	C/E	C	C/E	C/E adj	C	C/E	C/E adj	
1977												800	0.873	0.856	1.02
1978	41	0.245	437	0.828	199	2.211	491	1.569	1168	1.355	1.355	1278	0.794	0.794	1.00
1979	619	0.442	838	0.875	943	1.233	1117	1.320	3517	1.036	0.871	1010	1.027	0.863	1.19
1980	616	1.116	853	0.831	1445	1.862	1652	1.754	4566	1.530	1.168	1692	0.769	0.587	1.31
1981	481	0.667	817	1.338	889	0.573	601	0.706	2788	0.842	0.490	648	0.588	0.342	1.72
1982	12	0.091	1319	1.100	38	0.776	1135	0.710	2504	0.914	0.462	350	0.653	0.330	1.98
1983	887	1.090	429	1.298	394	0.602	358	0.470	2068	0.933	0.449	540	0.742	0.357	2.08
1984	469	1.830	648	1.971	218	0.836	237	0.791	1572	1.594	0.731	175	0.914	0.419	2.18

* Geometric mean.
** Average weighted by catches.

TABLE 7. Purse seine catch rates (weighted by catches) for the spring fishery in areas K and L and for the fall fishery in areas M and N, 1969-1984. (Sample size in parentheses).

K-L

	CATCH/SET	CATCH/SUCCESSFUL SET	CATCH/NIGHT	CATCH/SUCCESSFUL NIGHT
1969	–	–	–	–
70	–	–	–	–
71	11.88 (8)	22.50 (6)	15.00 (9)	33.75 (4)
72	32.52 (79)	33.99 (74)	53.33 (37)	59.95 (32)
73	50.41 (59)	51.40 (58)	131.26 (24)	137.27 (23)
74	32.02 (39)	34.19 (36)	34.36 (36)	51.17 (24)
75	79.66 (19)	79.66 (19)	91.77 (17)	119.34 (13)
76	100.26 (77)	105.09 (69)	98.36 (68)	165.73 (38)
77	67.63 (79)	71.16 (76)	105.82 (59)	113.68 (53)
78	47.17 (109)	48.51 (106)	86.31 (61)	99.35 (53)
79	72.56 (69)	90.10 (53)	85.90 (57)	100.65 (49)
80	102.63 (44)	121.76 (37)	98.41 (44)	151.69 (28)
81	198.20 (79)	231.70 (51)	185.00 (71)	264.53 (41)
82	17.68 (17)	60.75 (9)	36.05 (8)	64.84 (6)
83	103.33 (6)	103.33 (6)	124.00 (5)	124.00 (5)
84	38.72 (18)	46.71 (15)	72.51 (10)	82.26 (9)

APRIL - MAY

M-N

CATCH/SET	CATCH/SUCCESSFUL SET	CATCH/NIGHT	CATCH/SUCCESSFUL NIGHT
88.25 (4)	117.67 (3)	96.60 (5)	96.60 (5)
24.11 (17)	31.01 (15)	53.48 (24)	108.10 (16)
–	–	30.00 (11)	165.00 (2)
–	–	–	–
131.05 (22)	149.46 (20)	128.21 (26)	176.88 (18)
500.00 (1)	500.00 (1)	250.00 (2)	500.00 (1)
–	–	–	–
38.33 (6)	57.50 (4)	32.86 (7)	57.50 (4)
–	–	35.00 (3)	35.00 (3)
135.00 (7)	135.00 (7)	137.64 (11)	150.80 (10)
76.81 (26)	95.20 (20)	100.49 (20)	120.02 (16)
75.90 (34)	80.05 (32)	72.48 (36)	126.27 (20)
13.82 (6)	20.04 (4)	8.75 (4)	27.64 (3)
86.07 (14)	135.00 (2)	109.55 (11)	133.89 (9)
38.08 (38)	68.87 (24)	56.14 (27)	104.84 (16)
34.39 (17)	50.15 (12)	25.26 (23)	50.15 (12)

NOVEMBER - DECEMBER

Table 8. Proportion (%) of spring and fall spawner herring in the purse seine catch, NAFO division 4R. 1965-1984.

SPRING

	FISHING AREA																			
	K					L							M					N		
	FEB	MAR	APR	MAY	NOV	APR	MAY	AUG	SEPT	OCT	NOV	DEC	JAN	APR	OCT	NOV	DEC	OCT	NOV	DEC
1965																	58.1			
1966					34.0												60.5			
1967			54.3	21.4									26.0			78.0	61.6			
1968		32.0	26.0													50.8	51.0			
1969	68.0															42.0	61.7			
1970																59.0	82.0			
1971			6.0				5.3									66.0	86.0			98.0
1972				53.7				90.7								93.1				
1973			55.2			26.0	36.7						91.6		92.0	91.2				76.7
1974			71.0	39.0			18.0										96.0			91.7
1975			98.0	82.5																
1976			93.9	99.6			52.7													87.3
1977			96.1	99.0			23.6										89.0	49.3	92.0	
1978			82.5			80.9													86.6	84.9
1979			85.9			44.6	22.9									93.3			90.0	89.3
1980			95.6			98.0						75.9				87.7				
1981			96.4	94.5		98.4									89.3	69.8	60.8			
1982			100.0	98.2		100.0	99.6		54.0						75.1	79.1				
1983						75.3	65.1			44.3	34.4	56.5				45.7	74.5		44.6	58.2
1984						61.9				30.0				66.8	28.7	40.3	48.0		50.0	

FALL

	FISHING AREA																			
	K					L							M					N		
	FEB	MAR	APR	MAY	NOV	APR	MAY	AUG	SEPT	OCT	NOV	DEC	JAN	APR	OCT	NOV	DEC	OCT	NOV	DEC
1965																	41.9			
1966					66.0												39.5			
1967			45.6	78.6									74.0			22.0	38.4			
1968		68.0	74.0													49.2	49.0			
1969	32.0															58.0	38.3			
1970																41.0	18.0			
1971			94.0				94.7									34.0	14.0			2.0
1972				46.3				9.3								6.9				
1973			44.8			74.0	63.3						8.4		8.0	8.8				23.3
1974			29.0	61.0			82.0										4.0			8.3
1975			2.0	17.5																
1976			6.1	0.4			47.3													12.7
1977			3.9	1.0			76.4										11.0	50.7	8.0	
1978			17.5			19.1													13.4	15.1
1979			14.1			55.4	77.1									6.7			10.0	10.7
1980			4.4			2.0						24.1				12.2				
1981			3.6	5.5		1.6									10.7	30.2	39.2			
1982			0	1.8		0	0.4		46.0						24.9	20.9				
1983						24.7	34.9			55.7	65.6	43.5				54.3	25.5		55.4	41.8
1984						38.1				70.0				32.2	71.3	59.7	52.0		50.0	

Table 9. Catches at age ($X10^{-3}$) and proportion of spring and fall spawners in NAFO division 4R herring landings, 1966-1984. (SS = spring spawners; FS = fall spawners)

	Age	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
SS	1	0	0	0	0	0	0	372	0	0	0	0	29	0	0	4	0	0	4	9
	2	189	1	103	240	3 011	0	375	4 384	137	96	511	11	0	143	320	51	0	23	107
	3	390	8	296	1 093	1 458	3 238	254	910	235	738	997	664	40	30	992	317	433	2 776	132
	4	298	337	336	1 910	438	271	7 843	1 177	108	345	982	533	2 097	176	85	1 832	510	3 400	4 913
	5	586	70	583	965	660	544	1 341	30 697	294	190	229	516	210	10 967	327	97	1 960	1 300	2 743
	6	2 052	296	206	314	261	572	1 577	2 820	10 512	1 283	319	287	749	575	14 894	318	420	649	673
	7	4 127	3 545	616	173	201	453	1 879	3 139	254	8 261	2 745	346	287	1 039	412	8 773	1 811	215	597
	8	2 158	3 039	1 304	439	234	1 194	1 113	3 018	857	237	15 428	4 160	2 266	456	1 304	250	5 000	812	112
	9	1 670	1 429	2 282	975	1 015	98	1 099	1 796	689	360	764	16 333	8 617	2 710	258	593	957	1 309	415
	10	303	860	508	372	1 012	908	476	1 502	195	140	2 851	926	15 951	7 042	991	215	574	738	564
	11+	505	969	433	446	1 755	1 062	4 400	6 271	2 143	671	3 134	5 547	4 380	14 466	21 735	15 134	9 112	4 566	3 312
Total		12 278	10 554	6 667	6 927	10 045	8 340	20 729	55 714	15 424	12 321	27 960	29 352	34 597	37 604	41 322	27 580	20 777	15 792	13 577
FS	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	104	0	0	17	0	31	29	0	0	0	0	0	0	0	16	0	0	7	0
	3	181	28	226	300	890	0	102	810	16	96	59	3	15	19	215	28	43	58	42
	4	639	51	131	642	176	81	113	769	269	174	47	61	53	70	83	337	954	2 153	422
	5	277	529	201	355	142	368	403	1 102	388	1 110	102	113	452	288	143	158	562	1 144	5 133
	6	274	306	1 037	692	250	590	755	2 596	284	327	338	302	311	2 542	253	82	337	968	1 258
	7	277	116	294	519	493	2 144	1 218	2 028	288	78	470	746	1 130	626	1 542	191	121	450	850
	8	1 007	322	223	158	173	3 562	1 275	2 525	222	112	108	388	1 841	1 396	224	717	316	186	302
	9	1 105	927	288	122	128	1 899	2 097	5 196	293	67	158	214	589	2 038	691	120	879	410	156
	10	926	1 128	1 208	164	228	1 273	1 254	8 047	336	63	52	99	379	552	282	98	260	730	259
	11+	2 781	3 155	2 568	1 411	2 171	14 105	9 513	17 386	4 202	2 229	3 969	7 213	5 681	6 824	5 027	2 716	2 168	2 928	2 147
Total		7 571	6 562	6 176	4 380	4 651	24 053	16 759	40 459	6 298	4 256	5 303	9 139	10 451	14 355	8 476	4 447	5 640	9 034	10 569
Total FS+SS		19 849	17 116	12 843	11 307	14 696	32 393	37 488	96 173	21 722	16 577	33 263	38 491	45 048	51 959	49 798	32 027	26 417	24 826	24 146
% SS		61.9	61.7	51.9	61.3	68.3	25.8	55.3	57.9	71.0	74.3	84.1	76.3	76.8	72.4	83.0	86.1	78.7	63.6	56.2
% FS		38.1	38.1	48.1	38.7	31.7	74.2	44.7	42.1	29.0	25.7	15.9	23.7	23.2	27.6	17.0	14.9	21.3	36.4	43.8

Table 10. Age compositions (%) and mean ages* of spring and fall spawners in NAFO division 4R herring landings, 1966-1984. (SS = spring spawners; FS = fall spawners)

	Age	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
SS	1	0.00	0.00	0.00	0.00	0.00	0.00	1.79	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.01	0.00	0.00	0.03	0.07
	2	1.54	0.01	1.54	3.46	29.98	0.00	1.81	7.87	0.89	0.78	1.83	0.04	0.00	0.38	0.77	0.18	0.00	0.15	0.79
	3	3.18	0.08	4.44	15.78	14.51	38.82	1.23	1.63	1.52	5.99	3.57	2.26	0.12	0.08	2.40	1.15	2.08	17.58	0.97
	4	2.43	3.19	5.04	27.57	4.36	3.25	37.84	2.11	0.70	2.80	3.51	1.82	6.06	0.47	0.21	6.64	2.45	21.53	36.19
	5	4.77	0.66	8.74	13.93	6.57	6.52	6.47	55.10	1.91	1.54	0.82	1.76	0.61	29.16	0.79	0.35	9.43	8.23	20.20
	6	16.71	2.80	3.09	4.53	2.60	6.86	7.61	5.06	68.15	10.41	1.14	0.98	2.16	1.53	36.04	1.15	2.02	4.11	4.96
	7	33.61	33.59	9.24	2.50	2.00	5.43	9.06	5.63	1.65	67.05	9.82	1.18	0.83	2.76	1.00	31.81	8.72	1.36	4.40
	8	17.58	28.79	19.56	6.34	2.33	14.32	5.37	5.42	5.56	1.92	55.18	14.17	6.55	1.21	3.16	0.91	24.07	5.14	0.82
	9	13.60	13.54	34.23	14.08	10.10	1.18	5.30	3.22	4.47	2.92	2.73	55.65	24.91	7.21	0.62	2.15	4.61	8.29	3.06
	10	2.47	8.15	7.62	5.37	10.07	10.89	2.30	2.70	1.26	1.14	10.20	3.15	46.11	18.73	2.40	0.78	2.76	4.67	4.15
	11+	4.11	9.18	6.49	6.44	17.47	12.73	21.23	11.26	13.89	5.45	11.21	18.90	12.66	38.47	52.60	54.87	43.86	28.91	24.39
	< 4	4.72	0.09	5.98	19.24	44.49	38.82	4.83	9.50	2.41	6.77	5.40	2.40	0.12	0.46	3.18	1.33	2.08	17.76	1.83
mean age		7.1	8.0	7.9	5.8	5.9	6.2	6.5	6.0	6.9	6.8	8.0	8.9	9.2	8.6	8.7	9.0	8.8	6.9	6.5
FS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	1.37	0.00	0.00	0.39	0.00	0.13	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.08	0.00
	3	2.39	0.43	3.66	6.85	19.14	0.00	0.61	2.00	0.25	2.26	1.11	0.03	0.14	0.13	2.54	0.63	0.76	0.64	0.40
	4	8.44	0.78	2.12	14.66	3.78	0.34	0.67	1.90	4.27	4.09	0.89	0.67	0.51	0.49	0.98	7.58	16.91	23.83	3.99
	5	3.66	8.06	3.25	8.11	3.05	1.53	2.40	2.72	6.16	26.08	1.92	1.24	4.32	2.01	1.69	3.55	9.96	12.66	48.57
	6	3.62	4.66	16.79	15.80	5.38	2.45	4.51	6.42	4.51	7.68	6.37	3.30	2.98	17.71	2.98	1.84	5.98	10.72	11.90
	7	3.66	1.77	4.76	11.85	10.60	8.91	7.27	5.01	4.57	1.82	8.86	8.16	10.81	4.36	18.19	4.30	2.15	4.98	8.04
	8	13.30	4.91	3.61	3.61	3.72	14.81	7.61	6.24	3.52	2.63	2.04	4.25	17.62	9.72	2.64	16.12	5.60	2.06	2.86
	9	14.60	14.13	4.66	2.79	2.75	7.90	12.51	12.84	4.65	1.57	2.98	2.34	5.64	14.20	8.15	2.70	15.59	4.54	1.48
	10	12.23	17.19	19.56	3.74	4.90	5.29	7.48	19.89	5.34	1.48	0.98	1.08	3.63	3.85	3.33	2.20	4.61	8.08	2.45
	11+	36.73	48.08	41.58	32.21	46.68	58.64	56.76	42.97	66.72	52.37	74.84	78.93	54.36	47.54	59.31	61.07	38.44	32.41	20.31
	< 4	3.76	0.43	3.66	7.24	19.14	0.13	0.78	2.00	0.25	2.26	1.11	0.03	0.14	0.13	2.73	0.63	0.76	0.72	0.40
mean age		8.7	9.5	8.9	7.4	8.1	9.7	9.7	9.4	9.7	8.4	9.9	10.2	9.4	9.2	9.5	9.4	8.2	7.5	6.7

*Assuming ages 11+ to be 11.

Table 11. Calculation of the purse seine selectivity factors from the age compositions of discarded sets and commercial landings.

AGE	DISC.	COM.	RATIO	SELECTIVITY FACTOR	P.R.
SPRING SPAWNERS					
2	20.9	0.8	0.04	.023	.023
3	2.5	1.0	0.39	.239	.24
4	35.0	36.2	1.03	.630	.63
5	12.3	20.2	1.64	1.000	.90
6	4.7	4.9	1.05	.641	.64
7	2.9	4.4	1.52	.924	1.00
8	0.7	0.8	1.19	.722	1.00
9	1.4	3.1	2.19	1.331	1.00
10	4.7	4.2	0.88	.538	1.00
11+	14.4	24.4	1.69	1.032	1.00
FALL SPAWNERS					
2	-	-	-	-	-
3	2.1	0.4	0.19	.100	.10
4	5.1	4.0	0.78	.412	.41
5	63.6	48.6	0.76	.401	.40
6	11.0	11.9	1.08	.568	.57
7	4.2	8.0	1.90	1.000	1.00
8	1.7	2.9	1.71	.896	1.00
9	0.8	1.5	1.88	.984	1.00
10	2.1	2.5	1.19	.625	1.00
11+	9.3	20.3	2.18	1.146	1.00

Table 12. Average weights (g) at age (first half of the year) for spring and fall spawner herring in NAFO division 4R.

SPRING WEIGHTS AT AGE

	I	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
2	I	89	89	89	91	87	67	47	89	86	72	71	64	75	87	102	71	64	64	40
3	I	110	110	89	110	131	90	196	119	158	149	135	122	167	125	168	177	144	131	151
4	I	184	184	159	167	176	181	187	189	202	196	177	194	172	234	212	237	239	227	218
5	I	198	198	208	188	202	227	235	204	203	233	227	225	247	241	269	311	262	276	264
6	I	225	225	231	224	218	260	266	250	237	237	238	256	279	287	293	332	321	281	312
7	I	252	252	244	259	275	234	288	304	271	270	259	253	292	318	338	367	364	371	351
8	I	255	255	274	293	312	262	295	321	315	300	290	267	292	344	350	393	377	428	374
9	I	269	269	280	269	258	297	315	338	344	334	310	289	314	339	362	417	393	441	426
10	I	302	302	330	318	307	314	303	353	340	339	319	298	328	356	343	415	406	485	419
11	I	344	344	312	339	366	336	349	384	385	399	380	349	344	387	405	462	432	498	491

FALL WEIGHTS AT AGE

	I	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
2	I	115	116	116	118	106	95	114	98	82	89	96	105	105	105	115	136	158	88	88
3	I	167	158	179	160	173	166	159	158	134	93	159	242	138	210	210	207	150	195	151
4	I	197	181	226	196	218	244	189	205	218	183	206	232	217	237	264	269	223	234	230
5	I	232	242	256	216	266	246	258	233	265	271	221	295	270	292	322	331	301	269	271
6	I	229	258	284	247	271	268	257	288	254	305	260	296	335	336	355	351	325	306	314
7	I	245	286	297	271	286	287	265	316	325	380	292	333	355	381	406	419	389	339	352
8	I	240	290	294	287	324	305	315	366	328	346	292	337	381	413	416	457	427	383	386
9	I	269	317	317	291	333	322	317	355	364	376	300	336	372	445	458	473	442	426	398
10	I	293	333	348	300	318	326	315	390	391	400	419	342	392	444	460	516	501	432	452
11	I	347	376	371	338	415	368	394	402	448	510	479	438	504	510	547	567	529	471	491

Table 13. Correlation coefficients and intercepts for different relationships between fall spawner biomass and gillnet catch rates at various F values for cohort analysis.

F		0.20	0.30	0.35	0.40
MID-YEAR BIOMASS					
5+	r	.89	.92	.93	.93
	bo	6683	1031	-585	-1797
6+	r	.92	.92	.92	.92
	bo	-596	-3648	-4520	-5174
MID-YEAR FISHABLE BIOMASS					
2+	r	.89	.89	.89	.89
	bo	5352	785	-520	-1498

Table 14. (a) Population numbers ('000) and (b) fishing mortality rates as estimated from cohort analysis for spring spawner herring in NAFO division 4R, 1966-1984.

(a)

SPRING SPAWNERS POPULATION NUMBERS

	I	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
2	I	34646	60530	167615	54746	936930	366232	54172	16978	35620	46933	146540	29700	6362	28845	30868	70222	136054	7580	51386
3	I	55458	28194	49557	137138	44605	764369	299846	44013	9933	29039	38338	119514	24306	5209	23487	24983	57447	111392	6185
4	I	22203	45052	23076	40306	111290	35200	622882	245263	35211	7920	23107	30487	97249	19864	4237	18332	20168	46641	88688
5	I	93527	17908	36581	18589	31271	90721	28574	502876	199739	28731	6172	18030	24478	77723	16104	3392	13351	16050	35110
6	I	51397	76043	14599	29422	14346	25006	73784	22181	383945	163267	23351	4846	14295	19851	53711	12889	2690	9157	11965
7	I	44623	40224	61991	11766	23805	11510	19955	58982	15609	304836	132511	18829	3708	11026	15732	30498	10265	1822	6910
8	I	26108	32800	29725	50197	9477	19308	9013	14638	45450	12550	242103	106007	15103	2776	8087	12508	17032	6766	1296
9	I	11506	19423	24105	23157	40700	7547	14728	6373	9254	36436	10060	184258	83027	10315	1860	5441	10014	9420	4804
10	I	4400	7909	14609	17670	18077	32404	6090	11063	3592	6953	29505	7545	136079	60180	5993	1290	3918	7333	6528
11	I	7044	3328	5698	11501	14131	13884	25709	4556	7699	2765	5566	21577	5340	96979	42899	4010	861	2689	5336
12	I	0	5310	2397	4480	9198	10847	11016	19213	3175	5929	2213	4067	15275	3804	69130	28684	2686	589	1956
13	I	0	0	3799	1884	3580	7063	8604	8232	13371	2447	4746	1616	2876	10887	2710	46220	19196	1844	428
14	I	0	0	0	2981	1506	2743	5604	6426	5729	10297	1959	3470	1142	2048	7762	1809	30931	13171	1343
15	I	0	0	0	0	2380	1153	2173	4188	4467	4411	8244	1433	2455	813	1459	5191	1209	21221	9584
16	I	0	0	0	0	0	1818	913	1618	2915	3438	3532	6029	1015	1750	579	973	3476	828	15441
17	I	0	0	0	0	0	0	1439	679	1116	2244	2753	2584	4268	724	1247	386	650	2386	602
18	I	0	0	0	0	0	0	0	1067	467	857	1797	2012	1831	3043	517	834	257	446	1736
19	I	0	0	0	0	0	0	0	0	731	358	685	1314	1424	1306	2170	346	558	175	324
20	I	0	0	0	0	0	0	0	0	0	558	286	498	930	1015	932	1452	232	382	127
21	I	0	0	0	0	0	0	0	0	0	0	445	206	349	663	723	624	973	159	278
22	I	0	0	0	0	0	0	0	0	0	0	0	319	142	246	472	483	417	668	116
23	I	0	0	0	0	0	0	0	0	0	0	0	0	220	99	173	315	323	287	486
24	I	0	0	0	0	0	0	0	0	0	0	0	0	0	152	68	114	210	222	208
25	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	105	43	74	144	162
26	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	67	27	50	104
27	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43	50	93
2+	I	350912	336723	433751	403838	1261297	1389806	1184502	968346	778023	669968	683914	564342	441874	359316	291026	271107	333063	261474	251197
3+	I	316267	276193	266136	349092	324367	1023574	1130330	951369	742403	623035	537375	534642	435512	330471	260157	200886	197009	253894	199811
4+	I	260809	247999	216579	211954	279762	259205	830485	907356	732470	593996	499036	415128	411206	325262	236671	175902	139562	142502	193626
5+	I	238606	202946	193503	171648	168472	224004	207602	662093	697258	586076	475929	384641	313956	305398	232433	157571	119394	95860	104938

(b)

FISHING MORTALITY

	I	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
2	I	0.006	0.000	0.001	0.005	0.004	0.000	0.008	0.336	0.004	0.002	0.004	0.000	0.000	0.005	0.012	0.001	0.000	0.003	0.002
3	I	0.008	0.000	0.007	0.009	0.037	0.005	0.001	0.023	0.026	0.028	0.029	0.006	0.002	0.006	0.048	0.014	0.008	0.028	0.024
4	I	0.015	0.008	0.016	0.054	0.004	0.009	0.014	0.005	0.003	0.049	0.048	0.020	0.024	0.010	0.022	0.117	0.028	0.084	0.063
5	I	0.007	0.004	0.018	0.059	0.024	0.007	0.053	0.070	0.002	0.007	0.042	0.032	0.010	0.170	0.023	0.032	0.177	0.094	0.090
6	I	0.045	0.004	0.016	0.012	0.020	0.026	0.024	0.151	0.031	0.009	0.015	0.068	0.060	0.033	0.366	0.028	0.189	0.082	0.064
7	I	0.108	0.102	0.011	0.016	0.009	0.044	0.110	0.061	0.018	0.030	0.023	0.021	0.089	0.110	0.029	0.383	0.217	0.140	0.100
8	I	0.096	0.108	0.050	0.010	0.028	0.071	0.147	0.259	0.021	0.021	0.073	0.044	0.181	0.200	0.196	0.022	0.392	0.142	0.100
9	I	0.175	0.085	0.111	0.048	0.028	0.014	0.086	0.373	0.086	0.011	0.088	0.103	0.122	0.343	0.166	0.128	0.112	0.167	0.100
10	I	0.079	0.128	0.039	0.024	0.064	0.031	0.090	0.163	0.062	0.023	0.113	0.146	0.139	0.138	0.202	0.204	0.177	0.118	0.100
11	I	0.070	0.128	0.040	0.023	0.064	0.031	0.091	0.161	0.061	0.023	0.114	0.145	0.139	0.139	0.203	0.201	0.179	0.118	0.100
12	I	0.000	0.112	0.040	0.024	0.064	0.032	0.091	0.163	0.061	0.022	0.114	0.147	0.139	0.139	0.203	0.202	0.176	0.119	0.100
13	I	0.000	0.000	0.035	0.024	0.066	0.031	0.092	0.163	0.061	0.022	0.113	0.147	0.140	0.138	0.204	0.202	0.177	0.117	0.100
14	I	0.000	0.000	0.000	0.020	0.067	0.033	0.091	0.164	0.061	0.022	0.113	0.146	0.140	0.139	0.202	0.203	0.177	0.118	0.100
15	I	0.000	0.000	0.000	0.000	0.056	0.033	0.095	0.162	0.062	0.022	0.113	0.145	0.139	0.140	0.204	0.201	0.179	0.118	0.100
16	I	0.000	0.000	0.000	0.000	0.000	0.027	0.096	0.171	0.061	0.022	0.112	0.145	0.138	0.139	0.205	0.203	0.176	0.119	0.100
17	I	0.000	0.000	0.000	0.000	0.000	0.000	0.078	0.174	0.064	0.022	0.113	0.145	0.138	0.137	0.203	0.206	0.178	0.118	0.100
18	I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.136	0.066	0.023	0.113	0.146	0.138	0.138	0.201	0.202	0.183	0.118	0.100
19	I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.051	0.025	0.120	0.146	0.139	0.138	0.202	0.201	0.177	0.120	0.100
20	I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.019	0.128	0.156	0.139	0.139	0.202	0.201	0.177	0.120	0.100
21	I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.095	0.169	0.150	0.139	0.203	0.202	0.176	0.118	0.100
22	I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.118	0.169	0.150	0.205	0.202	0.176	0.118	0.100
23	I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.109	0.171	0.221	0.206	0.175	0.119	0.100
24	I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.100	0.258	0.228	0.178	0.116	0.100
25	I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.138	0.263	0.197	0.122	0.100
26	I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.118	0.227	0.142	0.100
27	I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.227	0.142	0.100
5+	I	0.055	0.058	0.035	0.024	0.034	0.024	0.066	0.087	0.024	0.021	0.061	0.085	0.122	0.146	0.216	0.202	0.206	0.117	0.093

Table 15. (a) Population numbers ('000) and (b) fishing mortality rates as estimated from cohort analysis for fall spawner herring in NAFO division 4R, 1966-1984.

(a)

FALL SPAWNERS POPULATION NUMBERS

I	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
2 I	88212	33154	16597	15623	22682	25340	31207	16678	13721	33509	10298	4347	6909	14146	23529	94683	6068	1922	0
3 I	264196	72128	27144	13588	12776	18570	20718	25524	13655	11234	27435	8432	3559	5656	11581	19250	77520	4968	1567
4 I	76089	216141	59028	22019	10854	9655	15204	16870	20165	11165	9111	22408	6900	2900	4614	9287	15735	63429	4015
5 I	46716	61718	176915	48210	17447	8727	7831	12346	13116	16266	8984	7417	18291	5602	2311	3702	7299	12019	49983
6 I	49119	37997	50052	144664	39150	14156	6812	6047	9111	10388	12313	7263	5970	14567	4326	1763	2888	5467	8806
7 I	49249	39967	30833	40041	117815	31827	11056	4894	2602	7202	8209	9775	5673	4607	9626	3313	1369	2060	3600
8 I	136253	40071	32617	24978	32313	96013	24118	7950	2172	1870	5826	6296	7335	3622	3205	6486	2539	1012	1279
9 I	79859	110643	32516	26503	20307	26299	75385	18592	4224	1577	1429	4672	4804	4339	1702	2421	4661	1793	661
10 I	53213	64383	89748	26362	21588	16510	19814	59823	10520	3193	1231	1027	3632	3400	1709	769	1874	3021	1097
11 I	158753	42729	51692	72387	21435	17469	12365	15087	41698	8309	2557	961	752	2630	2285	1144	541	1299	1813
12 I	0	127459	34271	41709	58856	17345	13089	9411	10519	32936	6654	1995	702	545	1766	1529	805	375	779
13 I	0	0	102213	27631	33920	47624	12998	9965	6554	8309	26375	5189	1458	509	366	1182	1077	558	224
14 I	0	0	0	82401	22463	27455	35677	9898	6946	5176	6654	20570	3788	1056	343	246	833	747	335
15 I	0	0	0	0	66985	18172	20622	27159	6903	5487	4145	5189	15019	2741	710	230	173	578	449
16 I	0	0	0	0	0	54182	13585	15735	18925	5454	4394	3232	3788	10871	1839	475	162	120	347
17 I	0	0	0	0	0	0	40478	10322	11029	14947	4367	3426	2359	2741	7294	1229	335	113	72
18 I	0	0	0	0	0	0	0	30739	7160	8723	11969	3407	2500	1707	1839	4877	865	233	68
19 I	0	0	0	0	0	0	0	0	21289	5649	6991	9334	2488	1808	1145	1229	3433	600	140
20 I	0	0	0	0	0	0	0	0	0	16790	4520	5462	6814	1801	1212	766	865	2379	360
21 I	0	0	0	0	0	0	0	0	0	0	13433	3518	4006	4931	1208	809	539	600	1427
22 I	0	0	0	0	0	0	0	0	0	0	0	10456	2557	2915	3308	808	569	374	360
23 I	0	0	0	0	0	0	0	0	0	0	0	0	7597	1840	1976	2212	569	395	224
24 I	0	0	0	0	0	0	0	0	0	0	0	0	0	5466	1221	1338	1557	395	237
25 I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3625	805	953	1079	237
26 I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2389	560	670	648
27 I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1660	1849	1372
2+I	1001658	846392	703626	586116	498589	429342	360959	297041	220310	208185	176894	144378	116902	100400	92741	162944	135451	108053	80103
3+I	913446	813238	687030	570492	475908	404002	329751	280364	206588	174676	166596	140031	109993	86255	69212	68261	129383	106131	80103
4+I	649250	741110	659885	556904	463132	385432	309033	254839	192934	163441	139161	131599	106434	80598	57630	49011	51863	101164	78536
5+I	573161	524969	600857	534885	452278	375777	293829	237969	172769	152276	130050	109191	99534	77698	53017	39723	36128	37734	74521

(b)

FISHING MORTALITY

I	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
2 I	0.001	0.000	0.000	0.001	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.004	0.000
3 I	0.001	0.000	0.009	0.025	0.080	0.000	0.005	0.036	0.001	0.009	0.002	0.000	0.005	0.004	0.021	0.002	0.001	0.013	0.030
4 I	0.009	0.000	0.002	0.033	0.018	0.009	0.008	0.052	0.015	0.017	0.006	0.003	0.009	0.027	0.020	0.041	0.069	0.038	0.123
5 I	0.007	0.010	0.001	0.008	0.009	0.048	0.059	0.104	0.033	0.078	0.013	0.017	0.028	0.058	0.071	0.048	0.089	0.111	0.120
6 I	0.006	0.009	0.023	0.005	0.007	0.047	0.131	0.643	0.035	0.035	0.031	0.047	0.059	0.214	0.067	0.053	0.138	0.218	0.171
7 I	0.006	0.003	0.011	0.014	0.005	0.077	0.130	0.612	0.130	0.012	0.065	0.087	0.249	0.163	0.195	0.066	0.103	0.276	0.300
8 I	0.008	0.009	0.008	0.007	0.006	0.042	0.060	0.432	0.120	0.068	0.021	0.070	0.325	0.555	0.080	0.130	0.148	0.226	0.300
9 I	0.015	0.009	0.010	0.005	0.007	0.083	0.031	0.369	0.080	0.048	0.130	0.052	0.146	0.732	0.595	0.056	0.234	0.291	0.300
10 I	0.019	0.020	0.015	0.007	0.012	0.089	0.073	0.161	0.036	0.022	0.048	0.113	0.123	0.198	0.201	0.152	0.166	0.311	0.300
11 I	0.017	0.021	0.015	0.007	0.012	0.089	0.073	0.161	0.036	0.022	0.048	0.113	0.122	0.198	0.201	0.151	0.166	0.311	0.300
12 I	0.000	0.018	0.015	0.007	0.012	0.088	0.073	0.162	0.036	0.022	0.049	0.114	0.122	0.197	0.202	0.150	0.167	0.312	0.300
13 I	0.000	0.000	0.014	0.007	0.011	0.089	0.072	0.161	0.036	0.022	0.049	0.115	0.122	0.196	0.200	0.150	0.166	0.311	0.300
14 I	0.000	0.000	0.000	0.006	0.012	0.086	0.073	0.160	0.036	0.022	0.049	0.115	0.123	0.197	0.199	0.150	0.166	0.309	0.300
15 I	0.000	0.000	0.000	0.000	0.011	0.091	0.070	0.161	0.036	0.022	0.049	0.115	0.123	0.199	0.201	0.150	0.166	0.309	0.300
16 I	0.000	0.000	0.000	0.000	0.000	0.080	0.075	0.155	0.036	0.022	0.049	0.115	0.123	0.199	0.203	0.150	0.163	0.311	0.300
17 I	0.000	0.000	0.000	0.000	0.000	0.000	0.065	0.166	0.035	0.022	0.048	0.115	0.123	0.199	0.203	0.151	0.165	0.308	0.300
18 I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.143	0.037	0.021	0.049	0.114	0.124	0.199	0.203	0.151	0.166	0.309	0.300
19 I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.031	0.023	0.047	0.115	0.123	0.200	0.203	0.151	0.167	0.311	0.300
20 I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.019	0.050	0.110	0.123	0.199	0.204	0.151	0.166	0.311	0.300
21 I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.042	0.119	0.118	0.199	0.202	0.152	0.167	0.311	0.300
22 I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.098	0.129	0.189	0.203	0.150	0.166	0.309	0.300
23 I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.103	0.210	0.190	0.151	0.166	0.309	0.300
24 I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.162	0.216	0.140	0.166	0.309	0.300
25 I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.158	0.164	0.153	0.310	0.300
26 I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.113	0.183	0.276	0.300
27 I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.183	0.276	0.300
5+I	0.012	0.013	0.010	0.007	0.009	0.072	0.063	0.202	0.039	0.029	0.044	0.094	0.123	0.233	0.186	0.118	0.154	0.226	0.164

Table 16. Catch and population estimates for (a) spring and (b) fall spawner herring in NAFO division 4R, 1984-1986, assuming a fishing mortality rate F=0.3 in 1986.

(a) SPRING

	POPULATION NUMBERS ('000)			POPULATION BIOMASS (t)			FISHING MORTALITY			CATCH NUMBERS ('000)			CATCH BIOMASS (t)		
I	1984	1985	1986	1984	1985	1986	1984	1985	1986	1984	1985	1986	1984	1985	1986
2 I	61232	61232	61232	2259	2258	2254	0.002	0.003	0.007	107	149	382	4	6	16
3 I	50112	50036	49998	6976	6881	6733	0.003	0.028	0.072	133	1256	3152	20	193	485
4 I	88688	40908	39832	17316	7947	7327	0.063	0.074	0.189	4913	2637	6237	1091	586	1385
5 I	35110	68178	31113	8196	15799	6675	0.090	0.105	0.270	2743	6186	6703	738	1663	1802
6 I	11965	26272	50242	3342	7155	12565	0.064	0.117	0.300	673	2634	11861	214	837	3769
7 I	6910	9189	19135	2134	2815	5384	0.100	0.117	0.300	597	921	4517	213	329	1615
8 I	1296	5119	6692	427	1671	2006	0.100	0.117	0.300	112	513	1580	43	196	602
9 I	4804	960	3729	1801	357	1273	0.100	0.117	0.300	415	96	880	180	42	382
10 I	6528	3559	699	2407	1302	235	0.100	0.117	0.300	564	357	165	241	152	70
11 I	5336	4836	2592	2306	2073	1020	0.100	0.117	0.300	461	485	612	231	242	306
12 I	1956	3953	3522	845	1694	1386	0.100	0.117	0.300	169	396	832	85	198	416
13 I	428	1449	2879	185	621	1133	0.100	0.117	0.300	37	145	680	19	73	340
14 I	1343	317	1055	580	136	415	0.100	0.117	0.300	116	32	249	58	16	125
15 I	9584	995	231	4141	426	91	0.100	0.117	0.300	828	100	55	414	50	27
16 I	15441	7100	724	6672	3043	285	0.100	0.117	0.300	1334	712	171	667	356	86
17 I	602	11439	5171	260	4903	2035	0.100	0.117	0.300	52	1147	1221	26	574	611
18 I	1736	446	8331	750	191	3279	0.100	0.117	0.300	150	45	1967	75	22	984
19 I	1898	1286	325	820	551	128	0.100	0.117	0.300	164	129	77	82	64	38
20 I	0	1406	937	0	603	369	0.000	0.117	0.300	0	141	221	0	71	111
21 I	0	0	1024	0	0	403	0.000	0.117	0.300	0	0	242	0	0	121
2+I	304970	298680	289465	61416	60427	54996				13568	18080	41802	4400	5670	13290
3+I	243738	237448	228233	59157	58169	52743				13461	17931	41420	4396	5664	13274
4+I	193626	187413	178236	52181	51288	46010				13328	16675	38269	4375	5471	12789
5+I	104938	146504	138404	34865	43341	38683				8415	14038	32032	3284	4885	11405

(b) FALL

	POPULATION NUMBERS ('000)			POPULATION BIOMASS (t)			FISHING MORTALITY			CATCH NUMBERS ('000)			CATCH BIOMASS (t)		
I	1984	1985	1986	1984	1985	1986	1984	1985	1986	1984	1985	1986	1984	1985	1986
2 I	19133	19133	19133	1449	1449	1449	0.000	0.000	0.000	0	7	5	0	1	0
3 I	15658	15665	15659	2032	1998	2006	0.003	0.039	0.030	42	543	420	6	78	60
4 I	4015	12782	12335	749	2345	2302	0.123	0.160	0.123	422	1715	1297	92	375	283
5 I	49983	2907	8920	11007	629	1964	0.120	0.156	0.120	5133	381	916	1321	98	236
6 I	8806	36295	2036	2193	8828	507	0.171	0.222	0.171	1258	6575	291	375	1960	87
7 I	3600	6076	23798	947	1534	6260	0.300	0.390	0.300	850	1789	5618	284	598	1878
8 I	1279	2184	3370	369	605	972	0.300	0.390	0.300	302	643	795	111	236	292
9 I	661	776	1211	197	222	360	0.300	0.390	0.300	156	228	286	59	86	108
10 I	1097	401	430	371	130	145	0.300	0.390	0.300	259	118	102	111	51	44
11 I	1813	665	222	665	234	82	0.300	0.390	0.300	428	196	52	200	91	24
12 I	779	1100	369	286	387	135	0.300	0.390	0.300	184	324	87	86	151	41
13 I	224	473	610	82	167	224	0.300	0.390	0.300	53	139	144	25	65	67
14 I	335	136	262	123	48	96	0.300	0.390	0.300	79	40	62	37	19	29
15 I	449	203	76	165	71	28	0.300	0.390	0.300	106	60	18	49	28	8
16 I	347	272	113	127	96	41	0.300	0.390	0.300	82	80	27	38	37	12
17 I	72	211	151	26	74	55	0.300	0.390	0.300	17	62	36	8	29	17
18 I	68	44	117	25	15	43	0.300	0.390	0.300	16	13	28	7	6	13
19 I	5007	41	24	1837	14	9	0.300	0.390	0.300	1182	12	6	551	6	3
20 I	0	3037	23	0	1070	8	0.000	0.390	0.300	0	894	5	0	417	3
21 I	0	0	1684	0	0	618	0.000	0.390	0.300	0	0	398	0	0	185
2+I	113327	102400	90543	22650	19916	17304				10569	13818	10591	3360	4330	3389
3+I	94194	83267	71410	21201	18468	15855				10569	13811	10586	3360	4329	3389
4+I	78536	67602	55751	19169	16470	13850				10527	13268	10167	3354	4252	3328
5+I	74521	54820	43416	18420	14125	11548				10105	11553	8370	3262	3877	3045

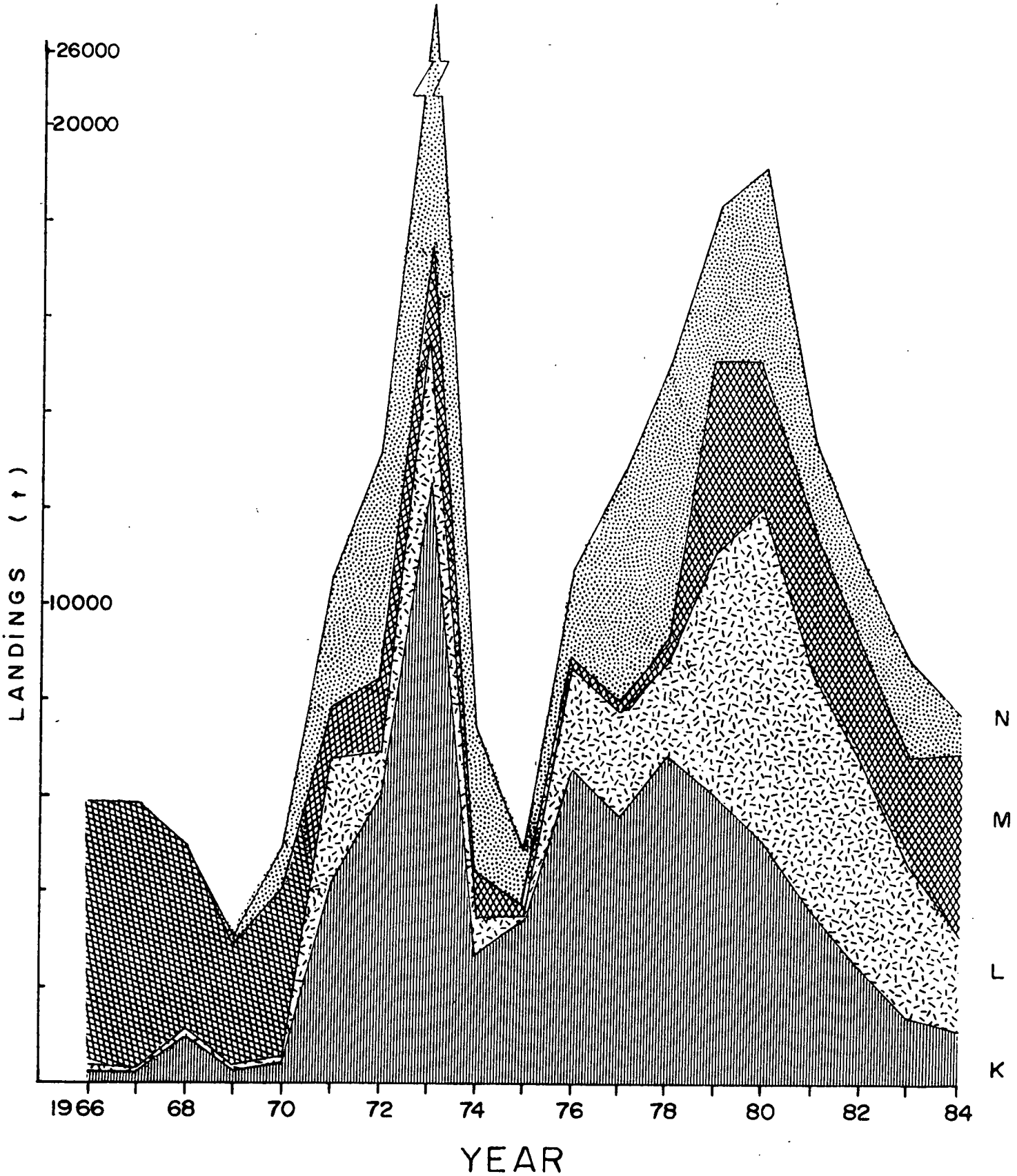

Figure 1. Commercial herring landings (t) from NAFO division 4R by fishing area, 1966-1984.

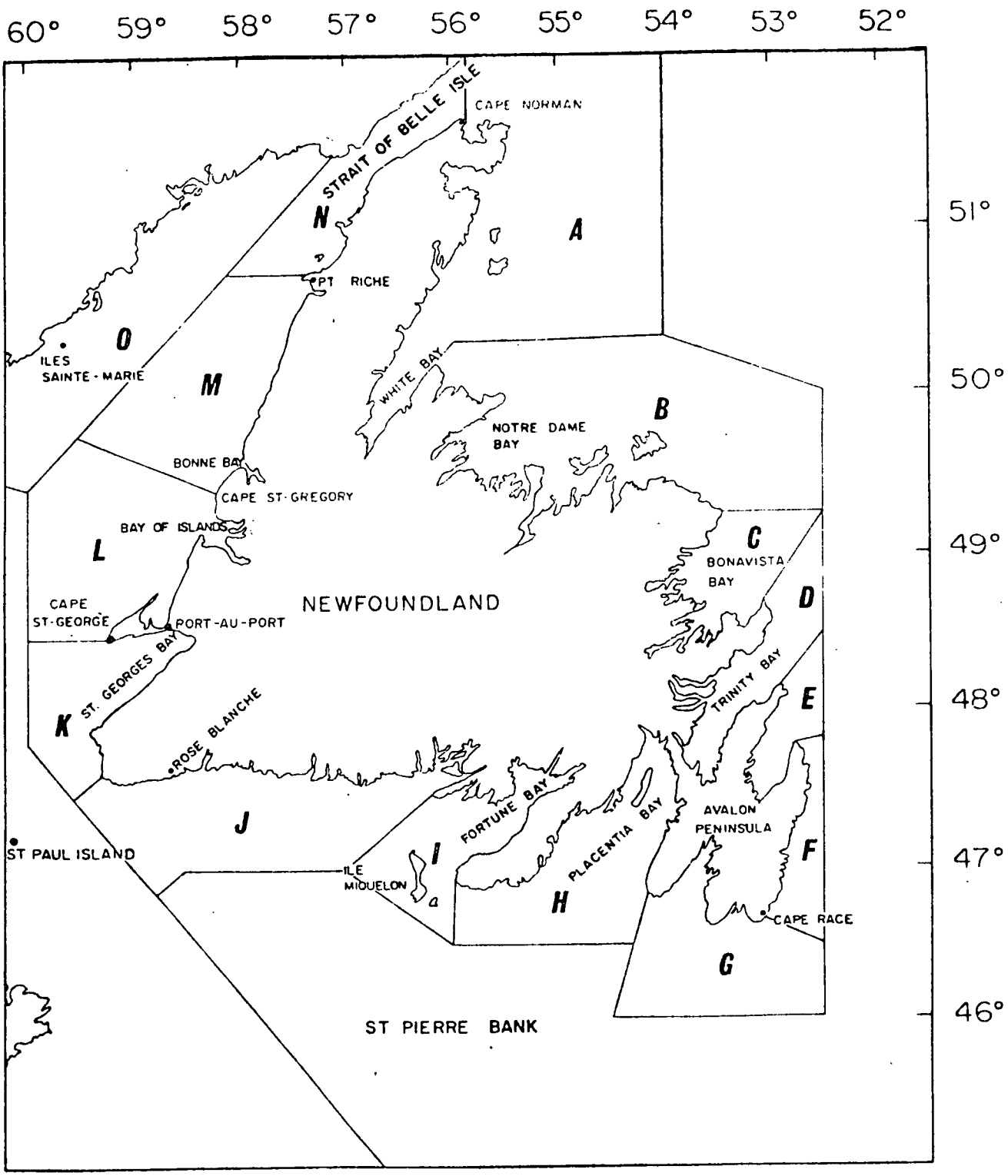

Figure 2. Newfoundland fishing areas.

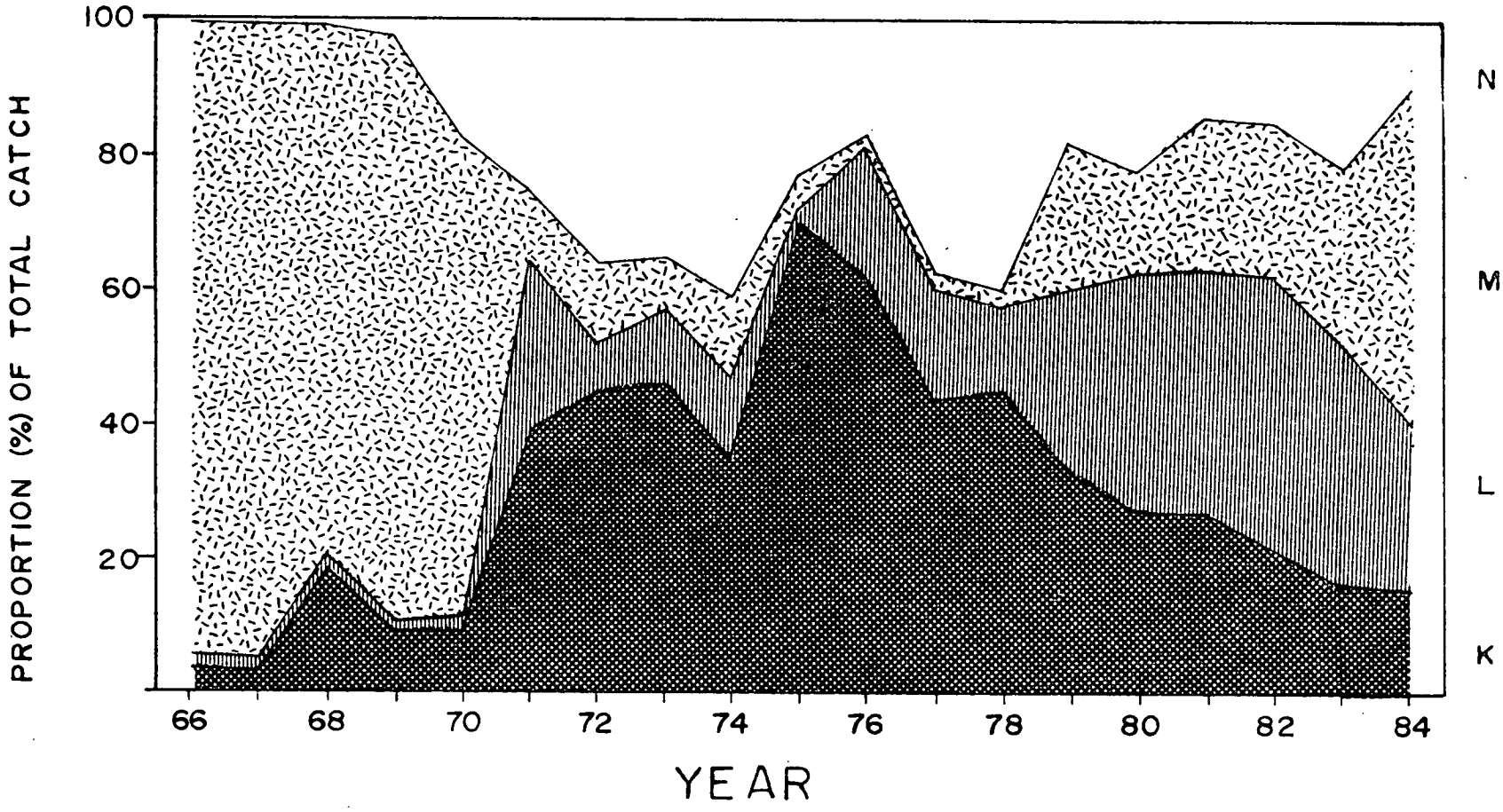

Figure 3. Proportions of the total annual herring catches separated by fishing areas, 1966-1984.

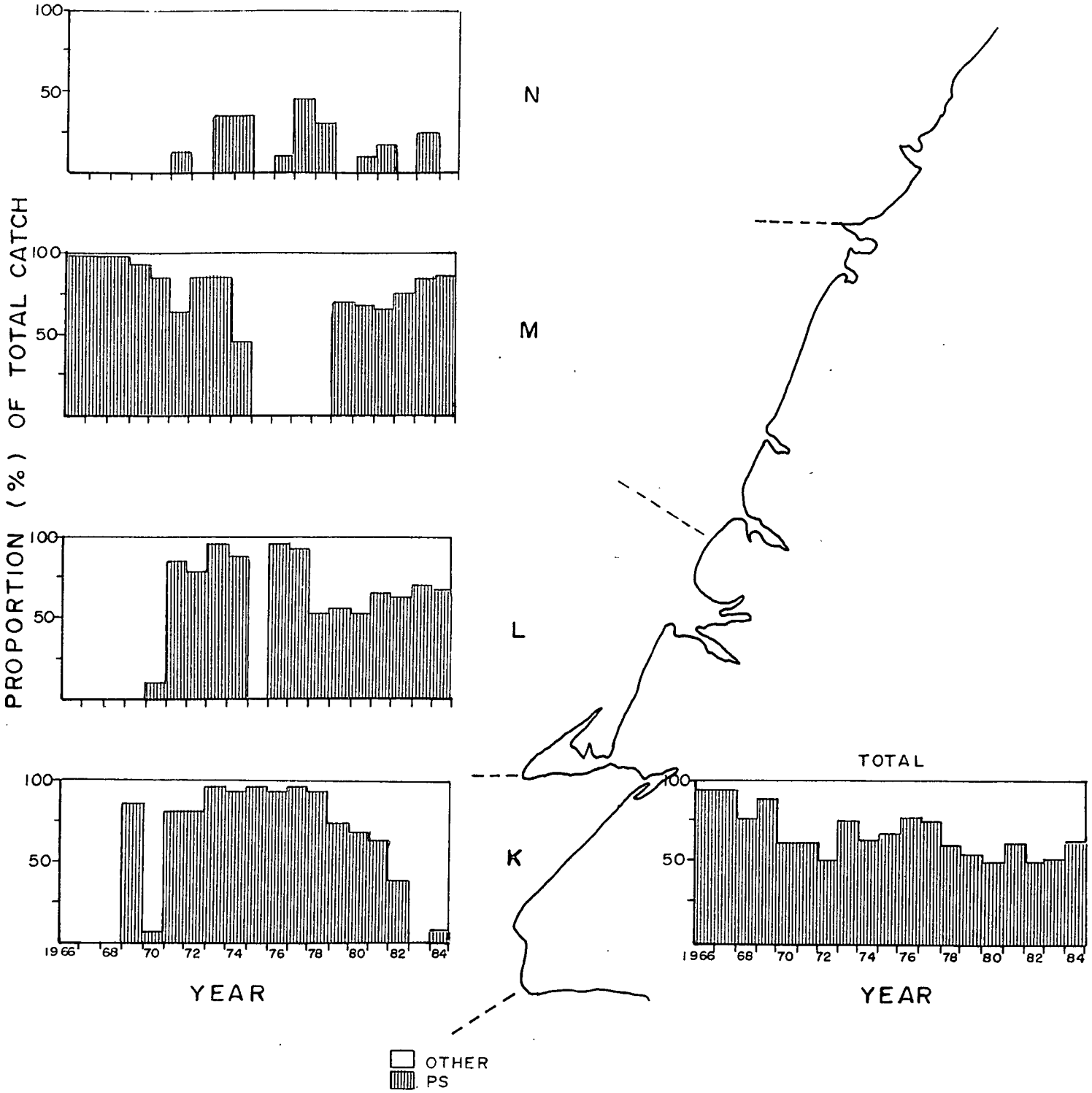

Figure 4. Proportions of the annual herring catches taken by purse seines and by all other gears separated by fishing areas, 1966-1984.

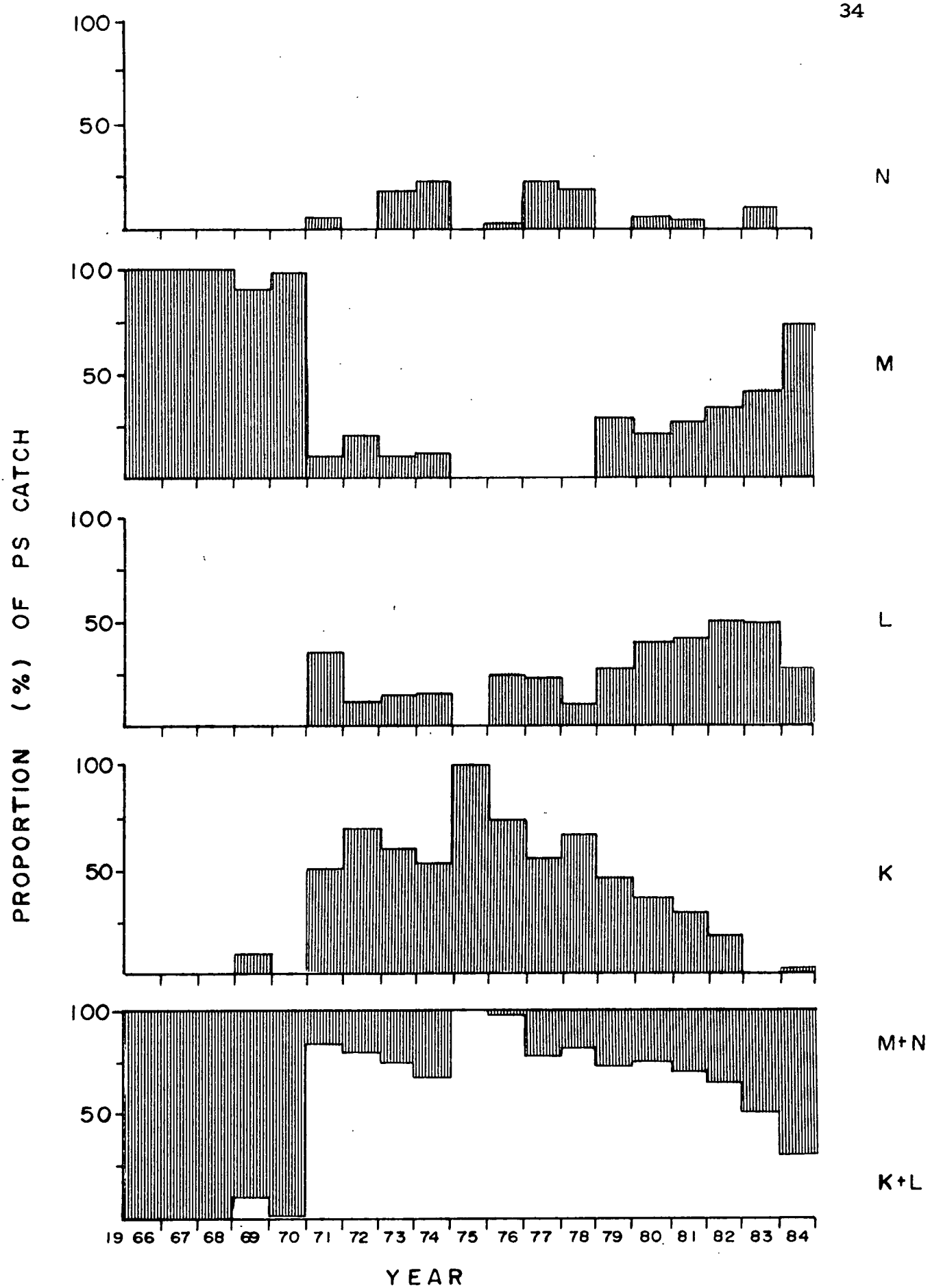

Figure 5. Proportions of the annual herring purse seine catches separated by fishing areas, 1966-1984.

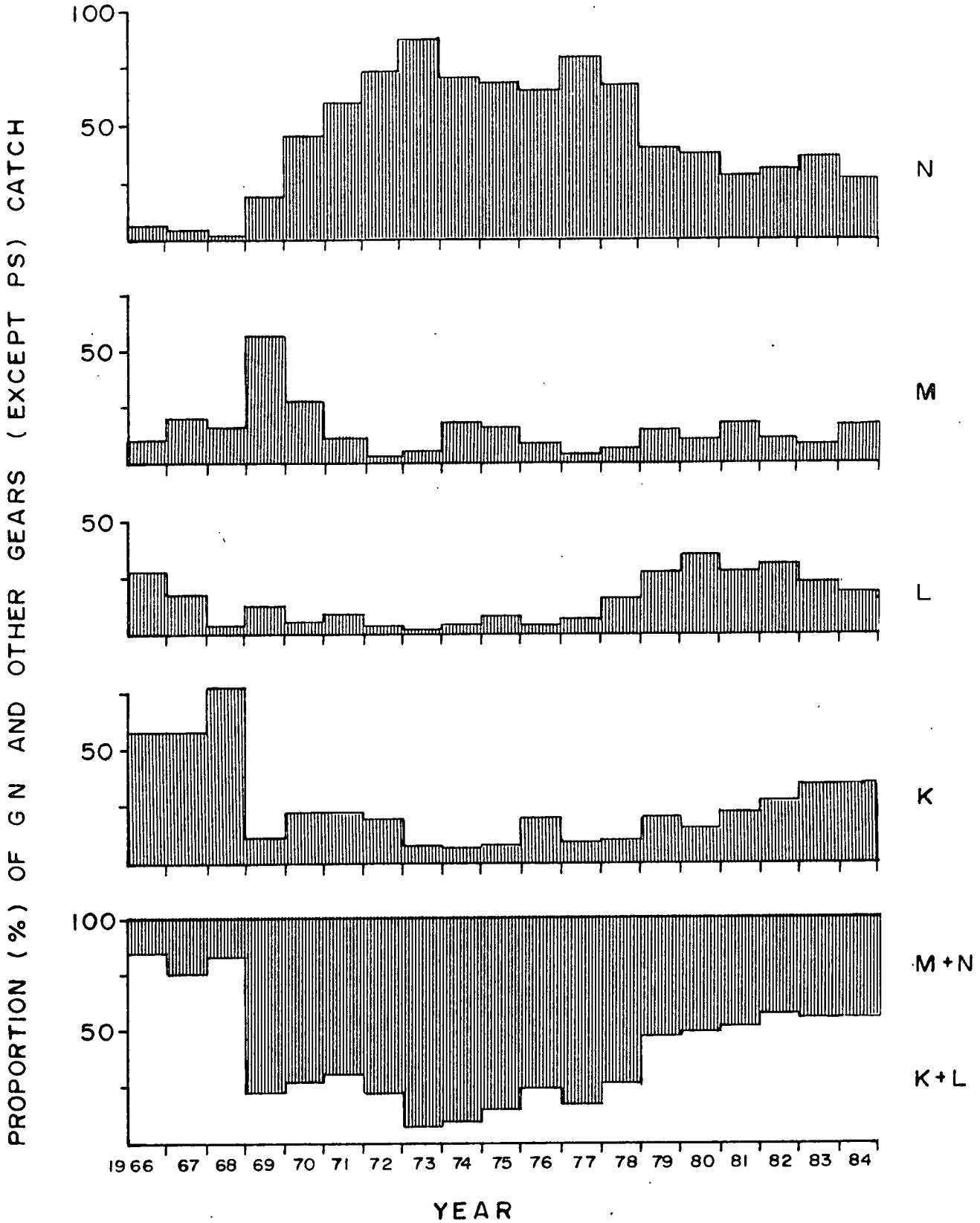

Figure 6. Proportions of the annual herring catches taken by all gears except purse seines separated by fishing areas, 1966-1984.

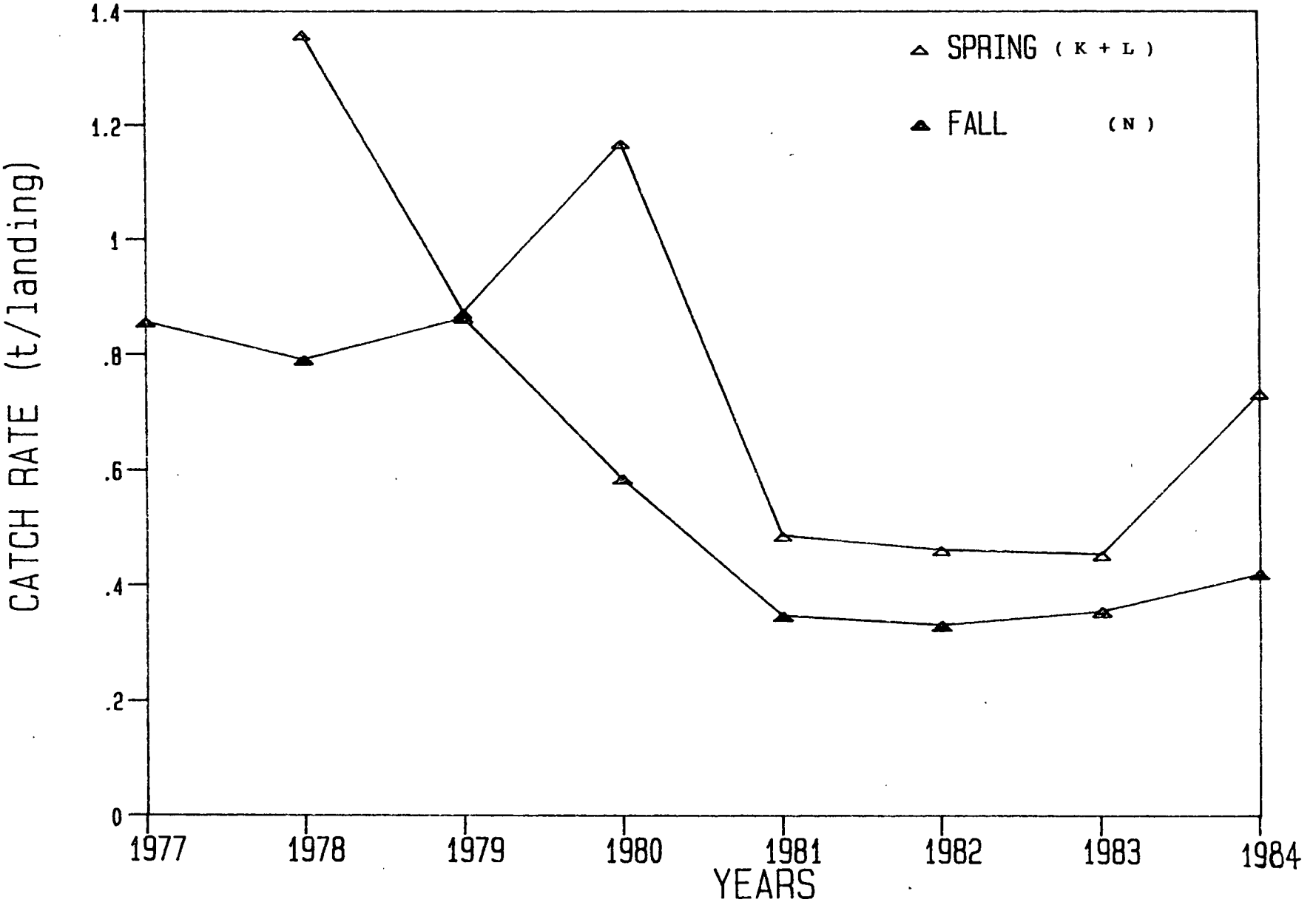

Figure 7. Gillnet catch rates, adjusted for gang size, from the spring and fall fisheries in NAFO division 4R, 1977-1984.

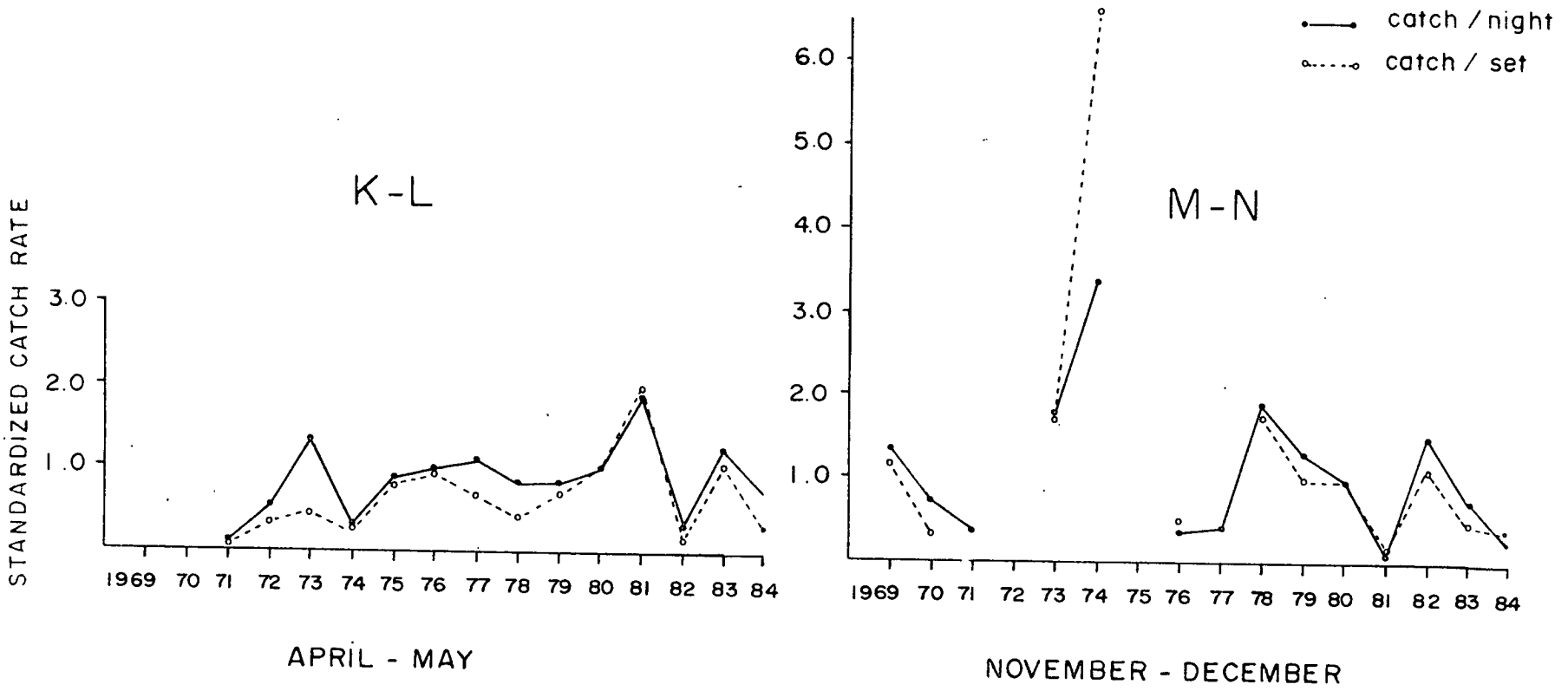

Figure 8. Purse seine catch rates, standardized to 1980, from the spring and fall fisheries in NAFO division 4R, 1969-1984.

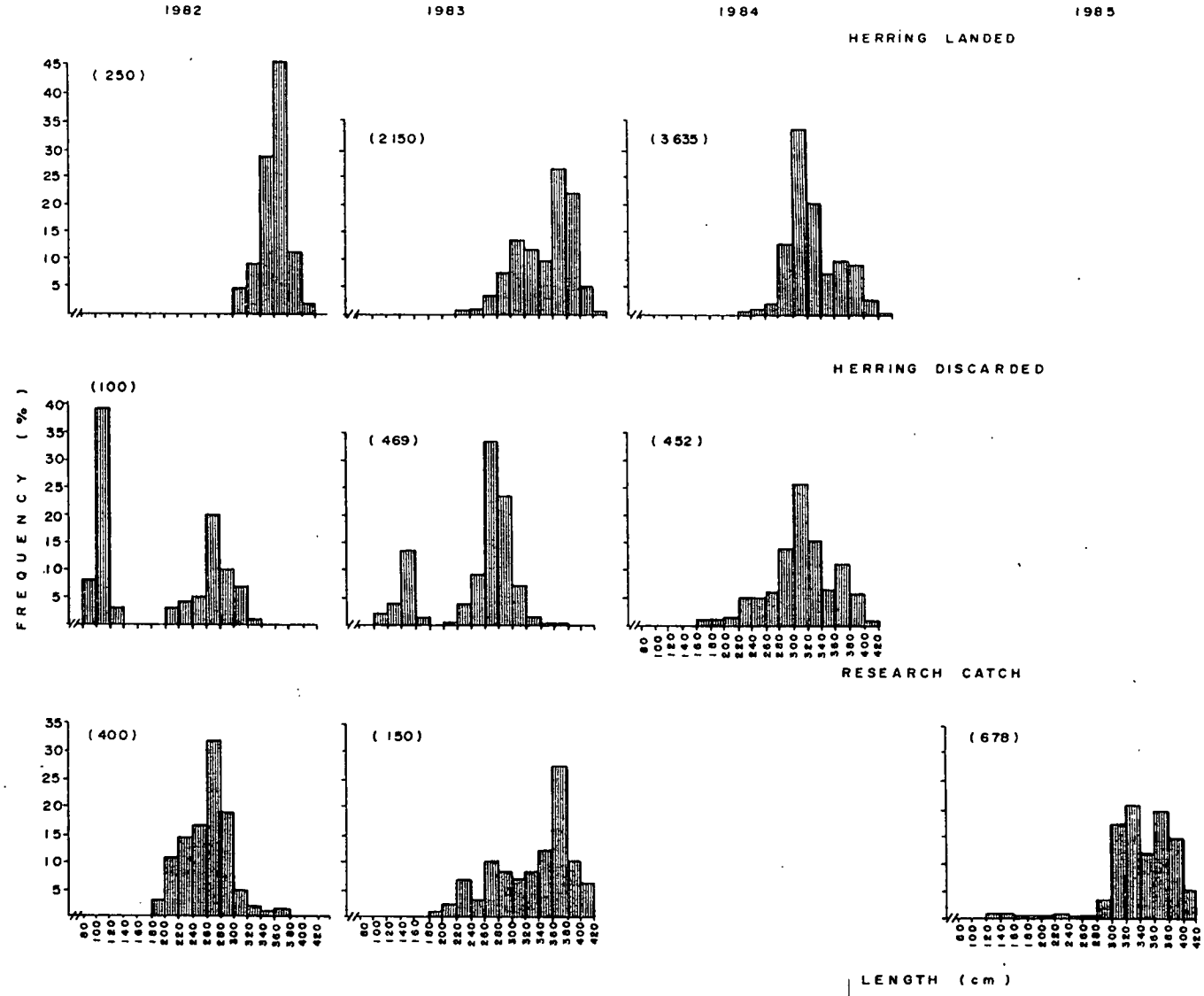

Figure 9. Herring length frequencies from the purse seine commercial samples (landed and discarded) in 1982, 1983 and 1984 and from the bottom trawl research survey in 1982, 1983 and 1985 in NAFO division 4R.

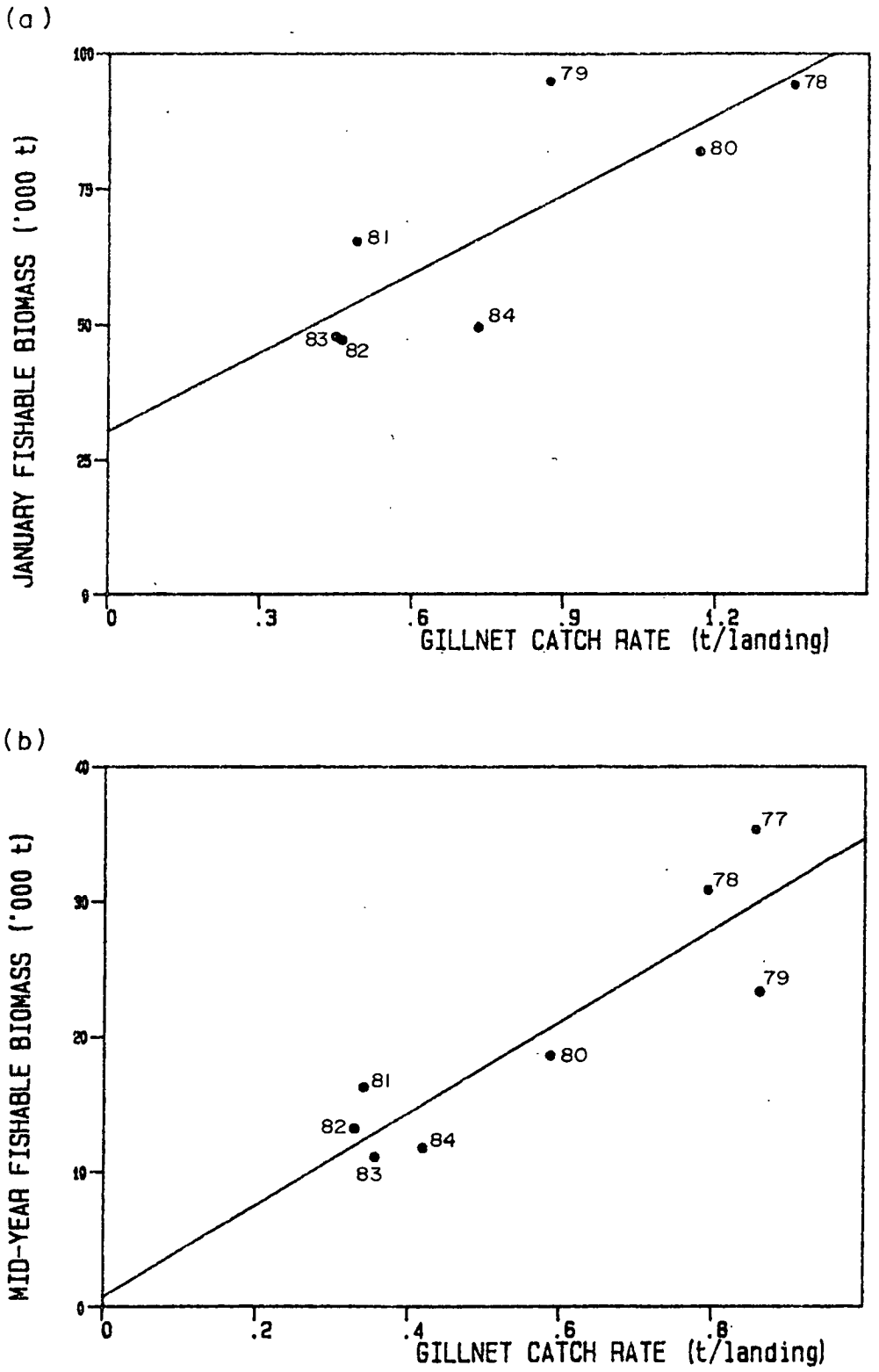

Figure 10. (a) Least squares regression of January spring spawner fishable biomass and gillnet catch rates for areas K and L in April and May, 1978-1984 and (b) mid-year fall spawner fishable biomass and gillnet catch rates for area N in August, 1977-1984.

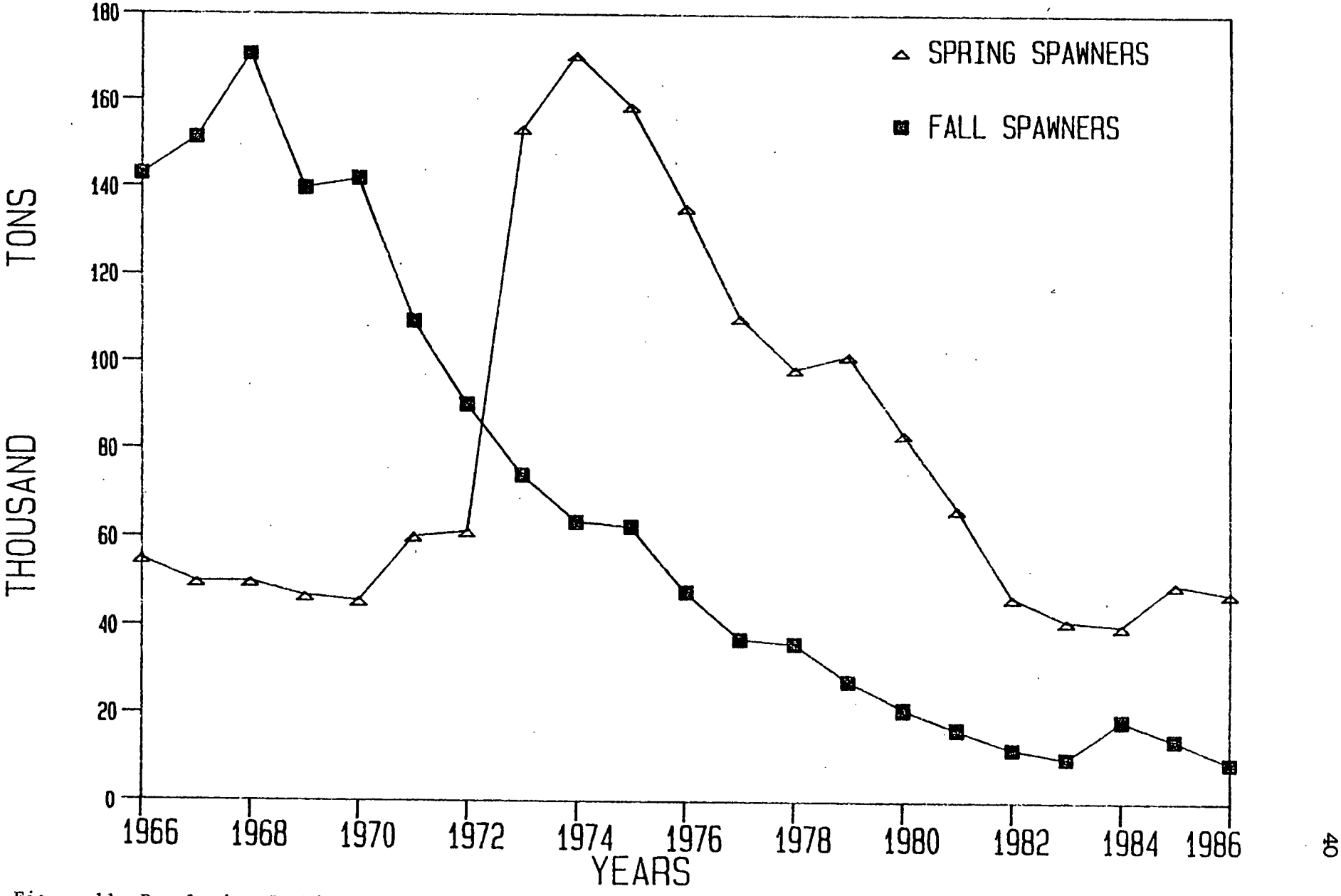

Figure 11. Population 5+ biomass estimates ('000 t) for spring and fall spawning herring in NAFO division 4R, 1966-1986. Estimates for spring spawners are beginning of the year and for fall spawners are mid-year.