Not to be cited without the permission of the authors[1]

Ne pas citer sans autorisation des auteurs[1]

Canadian Atlantic Fisheries Scientific Advisory Committee

Comité scientifique consultatif des pêches canadiennes dans l'Atlantique

CAFSAC Research Document 86/68

CSCPCA Document de recherche 86/68

ASSESSMENT OF THE WEST COAST OF NEWFOUNDLAND HERRING STOCKS IN 1985

by

I.H. McQuinn

Direction de la Recherche sur les Pêches
Ministère des Pêches et des Océans
C.P. 15500
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

Herring landings in NAFO Division 4R in 1985 were approximately 9,100 t, from a TAC of 10,000 t. Spring spawner gillnet catch rates generally declined from 1978 to 1983 and then increased from 1984 to 1985. The fall spawner CPUE decreased from 1977 to 1982, increased in 1983 and has been relatively stable to the present. Spring spawners have generally dominated the annual catch since 1966. Historically, this spawning group has been dominated by the 1968 and 1974 year-classes. In 1985, the 1980 year-class represented 62% of the catch in numbers. The fall spawners had been dominated by the 11+ age group until 1983. In 1985, the 1979 year-class made up 63% of the catch in numbers. Cohort analyses showed that the spring spawner population biomass has decreased from 192,000 t in 1972 to 45,000 t in 1985. The fall spawner population biomass in 1985 stands at approximately 12,000 t, 12% of the historical high in 1966. Poor recruitment has been the major reason for the decline of these two stocks. Projections using the expected 1986 catch of 10,000 t of spring spawners would result in Ft=0.3 and a slight decrease in population biomass from 44,700 t in 1986 to 41,100 t in 1987. The 1987 $F_{0.1}$ catch would be 8,800 t. The expected 1986 fall spawner catch of 7,000 t would result in an Ft=0.95 and a drop in the 4+ biomass from 15,900 t in 1986 to 9,400 t in 1987. The 1987 $F_{0.1}$ catch would be 1,600 t.

RÉSUMÉ

Les débarquements de hareng dans la division 4R de l'OPANO en 1985 étaient d'environ 9 100 t, sur un TPA de 10 000 t. Les taux de captures des filets maillants pour la population du printemps montrent une baisse générale entre 1978 et 1983, et ensuite une augmentation de 1984 à 1985. Quant aux reproducteurs d'automne, les PUE ont indiqué un déclin d'abondance entre 1977 et 1982, et ensuite une augmentation en 1983. Elles ont depuis été stables. Les reproducteurs de printemps sont généralement dominants dans la capture depuis 1966. Les classes d'âge de 1968 et 1974 ont dominé les captures historiques de ce groupe reproducteur. La classe d'âge de 1980 a représenté 62% de la capture en nombre en 1985. Les captures de reproducteurs d'automne ont compris une forte proportion de poissons âgés de plus de 11 ans entre 1966 et 1983. En 1985, la classe d'âge de 1979 a dominé (63%) la capture en nombre. Les analyses de cohorte ont démontré que la biomasse de reproducteurs de printemps a passé de 192 000 t en 1972 à 45 000 t en 1985. La biomasse des reproducteurs d'automne en 1985 est d'environ 12 000 t, 12% du maximum observé en 1966. La cause des déclins observés est attribuée à l'insuffisance du recrutement. La capture de 10 000 t de reproducteurs de printemps en 1986 résulterait en un taux de mortalité de 0,3 et la biomasse totale passerait alors de 44 700 t en 1986 à 41 100 t en 1987. Une mortalité par la pêche de $F_{0,1}$ en 1987 permettrait de capturer 8 800 t. La capture de 7 000 t de reproducteurs d'automne prévue pour 1986 occasionnerait un taux de mortalité de 0,95 et une baisse de la biomasse (4+) de 15 900 t en 1986 à 9 400 t en 1987. En pêchant à un taux de $F_{0,1}$ en 1987, on récolterait 1 600 t.

INTRODUCTION

Total herring landings from the west coast of Newfoundland (NAFO division 4R) had ranged between 3,000 and 6,000 t from 1966 to 1970 when in 1971, a dramatic increase began which peaked at 27,000 t in 1973 (Table 1, Figure 1). Landings decreased sharply in 1974 and 1975 as the number of seiners in the commercial fleet was greatly reduced and then increased steadily until 1980. Since 1980, official landings have again declined, presumably due to depressed markets. In 1985, improved market conditions allowed for a marginal increase in landings.

Historically, these herring stocks have been exploited by both fixed (mainly anchored gillnets) and mobile gears (mainly purse seines). However,the proportion of the total catch taken by each gear component in each unit area has been extremely variable, and complete disappearance of one or the other fishery has occurred in some years (Table 1, Figure 2). In 1985, the gillnet proportion of the total landings dropped from 41% in 1984 to 10%.

Total allowable catches (TAC) have been in effect since 1977, when the west coast of Newfoundland was defined as a herring management unit. The TAC has been exceeded every year except in 1981 and from 1983 to 1985 (Table 1). In order to prevent overexploitation of local stocks, the TAC was originally broken down into quotas for three areas (Moores and Winters, 1978): (1) St. George's Bay (area 4Rd), (2) Cape St. George to Cape St. Gregory (area 4Rc) and (3) Cape St. Gregory to Cape Norman (areas 4Rb + 4Ra) (Figure 3). In recent years, the TAC has been divided between the purse seine (55%) and the gillnet (45%) fisheries. In addition, the purse seine quota has been proportioned among the five remaining vessels and the gillnet allocation has been divided evenly between the regions north and south of Cape St. Gregory.

Historical Fishing Patterns:

The fishing pattern of the herring fleet has varied greatly over time. Before 1971 most of the catch was reported in area 4Rb, while from 1971 to 1978 area 4Rd was the single most important fishing zone (Figure 4c). More recently, the proportion of the total catch reported in area 4Rd has slowly diminished while increasing in area 4Rc and again in area 4Rb.

The purse seine fleet, being very mobile, can direct its fishing effort wherever success and markets are optimal. The fishing pattern of the fleet has therefore fluctuated considerably over time in response to shifting concentrations of herring schools and the accessability to buyers (Figure 4a). For instance, in the southern fishery (areas 4Rc + 4Rd) during the 70's, most of the catch was reported in area 4Rd. As the proportion of market size fish decreased in St. George's Bay in the early 80's, more and more catches had been reported from area 4Rc. In 1983 and 1984, catches were taken almost exclusively in area 4Rc. In the spring of 1985, the seiners once again began fishing in St. George's Bay and reduced their effort in area 4Rc, resulting in catches being split almost evenly between these two areas (Table 2).

In the northern fishery (areas 4Ra + 4Rb), Moores and Winters (1980) noted that in 1979, the bulk of the catch, which previously came from St. John's Bay (area 4Ra), was now being reported from south of Pointe Riche (area 4Rb). Since then, this shift has become more and more pronounced resulting in catches from area 4Rb being 4 times higher than in area 4Ra in 1983 (Figure 4a). In 1984 and 1985, there was virtually no purse seine catch taken in area 4Ra (Table 2).

The nearshore fishery, made up of all gears other than purse seines (mostly gillnets), has also gone through pronounced changes since 1966. In the late sixties, the dominance of this fishery in the southern areas rapidly declined (Figure 4b). From 1971 to 1978, most of the catch was reported from area 4Ra. After 1975, the development of a major spring gillnet fishery south of Cape St. Gregory (Moores and Winters, 1980) resulted in a steady increase in landings reported from areas 4Rc and 4Rd. Since 1979, almost equal proportions of the total gillnet catch have been taken from the southern and the northern zones, although the total gillnet landings from these fisheries have declined in both regions since 1980 (Table 1).

Recent Trends and Market Conditions:

The TAC was set at 10,000 t from 1982 to 1985. In 1982 and 1983, purse seine catches in St. George's Bay were below the area allocations (no catches 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 similar to the previous year (Table 2) with little catch being taken in St. George's Bay and over 90% of the purse seine landings being reported from between Cape St. George to Pointe Richie (areas 4Rb + 4Rc). In 1985, the spring fishery resumed in St. George's Bay (area 4Rd) as the fish were once again of marketable size. The easy availability of large concentrations of herring in Bonne Bay (area 4Rb) throughout the autumn and early winter of 1985, resulted in 71% of the total purse seine catch being reported from this fishery.

The fixed gear allocations were overrun in all areas in 1982 but have not been reached since. In 1985, very few landings were reported from the gillnet fishery (937 t) as there was little market demand for gillnetted herring. In 1984, the gillnet catches in areas 4Rc and 4Rd were taken almost exclusively in

April and May (Table 2). Again in 1985, the majority of the landings from unit areas 4Rd, 4Rc and 4Rb were reported in the spring of the year. Most of the annual gillnet catch (66%) was taken in St. George's Bay in May and north of Pointe Riche in the fall.

INPUT DATA

Population Abundance Indices:

Catch rate indices have been calculated for the gillnet and purse seine fisheries for both the spring and fall seasons.

The Gillnet Fishery:

Gillnet catch rates (t/fisherman/day) were calculated using landings from all available purchase slips from 1977 to 1985. All pertinent information, including the name of the fisherman, was computerized in order to conduct a series of detailed analyses to find and correct for a number of the known biases associated with these data (HERRING CPUE v1.0).

It was known that certain fishermen would often split their daily catch among the crew members who would then sell their shares separately. This resulted in several slips being issued for the same catch. Purchase slips were therefore sorted by day and amount landed to identify those groups of fishermen who repeatedly sold the same amount of fish on the same day. These split landings were then combined. In addition, some fisherman were issued several slips on the same day, either because the catch was separated during weighing and a slip was issued for each batch or because the fisherman made several trips during the day to empty his nets. In either case, the sum of the day's landings represented one day of fishing and therefore the amounts on the slips were combined.

The percent of spring and fall spawners in the commercial gillnet samples were tabulated by month and unit area to determine during which periods the fishery has historically been directed upon only one of each of the spawning components. From this table, the major spawning sites were determined to be areas 4Rc and 4Rd in April and May for the spring spawners, and area 4Ra in August for the fall spawners (Table 3). A weekly catch rate index was then calculated for the weeks within these areas for which the catch was >85 % of only one spawning stock (Table 4). The weekly catch rates during these periods varied greatly from one week to the next in most years (eg. Figure 5). It was felt that this was due to changes in catchability as the herring migrated in and out of the fishing areas in preparation for spawning. The abundance indices were therefore calculated as the unweighted mean of the weekly catch rates (where slips were available) over the entire period.

In 1985, there were only 2 purchase slips issued in area 4Ra in August, therefore an abundance index for the fall spawners could not be calculated from these data. The catch rate was therefore calculated using data from logbooks filled out by gillnet fishermen during this period. It was felt that these data were consistant with the historic series as the 1984 logbook and purchase slip catch rate estimates were virtually identical (Figure 5).

The resulting indices were then adjusted for gang size, to account for annual changes in the number of nets fished per day. The estimated number of nets per gang for 1977 to 1981 were based on surveys carried out on the Newfoundland east coast. For 1982 to 1985, the gang size was obtained from written surveys conducted on the west coast in 1984 and 1985. The number of nets fished from 1981 to 1983, recorded on the licence applications, was used to standardize the two series of data. The gang size estimates for 1982 to 1985 were calculated using the average number of nets fished by those fishermen who sold the majority of their catches, so as not to include bait fishermen who did not receive purchase slips. The gang size estimates were normalized to 1978. The adjusted catch rates (Table 5) were used to calibrate the cohort analyses for the two spawning stocks.

The spring gillnet catch rates showed a generally declining trend in abundance from 1978 to 1983 (Figure 6). This trend was reversed in 1984 and 1985 as the index increased to above the 1981 value. For the fall spawners, the gillnet catch rates followed a constant decline between 1977 and 1982. In 1983, the CPUE increased slightly and has remained stable to the present.

The Purse Seine Fishery:

Catch and effort data from purse seine logbooks have also been analysed for trends in abundance. Historical catch and effort data were more consistently available for the months of April and May in areas 4Rc and 4Rd for the spring fishing season and for the months of November and December in areas 4Ra and 4Rb for the fall fishing season. Catch rates, weighted by the corresponding purse seine catches of each category (month and unit area), were calculated for these selected months and areas.

Historical trends in c/set and c/night were very similar (Table 6, Figure 7). 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. All catch rate indices increased in 1985.

In the spring fishery, catch rates were relatively stable between 1975 and 1980, but have been variable 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 during the same period. In 1982, both c/set and c/night increased sharply and then decreased until 1984. 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 7), the more or less constant decline in catch rate, most evident in the fall fishery between 1978 and 1981 and again from 1982 to 1984, could indicate a decrease in the fall spawner fishable biomass. The fact that all measurements of purse seine CPUE increased in 1985 could be interpreted as a recent increase in the biomass available to the purse seine fleet.

The validity of purse seine catch rates as representative of pelagic fish population abundance has often been discussed (Powles, 1981; Pope, 1978; Ulltang, 1978; Cleary, 1982) and is generally considered to be difficult to interpret. In addition, logbook coverage has been rather limited in most years and particularly from 1981 to 1985. Consequently, these data were not used to calibrate the cohort analyses, but are presented only as additional information on trends in abundance.

Age Composition of the Commercial Catch:

Random samples from the commercial fishery were collected by port samplers, by gillnet fishermen hired to keep detailed catch and effort data on herring caught on the spawning grounds and by observers on the purse seine vessels. Because of the number of people involved, coverage of the major commercial landings was more than adequate (Annex 1). These samples were frozen and sent to the Quebec laboratory for analyses (length, weight, gonad weight, maturity stage and otolith collection).

Individual herring were assigned as either spring or fall spawners by relating the maturity stage to the date of capture and ages were determined from the otoliths (Cleary et al., 1982).

Catch-at-age data from 1966 to 1983 were taken from McQuinn and Cleary (1985). The 1984 catch at age was updated with the most recent 1984 landing statistics. As official landings were not available at the time of the assessment, the 1985 catch at age was calculated using inshore landings provided from the Moncton Statistics Branch and from the purse seine Quota Reports.

The catch at age was calculated by first multiplying the proportion of each spawning group caught in each category (gear, month and unit area) by the corresponding landings and dividing by the mean weight to produce the total number of fish of each spawning group caught per category. The total number of fish of each spawning group was then multiplied by the proportion at age of each category and summed across categories to give the total catch at age by spawning group (programme CAT△AGE v1.0).

The Spring Spawner Catch:

Spring spawners have dominated the catch in every year since 1966, except for 1971 (Table 8) 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 from 1970 to 1978 (Table 9). Between 1971 and 1982, the only significant recruitment to the spring spawning stock came from the 1974 year-class. In 1983 about 39% of the catch consisted of the 1979 and 1980 year-classes, which again dominated the 1984 fishery, representing 49% of the catch in numbers. In 1985, the 1980 year-class was the dominant cohort and the most important since 1974, contributing 62% of the catch in numbers. Consequently, the mean age of the spring spawners dropped to 5 years old in 1985; the lowest recorded average.

The Fall Spawner Catch:

Herring of the 11+ age group have historically dominated the fall spawner catch. In 1984, the 1979 year-class strongly recruited into the fishery and contributed to more than 46% of the catch in numbers. In 1985, this same cohort increased its dominance to an historical high of 63%. The mean age of fall spawners in the catch has therefore decreased in recent years, from 10 years old in 1976 to 6 years old in 1985; again an historical low.

Length Frequencies of Commercial and Research Catches:

Length frequencies of herring landed, as well as discarded, have been recorded by observers on board the vessels since 1982 (Figure 8). Sets were released if the percentage of fish too small for the market was judged to be too high.

In 1982 and 1983, the dominant lengths of landed fish were between 340 and 400 mm. In 1984 and 1985, the modal length group was much smaller, from 300 to 340 mm. The length distributions of fish discarded in 1982 and 1983 were bimodal, with peak lengths below 280 mm. 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 mm were observed in 1984 in either the landed or discarded samples. In 1985, the discarded set length frequency was polimodal, with a significant number of fish below 240 mm and two additional peaks between 280 and 300 mm and 320 to 340 mm.

Length frequencies of herring caught during the January bottom trawl surveys in 1982 and 1983 also indicated that herring smaller than 280 mm were available. The modes in the 1983 research data corresponded very closely to those of the landed catch and discarded sets. In January 1985 and 1986, the proportion of fish smaller than 300 mm was negligible in the research catch. There were however concentrations of fish similar in length to the landed samples (300 - 340 mm) as well as older fish (360 - 400 mm).

These data indicate that the length distribution of herring available to the commercial fishery has changed considerably since 1982. According to the proportion-at-age matrix (Table 9), the proportion of "bigger" fish, which are preferred for commercial purposes and which have dominated the fishery for many years, has decreased.

A comparison of the commercial and research length frequency data showed clearly that the purse seine fishery has been very selective in most years. Length frequencies from the discarded sets and the groundfish cruises indicated that both smaller and larger fish were available but were not being picked up in the commercial purse seine fishery.

ESTIMATION OF PARAMETERS

Natural Mortality Rate:

An value of 0.2 for the instantaneous natural mortality rate (M) was assumed for the present analyses. This value was used in the previous assessment (McQuinn and Cleary, 1985) and is consistent with that for other herring stocks (Lea, 1930; Runnstrom, 1936; Beverton, 1963).

Partial Recruitment:

Partial recruitment for ages 4, 5 and 6 were estimated for the two spawning stocks from a purse seine selectivity coefficient, derived from the ratio of the proportion at age from the commercial landings and the discarded sets (Table 10). However, the selectivity coefficient estimated for age 4 spring spawners was felt to be too high, given the small catch of this cohort. It was therefore adjusted downward to the value of the fall spawner 5 year olds, which were approximately the same length. Partial recruitment for ages 2 and 3 were were set to the historical mean from 1974 to 1982 for spring spawners and 1972 to 1982 for fall spawners. Spring spawners 5 years and older and fall spawners 6 years and older were considered to be fully recruited. The resulting partial recruitment vectors were as follows:

AGE	2	3	4	5	6	7+
SS	.04	.26	.63	1	1	1
FS	.001	.04	.26	.63	1	1

These partial recruitment vectors differ from the previous assessment (McQuinn and Cleary, 1985) because of the dominance of the 1979 and 1980 year-classes. This has led to a concentration of fishing effort on these cohorts and therefore ages 5 and 6 for spring and fall spawners, respectively, were fully recruited in 1985.

<u>Fishing Mortality for the Oldest Ages</u>:

The vector of fishing mortalities for the oldest ages (Fo) was estimated in the following manner: the Fo for age 10, when there is an 11+ group, was calculated by (a) determining the population numbers and Fo for the 10+ group from the 10+ catch and the 11+ population numbers of the following year, and (b) partitioning the 10+ numbers between age 10 and the 11+ group, assuming the same F applies to both. The resulting vector is used as input for cohort analysis starting at age 10. The 11+ population numbers are then concatinated to the population matrix (FISH/\HER v1.0).

<u>Weights at Age</u>:

Mean weights at age were calculated as the average weights for the first half of the year for spring spawners and for the second half of the year for fall spawners (Table 11).

<u>Calibration of Cohort Analyses</u>:

Cohort analysis was run separately for spring and fall spawners. Population biomasses were calculated for the beginning of the year for spring spawners and mid-year for fall spawners as these were the biomasses available during the periods for which the gillnet catch rates were estimated.

A series of cohort analyses was run at various values of terminal fishing mortality (Ft) (Table 12). Least squares regression of mature (4+) population biomass on gillnet CPUE was used to calibrate the cohort analyses for the two stocks. The Ft for each spawning stock was determined by choosing the regression line with the best combination of (a) correlation coefficient and intercept, (b) the closeness of the 1985 point to the regression line and (c) the sums of squares of the standardized residuals for the 1983 to 1985 points.

ASSESSMENT RESULTS

Cohort Analyses:

Cohort analyses indicated an Ft in 1985 of 0.15 and 0.35 for spring and fall spawners, respectively (Table 12, Figure 9 a,b). The spring spawner population biomass has remained relatively constant at around 45,000 t since 1982 (Table 13), mainly due to the strength of the 1980 year-class and the low fishing mortality exerted on this component over this period (Table 14a,b). This biomass level is however only 23 % of the historical high of 192,000 t in 1972 (Table 13). This drop in abundance has occurred even though the annual fully recruited fishing mortality rates, weighted on population numbers, have been below the F0.1 value of .3 in all years except for 1980 to 1982 (Table 14b). The decline of this stock since the early 70's (Figure 10) has been due to the poor recruitment experienced in the last decade. Since 1972, only the 1974 and, more recently, the 1980 year-classes have contributed significantly to the stock. During the decade following the entry of the 1968 year-class into the fishery, recruitment at age 2 has been substantially below previous levels (1966-1971: 218 x 106 fish vs 1972-1981: 34 x 106).

The results of cohort analysis indicated a gradual decline in the fall spawner population numbers since 1981 (Table 15a). The population biomass now stands at 22,000 t, 12 % of the historical high in 1966 (Table 16). Except for 1979, the annual fully recruited fishing mortality rates, weighted on population numbers, had been below F0.1 until 1983 but have been above this level since then (Table 15b). Again, the lack of recruitment appears to be the dominant reason for the constant drop in biomass since 1967 (Figure 10), as the only recruitment of significance since the 1958 and 1963 year-classes has been from the 1979 year-class.

PROGNOSES

Catch and Biomass Projections:

Projections for 1986 and 1987 were run using population numbers obtained from the cohort analyses and recruitment at age 2 for 1985 to 1987 set to the geometric mean of the estimated recruitment from 1974 to 1982 for spring spawners and 1972 to 1982 for fall spawners (FISH△HER v1.0). It was assumed that the 1986 TAC would be taken as allocated and that the proportion of spring and fall spawners in the catch would be the same as was observed in the 1985 catch. Projections for 1987 were calculated using the assumed F0.1 value of 0.3.

Spring Spawners:

According to the present projections, the expected catch of 10,000 t in 1986 will result in a fishing mortality of F=.30 on fully recruited ages (Table 17a). The relatively strong 1980 year-class will help to maintain the population biomass at 40,100 t in 1987, a slight decrease from 44,700 t in 1986. The estimated 1987 F0.1 catch would therefore be 8,800 t.

Fall Spawners:

Assuming the expected 1986 catch of 7,000 t is taken, the projected fishing mortality will be F=.95 on fully recruited ages (Table 17b). At this level of exploitation, the mature (4+) biomass would be reduced from 15,900 t in 1986 to 9,400 t in 1987, 6% of the 1967 historical high. The 1987 F0.1 catch would therefore drop to 1,600 t (Table 17b). It is clear from the present analyses, that this spawning component cannot support this level of fishing and therefore a reduction in fishing effort on the fall spawners is strongly advised.

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., J.J. Hunt, J. Moores and D. Tremblay, 1982. Herring aging workshop, St. John's, Newfoundland, March - 1982. CAFSAC Res. Doc. 82/41.

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

McQuinn, I.H. and L. Cleary, 1985. Status of the west coast of Newfoundland herring stock in 1983. CAFSAC Res. Doc. 85/69.

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.

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.

Table 1. Herring catches (t) by gear type and fishing area and total allowable catches from NAFO division 4R from 1966 to 1985.

YEAR	4Rd				4Rc				4Rb				4Ra				COMBINED				TAC
	Purse seine	Gill-net	Other gears*	Total	Purse seine	Gill-net	Other gears	Total	Purse seine	Gill-net	Other gears	Total	Purse seine	Gill-net	Other gears	Total	Purse seine	Gill-net	Other gears	Total	
1966	0	216	0	216	0	103	0	103	5491	39	0	5530	0	18	0	18	5491	376	0	5867	
1967	0	215	0	215	0	66	0	66	5464	76	0	5540	0	13	0	13	5464	370	0	5834	
1968	0	156	789	945	0	59	0	59	3776	67	136	3979	0	11	0	11	3776	293	925	4994	
1969	241	33	6	280	0	46	0	46	2344	201	4	2549	0	68	1	69	2585	348	11	2944	
1970	28	410	3	441	12	81	17	110	2939	526	4	3469	0	763	92	855	2979	1780	116	4875	
1971	3287	424	427	4138	2239	333	24	2596	725	405	21	1151	356	2252	11	2619	6607	3414	483	10504	
1972	4743	351	866	5960	727	134	64	925	1330	214	0	1544	0	4619	146	4765	6800	5318	1076	13194	
1973	12112	428	0	12540	2740	122	0	2862	1763	302	2	2067	3453	6047	15	9515	20068	6899	17	26984	
1974	2465	159	0	2624	756	96	4	856	439	456	47	942	1071	1959	5	3035	4731	2670	56	7457	
1975	3221	117	3	3341	0	97	16	113	0	216	26	242	0	1076	22	1098	3221	1506	67	4794	
1976	6067	496	3	6566	1956	111	2	2069	0	207	20	227	184	1477	140	1801	8207	2291	165	10663	
1977	5289	273	7	5569	2009	193	3	2205	0	125	31	156	2155	2428	183	4766	9453	3019	224	12696	12000
1978	6252	523	33	6808	1037	931	16	1984	0	284	81	365	1834	4103	22	5959	9123	5841	152	15116	12500
1979	4387	1641	3	6031	2774	2267	2	5043	2829	1048	121	3998	0	3247	7	3254	9990	8203	133	18326	12500
1980	3499	1557	41	5097	3703	3224	17	6944	2002	878	88	2968	428	3681	5	4114	9632	9340	151	19123	18000
1981	2269	1367	2	3638	3277	1623	0	4900	2037	912	140	3089	342	1600	27	1969	7925	5502	169	13596	16000
1982	934	1462	3	2399	2762	1572	11	4345	1888	517	58	2463	0	1675	1	1676	5584	5226	73	10883	10000
1983	0	1409	2	1411	2240	871	46	3157	1906	226	108	2240	465	1421	34	1920	4611	3927	190	8728	10000
1984	56	1006	1	1063	4115	901	0	5016	604	554	2	1160	9	809	4	822	4784	3270	7	8061	10000
1985	801	398	0	1199	1583	164	0	1747	5776	80	4	5860	0	295	6	301	8160	937	10	9107	10000

* Includes shrimp trawl, bar seine, trap, midwater trawl and otter trawl.

Table 2. Herring catches (t) from NAFO division 4R by month, gear type and fishing area in 1983, 1984 and 1985.

	4Rd			4Rc			4Rb			4Ra		
	Purse seine	Gill-net	Other gears	Purse seine	Gill-net	Other gears	Purse seine	Gill-net	Other gears	Purse seine	Gill-net	Other gears
1983												
J		1			2							
F		2			1				1			
M		15			5				54			4
A		887	1	1585	394	46		29	52		9	3
M		429	1	590	357			48			5	
J		29		65	44			9	1		43	
J		25			36			23			233	10
A		12			26			18			531	1
S		3						6			233	
O		5			1		284	25			71	
N					2		1338	29		357	159	16
D		1			3		284	39		108	137	
T	0	1409	2	2240	871	46	1906	226	108	465	1421	34
1984												
J				183							19	
F												
M												
A		253		241	248		21	64		1		
M	55	673		2124	208			117			1	
J		30			47			82	1		47	1
J		21	1		23			3	1		99	
A	1	9			15			2			154	
S		8			7			59			131	
O		8		554	199		12	76			225	3
N		3		638	106		277	138		8	122	
D		1		375	48		294	13			11	
T	56	1006	1	4115	901	0	604	554	2	9	809	4
1985												
J												
F												
M												
A					2			1				
M	801	324		682	93			22	4		1	
J		28		46	28			38			4	
J		19			11			2				5
A		5		477	9			11			20	1
S		11			4			6			152	
O		10		111	11		344				2	
N				267	1		3382				112	
D		1			5		2050				4	
T	801	398	0	1583	164	0	5776	80	4	0	295	6

Table 3. Proportion (%) of spring and fall spawning herring in the gillnet catch by month and fishing area, NAFO division 4R from 1965 to 1985.

SPRING	4Rd			4Rc					4Rb							4Ra							
	APR	MAY	OCT	APR	MAY	JUN	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		100.0			89.4			22.0					19.4	24.0	42.4				6.4	27.2	19.0	28.0	45.2
1985		99.7			89.9	99.1												32.0	8.4	14.8		8.0	

FALL	4Rd			4Rc					4Rb							4Ra							
	APR	MAY	OCT	APR	MAY	JUN	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					10.6			78.0					80.6	76.0	57.6				93.6	72.8	81.0	72.0	54.8
1985		0.3			10.1	0.9												68.0	91.6	85.2		92.0	

Table 4. Distribution of samples by week with greater than (*) and less than (-) 85% of spring spawners for areas 4Rb and 4Rc and fall spawners in area 4Ra. The weeks chosen for the catch rate calculations are between the hash marks (|).

<table>
<tr><th colspan="10">SPRING SPAWNERS (4Rc-L + 4Rd-K)</th></tr>
<tr><th>WEEK</th><th>14</th><th>15</th><th>16</th><th>17</th><th>18</th><th>19</th><th>20</th><th>21</th><th>22</th></tr>
<tr><td>YEAR</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>1978</td><td></td><td>|</td><td></td><td></td><td></td><td>*</td><td>*</td><td></td><td>|</td></tr>
<tr><td>1979</td><td>| *</td><td>*</td><td>*</td><td>*</td><td>*</td><td></td><td></td><td></td><td>|</td></tr>
<tr><td>1980</td><td>|</td><td>*</td><td>*</td><td>*</td><td></td><td></td><td></td><td></td><td>|</td></tr>
<tr><td>1981</td><td>| *</td><td>*</td><td>*</td><td>*</td><td>*</td><td></td><td></td><td>|</td><td></td></tr>
<tr><td>1982</td><td></td><td></td><td></td><td>|</td><td></td><td>*</td><td>*</td><td></td><td>|</td></tr>
<tr><td>1983</td><td></td><td>|</td><td></td><td></td><td></td><td></td><td></td><td>| -</td><td></td></tr>
<tr><td>1984</td><td></td><td>|</td><td></td><td></td><td></td><td>*</td><td>|</td><td></td><td></td></tr>
<tr><td>1985</td><td></td><td></td><td></td><td></td><td>| *</td><td>*</td><td>*</td><td>*</td><td>| -</td></tr>
</table>

<table>
<tr><th colspan="15">FALL SPAWNERS (4Ra-N)</th></tr>
<tr><th>WEEK</th><th>27</th><th>28</th><th>29</th><th>30</th><th>31</th><th>32</th><th>33</th><th>34</th><th>35</th><th>36</th><th>37</th><th>38</th><th>39</th><th>40</th></tr>
<tr><td>YEAR</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>1977</td><td>-</td><td></td><td>-</td><td>-</td><td>-</td><td>|</td><td></td><td></td><td></td><td>*</td><td>*</td><td>*</td><td>| -</td><td>-</td></tr>
<tr><td>1978</td><td>-</td><td>-</td><td>-</td><td>-</td><td>|</td><td></td><td></td><td></td><td></td><td></td><td>|</td><td></td><td></td><td></td></tr>
<tr><td>1979</td><td></td><td>-</td><td>-</td><td>-</td><td>| *</td><td>*</td><td></td><td>*</td><td>*</td><td></td><td>|</td><td></td><td></td><td></td></tr>
<tr><td>1980</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>|</td><td></td><td>*</td><td>*</td><td>*</td><td>|</td><td></td><td></td><td></td></tr>
<tr><td>1981</td><td></td><td></td><td>-</td><td>-</td><td>|</td><td>*</td><td>*</td><td>*</td><td>*</td><td></td><td>|</td><td></td><td></td><td></td></tr>
<tr><td>1982</td><td></td><td></td><td></td><td>| *</td><td></td><td></td><td></td><td></td><td></td><td></td><td>|</td><td></td><td></td><td></td></tr>
<tr><td>1983</td><td></td><td></td><td>-</td><td></td><td>|</td><td></td><td></td><td>*</td><td>*</td><td></td><td>|</td><td></td><td>-</td><td></td></tr>
<tr><td>1984</td><td></td><td></td><td></td><td></td><td>| *</td><td>*</td><td>*</td><td>*</td><td>*</td><td>*</td><td>| -</td><td>-</td><td>-</td><td></td></tr>
<tr><td>1985</td><td></td><td>-</td><td></td><td></td><td></td><td>| *</td><td>*</td><td>*</td><td>*</td><td>*</td><td>| -</td><td></td><td></td><td></td></tr>
</table>

Table 5. Gillnet catch rates (t/fisherman/day) for spring (4Rc+4Rd) and fall (4Ra) spawners and adjusted for gang size (n = no. of weeks).

	4Rc + 4Rd					4Ra				
YEAR	t/f/day	(n)	var.	gang size	adj. CPUE	t/f/day	(n)	var.	gang size	adj. CPUE
1977						.9833	(7)	.3924	1.02	.9640
1978	1.3348	(7)	.3823	1.00	1.3348	.6731	(6)	.3046	1.00	.6731
1979	.9608	(8)	.3537	1.19	.8074	.7989	(6)	.5312	1.19	.6713
1980	1.6735	(8)	.1606	1.31	1.2778	.6806	(5)	.2294	1.31	.5195
1981	.9644	(7)	.2772	1.72	.5607	.5443	(6)	.1501	1.72	.3165
1982	1.0045	(5)	.3323	1.98	.5073	.5057	(7)	.3229	1.98	.2554
1983	1.0165	(6)	.2134	2.12	.4795	.7423	(6)	.2728	2.11	.3518
1984	1.4631	(5)	.3285	2.32	.6306	.6754	(6)	.5305	2.19	.3084
1985	1.2257	(4)	.4987	1.94	.6318	.3342	(5)	.1340	1.02	.3276

Table 6. Purse seine catch rates (tons weighted by landings) for the spring fishery in areas K and L and for the fall fishery in areas M and N from 1969 to 1985. Sample size is in parentheses.

YEAR	4Rc-4Rd (APRIL-MAY)				4Ra-4Rb (NOVEMBER-DECEMBER)			
	C/Set	C/Successful set	C/Night	C/Successful Night	C/Set	C/Successful set	C/Night	C/Successful Night
1969	-	-	-	-	88.25 (4)	117.67 (3)	96.60 (5)	96.60 (5)
1970	-	-	-	-	24.11 (17)	31.01 (15)	53.48 (24)	108.10 (16)
1971	11.88 (8)	22.50 (6)	15.00 (9)	33.75 (4)	-	-	30.00 (11)	165.00 (2)
1972	32.52 (79)	33.99 (74)	53.33 (37)	59.85 (32)	-	-	-	-
1973	50.41 (59)	51.40 (58)	131.26 (24)	137.27 (23)	131.05 (22)	149.46 (20)	128.21 (26)	176.88 (18)
1974	32.02 (39)	34.19 (36)	34.36 (36)	51.19 (24)	500.00 (1)	500.00(1)	250.00 (2)	500.00 (1)
1975	79.66 (19)	79.66 (19)	91.77 (17)	119.34 (13)	-	-	-	-
1976	100.26 (77)	105.09 (69)	98.36 (68)	165.73 (38)	38.33 (6)	57.50 (4)	32.86 (7)	57.50 (4)
1977	67.63 (79)	71.16 (76)	105.82 (59)	113.68 (53)	-	-	35.00 (3)	35.00 (3)
1978	47.17 (109)	48.51 (106)	86.31 (61)	99.35 (53)	135.00 (7)	135.00 (7)	137.64 (11)	150.80 (10)
1979	72.56 (69)	90.10 (53)	85.90 (57)	100.65 (49)	76.81 (26)	95.20 (20)	100.49 (20)	120.02 (16)
1980	102.63 (44)	121.76 (37)	98.41 (44)	151.69 (28)	75.90 (34)	80.05 (32)	72.48 (36)	126.27 (20)
1981	198.20 (79)	231.70 (51)	185.00 (71)	264.53 (41)	13.82 (6)	20.04 (4)	8.75 (4)	27.64 (3)
1982	17.68 (17)	60.75 (9)	36.05 (8)	64.84 (6)	86.07 (14)	135.00 (2)	109.55 (11)	133.89 (9)
1983	103.33 (6)	103.33 (6)	124.00 (5)	124.00 (5)	38.08 (38)	68.87 (24)	56.14 (27)	104.84 (16)
1984	38.85 (17)	43.14 (14)	65.07 (9)	66.42 (8)	34.82 (19)	52.80 (13)	24.80 (26)	52.80 (13)
1985	67.15 (19)	75.23 (17)	106.11 (12)	106.11 (12)	49.25 (68)	54.82 (61)	70.92 (47)	73.73 (45)

Table 7. Proportion (%) of spring and fall spawning herring in the purse seine catch by month and fishing area, NAFO division 4R from 1965 to 1985.

FISHING AREA

SPRING	4Rd					4Rc									4Rb						4Ra		
	FEB	MAR	APR	MAY	NOV	JAN	APR	MAY	JUN	AUG	SEPT	OCT	NOV	DEC	JAN	APR	AUG	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						65.5	62.0					30.0				66.8		28.6	40.3	48.0		50.0	
1985				95.2				82.4	91.5	78.0		36.7					12.9	35.9	49.0	55.2			

FALL	4Rd					4Rc									4Rb						4Ra		
	FEB	MAR	APR	MAY	NOV	JAN	APR	MAY	JUN	AUG	SEPT	OCT	NOV	DEC	JAN	APR	AUG	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						34.5	38.0					70.0				32.2		71.4	59.7	52.0		50.0	
1985				4.8				17.6	8.5	22.0		63.3					87.1	64.1	51.0	44.8			

Table 8. Catch at age ($X10^{-3}$) and proportion of spring and fall spawners in NAFO division 4R herring landings from 1966 to 1985. (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	1985
SS	1	0	0	0	0	0	0	372	0	0	0	0	29	0	0	4	0	0	4	10	28
	2	189	1	103	240	3011	0	375	4384	137	96	511	11	0	143	320	51	0	23	99	233
	3	390	8	296	1093	1458	3238	254	910	235	738	997	664	40	30	992	317	433	2776	199	2266
	4	298	337	336	1910	438	271	7843	1177	108	345	982	533	2097	176	85	1832	510	3400	3976	384
	5	586	70	583	965	660	544	1341	30697	294	190	229	516	210	10967	327	97	1960	1300	2491	11252
	6	2052	296	206	314	261	572	1577	2820	10512	1283	319	287	749	575	14894	318	420	649	572	2067
	7	4127	3545	616	173	201	453	1879	3139	254	8261	2745	346	287	1039	412	8773	1811	215	653	282
	8	2158	3039	1304	439	234	1194	1113	3018	857	237	15428	4160	2266	456	1304	250	5000	812	129	254
	9	1670	1429	2282	975	1015	98	1099	1796	689	360	764	16333	8617	2710	258	593	957	1309	523	122
	10	303	860	508	372	1012	908	476	1502	195	140	2851	926	15951	7042	991	215	574	738	586	229
	11+	505	969	433	446	1755	1062	4400	6271	2143	671	3134	5547	4380	14466	21735	15134	9112	4566	3839	1105
Total		12278	10554	6667	6927	10045	8340	20729	55714	15424	12321	27960	29352	34597	37604	41322	27580	20777	15792	13077	18222
FS	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12
	2	104	0	0	17	0	31	29	0	0	0	0	0	0	0	16	0	0	7	2	8
	3	181	28	226	300	890	0	102	810	16	96	59	3	15	19	215	28	43	58	35	145
	4	639	51	131	642	176	81	113	769	269	174	47	61	53	70	83	337	954	2153	472	1415
	5	277	529	201	355	142	368	403	1102	388	1110	102	113	452	288	143	158	562	1144	5095	1359
	6	274	306	1037	692	250	590	755	2596	284	327	338	302	311	2542	253	82	337	968	1271	8930
	7	277	116	294	519	493	2144	1218	2028	288	78	470	746	1130	626	1542	191	121	450	751	1182
	8	1007	322	223	158	173	3562	1275	2525	222	112	108	388	1841	1396	224	717	316	186	286	449
	9	1105	927	288	122	128	1899	2097	5196	293	67	158	214	589	2038	691	120	879	410	190	103
	10	926	1128	1208	164	228	1273	1254	8047	336	63	52	99	379	552	282	98	260	730	279	56
	11+	2781	3155	2568	1411	2171	14105	9513	17386	4202	2229	3969	7213	5681	6824	5027	2716	2168	2928	2640	513
Total		7571	6562	6176	4380	4651	24053	16759	40459	6298	4256	5303	9139	10451	14355	8476	4447	5640	9034	11021	14172
Total FS+SS		19849	17116	12843	11307	14696	32393	37488	96173	21722	16577	33263	38491	45048	51959	49798	32027	26417	24826	24098	32394
% 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	54.3	56.3
%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	45.7	43.7

Table 9. Age compositions (%) and mean ages* of spring and fall spawners in NAFO division 4R herring landings from 1966 to 1985. (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	1985
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	0.08	0.16
	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	0.76	1.23
	3	3.13	0.09	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	1.52	12.43
	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	30.40	2.10
	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	19.05	61.75
	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	4.57	11.34
	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	4.99	1.55
	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	0.99	1.40
	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	4.00	0.67
	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	4.48	1.26
	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	29.36	6.06
	< 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	2.36	13.87
	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	7.0	5.3
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	0.08
	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	0.02	0.06
	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	0.32	1.02
	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	4.28	9.99
	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	46.23	9.59
	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	11.53	63.01
	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	6.81	8.34
	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	2.60	3.17
	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	1.72	0.73
	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	2.53	0.39
	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	23.95	3.62
	< 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	0.34	1.16
	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	6.9	6.0

*Assuming ages 11+ to be 11.

Table 10. Calculation of the purse seine selectivity coefficients from the proportion at age of discarded sets and commercial landings and the partial recruitment for spring and fall spawners.

AGE	DISC.	COM.	RATIO	SELECTIVITY FACTOR	P.R.
SPRING SPAWNERS					
2	6.6	1.3	0.19	.059	.04 *
3	52.9	12.6	0.24	.074	.26 *
4	0.7	2.1	3.00	.929	.63 +
5	19.1	61.7	3.23	1.000	1.00
6	4.6	11.4	2.48	.768	1.00
7	-	1.5	-	-	1.00
8	-	1.4	-	-	1.00
9	-	0.7	-	-	1.00
10	-	1.2	-	-	1.00
11+	-	5.9	-	-	1.00
FALL SPAWNERS					
2	17.0	0.1	0.006	.004	.001 **
3	3.6	1.1	0.31	.190	.042 **
4	25.0	10.6	0.42	.258	.26
5	9.8	10.1	1.03	.632	.63
6	38.4	62.5	1.63	1.000	1.00
7	3.6	8.0	2.22	1.362	1.00
8	-	2.9	-	-	1.00
9	-	0.7	-	-	1.00
10	-	0.4	-	-	1.00
11+	-	3.5	-	-	1.00

* Historical average from 1974 to 1983
** Historical average from 1972 to 1983
\+ Adjusted (see text)

Table 11. Average weight at age (g) for spring (first half of the year) and fall (second half of the year) spawner herring in NAFO division 4R from 1966 to 1985.

SPRING SPAWNERS WEIGHT AT AGE (g)

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
2	89	89	89	91	87	67	47	89	86	72	71	64	75	87	102	71	64	64	39	61
3	110	110	89	110	131	90	196	119	158	149	135	122	167	125	168	177	144	131	171	113
4	184	184	159	167	176	181	187	189	202	196	177	194	172	234	212	237	239	227	217	214
5	198	198	208	188	202	227	235	204	203	233	227	225	247	241	269	311	262	276	265	243
6	225	225	231	224	218	260	266	250	237	237	238	256	279	287	293	332	321	281	313	289
7	252	252	244	259	275	234	288	304	271	270	259	253	292	318	338	367	364	371	350	334
8	255	255	274	293	312	262	295	321	315	300	290	267	292	344	350	393	377	428	374	351
9	269	269	280	269	258	297	315	338	344	334	310	289	314	339	362	417	393	441	423	392
10	302	302	330	318	307	314	303	353	340	339	319	298	328	356	343	415	406	485	419	391
11+	344	344	312	339	366	336	349	384	385	399	380	349	344	387	405	462	432	498	491	438

FALL SPAWNERS WEIGHT AT AGE (g)

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
2	115	116	116	118	106	95	114	98	82	89	96	105	105	105	115	136	158	88	96	55
3	167	158	179	160	173	166	159	158	134	93	159	242	138	210	210	207	150	195	151	149
4	197	181	226	196	218	244	189	205	218	183	206	232	217	237	264	269	223	234	230	196
5	232	242	256	216	266	246	258	233	265	271	221	295	270	292	322	331	301	269	271	268
6	229	258	284	247	271	268	257	288	254	305	260	296	335	336	355	351	325	306	314	299
7	245	286	297	271	286	287	265	316	325	380	292	333	355	381	406	419	389	339	352	334
8	240	290	294	287	324	305	315	366	328	346	292	337	381	413	416	457	427	383	386	353
9	269	317	317	291	333	322	317	355	364	376	300	336	372	445	458	473	442	426	398	381
10	293	333	348	300	318	326	315	390	391	400	419	342	392	444	460	516	501	432	452	451
11+	347	376	371	338	415	368	394	402	448	510	479	438	504	510	547	567	529	471	491	505

Table 12. Correlation coefficients, intercepts, sums of squares of the standardized residuals of the last three points and the residual of the last point for different relationships between spring and fall spawner mature (4+) population biomass at various F values from cohort analysis and gillnet catch rates.

SPRING SPAWNERS			
F	0.10	0.15	0.20
r	.77	.81	.81
bo	20342	8016	1859
S.S. OF ST. RES.	.0971	.0906	.1494
RES. OF LAST POINT	-.0065	-.1748	-.2898
FALL SPAWNERS			
F	.30	.35	.40
r	.91	.94	.95
bo	7949	5997	4536
S.S. OF ST. RES.	.0738	.0525	.0429
RES. OF LAST POINT	.0490	-.0129	-.0660

Table 13. Population biomass (t) as estimated from cohort analysis for spring spawning herring in NAFO division 4R from 1966 to 1985.

BEGINNING-OF-YEAR POPULATION BIOMASS (t)

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
2	2785	4768	12192	4202	66163	18612	2073	1283	2242	1857	8825	1383
3	5259	2800	3904	12327	4924	55792	44578	4258	1238	3162	2838	12359
4	3466	7137	3312	5952	15974	5331	94362	35151	5751	1216	2957	3165
5	15804	3000	6542	3149	5546	16778	5609	82833	30694	5408	1082	2878
6	10208	14584	2851	5650	2799	5689	15966	4582	72206	29276	4482	946
7	10103	8893	12884	2569	5601	2405	5010	14505	3375	64780	25894	3828
8	5868	7418	7038	12503	2485	4321	2361	4026	11411	2990	54799	21192
9	2815	4543	5899	5339	8911	1874	3914	1875	2593	9647	2463	40676
10	1197	2131	4136	4828	4718	8591	1538	3240	991	1881	7440	1733
11+	2273	2735	3333	6171	9755	10752	16379	14714	12337	10610	9742	12156
2+	59779	58010	62091	62692	126876	130146	191791	166466	142839	130828	120522	100315
3+	56994	53242	49899	58490	60714	111534	189718	165183	140597	128971	111697	98932
4+	51735	50443	45995	46163	55790	55742	145140	160925	139359	125809	108858	86573
5+	48269	43305	42683	40210	39816	50411	50777	125775	133608	124593	105901	83408

	1978	1979	1980	1981	1982	1983	1984	1985
2	483	1634	1198	3441	11258	476	3231	2698
3	2952	659	2561	1651	5707	18867	1038	7655
4	14162	3379	910	2745	1757	7277	25042	1025
5	3180	15789	3137	1069	2051	1534	6140	22070
6	2791	2970	12809	3072	875	1302	1056	4830
7	807	2389	2688	8190	2653	687	1122	749
8	3526	689	1824	2413	3895	1852	494	716
9	19223	2656	445	1287	1886	1736	1188	378
10	32950	15068	1359	320	808	1486	854	714
11+	9489	33648	35198	25113	13650	9440	6555	3817
2+	89563	78881	62129	49301	44540	44655	46720	44651
3+	89080	77247	60931	45860	33282	44179	43489	41954
4+	86127	76588	58370	44209	27575	25313	42451	34299
5+	71965	73210	57460	41464	25818	18036	17409	33274

Table 14. (a) Population numbers ('000) and (b) fishing mortalities as estimated from cohort analysis for spring spawning herring in NAFO division 4R from 1966 to 1985.

(a)

SPRING SPAWNERS POPULATION NUMBERS

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
2	31295	53573	136988	46174	760490	277795	44114	14415	26071	25787	124297	21606	6441	18779	11747	48462	175907	7440	82853	44229
3	47809	25451	43861	112063	37587	619912	227439	35776	7835	21221	21026	101304	17679	5273	15245	9328	39631	144020	6070	67744
4	19838	38790	20831	35643	30761	29454	504611	185582	28469	6202	16706	16312	82340	14438	4290	11584	7350	38056	115402	4789
5	79818	15154	31454	16751	27454	73912	23870	406044	151204	23211	4766	12789	12873	65517	11662	3436	7827	5556	23168	90825
6	45371	64819	12343	25225	12841	21880	60022	18330	304665	123529	18832	3695	10004	10349	43717	9252	2725	4634	5373	16711
7	40091	35290	52802	9920	20368	10277	17396	47715	12455	239927	99976	15129	2765	7513	7953	22316	7287	1651	3207	2244
8	23012	29090	25685	42673	7965	16494	8004	12543	36225	9968	188961	79370	12074	2004	5211	6139	10333	4328	1321	2039
9	10465	16888	21067	19849	34540	6309	12424	5546	7538	28883	7947	140748	61218	7835	1228	3087	4800	3935	2808	964
10	3965	7057	12534	15183	15369	27361	5077	3177	2916	5548	23322	5815	100456	42324	3963	772	1990	3064	2038	1835
11+	6608	7952	10683	18204	26653	32001	46930	38316	32045	26592	25637	34832	27584	86945	86909	54358	31598	18955	13351	6715
2+	307272	294064	368248	341684	1034027	1115396	949888	773846	609424	510869	531469	431600	333435	260978	191925	168733	289448	225840	253591	240084
3+	275977	240491	231260	295510	273537	837601	905774	759432	583353	485082	407172	409994	326994	242199	180178	120271	113541	218400	170739	195855
4+	228168	215040	187399	183446	235950	217689	678335	723653	575518	463861	386146	308691	309315	236926	164933	110943	73910	74380	164663	128112
5+	209330	176249	166568	147804	145190	188235	173724	537671	547049	457659	369440	292378	226975	222488	160643	99359	66559	43324	49266	123323

(b)

FISHING MORTALITY

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
2	.007	.000	.001	.006	.004	.000	.009	.410	.006	.004	.005	.001	.000	.008	.031	.001	.000	.003	.001	.006
3	.009	.000	.007	.011	.044	.006	.001	.029	.034	.039	.054	.007	.003	.006	.075	.038	.012	.022	.037	.039
4	.018	.010	.018	.061	.005	.010	.017	.007	.004	.063	.067	.037	.029	.014	.022	.192	.080	.125	.039	.095
5	.008	.005	.021	.066	.027	.008	.064	.087	.002	.009	.055	.046	.018	.205	.031	.032	.324	.299	.127	.150
6	.051	.005	.019	.014	.023	.029	.029	.186	.039	.012	.019	.090	.086	.063	.472	.039	.187	.168	.208	.150
7	.121	.118	.013	.019	.011	.050	.127	.075	.023	.039	.031	.026	.122	.166	.059	.570	.321	.137	.253	.150
8	.109	.123	.058	.011	.033	.083	.167	.309	.026	.027	.095	.060	.232	.290	.324	.046	.765	.232	.115	.150
9	.194	.098	.138	.056	.033	.017	.103	.443	.106	.014	.112	.137	.169	.482	.264	.239	.249	.458	.231	.150
10	.088	.144	.046	.027	.075	.037	.109	.198	.077	.028	.145	.193	.192	.202	.321	.364	.380	.307	.376	.150
11+	.088	.144	.046	.027	.075	.037	.109	.198	.077	.028	.145	.193	.192	.202	.321	.364	.380	.307	.376	.150
5+	.064	.068	.041	.028	.040	.029	.079	.108	.031	.027	.060	.113	.173	.206	.328	.345	.409	.290	.224	.150

MEAN FISHING MORTALITY (UNWEIGHTED)

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
5+	.1086	.1058	.0514	.0259	.0417	.0424	.1074	.2351	.0590	.0245	.0909	.1162	.1656	.2341	.2585	.2703	.3804	.2664	.2600	.1500

Table 15.(a) Population numbers ('000) and (b) fishing mortalities as estimated from cohort analysis for fall spawning herring in NAFO division 4R from 1966 to 1985.

(a)

FALL SPAWNERS POPULATION NUMBERS

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
2	80731	30743	15608	14737	19529	22079	29291	15665	10933	28165	7306	3495	5143	11628	18265	85635	15059	27642	13551	17623
3	233239	66003	25171	12779	12051	15969	18049	23957	12625	8951	23059	5982	2861	4210	9520	14956	70112	12330	22625	11379
4	67986	190796	54013	20403	10191	9061	13091	14685	18881	10486	7242	19926	4895	2329	3450	7600	12220	57364	10042	13491
5	41750	55084	156164	44104	16124	8185	7545	10616	11327	15215	8428	5887	15356	3960	1844	2733	5918	5141	45018	7783
6	43584	33931	44620	127675	35788	13073	6368	5649	7594	9923	11453	6808	4717	12165	2981	1380	2095	4336	6449	32123
7	43619	35436	27504	35594	103505	29074	10169	4530	2276	6042	7010	9071	5300	3581	7660	2212	1056	1410	2674	4116
8	120838	35462	28907	23252	28672	84624	21664	7224	1874	1603	4877	5314	6752	3317	2365	4876	1638	755	747	1516
9	68955	98022	28742	23465	18076	23318	66061	16747	3630	1334	1211	3895	3393	3862	1453	1734	3344	1055	450	360
10	48236	55440	79415	23271	19101	14683	17373	53169	9010	2707	1031	849	2995	2741	1318	564	1311	1542	493	208
11+	144865	155064	168823	200220	161883	162692	131794	112757	112678	95759	78713	61822	44897	33891	23493	15634	10785	7790	4741	1730
2+	893783	755961	628968	524501	445320	382779	321407	264019	191129	179165	150329	121947	96918	81685	72349	137325	123537	123766	107091	95649
3+	813052	725237	613360	509764	425791	360700	292114	248354	180196	151020	143023	118452	91775	70057	54064	51690	108477	96124	93240	77726
4+	579813	659234	588189	496985	413740	344710	274065	224398	167371	142069	119963	112470	88914	65846	44544	36734	38965	83794	70615	66387
5+	511828	468439	534176	476581	403549	335650	260974	209712	148489	131583	112722	93644	84019	63517	41114	29134	26146	26430	60573	47896

(b)

FISHING MORTALITY

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
2	.001	.000	.000	.001	.000	.002	.001	.000	.000	.000	.000	.000	.000	.000	.001	.000	.000	.000	.000	.000
3	.001	.000	.010	.026	.085	.000	.006	.038	.001	.012	.003	.001	.006	.005	.025	.002	.001	.005	.002	.015
4	.010	.000	.003	.035	.019	.010	.010	.060	.016	.019	.007	.004	.012	.034	.027	.050	.090	.042	.055	.091
5	.007	.011	.001	.009	.010	.051	.063	.122	.039	.084	.013	.021	.033	.084	.090	.066	.111	.149	.137	.220
6	.007	.010	.026	.006	.008	.051	.140	.709	.042	.041	.033	.050	.076	.263	.098	.068	.196	.283	.249	.350
7	.007	.004	.012	.016	.005	.085	.142	.683	.151	.014	.077	.095	.269	.215	.252	.100	.135	.435	.368	.350
8	.009	.010	.009	.008	.007	.048	.067	.488	.140	.080	.025	.084	.309	.626	.111	.177	.240	.318	.530	.350
9	.019	.011	.011	.006	.008	.094	.036	.420	.093	.057	.156	.063	.178	.875	.746	.080	.343	.561	.571	.350
10	.021	.023	.017	.008	.013	.100	.083	.186	.042	.026	.057	.137	.150	.250	.268	.212	.246	.530	.889	.350
11+	.021	.023	.017	.008	.013	.100	.083	.186	.042	.026	.057	.137	.150	.250	.268	.212	.246	.530	.889	.350
6+	.015	.016	.017	.008	.010	.083	.073	.243	.046	.028	.056	.120	.176	.312	.260	.180	.250	.453	.508	.350

MEAN FISHING MORTALITY (UNWEIGHTED)

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
6+	.0154	.0139	.0131	.0081	.0093	.0855	.0880	.3925	.0937	.0408	.0744	.1034	.2210	.4431	.2288	.1562	.2420	.4746	.6493	.3500

Table 16. Population biomass (t) as estimated from cohort analysis for fall spawning herring in NAFO division 4R from 1966 to 1985.

MID-YR POPULATION BIOMASS (t)

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
2	8401	3227	1638	1574	1873	1898	3022	1389	811	2268	635	332
3	35244	9436	4077	1850	1886	2402	2597	3425	1555	753	3318	1310
4	12119	31248	11045	3619	2010	2000	2239	2724	3724	1736	1350	3952
5	8764	12062	36174	8620	3881	1822	1715	2238	2716	3731	1685	1571
6	9031	7921	11466	28535	8776	3170	1481	1472	1768	2463	2694	1823
7	9670	9170	7391	8728	26889	7550	2438	1295	669	2078	1852	2733
8	26241	9305	7690	5779	8406	23354	6232	2392	556	502	1288	1620
9	16779	28116	8244	6179	5446	6794	18949	5380	1195	454	329	1184
10	12788	16705	25007	6317	5496	4331	4952	18417	3188	980	391	263
11+	45485	52756	56673	61234	68298	54173	46985	41015	45676	44190	34115	24501
2+	184521	179945	169405	132433	132962	107495	90608	79747	61860	59154	47657	39290
3+	176121	176718	167767	130860	131089	105597	87587	78358	61048	56886	47023	38958
4+	140877	167282	163690	129010	129202	103195	84990	74933	59493	56132	43705	37648
5+	128758	136035	152645	125391	127192	101195	82751	72209	55769	54396	42355	33696

	1978	1979	1980	1981	1982	1983	1984	1985
2	489	1105	1903	10538	2153	2201	1203	892
3	357	800	1809	2801	9516	2175	3091	1529
4	961	499	819	1850	2466	12146	2090	3279
5	3752	1046	537	819	1612	2225	11039	1887
6	1430	3699	958	438	616	1201	1832	8691
7	1703	1234	2814	839	372	433	852	1244
8	2328	1240	890	2016	633	262	261	484
9	1346	1555	602	742	1337	407	162	124
10	1062	1101	549	263	594	759	202	85
11+	20475	15640	11628	8021	5162	3320	2106	818
2+	33903	27919	22509	28328	24461	25128	22838	19033
3+	33414	26814	20606	17790	22308	22927	21635	18141
4+	33057	26014	18797	14988	12792	20751	18544	16613
5+	32096	25515	17977	13138	10326	8606	16454	13333

Table 17. Catch and population estimates for (a) spring and (b) fall spawner herring in NAFO division 4R from 1985 to 1987 assuming a fishing mortality rate F= 0.3 in 1987.

(a) SPRING

	POPULATION NUMBERS			POPULATION BIOMASS AT BEGINNING OF YEAR			FISHING MORTALITY			CATCH NUMBERS			CATCH BIOMASS		
	1985	1986	1987	1985	1986	1987	1985	1986	1987	1985	1986	1987	1985	1986	1987
2	44307	44307	44307	2259	2259	2259	.006	.012	.012	240	485	479	17	34	33
3	67744	36058	35837	6399	3406	3385	.039	.079	.078	2350	2485	2440	302	319	314
4	4789	53342	27281	847	9437	4826	.095	.191	.189	392	8446	4272	95	2056	1040
5	90825	3567	36068	23564	925	9357	.150	.304	.300	11495	851	8515	3178	235	2354
6	16711	64003	2156	5038	19297	650	.150	.304	.300	2115	15271	509	695	5021	167
7	2244	11776	38676	793	4162	13671	.150	.304	.300	284	2810	9131	108	1068	3470
8	2039	1581	7116	794	616	2772	.150	.304	.300	258	377	1680	103	151	671
9	964	1437	956	407	606	403	.150	.304	.300	122	343	226	54	153	101
10	1825	679	868	813	303	387	.150	.304	.300	231	162	205	103	72	91
11+	8715	1286	410	4103	606	193	.150	.304	.300	1103	307	97	550	153	48
12+	0	6141	777	0	3060	387	.000	.304	.300	0	1465	183	0	730	91
13+	0	0	3711	0	0	1849	.000	.304	.300	0	0	876	0	0	437
2+	240162	224179	198163	45017	44678	40141	.091	.183	.180	18590	33002	28613	5205	9992	8817
3+	195855	179872	153856							18350	32516	28134	5189	9956	8784
4+	128112	143814	118019							16000	30032	25693	4887	9639	8470
5+	123323	90471	90738							15608	21586	21422	4791	7583	7430

(b) FALL

	POPULATION NUMBERS			POPULATION BIOMASS (MID-YEAR)			FISHING MORTALITY			CATCH NUMBERS			CATCH BIOMASS		
	1985	1986	1987	1985	1986	1987	1985	1986	1987	1985	1986	1987	1985	1986	1987
2	17953	17953	17953	1041.05	1041.05	1041.05	.000	.001	.000	8	22	7	0	1	0
3	11339	14691	14679	1781.25	2307.93	2305.99	.015	.040	.013	150	519	167	21	74	24
4	18491	9148	11559	3821.24	1890.39	2388.73	.091	.246	.078	1460	1816	787	273	340	147
5	7783	13823	5856	2199.16	3905.74	1654.56	.220	.596	.189	1401	5683	917	358	1453	234
6	32123	5111	6233	10126.69	1611.29	1965.08	.350	.947	.300	8648	2879	1472	2467	821	420
7	4116	18533	1624	1449.33	6526.51	571.84	.350	.947	.300	1108	10440	383	353	3326	122
8	1516	2375	5888	564.05	883.76	2191.48	.350	.947	.300	408	1338	1390	137	450	468
9	360	874	754	144.74	351.24	303.05	.350	.947	.300	97	493	178	35	179	65
10	208	208	278	98.91	98.85	132.09	.350	.947	.300	56	117	66	24	50	28
11+	1790	120	66	953.28	63.90	35.16	.350	.947	.300	482	68	16	232	33	8
12+	0	1033	38	.00	549.99	20.30	.000	.947	.300	0	582	9	0	280	4
13+	0	0	328	.00	.00	174.74	.000	.947	.300	0	0	77	0	0	37
2+	95679	83869	65257	22179.69	19230.64	12784.08	.184	.451	.104	13818	23956	5468	3902	7008	1558
3+	77726	65916	47304	21138.64	18189.59	11743.03				13810	23934	5461	3901	7007	1557
4+	66387	51225	32625	19357.39	15881.66	9437.04				13660	23415	5235	3880	6933	1534
5+	47896	42077	21066	15536.15	13991.27	7048.31				12200	21598	4508	3607	6593	1387

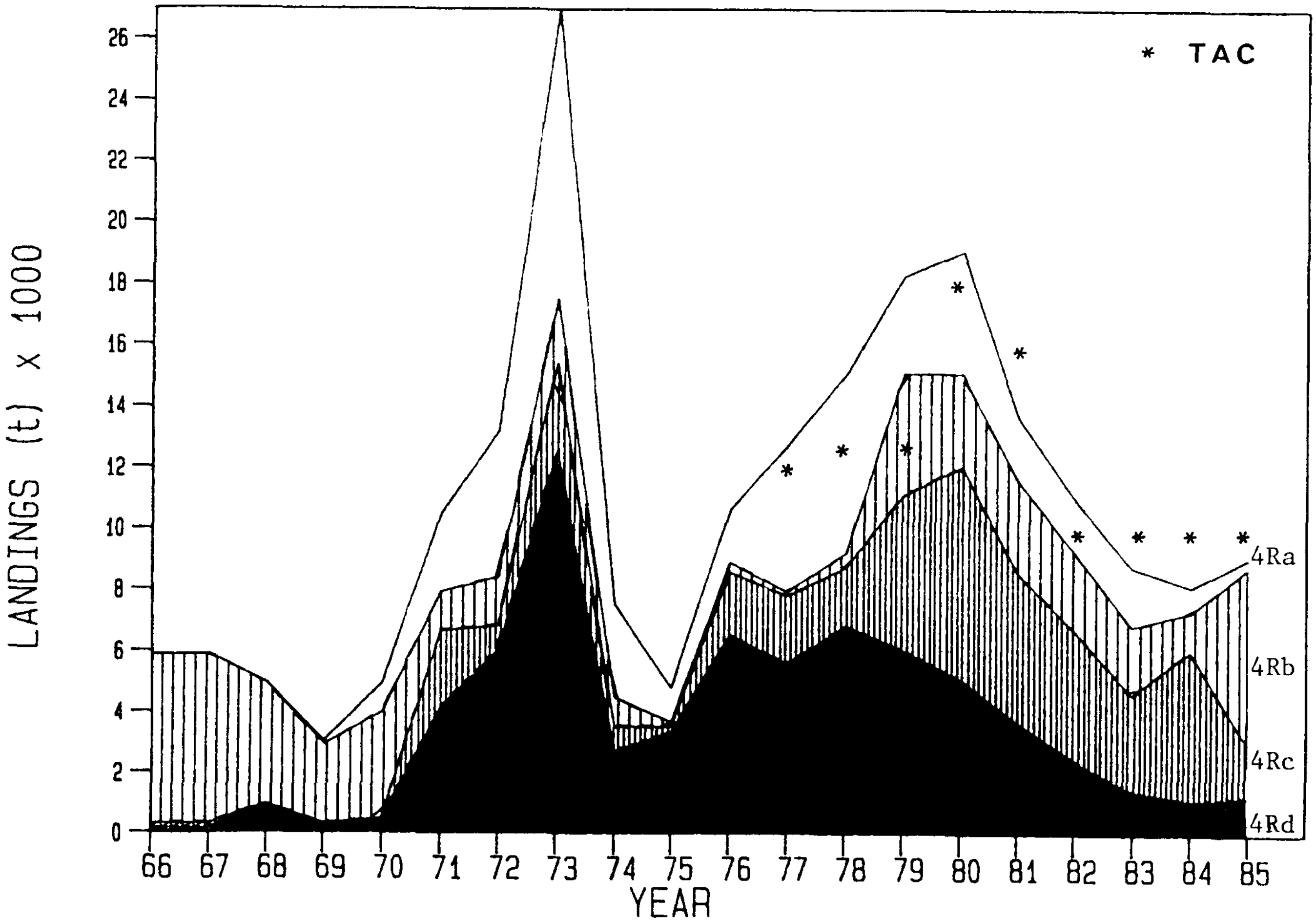


Figure 1. Commercial herring landings (t) by fishing area from NAFO division 4R from 1966 to 1985. Stars indicate annual TAC's.

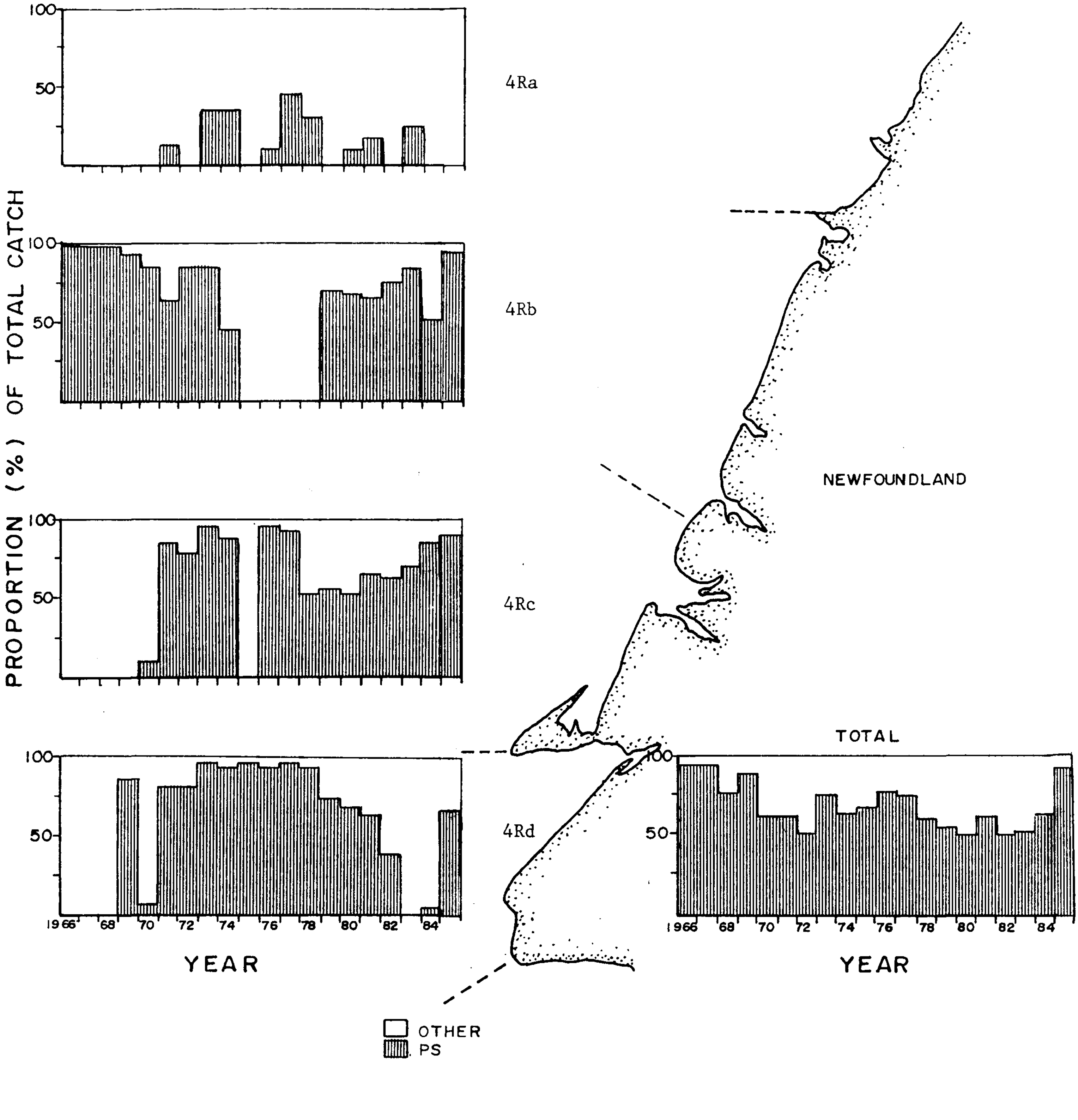


Figure 2. Proportions of herring catches taken by purse seines and all other gears for each fishing area and all areas combined from 1966 to 1985.

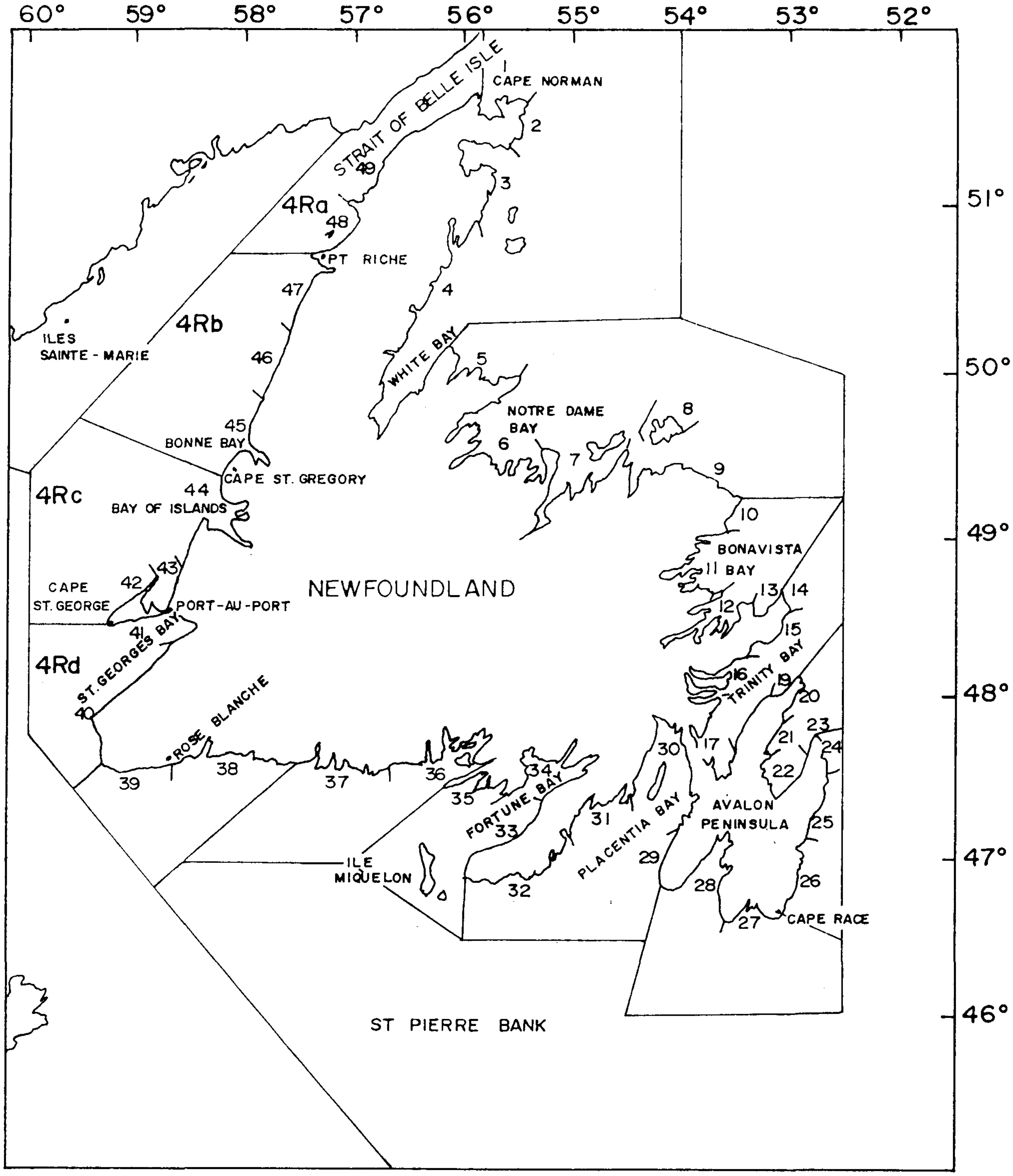


Figure 3. Newfoundland fishing areas.

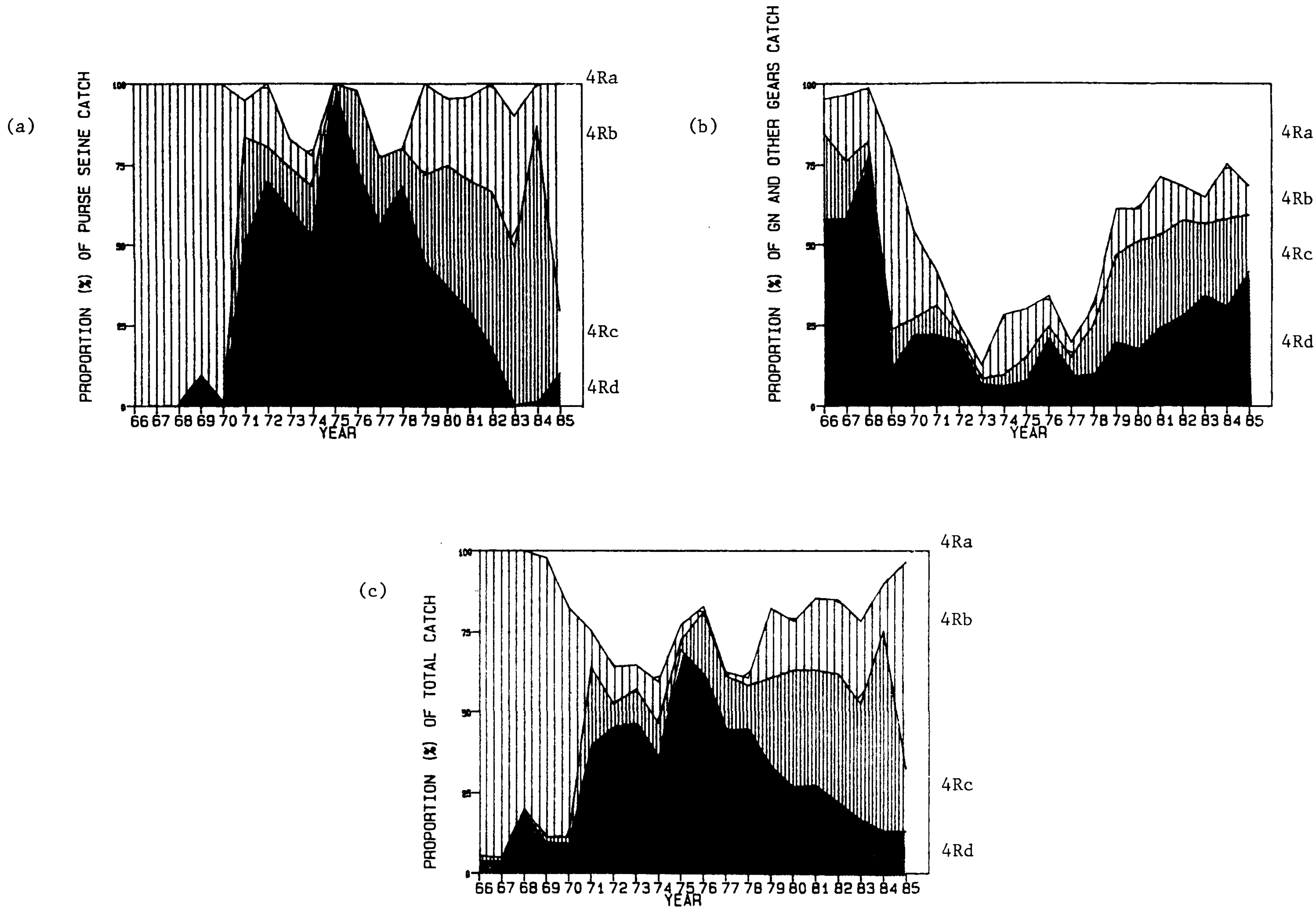


Figure 4. Proportions of herring catches from each fishing area for (a) purse seines, (b) all other gears and (c) all gears combined from 1966 to 1985.

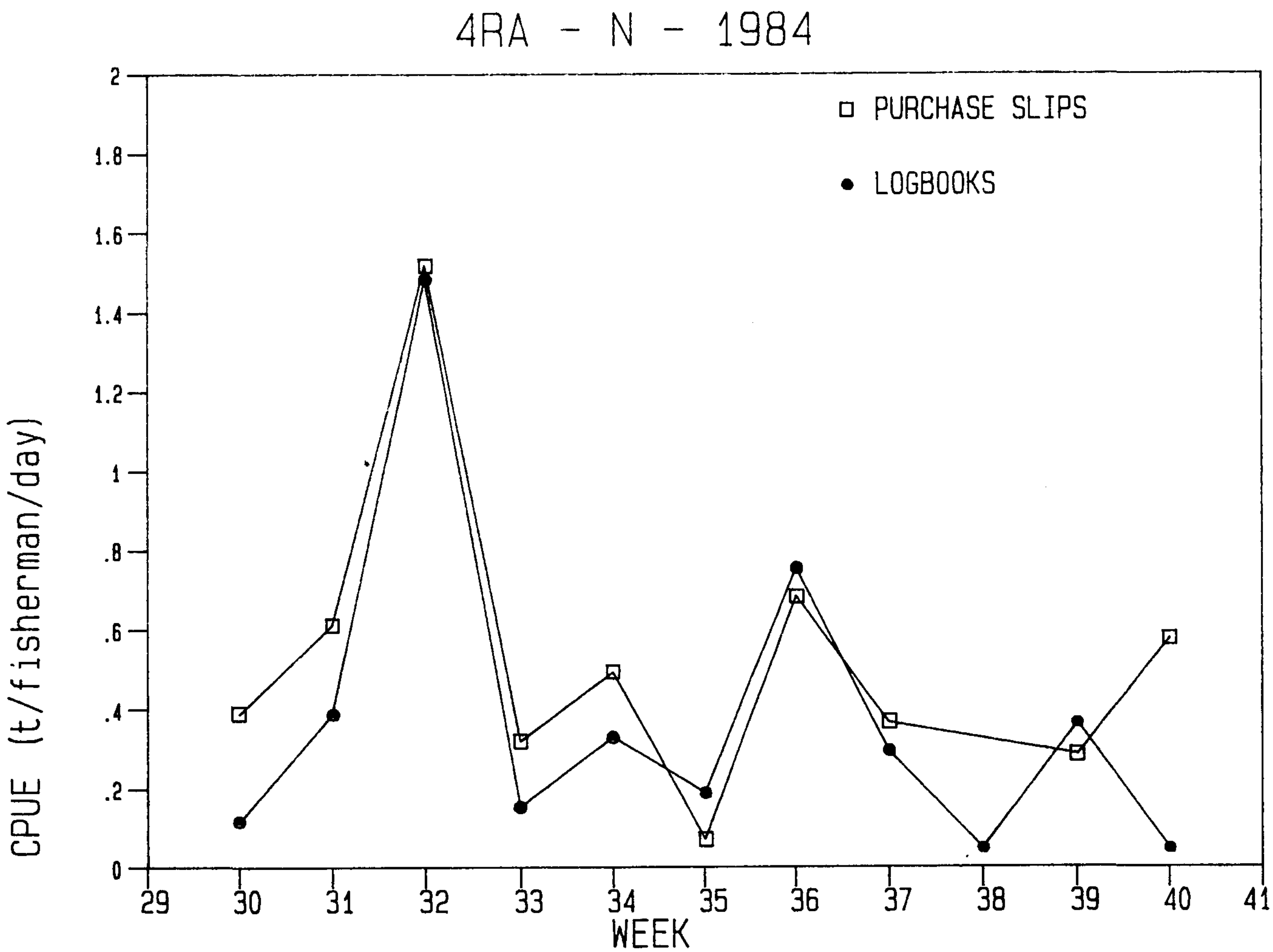


Figure 5. Weekly gillnet catch rates (t/fisherman/day) calculated from purchase slips and logbooks for area N in 1984. The catch rate for the fall spawning stock was calculated as the mean of the weekly rates between the hashed lines.

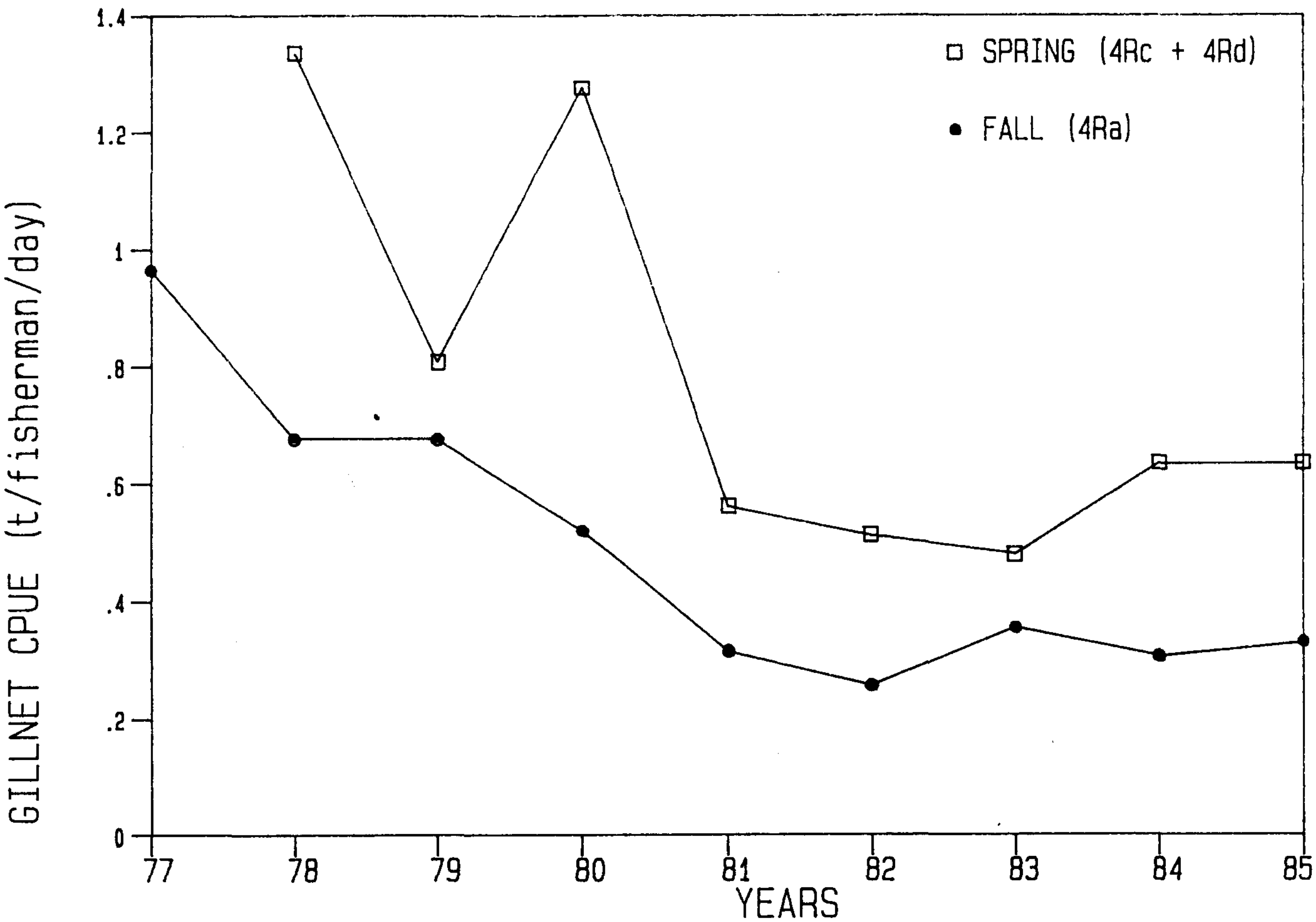


Figure 6. Gillnet catch rates, adjusted for gang size, for spring and fall spawners in NAFO division 4R from 1977 to 1985.

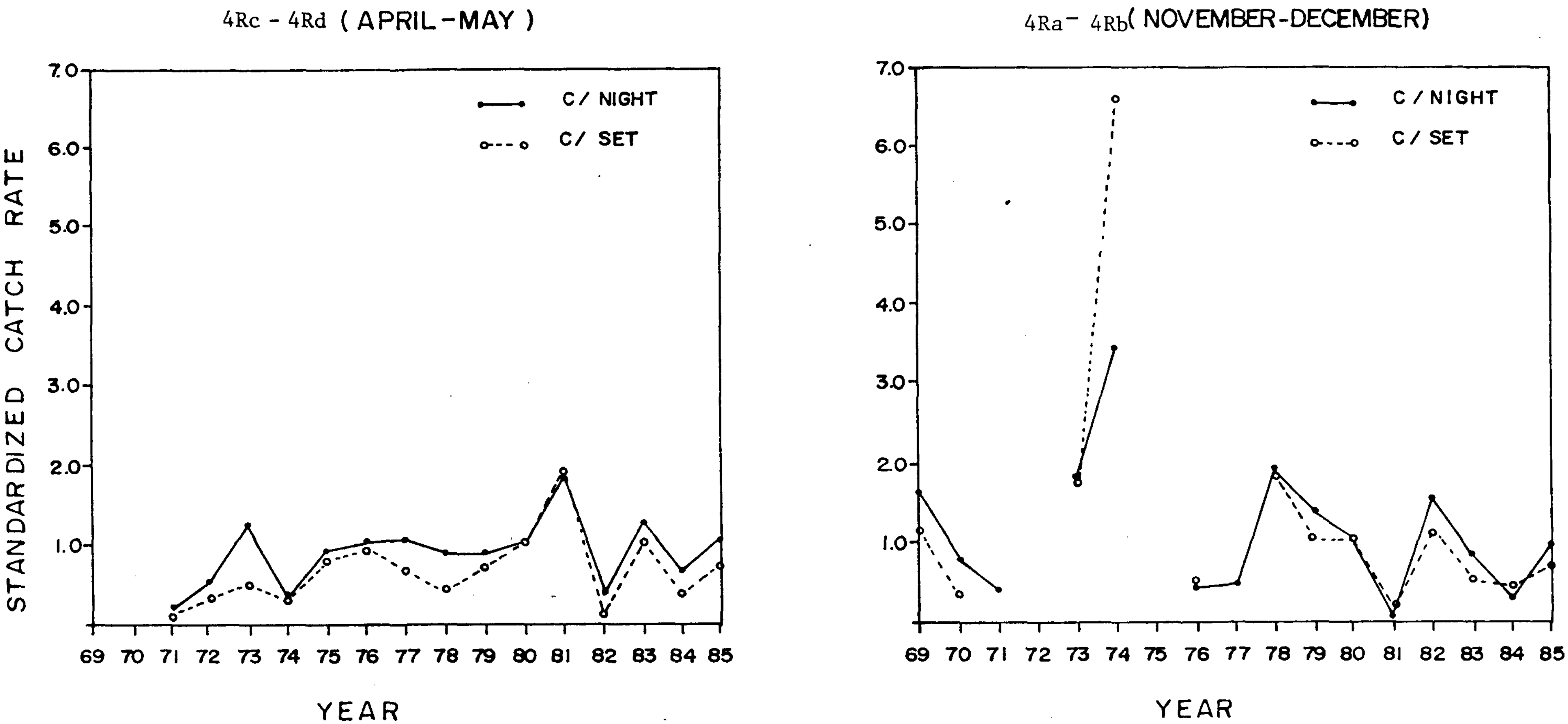


Figure 7. Purse seine catch rates, standardized to 1980, from spring and fall fisheries in NAFO division 4R from 1969 to 1985.

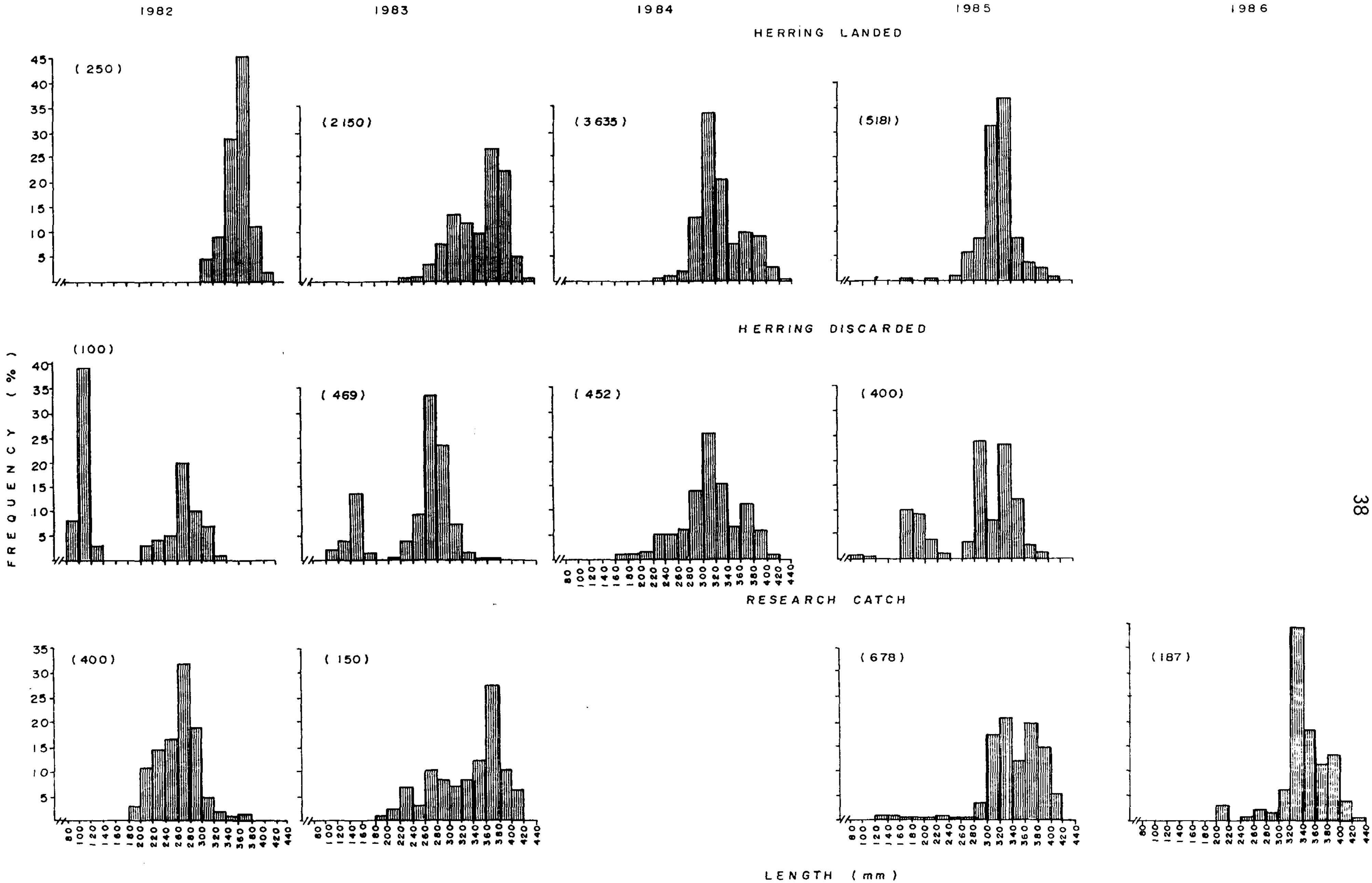
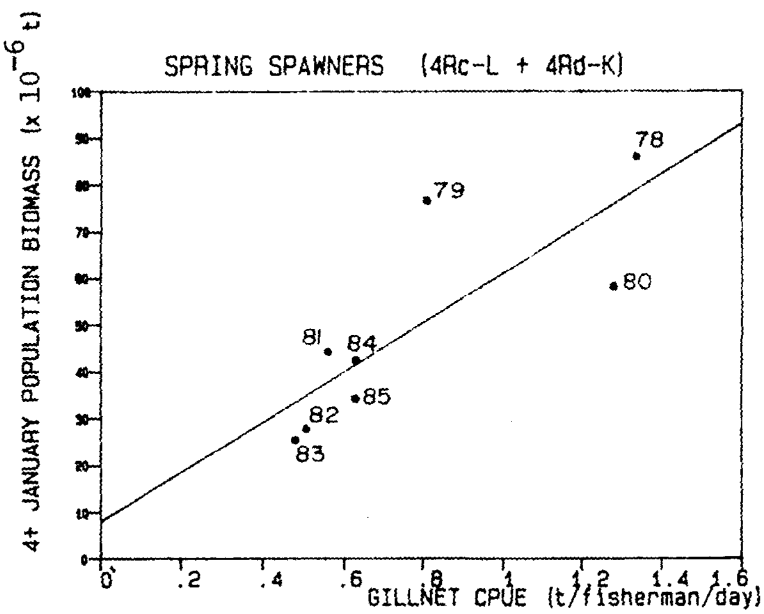


Figure 8. Herring length frequencies (20mm) from the purse seine commercial samples (landed and discarded) from 1982 to 1985 and from the bottom trawl research surveys of 1982, 1983, 1985 and 1986 in NAFO division 4R.

(a)



(b)

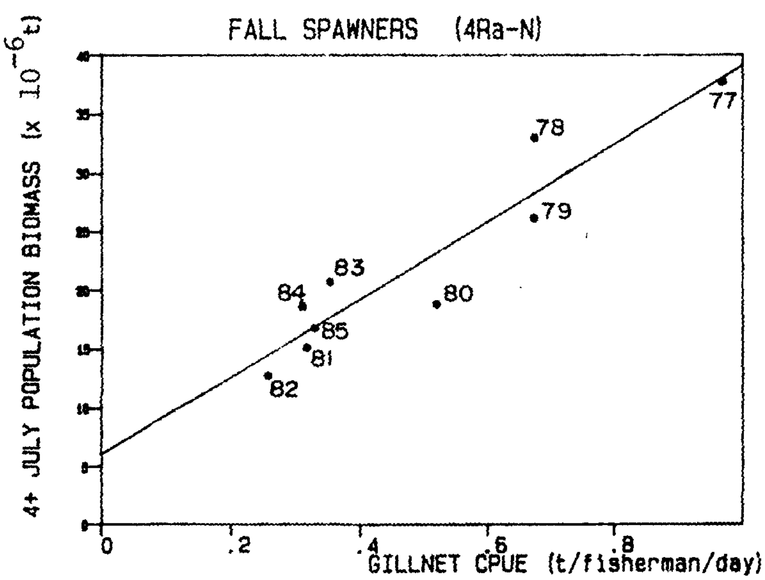


Figure 9. Least square regression of (a) spring spawner mature (4+) January population biomass and gillnet catch rate for areas K and L in April and May from 1978 to 1985 and (b) fall spawner mature (4+) population biomass and gillnet catch rate for area N in August from 1977 to 1985.

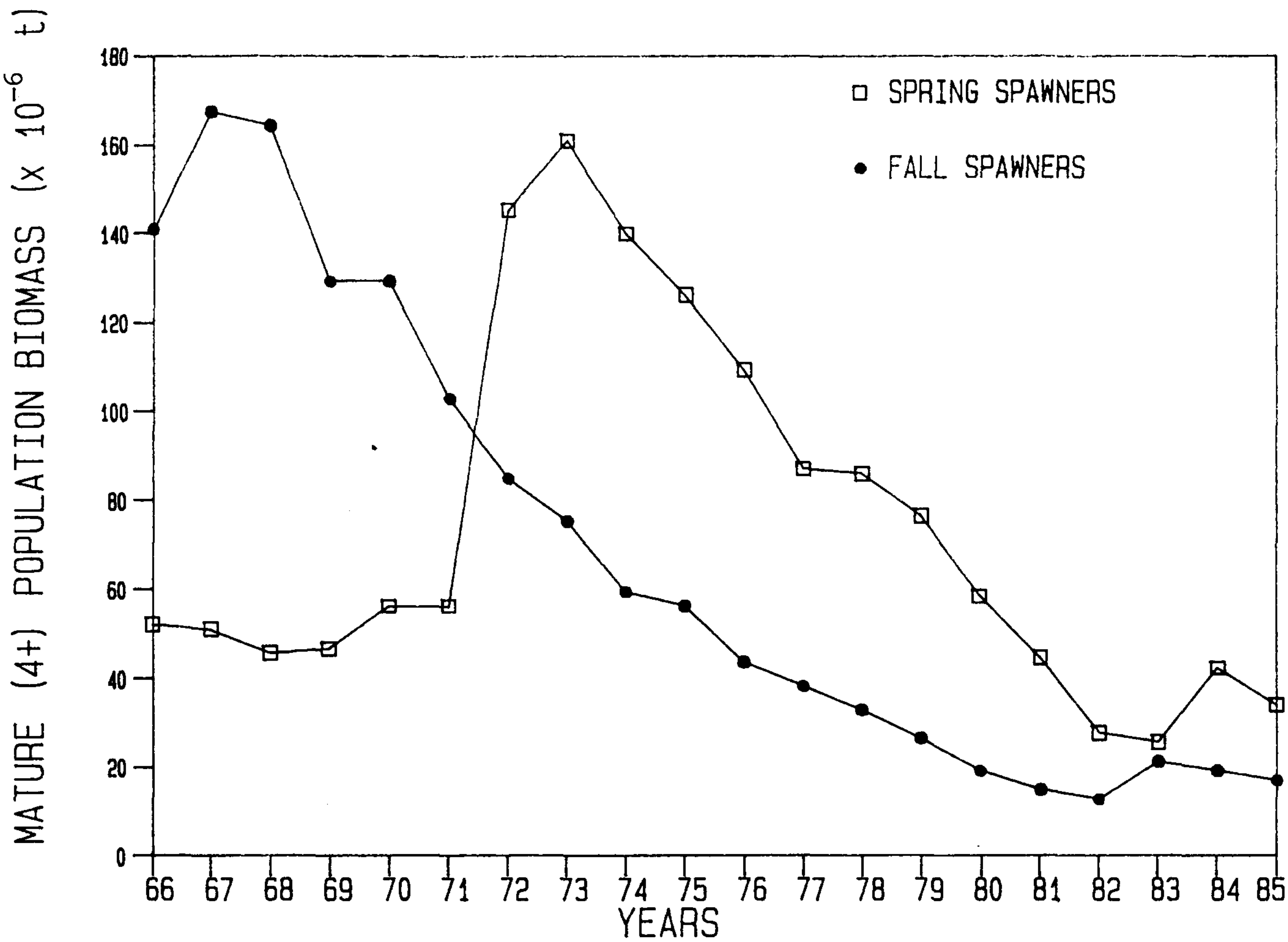


Figure 10. Mature (4+) population biomass estimates (x10^{-6} t) for spring and fall spawning herring in NAFO division 4R from 1966 to 1985. Estimates for spring spawners are for the beginning of the year and for fall spawners are for mid-year.

Annex 1. Number of herring sampled (shadow print) and commercial landings in 4R by month, area and gear in 1985.

AREA	GEAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
4R N	GN				50	656	243		100	
			1	4		20	152	2	112	4
	PS									
	OTB									
			*		5	*				
M	GN									
		1	22	38	2	11	6	26	234	8
	PS					250		800	1950	650
								344	3382	2050
	OTB		50							
			4							
L	GN		327	220						
		2	93	28	11	9	4	11	1	5
	PS		965	165		50		150		
			682	46		477		111	267	
K	GN		355							
		*	324	28	19	5	11	10	*	1
	PS		250							
			801							