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An Assessment and Risk Projections of the West Coast of Newfoundland (NAFO division 4R) Herring Stocks (1965 to 2000).

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Abstract

Both spring- and autumn-spawning herring are found along the west coast of Newfoundland (4R). The 1999 assessment indicates that the status of the spring-spawning stock is in danger of collapse. The autumn spawning stock is declining gradually while the exploitation rate has been slowly increasing. Apart from the 1990 year-class, recruitment to the spring-spawning stock has been below average (1965-1996) since the 1987 year-class. The spring-spawner spawning-stock biomass (SSB) has declined to an historical low of 14,000 t in 1999. If the spring-spawner $F_{0.1}$ catch of 2,300 t is caught in 1999, the risk that the SSB would not increase by even 20% by the year 2000 would be about 40%, and the minimum SSB target of 38,000 cannot be achieved even without fishing.

Recruitment to the autumn-spawning stock has been above average (1973-1996) since the large 1979 year-class, which has kept this stock at an intermediate level. The autumn-spawner SSB has been declining slowly, from 80,000 t in 1984 to 42,000 t in 1998. An autumn-spawner $F_{0.1}$ yield for 1999 would be approximately 9,000 t and would result in a 90% risk that the SSB will decrease by 10%, although there is a 70% probability that the SSB will not decline below 35,000 t. It is essential that fishing effort be reduced and be shifted to the north as much as possible to avoid directed fishing on the spring-spawning stock.

Résumé

Les deux groupes de hareng qui fraye soit le printemps ou l'automne se retrouvent le long de la côte Ouest de Terre-Neuve (4R). L'évaluation de 1999 montre que le stock de géniteurs de printemps risque de s'effondrer, tandis que le stock de géniteurs d'automne diminue progressivement en même temps que le taux d'exploitation augmente lentement. Outre la classe annuelle de 1990, le recrutement du stock de géniteurs de printemps a été inférieur à la moyenne depuis la classe d'âge de 1987. La biomasse du stock reproducteur (BSR) de printemps a baissé à un plancher jamais atteint de 14 000 t en 1999. Si le niveau de captures des géniteurs de printemps à $F_{0,1,}$ fixé à 2 300 t, est atteint en 1999, le risque que la BSR n'augmente pas de même 20 % d'ici l'an 2000 est de 40 %, bien que la valeur cible minimum de la BSG de 38 000 t ne puisse pas atteinte même en l'absence de pêche.

Le recrutement du stock de géniteurs d'automne a été supérieur à la moyenne depuis l'importante cohorte de 1979, ce qui a maintenu ce stock à un niveau moyen. La BSR d'automne a diminué progressivement, passant de 80 000 t en 1984 à 42 000 t en 1998. Une exploitation à $F_{0,1}$ des géniteurs d'automne pour 1999 serait d'environ 9 000 t et se traduirait par 90 % de risque que la BSR diminue de 10 %, bien qu'il y ait une probabilité de 70 % que la BSR ne descende pas en dessous de 35 000 t. Il est essentiel de réduire l'effort de pêche, et de l'orienter le plus possible vers le nord pour éviter une pêche axée sur le stock de géniteurs de printemps.

Introduction

Herring (*Clupea harengus*) are found throughout the waters of the northwest Atlantic from Labrador to Cape Hatteras. In Canada, they are fished mainly in southwestern Nova Scotia and the Bay of Fundy, within the Gulf of St. Lawrence, and around the island of Newfoundland. Both spring- and autumn-spawning herring are found within the west coast of Newfoundland (NAFO division 4R) herring metapopulation (McQuinn 1997). The two seasonal-spawning populations are considered as separate stocks and are assessed independently.

The major spawning areas for the spring-spawning stock are located at the southern end of the coast in and around St. George's Bay (4Rd) and Port-au-Port Bay (4Rc) although several other spawning sites are known along the coast towards the north (Figure 1). Mature herring arrive and spawn in these areas from the end of April to the middle of June before dispersing. Autumn spawning is concentrated mainly north of Point Riche (4Ra) from mid-July to mid-September (Figure 1). At other times of the year, these two spawning stocks are found mostly in mixed schools in either feeding or over-wintering areas (McQuinn and Lefebvre 1995b). The major feeding areas, i.e. off St. George's Bay in the spring, north of Point Riche and in the Strait of Belle Isle in the summer and off Bonne Bay in the fall, are associated with concentrations of copepods (red-feed) and/or euphausiids (krill) which are their main food items. Based on winter research survey data (McQuinn and Lefebvre 1995b), they are believed to over-winter in the deeper waters of the Esquiman Channel (Figure 2).

Description of the Fishery

Management Plan

Total allowable catches (TAC) have been in effect since 1977. Since 1981, 45% of the TAC has been allocated to the fixed gear sector and 55% to the mobile gear sector. In addition, the purse seine quota has been allocated more or less equally among the half-dozen active vessels, and the gillnet allocation has been divided evenly between the regions north and south of Cape St. Gregory. Since 1989, an additional inshore allocation has been made for the small-purse-seine fishery.

The advised TAC has been estimated at 22,000 t since 1991, the only year in which this catch level was exceeded (Figure 3). In 1994, a limit of 5,400 t of spring spawners was imposed as a conservation measure for the St. George’s Bay component of the spring-spawning stock. In 1995, this spring-spawner cap was lifted, in favour of a delayed opening to fishing (June 15) of St. George’s Bay and Port-au-Port Bay to protect these local spring-spawning components in accordance with the recommendations of the west coast Herring Co-management Group (McQuinn and Lefebvre, 1995a).

Total Catches

Since 1986, total herring landings from the west coast of Newfoundland have averaged 17,300 t (from 12,400 t to 26,400 t) as compared to an average of 14,100 t for the previous decade (Table 1; Figure 3). In 1998, total landings were 16,100 t. Herring catches in western Newfoundland are taken mainly by large (>85') and small (<65') purse seiners and to a much lesser extent by fixed gillnetters from April to December on both spawning and autumn-feeding concentrations. Since 1985, the proportion of the total catch taken by all purse seines has been in excess of 80%, and even reached 98% in 1993 (Figure 4).

The Purse Seine Fleet

From 1984 to 1987, up to 80% of catches from the large purse-seine fleet were taken from October to December on autumn-feeding concentrations of herring in areas 4Rb and 4Rc (Figure 5a). In 1988, the development of an over-the-side market to Russian vessels contributed to a considerable increase in landings in the spring fishery in the St. George's Bay/Port-au-Port area from approximately 2,000 t in 1987 to 16,000 t in 1991 (Table 2a). This spring purse-seine fishery accounted for over 70% of the total catch in 1990 and 1993 (McQuinn and Lefebvre 1997). This proportion has diminished to below 40% since 1994 when St. George's and Port-au-Port Bays were closed to commercial fishing during the spawning season. Annual landings from small purse seiners have ranged between 3,100 t and 3,800 t since 1993 (Table 2b).

In 1997, the purse seine fleets had begun fishing in the St. George's Bay in May, moving into Port-au-Port Bay and Bay of Islands in June (Figure 6a,b). There was very little activity in July and August (Figure 6c,d). Starting in September, fishing activity was renewed along the southern half of the coast, although centred around Bonne Bay (Figure 6e,f). By November, concentrations of herring were becoming scarce as schools moved offshore (Figure 6g).

In 1998, the purse seine fleets again began fishing in the southern bays in May, although very few catches were being recorded by June and the fleet had moved northward (Figure 7a,b). There was not much activity in July, but by August good catches were made off Bonne Bay and north of Point Riche (Figure 7c,d) entirely on autumn spawners (Table 3a,b,c). It would appear from this unusual displacement of purse-seine effort towards the north in recent years that herring densities were higher in the north than in the south. By September, fishing activity again became centred around Bonne Bay and Bay of Islands (Figure 7e,f) until the schools moved offshore in November (Figure 7g).

The Gillnet Fleet

Due to limited market demand, reported landings from the fixed gears have generally been below 10% of the total 4R landings since 1985 (Figure 4). Recorded landings from 1990 to 1994 ranged between only 140 and 840 t (Table 2c). There has been an improvement in sales in the northern areas since 1995, which has increased the proportion of the catch from 4Ra (Figure 5b) as well as increased the total landings from 800 t in 1994 to 2,800 t in 1998.

Biological Characteristics

Data collection and Analysis

Random samples were collected by port samplers and by index gillnet fishermen in 1997 and 1998 (Annexes 1 and 2). These samples were frozen and sent to the Maurice Lamontagne Institute (MLI) in Mont-Joli, Quebec for analyses (i.e. length, weight, gonad weight, maturity stage and age determination). Reduction in sampling coverage over the past two years has resulted in important sampling deficiencies for certain landings, i.e. 65% of total landings by area and month were not sampled in 1998. For the calculation of the catch at age, samples from the small seiner fleet were often used to estimate the age composition for the large purse seine fleet (especially in the late fall fishery) and vice versa (in the spring fishery).

Individual herring were assigned as either spring or autumn spawners by relating the maturity stage, estimated from a gonadosomatic index model (McQuinn 1989), to the date of capture, using the 4R maturity cycle chart (McQuinn 1987a). In the case of immature fish, otolith

characteristics were used as described by Cleary *et al*. (1982). Ages were determined from the otoliths by counting the number of winter rings for spring spawners and the number of winter rings plus one for autumn spawners (Cleary *et al*. 1982). All herring aged 11 years or older were aggregated into an 11+ age-group. Otoliths collected from 1994 to 1996 were found to be more difficult than usual to age, presumably due to the effects of colder sea temperatures on ring formation (McQuinn and Lefebvre 1997). These otoliths were re-aged for the present assessment with special attention given to the effects of a change in growth patterns on ring formation in recent years.

Spawning Stock Proportions of the Catch

The proportion of each spawning stock in the catches varies among areas and seasons, as well as between the inshore and the offshore, as shown by differences between the gillnet and purse seine samples. In the spring (May and June), herring schools fished by gillnets in and around the major bays in the south near the spawning beds are typically dominated by spring spawners (Table 3a). Autumn spawners are more prevalent in deeper waters outside of St. George's Bay or north of Cape St. George in 4Rc as seen in the purse seine catches (McQuinn and Lefebvre 1995b). In the summer and fall (July to September), catches are mostly autumn spawners towards the north around the major autumn-spawning grounds (Table 3a) and are mixed in the southern regions (Table 3b,c). In the late-fall purse seine fishery (October to December), catches are a mix of spring and autumn spawners, although again there is a predominance of autumn spawners towards the north and spring spawners towards the south (Table 3b,c).

Catch At Age

The catch at age was generated for spring and autumn spawners (Table 4a,b) as described by McQuinn (1987b), weighing the age compositions by the corresponding landing as grouped in Annex 1 and 2. The catch-at-age matrix of McQuinn and Lefebvre (1997) was updated by incorporating the most recent landing information for the recent years, by adding the catch at age for 1997 and 1998, and also by extending the matrix from 1973 to 1965 using historical sample and landing data.

Historically, spring spawners have been dominant in the catch, averaging 72% of the catch in numbers (Figure 8), although this percentage has decreased to 55% or less in the last 5 years. This is partly due to a decrease in the concentration of fishing on the spring-spawning stock. However, there has also been a decrease in the spring-spawning stock itself, relative to the autumn spawners, as witnessed by a trend of decreasing percentage spring spawners in the late-fall purse-seine fishery, from 75% in 1987 to 45% at present (Figure 8).

Since 1995, the 1987, 1990 and recently the 1994 year-classes have been dominant in the overall spring-spawner catch (Table 5a). Since 1996, the 1988, 1990 and 1995 autumn-spawning year-classes have been the most important contributors to the fishery from this stock (Table 5b) although in 1998, the 1988 year-class was overshadowed by the two latter cohorts. The mean age for both spawning stocks has shown a decreasing trend since 1990 (Figure 9; Table 5).

Length Frequencies

These northern Gulf herring stocks are characterised by pulses of strong year-classes followed by a number of years of below average recruitment. This is particularly evident when examining the pattern of annual length frequencies for spring and autumn spawners (Figure 10a,b). In the past, these strong year-classes tended to dominate the fishery for a decade or more.

However, in the past decade, no single year-class has been dominant for more than 5-7 years before being replaced by another. This could indicate that the recruitment pulses are more frequent, but since there are few old individuals in the length frequencies, it is more likely the recruitment pulses are not as strong as in previous decades.

Weight at Age

The annual mean weights at age of the catch were estimated for each spawning stock (Table 6a,b) as the average of the weight at age of each sample (McQuinn, 1987b), weighted by the corresponding landings as grouped in Annexes 1 and 2 for 1997 and 1998. The mean weight at age in the fall purse seine fishery (October to December) was used as the annual mean population weight at age (Table 7a,b) as this was the period of the year with the most constant sampling throughout the time period. These weight-at-age matrices were used to calculate the catch and population biomass-at-age matrices, respectively.

Maturity at age

Annual maturity-at-age matrices were derived from biological samples taken from purse seines in the second quarter (April-June) for spring spawners and the third quarter (July-August) for autumn spawners (Table 8a,b). These maturity-at-age matrices were used to calculate the spawning-stock biomass-at-age matrices. Although a purse seine is a non-selective fishing gear, purse seine fishermen avoid areas with a high proportions of young herring. These data are therefore expected to be biased towards mature fish which will tend to overestimate spawning-stock biomass, although the bias should be relatively constant over time.

Biological Condition

There has been a more or less constant decline in the weight at age of both spring and autumn spawners since the early 1980s (Figure 11a,b). The overall condition factor (K) of west coast of Newfoundland herring in the fall, as estimated by the equation:

$$K = \frac{W_S}{L_T^{\,3}} \cdot 100$$

where W_S is somatic weight (g) and L_T is total length (cm), showed a major decrease in 1993 and 1994 (Figure 12), corresponding with a general decrease in the temperatures of the cold intermediate layer noted for the northern Gulf of St. Lawrence (Gilbert et al. 1997). However, when put into the context of the last 30 years, average condition was much lower from 1973 to 1976. In 1995, overall condition rebounded to the high values seen throughout the 1980's. A decreasing trend has again been seen over the last 4 years, indicating a return to poor feeding conditions, although average temperatures for the surface layer (0-30 m) where herring are found have been above normal in recent years (DFO, 1999).

Predators

Four species of seals: grey seals (*Halichœrus grypus*), harbour seals (*Phoca vitulina*), harp seals (*Phoca groenlandica*) and hooded seals (*Cystophora cristata*) occur in the northern Gulf of St. Lawrence. Harp seals and grey seals are the most important pinniped predators owing to their abundance (harp seals), or time of residency in this area and possibly high incidence of herring in the diet (grey seals). Pinniped consumption of herring in 4R has most likely increased

over the past decade with the growth of the harp seal population. Annual consumption by both harp and grey seals using the method of Hammill and Stenson (in press) and updated for 1998 was estimated to have reached in the order of tens of thousands of tons (Figure 13), and is most likely concentrated on young herring between 25 and 30 cm. These estimates should be considered as very tentative, as many uncertainties are involved in the calculations. The scarcity of comprehensive diet information for pinnipeds in the northern Gulf, as well as their resident times are two of the major factors limiting attempts to quantify fish consumption in this area. However, the true impact of predation on 4R herring stocks cannot be evaluated until predation is considered within the context of total natural mortality.

Abundance Indices

Acoustic Surveys

Fall acoustic surveys have been conducted on a biennial basis since 1989 with the last survey in 1997. The methodology and detailed result can be found in McQuinn and Lefebvre (1999). The 1995 and 1997 surveys were undertaken in close collaboration with the west coast large seiner fleet. This survey included the entire west coast of Newfoundland from St. George's Bay to the Strait of Belle Isle which adequately covered the stock area (Figure 14).

The 1997 total spawning-stock biomass estimate of 67,000 t [19,500 t of spring spawners and 47,500 t of autumn spawners] was a decrease over the 1995 estimate of 86,000 t [38,000 t of spring spawners and 48,000 t of autumn spawners] (Figure 15). In 1995, 64% of the herring biomass surveyed was in the two most northerly strata, while in 1997, 80% was in the most northerly stratum (McQuinn and Lefebvre 1999). The last four surveys have shown a constant decline in the spring-spawners numbers at age (Table 9) and thus the spawning biomass, while the autumn spawners appeared to be stable over the last three surveys. This is the first assessment that this time series has been used to calibrate the VPA, along with the index-fisherman catch rates.

Index-Fisherman Logbook Data

Abundance indices were estimated for both spring and autumn spawners from detailed logbooks of daily catch and effort compiled by index gillnet fishermen since 1984 (Annexes 3 and 4) and standardised using a multiplicative model (Gavaris 1980). The categorical variables for this model were year, month and fishing area, and were chosen to account for spatial and temporal variability (Annexes 5 and 6). Prior to these analyses, catches were proportionately allocated to spring and autumn spawners using the percent spawning-stock composition as determined from the commercial samples (Table 3a). Most of these fishermen set their nets in the vicinity of either the major spring-spawning sites in the St. George's Bay/Port-au-Port area (Figures 16 and 17) or the autumn-spawning areas north of Point Riche (Figure 18).

The standardised spring-spawner gillnet catch rates from index fishermen indicated a systematic decline since 1987 (Figure 19, Table 10). This catch-rate index increased slightly in 1991 and 1997, with the recruitment of the 1987 and 1990 year-classes to this fishery, although neither year-class was sufficiently abundant in the southern bays to reverse the declining trend. This index reached an historical low in 1998.

The autumn-spawning index-fisherman catch-rate series seemed to reflect the strong recruitment of the 1979 year-class in 1985, and the 1986 year-class in 1992, both well above the 10-year average (Figure 20, Table 10). The subsequent sharp decline of this index in 1993 and

1994 was unexpected given the low fishing effort on this stock. In addition, the recent recruitment of the 1988 and 1990 year-classes, which should have been apparent after 1994, has not been reflected in the index, which puts in doubt its usefulness as a measure of abundance. This index-fisherman catch-rate series has also become less reliable due to (1) a decrease in participation in the program (•3 logbooks annually since 1994, as compared to •4 previously) and (2) the decrease in availability to inshore gillnets as the herring have moved farther offshore. This index was therefore not used in the calibration of the autumn spawners sequential population analysis.

Questionnaires

Comments collected from written questionnaires sent to all licensed inshore herring fishermen in 4R as well as comments collected from index-fisherman logbooks indicated some improvement in the abundance of spring spawners around Port-au-Port Bay, St. George's Bay and Bay of Islands in 1996 relative to 1995 (McQuinn and Lefebvre 1997), although it was felt that spawning activity had not yet improved significantly. The 1990 spring-spawner year-class, which had been captured in the fall purse seine fishery since 1994, had started to spawn in these southern bays. However, comments were generally negative in 1997 and 1998 (Annexes 7 and 8), indicating that the improvement was short lived, and there was a widespread opinion that the herring was small (Figures 21 and 22). Index fishermen logbooks stated that herring were scarce, schools were small and catches were the lowest seen for many years (Annex 9).

North of Point Riche in 4Ra, the general opinion was that herring abundance was average to good in 1995 and 1996 especially in the summer and fall, although along the Labrador coast of the Strait of Belle Isle, comments indicated that the stock was in decline. Opinions were increasingly pessimistic in 1997 and 1998, although spawning was noted throughout St. John and St. Margaret Bays, around Ferolle Point (Figures 21 and 22). Fishermen noted that the herring showed a mixture of large and small sizes.

Sequential Population Analyses

The stock status assessments was based on sequential population analyses (SPA) which were calibrated age by age using the adaptive framework (ADAPT - Gavaris, 1988). The formulation involved estimating beginning-of-the-year population numbers (N) at ages 5 through 11+ in 1999 and the age-specific catchability coefficients (q) by predicting the index-fisherman gillnet catch rates at age (in numbers) and the acoustic survey population numbers at age, using the minimisation of the residual sums of squares in the natural log scale as the objective criteria. The spring-spawning stock analysis used the commercial catch at age, and abundance trends from both the index-fisherman catch rates (1984 to 1998) and the last 4 biennial acoustic surveys (1991 to 1997) as input data. For the autumn spawners, only the acoustic survey time series was used to calibrate the analysis. A summary of the formulations used in the calibrations is as follows:

Spring Spawners

Estimated parameters:

-	year-class estimates:	$N_{i,t}$ (i=5,6…11+; t=1999)
-	calibration coefficients:	$q(IF)_i$ (i=3,4…11+)
		$q(RV)_i$ (i=2,3…11+)
-	number of parameters:	26

IF = Index Fisherman catch rates
RV = Research Vessel (acoustic) survey

Model structure:
- M=0.2
- F for oldest age-group (11+) = F at age 10 (McQuinn, 1986).
- recruitment at age 2 in 1998, 1999 = average of medium recruitment level
- recruitment at age 2 in 1997 = average of low recruitment level
- no intercept term included

Input Data:
- catch at age: $C_{i,t}$ (i=2,3…11+; t=1965-98)
- index Fisherman catch rates at age: $IF_{i,t}$ (i=3,4…11+; t=1984-98)
- population estimates (N) from research vessel (acoustic) survey: $RV_{i,t}$ (i=3,4…11+; t=1991,1993,1995,1997)
- total number of observations(i, t): 166

Objective function:
- minimize $\Sigma_{i,t}$ $([(\ln IF_{i,t})-(\ln(q(IF)i\ N_{i,t}))]^2, [(\ln RV_{i,t})-(\ln(q(RV)i\ N_{i,t}))]^2)$

Autumn Spawners

Estimated parameters:
- year-class estimates: $N_{i,t}$ (i=4,5…11+; t=1998)
- calibration coefficients: $q(RV)_i$ (i=2,3…11+)
- number of parameters: 18

RV = Research Vessel (acoustic) survey

Model structure:
- M=0.2
- F for oldest age-group (11+) = F at age 10 (McQuinn, 1986).
- recruitment at age 2 in 1997 = average of medium recruitment
- no intercept term included

Input Data:
- catch at age: $C_{i,t}$ (i=2,3…11+; t=1965-97)
- pop. estimates (N) from research vessel (acoustic) survey: $RV_{i,t}$ (i=3,4…11+; t=1991,1993,1995,1997)
- total number of observations (i, t): 40

Objective function:
- minimize $\Sigma_{i,t}$ $[(\ln RV_{i,t})-(\ln(q(RV)i\ N_{i,t}))]^2$

Assessment Results

Spring Spawners

The spring-spawner ADAPT formulation estimated the population numbers and the age-specific catchability coefficients in 1999 for ages 5 through 11+ (bias corrected) and produced a mean square residual of 0.724. The coefficient of variation (relative error) ranged between 54 and

91% for the estimated numbers at age, and between 21 and 48% for the catchability coefficients (Annex 10). The majority of the values in the correlation matrix were below |0.2|, with a few values between –0.2 and –0.4, indicating that the parameter estimates were relatively independent (Annex 11). There were 6 of 126 (or 5%) of the IF standardised residuals, and 3 of 40 (7 %) of the RV residuals which were above |1.5| and only 1 within the last 3 years. Of these outliers, none involved important year-classes (Annex 12). There were no obvious signs of age-effects in the residuals, although there were some year-effects with the IF index. These diagnostics indicated that in general, the model fit was adequate, although the CV's were considered high (Anon, 1995). In addition, a comparison of the SPA results with the biomass estimates from the acoustic survey were very similar since 1992 (McQuinn and Lefebvre, 1999), lending support to these SPA results. The spring-spawner analysis did not suffer from a retrospective pattern (Figure 23).

This analysis suggested that the 5+ fishing mortality has risen more or less steadily on this stock since 1987 (Table 11). Although the average 5+ fishing mortality had remained around the $F_{0.1}$ target level of 0.3 in recent years, it rose sharply to 0.46 in 1998 (Figure 24), mainly due to the concentration of fishing on spring spawners in the southern bays in the spring of that year.

Apart from the 1990 year-class, recruitment has been below average since the 1987 year-class (Figure 25). Even the 1994 year-class, which was a significant portion of the 1998 catch at age, appears to be below average (Table 12). We have therefore not seen a renewal of the strong year-classes of the 1970s and 1980s (Figure 26) and the high population numbers of the early 1980s have not been sustained (Figure 27). The spawning-stock biomass (SSB) has therefore declined to an historical low of 14,000 t in 1999 (Figure 28; Table 13). If 20% of the virgin stock size is considered as the biological reference point for a stock in danger of collapse as suggested by the FFRC (pers. com.), that level would be around 38,000 t for this stock. This assumes that the virgin stock size is equal to the maximum observed SSB, which was 190,000 in 1973.

An examination of the production schedule of this stock in relation to fishing over the past 30 years (Figure 29) shows that losses through fishing have increased from an average of 4,000 t for the period 1965-1975 to 11,000 t between 1976-1986 and 1987-1997, while surplus production (recruitment + growth - natural mortality) decreased from 12,000 t between 1965-1975 and 1976-1986, to be in fact negative (-400 t) between 1987-1997 (Figure 30). We have therefore been through a 11-yr period of low productivity where annual surplus production has rarely been positive, and annual net production (surplus production - fishing mortality) has been consistently negative. This is principally due to reduced average recruitment in the last 10 years, brought about by either reduced survival of young herring with less favourable environmental conditions, reduced spawning due to increased fishing pressure on spawning concentrations and/or a possible increase in seal predation (although the consumption estimates are subject to large uncertainties). Regardless of the cause, the production of this stock (growth and recruitment) has not kept up with removals (catches and natural mortality) resulting in a declining spawning-stock biomass which is presently at a very low level.

It is obvious that the spring-spawning stock is in need of a strong recruitment pulse to reverse the steady decline in the mature biomass. Throughout the past 30 years, this stock has been supported by very large year-classes, up to 4 time the size of the standing stock which produced them, and which appear on roughly a 10-12 year cycle (Figure 29). Over 15 years have passed since the last large recruitment pulse (1980 and 1982 year-classes).

Autumn Spawners

Because of the uncertainties with the index-fisherman catch rate, only the acoustic survey

population estimates were used for the autumn-spawner SPA. As this index was last estimated in 1997 and is still a short time series, the autumn-spawning population was estimated only up to 1998 and was less certain than the spring-spawner analysis. The coefficient of variation (relative error) ranged between 60 and 148% for the estimated numbers at age, and between 30 and 42% for the catchability coefficients (Annex 13). This, along with the correlation matrix (Annex 14) and the mean square residual (0.350) indicated that the model fit was not very robust, although the standardised residuals showed few outliers and no year-effects. The acoustic time series was too short to conduct a retrospective analysis for this stock.

The SPA showed a very rapid decline of in autumn-spawner population numbers between 1965 and 1976 (Figure 31), the equivalent of 175,000 t in population biomass, even though the annual catches of autumn spawners averaged only 4,400 t during this period, indicating that the stock reduction was due to factors other than fishing in 4R (Table 14). This agrees with the conclusions of Moores (1983) who showed evidence that prior to 1973, there was a major migration of herring, and particularly autumn spawners, from the southern Gulf of St. Lawrence (4T) stocks into southern Division 4R. Therefore, the autumn-spawner SPA results will only be considered from 1973 onward, as suggested by Moores (1983).

The SPA indicated that the autumn-spawning stock has not experienced as high an exploitation rate in recent years as the spring-spawning component. The 6+ fishing mortality had risen slowly since 1985 but was still below the $F_{0.1}$ target of 0.3 in 1997 (Figure 32; Table 15). The spawning-stock biomass has nonetheless been declining slowly since 1984, and was estimated to be 42,000 t in 1998 (Figure 33; Table 16). The population estimates showed a well balanced age structure with an above-average 1994 year-class dominating the 1998 population (Figure 34). Recruitment has been above average since the large 1979 year-class which has kept this stock at an intermediate size (Figure 35).

The questionnaire responses also indicated that the situation with this spawning component north of Point Riche (the major spawning zone) is relatively good, although the percentage of responses indicating a positive outlook has diminished over the past few years.

The production schedule (Figure 36) shows that annual surplus production has been mainly positive since 1976. Comparing the first half of the time series (1973-1984) with the second half (1985-1996) shows that average annual losses due to fishing were relatively constant around 4,500-5,000 t in both periods, while average annual surplus production has declined from 3,000 to 1,600 t (Figure 37). The mature biomass has therefore declined by only 3,400 t annually between 1985-1996 (average annual net production), compared to 11,600 t for the spring spawners (1987-1997).

Outlook

A summary of the various stock status indicators have been tabulated with respect to their data quality (or knowledge status) and their inference about stock status, to produce an overall view or Report Card for each stock. Observations have been noted for each indicator, along with an interpretation, including the uncertainties associated with them. For the spring spawners, most of the indicators are either in the “Danger” or “Collapse” category (Annex 16). For the autumn spawners the majority of the indicators are in the “Pivotal” category, signifying that the stock cannot be considered healthy, but is not yet in danger of collapse (Annex 17).

Uncertainty about year-class abundance creates uncertainty in forecasted yields. This uncertainty is expressed as the risk of not achieving various reference targets. The primary

reference targets defined for these stocks are (a) B_{BUF}: the lowest observed historical spawning-stock biomass which produced good recruitment (b) B_{LIM}: 20 % of the maximum observed historical spawning-stock biomass, i.e. "virgin stock size" (Figures 38 and 39) and (a) F_{BUF}: the long term average $F_{0.1}$ of 0.3 (Figures 40 and 41). Catch projections were therefore estimated given various scenarios in relation to these reference points using risk projections (Gavaris, 1993). These uncertainty calculations do not include variations in catch at age, partial recruitment to the fishery, natural mortality or future recruitment. In particular, because the recruitment of age 2 fish in 1997, 1998, 1999 and 2000 is unknown, a level of recruitment must be assumed. Three levels of recruitment (poor, medium and good) were derived for the SPA and risk projections. These levels were defined as the geometric mean of the third poorest, the middle third and the third best recruiting year-classes observed at age 2 during the historical time series (Schweigert *et al.* 1998).

For the spring spawners, a medium recruitment was assumed for age 2 in 1998 and for the projections in 1999 and 2000. In addition, the ADAPT formulation was unable to estimate the recruitment at age 2 in 1997. Since this cohort was below average in the catch at age, the mean of the low recruitment level was assumed in the analysis. With these assumptions, a calculated $F_{0.1}$ yield for the spring-spawner stock in 1999 would be approximately 2,300 t (Figure 42). A *status quo* catch of 6,500 t in 1999 (the 1998 spring-spawner catch) would result in a 100% risk of a further decrease in the spawning-stock biomass. A catch of 2,300 t would result in a 40% risk that even a 20% increase in mature biomass would not be achieved by the year 2000 (from 14,000 t to 17,000 t). The minimum SSB target of 38,000 (B_{LIM}) cannot be achieved in 2000 even without fishing. A catch of 2,300 t therefore cannot be recommended if the primary objective is to rebuild this stock.

If however, the recruitment of the 1998-2000 year-classes is low, as has been observed since the 1990 year-class, the calculated $F_{0.1}$ yield in 1999 would be around 1,200 t, and would result in a 70% risk of the SSB not increasing by even 10% (Figure 43). This projection illustrates the sensitivity of the projection calculations to the recruitment assumption, and the need to be prudent when determining the TAC in 1999.

A medium recruitment was assumed for the autumn spawners at age 2 in 1997 and for the projections in 1998, 1999 and 2000. A calculated $F_{0.1}$ yield in 1999 for the autumn-spawning stock would be approximately 9,000 t (close to the 1998 autumn-spawner catch), although the flatness of the probability curve indicates that there is much uncertainty around this value (Figure 44). With this catch, there is a 90% risk that the spawning-stock biomass will decrease by at least 10%, but only about a 25% probability that the SSB will decline below 32,000 t (B_{BUF}). Additional uncertainty arises because these projections are two years into the future (from 1998 to 2000) and because medium recruitment at age 2 is assumed for 1997 through to 2000.

The autumn-spawning stock has historically received less fishing effort and has constituted less of the total catch (<28%) than the spring spawners because it is distributed more in the northern areas farther from the principal landing ports. This has resulted in a wider age distribution in this stock, with the 1990 year-class appearing as strong and the 1994 year-class as above average. Although the autumn-spawners are at an intermediate stock size, the mature biomass is declining slowly due to reduced production in the past decade.

Management Considerations

The 4R herring stocks can not support the present TAC of 22,000 t, nor recent total catches (between 12,000 and 16,000 t), and fishing will therefore have to be reduced to a

sustainable level. Precautionary principles suggest that this would be no more that 9,000 t for the autumn-spawners and that no directed fishery be prosecuted on concentrations of spring spawners. It is recommended that a harvest limit be imposed for the southern half of 4R. To avoid a repetition of intensive fishing on any other component, either spring- or autumn-spawning, it is recommended that fishing effort be reduced and spread-out along the remainder of the coast and throughout the year as much as possible. The continuation and enhancement of the index-fisherman program in St. George's Bay and Port-au-Port Bay is essential for the close monitoring of spawning activity in this area and as a spring-spawner abundance index.

The present assessment indicates that in general, fishing mortality on these stocks has been increasing over the past 12-15 years and had been around $F_{0.1}$ for the spring spawners between 1991 and 1997 (Figure 40). The closure of St. George's Bay and Port-au-Port Bay in 1995 had the desired effect of slowing the decline of this stock by concentrating fishing on the autumn spawners, of decreasing the quantity of spring spawners in the total catch and of allowing these fish to spawn undisturbed. However, the present analyses show that the resumption of fishing in these southern bays in 1998 was premature, and that the concentrated harvesting of spring spawners in the spring fishery resulted in a sharp increase in fishing mortality, well above $F_{0.1}$ (Figure 40). This is in agreement with comments received from fishermen as well as the index-fisherman catch rates which suggest that the stock has continued to decline since 1997 and has now reached an historical low. It is projected that the 1994 year-class will not be sufficient to bolster the spring-spawning stock.

The present analyses indicate that the spring-spawning stock has declined to a point where fishing must be curtailed to avoid a collapse. This dangerous reduction in the SSB has occurred even though the average fishing mortality has been around the $F_{0.1}$ target of 0.3 since 1991. The autumn-spawning stock has been declining gradually while the exploitation rate has been increasing since the mid-1980's (Figure 41). These divergent trends have occurred in the autumn spawning stock despite above-average recruitment over the past 15 years and a fishing mortality well below the $F_{0.1}$ target. This suggests that the target exploitation rate may be too high for these stocks and should be re-evaluated.

As a general guideline, over the past 30 years, the annual surplus production for the spring spawners has averaged 7,700 t (Figure 30), which approximates the long-term sustainable harvest for this stock. In contrast, the actual average annual harvest has been 8,700 t, which is 1,000 t above the sustainable level. However, because of the overwhelming influence of incoming year-classes on surplus production, there are large inter-annual and inter-decadal variations in production (Figure 29). Comparing the production over the past decade (1987-1997) with the previous decade (1976-1986), it is clear that surplus production was above average (12,000 t) between 1976 and 1986 mainly due to the recruitment of the 1980 and 1982 year-classes, and well below average - in fact negative - since 1987. In the mean time, the catch biomass remained relatively stable at 11,000 t over these two decades (Figure 30), but well above the long-term sustainable level of 7,700 t (annual surplus production).

The autumn-spawner long-term annual sustainable harvest, estimated in the same fashion as for the spring spawners although using data from 1973 to 1996 (see section Assessment Results - autumn spawners), appears to be in the order of 2,300 t, while the annual harvest of autumn spawners has been closer to 4,700 t over the past two decades (Figure 37). As with the spring spawners, the periodic appearance of large year-classes is mostly responsible for maintaining a positive average annual surplus production (Figure 36), and most of that can be accounted for by the strong 1979 (50,000 t) and 1990 (22,000 t) year-classes. This leaves these stocks in a very precarious position when the production frequency of these strong year-classes is

reduced, as has been the case in the past decade.

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Table 1. Herring catches (t) by gear type and fishing area and total allowable catches from NAFO Division 4R from 1965 to 1998.

YEAR	4Rd					4Rc					4Rb					4Ra					COMBINED					TAC
	Purse seine >65'	Purse seine <65'	Gill net	Other gears*	Total	Purse seine >65'	Purse seine <65'	Gill net	Other gears*	Total	Purse seine >65'	Purse seine <65'	Gill net	Other gears*	Total	Purse seine >65'	Purse seine <65'	Gill net	Other gears*	Total	Purse seine >65'	Purse seine <65'	Gill net	Other gears*	Total	
1965	0		0	0	0	0		0	0	0	3125		0	0	3125	0		0	0	0	3125		0	0	3125	
1966	0		216	0	216	0		103	0	103	5491		39	0	5530	0		45	0	45	5491		403	0	5894	
1967	0		215	0	215	0		66	0	66	5464		76	0	5540	0		40	0	40	5464		397	0	5861	
1968	0		156	789	945	0		59	0	59	3776		67	136	3979	0		11	0	11	3776		293	925	4994	
1969	241		36	6	283	0		46	0	46	2344		201	4	2549	0		68	1	69	2585		351	11	2947	
1970	28		51	3	82	12		15	17	44	2939		534	4	3477	0		407	92	499	2979		1007	116	4102	
1971	3287		543	427	4257	2239		185	24	2448	725		338	21	1084	356		1598	11	1965	6607		2664	483	9754	
1972	4743		178	866	5787	727		135	64	926	1330		214	0	1544	0		3628	146	3774	6800		4155	1076	12031	
1973	12112		429	0	12541	2740		122	0	2862	1763		305	2	2070	3453		5760	15	9228	20068		6616	17	26701	
1974	2465		159	0	2624	756		101	4	861	439		479	47	965	1071		1972	5	3048	4731		2711	56	7498	
1975	3221		116	3	3340	0		112	16	128	0		240	26	266	0		1764	22	1786	3221		2232	67	5520	
1976	6067		499	3	6569	1956		111	2	2069	0		226	20	246	184		2143	140	2467	8207		2979	165	11351	
1977	5289		272	7	5568	2009		193	3	2205	0		158	31	189	2155		2028	183	4366	9453		2651	224	12328	12000
1978	6252		522	33	6807	1037		931	16	1984	0		288	81	369	1834		3795	22	5651	9123		5536	152	14811	12500
1979	4387		1642	3	6032	2774		2267	2	5043	2829		1048	121	3998	0		3258	7	3265	9990		8215	133	18338	12500
1980	3499		1558	41	5098	3703		3224	17	6944	2002		879	88	2969	428		3810	5	4243	9632		9471	151	19254	18000
1981	2269		1368	2	3639	3277		1622	0	4899	2037		913	140	3090	342		1600	27	1969	7925		5503	169	13597	16000
1982	0		1463	3	1466	5575		1572	11	7158	3973		519	58	4550	0		1695	1	1696	9548		5249	73	14870 [2]	10000
1983	0		1410	2	1412	3269		873	46	4188	3223		226	108	3557	787		1438	34	2259	7279		3947	190	11416 [2]	10000
1984	0		1006	1	1007	3023		902	0	3925	4166		554	2	4722	15		790	4	809	7206		3252	7	10465 [2]	10000
1985	1720		398	0	2118	1733		164	0	1897	9718		348	4	10070	0		295	6	301	13171		1205	10	14386 [2]	10000
1986	1854		273	0	2127	1586		1069	0	2655	15830		468	0	16298	0		337	0	337	19270		2147	0	21417 [2]	17000
1987	222		550	0	772	3183		1137	0	4320	10164		327	5	10496	164		829	0	993	13733		2843	5	16581	30600
1988	2019		435	0	2454	13197		592	0	13789	1093		256	0	1349	44		509	0	553	16353		1792	0	18145	30600
1989	9111		177	0	9288	6589		444	0	7033	947		69	0	1016	13		337	0	350	16660		1027	0	17687	37000
1990	5050		152	0	5202	7247		187	0	7434	4004		174	13	4191	0		323	134	457	16301		836	147	17284	35000
1991	16287		133	0	16420	2318		175	0	2493	6838		103	7	6948	151		368	57	576	25594		779	63	26437	35000
1992	6191	2677	27	1	8895	1077	276	38	0	1391	3009	1090	47	1	4147	0	347	440	115	902	10277	4390	552	117	15336	35000
1993	8310	2845	55	1	11210	740	276	9	5	1030	1899	299	20	0	2218	362	332	55	103	852	11309	3752	139	108	15308	35000
1994	1472	1010	117	0	2599	2026	951	75	0	3053	4063	1487	161	0	5711	72	406	394	145	1017	7634	3854	747	146	12380	35000
1995	2755	201	163	14	3133	5457	1680	179	5	7321	2138	930	101	104	3273	464	580	1215	24	2283	10814	3392	1658	148	16012	22000
1996	600	450	65	0	1115	6751	1332	84	6	8173	1896	886	143	27	2952	226	404	1883	71	2584	9473	3072	2175	104	14824	22000
1997	1322	296	19	0	1637	4237	1042	11	10	5300	2192	1098	7	154	3451	0	617	1765	190	2572	7751	3053	1802	354	12960	22000
1998	349	160			509	4062	1925			5987	4498	1272			5770	559	492			1051	9468	3849	2803 [3]	0	16123 [1]	22000

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

[1] Preliminary

[2] Purse seine landings adjusted according to industry records.

[3] Gillnets landings not available by unit area.

Table 2a. Herring landings (t) by large purse seiners (>65') in NAFO division 4R by unit area and month from 1990 to 1998.

YEAR	AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1990	4Ra													
	4Rb										641	2266	1097	4004
	4Rc					6398	394	358	27	17		53		7247
	4Rd				6	4751	281					12		5050
	Total				6	11149	675	358	27	17	641	2331	1097	16301
1991	4Ra							77	62	13				151
	4Rb						78	139	18	61	502	4407	1634	6838
	4Rc					718	61	234		121	143	205	837	2318
	4Rd				6700	8283	236						1069	16287
	Total				6700	9001	374	449	79	194	645	4612	3540	25594
1992	4Ra													
	4Rb										87	2922		3009
	4Rc					8	532				46	492		1077
	4Rd					5882	185				2	122		6191
	Total					5890	717				135	3536		10277
1993	4Ra											362		362
	4Rb									1	780	1118		1899
	4Rc									1	700	39		740
	4Rd				1206	7070						34		8310
	Total				1206	7070				2	1480	1553		11311
1994	4Ra											72		72
	4Rb								640	1031	679	1714		4063
	4Rc					140	153	15	398	391	930			2026
	4Rd					817	31			13	612			1472
	Total					957	184	15	1037	1434	2220	1786		7634
1995	4Ra											464		464
	4Rb									333	328	297	1181	2138
	4Rc					570	2445			514	1169	321	439	5457
	4Rd					1693	69			181	736	77		2755
	Total					2263	2513			1028	2233	1160	1619	10815
1996	4Ra								226					226
	4Rb									253	193	1449		1896
	4Rc					323	546			278	1897	1829	1878	6751
	4Rd						27			75	129	368		600
	Total					323	574	0	226	606	2219	3646	1878	9472
1997	4Ra													
	4Rb									1610	233	350		2193
	4Rc						1356		169	202	2028	483		4238
	4Rd					743				578				1321
	Total					743	1356		169	2390	2261	833		7752
1998	4Ra							88	471					559
	4Rb								736	641	1841	1280		4498
	4Rc					1668	645	50	79	428	428	763		4061
	4Rd					350								350
	Total					2018	645	138	1287	1069	2269	2043		9469

Table 2b. Herring landings (t) by small purse seiners (< 65') in NAFO division 4R by unit area and month from 1992 to 1998.

YEAR	AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1992	4Ra						86	259	2					347
	4Rb						18					1072		1090
	4Rc					15	191			19	11	40		276
	4Rd					2480	79					118	1	2677
	Total					2495	374	259	2	19	11	1230	1	4390
1993	4Ra					11	127	78	51	4		61		332
	4Rb		15						57	61	44	123		299
	4Rc				2	143	29		9	1	63	28		276
	4Rd				131	2239					78	396		2845
	Total		15		133	2393	156	78	117	66	185	608		3752
1994	4Ra						87	18	13	20		267		406
	4Rb							49	123	941	258	116		1487
	4Rc					159	320	2	73	110	225	62		951
	4Rd					597	51				362			1010
	Total					756	459	69	209	1071	845	445		3854
1995	4Ra							74	46	8	21	383	48	580
	4Rb						391	1	38	308	147	45		930
	4Rc					126	317	44	428	406	263	4	94	1680
	4Rd						18				184			201
	Total					126	726	119	513	722	614	431	141	3392
1996	4Ra						170	13		21	183	17		404
	4Rb					3	263	2		103	380	91	45	886
	4Rc					241	62			243	574	101	111	1332
	4Rd										411	39		450
	Total					244	495	15		367	1548	248	156	3072
1997	4Ra						83	20	408		97	8		616
	4Rb									850	248			1098
	4Rc						250		32	247	496	17		1042
	4Rd					114	31			102	50			297
	Total					114	364	20	440	1199	890	25		3053
1998	4Ra					69	118		221	14	15	55		492
	4Rb					3	123		145	363	339	299		1272
	4Rc					381	64		8	676	690	105		1924
	4Rd					53						107		160
	Total					506	305		375	1053	1043	566		3848

Table 2c. Herring landings (t) by gillnets in NAFO division 4R by unit area and month from 1990 to 1998.

YEAR	AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1990	4Ra					4	9	3	13	49	28	216		323
	4Rb				10	13	20	9	3	1	1	117		174
	4Rc					42	89	46	3	2	5			187
	4Rd				1	34	66	40	9	2	1			152
	Total				11	93	184	98	28	54	35	333		836
1991	4Ra					6	49	178	43	24	24	45		368
	4Rb					13	27	2		1	12	47		103
	4Rc						104	40	6	16	9			175
	4Rd				30	40	23	10	12	12	6	4		133
	Total				30	58	203	230	59	53	51	96		779
1992	4Ra					9	15	179	34	11	108	84		440
	4Rb			2	3	15	20	1			3	3		47
	4Rc					22	2	2	6	1	2	3		38
	4Rd					15	3	1	5	1	1	2	1	27
	Total			2	3	61	39	183	45	13	115	91	1	552
1993	4Ra						5	47	1	1				55
	4Rb						10	2	1		4	4		20
	4Rc					2		1	1	3	3			9
	4Rd				6	38	1	1	2	2	5	1		55
	Total				6	40	16	51	5	5	11	5		139
1994	4Ra							232	51	107	5			394
	4Rb						3	5		116	26	10		161
	4Rc					21	42	7	2	4				75
	4Rd					34	59	16	3	6				117
	Total					55	104	260	56	233	31	10		747
1995	4Ra					1	10	537	359	116	41	129	23	1215
	4Rb				3	4	6	21	9	6	21	10	21	101
	4Rc			1	2	46	69	9	24	20	4	3		179
	4Rd					62	61	11	7	21	1			163
	Total			1	5	113	146	578	399	163	67	142	44	1658
1996	4Ra						253	275	123	440	745	48		1883
	4Rb					2	3	9		106	24			143
	4Rc					37	14		1	17	16			84
	4Rd						1			58	7			65
	Total					39	269	284	124	620	791	48		2175
1997	4Ra						273	220	273	697	245	57		1765
	4Rb									3	4			7
	4Rc						2			9				11
	4Rd					1	13	1	1	4				20
	Total					1	288	221	273	712	250	57		1802
1998*	Total						465	104	355	1277	580	22		2803

* data by unit area not available

Table 3a. Proportion (%) of spring-spawning herring in the gillnet catch by month and fishing area. NAFO division 4R from 1975 to 1998.

SPAWNING	FISHING AREA																								
GROUP	4Rd			4Rc						4Rb								4Ra							
SPRING	APR	MAY	JUN	APR	MAY	JUN	JUL	SEP	OCT	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1975		90.0								55.3	12.0														
1976		100.0								98.0									5.3				76.7		
1977										83.3	18.0					86.0		66.0	32.2	8.0	25.7	56.6	78.0		
1978		99.0							85.7	98.0								52.0	33.6				78.9		
1979	84.0			92.8					95.0						84.0				38.7	11.7	44.0	56.0			
1980	96.4			91.1					100.0						81.8		63.3	55.6	34.1	3.0	42.9	72.0	66.0		
1981				95.8					82.4	91.0								37.0	24.9	0.7			43.8		
1982					97.2										64.9				2.7						
1983		95.7										80.0		46.1	41.8				39.6	1.4	46.3	56.9	56.3	68.2	
1984		94.1			78.5			84.0						60.2		44.9				8.6	27.9	63.0	36.0	52.7	
1985		97.7			86.5	90.0													80.0	9.5	15.7		28.0		
1986	84.4	98.4		50.0	83.7			66.0	80.0							54.4				16.8	10.1	32.0	44.1	27.1	
1987	92.0	99.4		52.0	84.7	88.6								52.2						14.2	26.0	49.5	37.5		
1988	98.0	99.6	96.0	73.5	78.3	81.4	76.0							68.1				28.0	11.8	27.0	41.3	52.8	42.0		
1989		99.0	91.1	86.0	85.3	79.6									71.0	56.7				22.3	11.6	23.3	44.0	40.0	
1990		96.9	99.3		92.0	88.5	34.5									44.0				15.5	17.8	10.8	18.0	32.5	
1991		95.9	96.0		88.8	59.2								32.0	44.0	70.0				4.5	27.0	38.1	50.0	43.4	
1992		93.2	76.0		74.8	70.4	52.0												26.0	10.0	8.3	1.0	10.2		
1993		98.0			78.7	89.0													86.0	4.0	4.0	1.7			
1994		97.5	99.3		94.0	88.8	2.0													7.5	1.5	11.6			
1995		95.1	90.0		91.2	83.0	67.3					48.0							72.0	11.6	2.7	9.1	42.0	45.3	34.0
1996	97.0	97.7	95.9		94.2	88.4					68.0		0.0	3.0	32.0				46.0	2.0	1.8	1.9	23.5	30.0	
1997	100.0	97.2	98.7		99.0	98.8														2.0	1.5	4.0	16.8		
1998	100.0	99.4			99.4	100.0									38.0				99.0	22.0	0.4	4.9			

Table 3b. Proportion (%) of spring-spawning herring in the large purse seine (>65') catch by month and fishing area, NAFO Division 4R from 1975 to 1998.

YEAR	FISHING AREA																	
	4Rd						4Rc											
	APR	MAY	JUNE	SEPT	OCT	NOV	JAN	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC		
1975	98.0	84.7																
1976	90.4	97.8							52.3									
1977	95.4	99.0							32.4									
1978	82.4							81.9										
1979	86.2							43.2	26.0									
1980	95.2						98.0	98.0									73.4	
1981	96.4	92.0						97.3										
1982								99.8	98.0				65.0					
1983								61.0	54.5					73.8				
1984							76.4	43.9										
1985		92.0							66.0	49.7				82.6				
1986	77.0	100.0							93.6		78.0							
1987		97.0						100.0	93.0	100.0			65.3	84.7				
1988	83.6	99.5							34.0	100.0								
1989	91.3								34.0				79.5	66.9				
1990		89.8									78.0			88.0				
1991		71.6									72.0		48.0	66.0		80.0		
1992		94.7		72.7				100.0	100.0			28.6		68.2				
1993	90.0	85.0												67.8				
1994		94.5			40.5				93.9	94.5		29.3	54.2	47.4	48.0			
1995		44.0		52.0	48.7				98.0	99.3		48.7	59.0	64.0	76.0	33.0		
1996					68.0	72.0			100.0	98.8			58.1		50.0	37.2		
1997		97.5		48.0						98.5		34.0	4.0	48.7	47.0			
1998		100.0							100.0	100.0								

	4Rb								4Ra						
	APR	MAY	JUN	AUG	SEP	OCT	NOV	DEC	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1975															
1976															87.7
1977													47.3	89.3	
1978														85.8	84.4
1979							93.3							91.6	86.7
1980							88.2								
1981						87.3	63.5	55.7							
1982						78.8	77.7								
1983							79.8	68.9						74.7	62.7
1984	40.9					76.9	64.5	60.5						62.0	
1985				23.8		71.0	70.0	67.7							
1986						77.3	74.8	71.0							
1987				0.0		74.5	76.9	72.1						28.0	
1988	37.5				62.0	41.3	65.8	72.1		28.0	2.0				
1989						68.5	70.1	70.1							
1990						74.0	55.3	66.0							
1991						56.3	65.3	63.4							
1992			47.7			32.0	49.9								
1993		74.0				72.7	56.6					0.0		22.0	
1994				13.3	36.4	33.2	51.3							39.0	
1995			98.0		2.0	57.6	39.0	36.0						33.3	34.0
1996					18.0		40.0		99.0		0.0		35.0		
1997					2.0	26.0	46.0								
1998							44.0				0.0				

Table 3c. Proportion (%) of spring-spawning herring in the small purse seine (<65') catch by month and fishing area, NAFO Division 4R from 1992 to 1998.

YEAR	FISHING AREA																	
	4Rd						4Rc											
	APR	MAY	SEPT	OCT	NOV	DEC	JAN	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC		
1992					78.0					100.0			28.6					
1993	90.0	98.4																
1994		100.0		43.4					93.9	99.0			39.6	58.0	48.0			
1995				48.0						100.0		48.7	69.0	58.0				
1996									100.0				58.1					
1997																		
1998						46.0									52.0			

	4Rb								4Ra						
	APR	MAY	JUN	AUG	SEP	OCT	NOV	DEC	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1992		100.0												36.0	
1993												0.0		16.0	
1994				10.0	32.0	34.0								39.0	
1995			98.0											39.0	34.0
1996									99.0				35.0		
1997					19.0						0.0		22.0	22.0	
1998						21.0	42.0		98.0		0.0				

Table 4a. Spring-spawner catch at age ($x10^3$) in NAFO division 4R herring landings from 1965 to 1998 (all gears).

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
2	630	115	0	84	366	1067	0	284	1833	141	57	484	10	0	167	300	40
3	73	283	18	163	1730	570	2527	220	435	261	996	680	534	47	25	854	417
4	13	276	459	302	2778	297	303	8189	1063	130	420	846	541	1987	214	106	2114
5	693	520	139	549	1026	435	841	1308	27872	371	100	201	409	207	10828	355	129
6	1602	1822	318	203	500	182	720	1461	2570	9445	1063	350	304	679	617	13872	354
7	1293	4176	3403	569	264	75	651	1245	3222	318	8431	2802	348	241	1075	407	8872
8	651	2090	2745	1120	703	116	340	1115	3232	851	317	15567	4362	2162	547	1344	188
9	461	1652	1265	2049	1259	565	350	1377	2598	774	336	759	15959	8208	2772	247	515
10	305	382	742	420	1185	1615	2412	1034	4789	490	244	3136	1694	15260	7404	1427	283
11+	509	638	847	358	117	61	255	2013	5696	2175	665	3588	6003	5062	14032	20574	13181
2+	6230	11953	9936	5818	9928	4983	8400	18247	53310	14955	12629	28413	30165	33851	37681	39486	26093

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
2	594	34	198	362	323	455	702	305	114	577	90	79	14	12	1347	36	78
3	2374	2965	433	4587	2348	329	539	574	2136	2233	1243	1592	332	247	248	1006	825
4	693	3562	7773	787	13762	2781	402	763	670	9849	1707	3802	2597	1219	1156	131	7489
5	2452	1131	3809	21642	3349	15257	2461	461	405	1285	8538	3409	3183	5750	4056	259	363
6	421	1091	595	3993	28781	3507	15064	3036	997	768	998	6784	3762	5807	7712	1303	554
7	2153	293	814	445	5241	12952	3677	18704	5010	3018	998	1509	3434	2152	4211	6598	2091
8	6488	713	209	381	465	1736	13616	3072	16296	6955	2781	2102	1642	7126	551	1684	7289
9	704	2990	672	255	167	182	2527	10910	3773	21327	2168	2727	1589	185	3291	580	1010
10	950	798	755	380	260	37	423	779	6432	2366	11879	2800	1757	3083	419	2554	937
11+	12863	7975	4226	1764	1661	806	2060	1380	2187	6579	3902	8804	1945	4577	1597	1588	3024
2+	29692	21552	19485	34597	56356	38041	41472	39984	38019	54957	34306	33608	20254	30158	24587	15740	23660

Table 4b. Autumn-spawner catch at age ($x10^3$) in NAFO division 4R herring landings from 1965 to 1998 (all gears).

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
2	17	44	0	0	34	0	40	10	0	0	0	0	0	0	0	15	0
3	655	76	112	170	299	466	0	96	1798	20	19	48	3	10	7	181	33
4	476	682	181	108	711	187	112	115	1180	393	40	272	169	27	116	136	524
5	235	318	790	209	364	33	440	1310	1114	530	865	290	134	545	345	86	245
6	271	348	369	935	876	51	638	1345	2626	325	925	422	404	393	2689	176	90
7	303	232	124	223	736	251	2150	2852	1527	592	107	561	721	1108	520	1729	295
8	1010	1181	433	174	200	90	3485	2165	2631	258	157	325	405	1689	1287	250	1234
9	653	931	934	284	142	71	2071	3577	3830	308	147	253	342	503	1847	675	153
10	355	845	1011	998	214	89	1073	2173	8265	313	218	88	293	341	468	308	124
11+	722	2517	3108	1913	1859	1688	14138	28342	17653	5610	3371	4818	6646	6051	6286	5243	3369
2+	4697	7174	7061	5013	5436	2925	24147	41985	40624	8349	5849	7077	9117	10667	13565	8799	6067

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
2	101	15	0	15	35	0	484	43	27	73	0	21	0	65	0	0	0
3	567	83	55	235	426	156	207	599	530	832	337	210	61	91	1969	593	566
4	1824	2330	668	1340	1431	487	511	539	1568	1278	1446	672	994	1419	1358	1726	4529
5	956	1356	6259	1907	2671	1354	481	923	424	5763	1448	1957	2777	6159	2531	877	8267
6	509	1309	1147	9678	2292	2009	1240	807	306	674	1236	1015	4032	3512	8573	1086	2500
7	140	506	908	902	8421	1728	1740	749	429	1501	775	1661	3104	3905	2304	7649	1712
8	377	159	220	622	794	5927	1667	828	384	919	543	558	2435	1211	3927	2193	11093
9	972	467	146	115	384	474	4165	961	839	649	779	911	1630	3189	828	4949	997
10	315	618	268	36	66	163	705	2873	481	2144	390	877	1179	411	1968	562	3387
11+	2609	2824	3091	468	227	196	777	983	4718	7124	3928	4608	3999	4246	3130	4200	3470
2+	8370	9667	12762	15318	16747	12494	11977	9305	9705	20955	10883	12491	20211	24208	26588	23834	36521

Table 4c. Proportion of spring-spawners in NAFO division 4R herring landings from 1965 to 1998 (all gears) and total no. of fish (spring + autumn spawners).

YEAR	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
TOTAL	10927	19127	16997	10831	15364	7909	32547	60231	93934	23304	18478	35490	39282	44518	51246	48285	32160
% SS	57.0	62.5	58.5	53.7	64.6	63.0	25.8	30.3	56.8	64.2	68.3	80.1	76.8	76.0	73.5	81.8	81.1

YEAR	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
TOTAL	38062	31219	32247	49915	73103	50535	53449	49289	47724	75912	45189	46099	40465	54366	51174	39575	60181
% SS	78.0	69.0	60.4	69.3	77.1	75.3	77.6	81.1	79.7	72.4	75.9	72.9	50.1	55.5	48.0	39.8	39.3

Table 5a. Age composition (%) and mean age* of spring-spawners in NAFO division 4R herring landings from 1965 to 1998 (dominant year-classes have been underlined).

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
2	10.1	1.0	0.0	1.5	3.7	21.4	0.0	1.6	3.4	0.9	0.5	1.7	0.0	0.0	0.4	0.8	0.2
3	1.2	2.4	0.2	2.8	17.4	11.4	30.1	1.2	0.8	1.7	7.9	2.4	1.8	0.1	0.1	2.2	1.6
4	0.2	2.3	4.6	5.2	28.0	6.0	3.6	44.9	2.0	0.9	3.3	3.0	1.8	5.9	0.6	0.3	8.1
5	11.1	4.4	1.4	9.4	10.3	8.7	10.0	7.2	52.3	2.5	0.8	0.7	1.4	0.6	28.7	0.9	0.5
6	25.7	15.2	3.2	3.5	5.0	3.7	8.6	8.0	4.8	63.2	8.4	1.2	1.0	2.0	1.6	35.1	1.4
7	20.8	34.9	34.2	9.8	2.7	1.5	7.8	6.8	6.0	2.1	66.8	9.9	1.2	0.7	2.9	1.0	34.0
8	10.4	17.5	27.6	19.2	7.1	2.3	4.0	6.1	6.1	5.7	2.5	54.8	14.5	6.4	1.5	3.4	0.7
9	7.4	13.8	12.7	35.2	12.7	11.3	4.2	7.5	4.9	5.2	2.7	2.7	52.9	24.2	7.4	0.6	2.0
10	4.9	3.2	7.5	7.2	11.9	32.4	28.7	5.7	9.0	3.3	1.9	11.0	5.6	45.1	19.6	3.6	1.1
11+	8.2	5.3	8.5	6.2	1.2	1.2	3.0	11.0	10.7	14.5	5.3	12.6	19.9	15.0	37.2	52.1	50.5
mean age*	6.7	7.3	7.9	7.8	5.8	6.4	6.5	6.1	6.5	7.0	6.8	8.1	9.0	9.3	8.6	8.7	8.8

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
2	2.0	0.2	1.0	1.0	0.6	1.2	1.7	0.8	0.3	1.0	0.3	0.2	0.1	0.0	5.5	0.2	0.3
3	8.0	13.8	2.2	13.3	4.2	0.9	1.3	1.4	5.6	4.1	3.6	4.7	1.6	0.8	1.0	6.4	3.5
4	2.3	16.5	39.9	2.3	24.4	7.3	1.0	1.9	1.8	17.9	5.0	11.3	12.8	4.0	4.7	0.8	31.7
5	8.3	5.2	19.5	62.6	5.9	40.1	5.9	1.2	1.1	2.3	24.9	10.1	15.7	19.1	16.5	1.6	1.5
6	1.4	5.1	3.1	11.5	51.1	9.2	36.3	7.6	2.6	1.4	2.9	20.2	18.6	19.3	31.4	8.3	2.3
7	7.3	1.4	4.2	1.3	9.3	34.0	8.9	46.8	13.2	5.5	2.9	4.5	17.0	7.1	17.1	41.9	8.8
8	21.9	3.3	1.1	1.1	0.8	4.6	32.8	7.7	42.9	12.7	8.1	6.3	8.1	23.6	2.2	10.7	30.8
9	2.4	13.9	3.5	0.7	0.3	0.5	6.1	27.3	9.9	38.8	6.3	8.1	7.8	0.6	13.4	3.7	4.3
10	3.2	3.7	3.9	1.1	0.5	0.1	1.0	1.9	16.9	4.3	34.6	8.3	8.7	10.2	1.7	16.2	4.0
11+	43.3	37.0	21.7	5.1	2.9	2.1	5.0	3.5	5.8	12.0	11.4	26.2	9.6	15.2	6.5	10.1	12.8
mean age*	8.4	7.7	6.3	5.2	5.6	5.9	7.0	7.6	8.0	7.7	7.9	7.6	6.9	7.4	6.5	7.7	6.9

*assuming ages 11+ to be 11

Table 5b. Age composition (%) and mean age* of autumn-spawners in NAFO division 4R herring landings from 1965 to 1998 (dominant year-classes have been underlined).

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
2	0.4	0.6	0.0	0.0	0.6	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
3	14.0	1.1	1.6	3.4	5.5	15.9	0.0	0.2	4.4	0.2	0.3	0.7	0.0	0.1	0.1	2.1	0.5
4	10.1	9.5	2.6	2.2	13.1	6.4	0.5	0.3	2.9	4.7	0.7	3.8	1.9	0.3	0.9	1.5	8.6
5	5.0	4.4	11.2	4.2	6.7	1.1	1.8	3.1	2.7	6.3	14.8	4.1	1.5	5.1	2.5	1.0	4.0
6	5.8	4.8	5.2	18.6	16.1	1.8	2.6	3.2	6.5	3.9	15.8	6.0	4.4	3.7	19.8	2.0	1.5
7	6.4	3.2	1.7	4.4	13.5	8.6	8.9	6.8	3.8	7.1	1.8	7.9	7.9	10.4	3.8	19.6	4.9
8	21.5	16.5	6.1	3.5	3.7	3.1	14.4	5.2	6.5	3.1	2.7	4.6	4.4	15.8	9.5	2.8	20.3
9	13.9	13.0	13.2	5.7	2.6	2.4	8.6	8.5	9.4	3.7	2.5	3.6	3.8	4.7	13.6	7.7	2.5
10	7.6	11.8	14.3	19.9	3.9	3.0	4.4	5.2	20.3	3.7	3.7	1.2	3.2	3.2	3.5	3.5	2.0
11+	15.4	35.1	44.0	38.2	34.2	57.7	58.5	67.5	43.5	67.2	57.6	68.1	72.9	56.7	46.3	59.6	55.5
mean age*	7.3	8.7	9.1	8.8	7.6	8.6	9.7	10.0	9.2	9.6	9.0	9.6	10.0	9.5	9.0	9.5	9.2

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
2	1.2	0.2	0.0	0.1	0.2	0.0	4.0	0.5	0.3	0.3	0.0	0.2	0.0	0.3	0.0	0.0	0.0
3	6.8	0.9	0.4	1.5	2.5	1.2	1.7	6.4	5.5	4.0	3.1	1.7	0.3	0.4	7.4	2.5	1.6
4	21.8	24.1	5.2	8.7	8.5	3.9	4.3	5.8	16.2	6.1	13.3	5.4	4.9	5.9	5.1	7.2	12.4
5	11.4	14.0	49.0	12.4	15.9	10.8	4.0	9.9	4.4	27.5	13.3	15.7	13.7	25.4	9.5	3.7	22.6
6	6.1	13.5	9.0	63.2	13.7	16.1	10.4	8.7	3.2	3.2	11.4	8.1	20.0	14.5	32.2	4.6	6.8
7	1.7	5.2	7.1	5.9	50.3	13.8	14.5	8.0	4.4	7.2	7.1	13.3	15.4	16.1	8.7	32.1	4.7
8	4.5	1.6	1.7	4.1	4.7	47.4	13.9	8.9	4.0	4.4	5.0	4.5	12.0	5.0	14.8	9.2	30.4
9	11.6	4.8	1.1	0.8	2.3	3.8	34.8	10.3	8.6	3.1	7.2	7.3	8.1	13.2	3.1	20.8	2.7
10	3.8	6.4	2.1	0.2	0.4	1.3	5.9	30.9	5.0	10.2	3.6	7.0	5.8	1.7	7.4	2.4	9.3
11+	31.2	29.2	24.2	3.1	1.4	1.6	6.5	10.6	48.6	34.0	36.1	36.9	19.8	17.5	11.8	17.6	9.5
mean age*	7.4	7.3	6.8	6.0	6.3	7.1	7.7	7.9	8.5	7.8	7.8	8.2	7.6	7.2	6.9	7.8	7.1

*assuming ages 11+ to be 11

Table 6a. Spring-spawner annual catch weight at age (kg) of NAFO division 4R herring from 1965 to 1998 (all gears).

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
2	0.128	0.128	0.128	0.128	0.145	0.106	0.102	0.098	0.101	0.129	0.077	0.069	0.064	0.103	0.115	0.117	0.085
3	0.166	0.166	0.166	0.169	0.191	0.189	0.159	0.139	0.158	0.172	0.156	0.122	0.156	0.184	0.121	0.201	0.196
4	0.266	0.266	0.266	0.244	0.233	0.259	0.229	0.178	0.224	0.223	0.197	0.193	0.208	0.228	0.234	0.247	0.262
5	0.312	0.312	0.312	0.288	0.259	0.280	0.257	0.203	0.222	0.236	0.242	0.241	0.247	0.275	0.268	0.298	0.327
6	0.327	0.327	0.327	0.304	0.287	0.296	0.271	0.250	0.268	0.262	0.243	0.252	0.278	0.305	0.319	0.321	0.344
7	0.348	0.348	0.348	0.328	0.309	0.353	0.289	0.279	0.303	0.300	0.279	0.269	0.262	0.313	0.343	0.354	0.385
8	0.361	0.361	0.361	0.338	0.323	0.375	0.308	0.305	0.322	0.324	0.301	0.299	0.290	0.318	0.357	0.380	0.415
9	0.387	0.387	0.387	0.357	0.357	0.380	0.332	0.310	0.333	0.351	0.335	0.315	0.313	0.340	0.366	0.398	0.430
10	0.425	0.425	0.425	0.381	0.371	0.377	0.339	0.313	0.350	0.335	0.350	0.334	0.332	0.362	0.373	0.389	0.429
11+	0.425	0.425	0.425	0.370	0.370	0.370	0.376	0.372	0.367	0.384	0.382	0.382	0.353	0.393	0.409	0.430	0.472

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
2	0.095	0.142	0.134	0.109	0.142	0.165	0.153	0.149	0.120	0.154	0.103	0.115	0.112	0.106	0.107	0.107	0.082
3	0.216	0.190	0.206	0.168	0.171	0.235	0.192	0.193	0.180	0.159	0.115	0.149	0.158	0.174	0.149	0.173	0.141
4	0.263	0.263	0.239	0.247	0.230	0.250	0.223	0.233	0.257	0.203	0.214	0.194	0.192	0.179	0.217	0.153	0.171
5	0.290	0.305	0.297	0.283	0.268	0.289	0.261	0.301	0.270	0.276	0.246	0.251	0.223	0.216	0.244	0.233	0.223
6	0.357	0.337	0.348	0.329	0.315	0.349	0.302	0.307	0.301	0.318	0.276	0.277	0.273	0.258	0.284	0.277	0.274
7	0.386	0.385	0.379	0.373	0.338	0.370	0.338	0.350	0.343	0.332	0.366	0.323	0.320	0.272	0.326	0.296	0.283
8	0.395	0.424	0.406	0.404	0.413	0.390	0.371	0.384	0.373	0.374	0.368	0.383	0.354	0.326	0.335	0.329	0.315
9	0.423	0.434	0.431	0.434	0.415	0.428	0.385	0.399	0.409	0.401	0.399	0.401	0.380	0.336	0.389	0.347	0.364
10	0.434	0.492	0.437	0.425	0.449	0.422	0.457	0.408	0.417	0.408	0.411	0.420	0.390	0.377	0.413	0.370	0.375
11+	0.454	0.475	0.485	0.477	0.459	0.515	0.490	0.488	0.461	0.440	0.422	0.434	0.412	0.406	0.469	0.428	0.412

Table 6b. Autumn-spawner annual catch weight at age (kg) of NAFO division 4R herring from 1965 to 1998 (all gears).

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
2	0.124	0.115	0.124	0.124	0.124	0.109	0.095	0.112	0.100	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.144
3	0.179	0.167	0.160	0.179	0.170	0.173	0.176	0.178	0.105	0.171	0.120	0.107	0.250	0.161	0.218	0.222	0.204
4	0.223	0.223	0.190	0.227	0.198	0.198	0.187	0.200	0.156	0.218	0.188	0.155	0.229	0.238	0.216	0.242	0.280
5	0.260	0.260	0.265	0.256	0.223	0.233	0.210	0.187	0.231	0.259	0.266	0.282	0.250	0.282	0.281	0.360	0.328
6	0.258	0.258	0.268	0.280	0.254	0.283	0.230	0.249	0.274	0.265	0.297	0.271	0.255	0.316	0.308	0.341	0.358
7	0.264	0.264	0.268	0.297	0.278	0.293	0.262	0.279	0.297	0.284	0.352	0.287	0.301	0.345	0.355	0.404	0.406
8	0.281	0.281	0.321	0.295	0.301	0.339	0.275	0.295	0.329	0.307	0.323	0.277	0.321	0.367	0.381	0.419	0.436
9	0.318	0.318	0.324	0.319	0.301	0.347	0.286	0.303	0.334	0.355	0.370	0.308	0.308	0.366	0.405	0.461	0.485
10	0.293	0.293	0.337	0.350	0.312	0.306	0.308	0.325	0.346	0.378	0.391	0.426	0.330	0.390	0.408	0.468	0.498
11+	0.364	0.364	0.379	0.371	0.346	0.399	0.336	0.359	0.382	0.422	0.465	0.454	0.421	0.471	0.458	0.534	0.515

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
2	0.166	0.105	0.078	0.050	0.105	0.110	0.115	0.115	0.088	0.068	0.070	0.072	0.080	0.089	0.089	0.089	0.089
3	0.150	0.205	0.164	0.155	0.157	0.187	0.139	0.139	0.161	0.104	0.158	0.121	0.124	0.127	0.116	0.143	0.131
4	0.252	0.218	0.209	0.202	0.214	0.235	0.216	0.216	0.200	0.220	0.189	0.188	0.174	0.197	0.164	0.193	0.173
5	0.306	0.268	0.249	0.258	0.240	0.272	0.259	0.259	0.231	0.204	0.227	0.197	0.210	0.207	0.221	0.217	0.190
6	0.328	0.309	0.293	0.292	0.280	0.319	0.281	0.281	0.282	0.299	0.276	0.252	0.254	0.242	0.253	0.269	0.221
7	0.449	0.338	0.343	0.326	0.317	0.334	0.310	0.310	0.313	0.322	0.295	0.296	0.305	0.303	0.289	0.303	0.248
8	0.441	0.374	0.359	0.347	0.340	0.363	0.354	0.354	0.356	0.363	0.346	0.324	0.349	0.331	0.320	0.318	0.300
9	0.444	0.430	0.429	0.374	0.356	0.364	0.377	0.377	0.377	0.381	0.384	0.369	0.385	0.355	0.377	0.374	0.299
10	0.485	0.462	0.450	0.444	0.363	0.392	0.398	0.398	0.400	0.415	0.420	0.410	0.402	0.397	0.377	0.430	0.337
11+	0.507	0.503	0.494	0.432	0.465	0.513	0.428	0.428	0.432	0.426	0.442	0.433	0.438	0.439	0.456	0.450	0.425

Table 7a. Spring-spawner 4th quarter of the year weight at age (kg) of NAFO division 4R herring from 1965 to 1998 (purse seines).

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
2	0.128	0.128	0.128	0.128	0.148	0.106	0.123	0.139	0.118	0.148	0.133	0.138	0.142	0.142	0.145	0.184	0.157
3	0.166	0.166	0.166	0.166	0.190	0.165	0.144	0.176	0.191	0.169	0.180	0.209	0.206	0.226	0.227	0.229	0.225
4	0.266	0.266	0.266	0.244	0.237	0.255	0.205	0.205	0.206	0.223	0.215	0.229	0.229	0.244	0.253	0.291	0.273
5	0.312	0.312	0.312	0.292	0.265	0.276	0.252	0.248	0.238	0.241	0.239	0.252	0.293	0.307	0.295	0.334	0.358
6	0.327	0.327	0.327	0.308	0.287	0.292	0.258	0.295	0.263	0.281	0.272	0.270	0.294	0.333	0.336	0.382	0.372
7	0.348	0.348	0.348	0.333	0.315	0.358	0.287	0.323	0.311	0.320	0.315	0.280	0.331	0.354	0.365	0.411	0.411
8	0.361	0.361	0.361	0.340	0.323	0.387	0.291	0.316	0.347	0.336	0.341	0.306	0.329	0.359	0.365	0.445	0.445
9	0.387	0.387	0.387	0.358	0.357	0.388	0.315	0.357	0.343	0.357	0.350	0.340	0.356	0.376	0.403	0.463	0.442
10	0.425	0.425	0.425	0.384	0.370	0.380	0.339	0.399	0.349	0.374	0.362	0.327	0.374	0.395	0.396	0.458	0.453
11+	0.425	0.425	0.425	0.390	0.390	0.390	0.390	0.390	0.390	0.392	0.391	0.345	0.394	0.428	0.434	0.506	0.477

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
2	0.130	0.148	0.118	0.107	0.142	0.137	0.144	0.137	0.122	0.163	0.103	0.115	0.111	0.111	0.107	0.107	0.082
3	0.198	0.187	0.190	0.187	0.173	0.215	0.205	0.214	0.183	0.191	0.155	0.173	0.149	0.168	0.142	0.185	0.141
4	0.283	0.280	0.252	0.261	0.241	0.253	0.268	0.252	0.268	0.250	0.231	0.213	0.211	0.182	0.224	0.211	0.173
5	0.329	0.328	0.310	0.300	0.283	0.301	0.288	0.304	0.307	0.293	0.272	0.256	0.237	0.241	0.255	0.236	0.223
6	0.400	0.368	0.353	0.346	0.328	0.358	0.334	0.340	0.347	0.360	0.311	0.299	0.299	0.293	0.300	0.283	0.264
7	0.415	0.399	0.400	0.381	0.351	0.388	0.373	0.384	0.351	0.369	0.369	0.314	0.386	0.332	0.345	0.309	0.257
8	0.417	0.433	0.442	0.406	0.433	0.388	0.396	0.406	0.396	0.426	0.394	0.391	0.385	0.383	0.364	0.344	0.323
9	0.469	0.437	0.437	0.471	0.445	0.475	0.402	0.430	0.409	0.434	0.425	0.431	0.435	0.424	0.412	0.346	0.392
10	0.463	0.462	0.445	0.447	0.458	0.479	0.524	0.451	0.459	0.416	0.431	0.438	0.431	0.459	0.418	0.382	0.419
11+	0.482	0.486	0.485	0.472	0.455	0.526	0.498	0.512	0.459	0.483	0.460	0.478	0.504	0.493	0.500	0.406	0.418

Table 7b. Autumn-spawner 4th quarter of the year weight at age (kg) of NAFO division 4R herring from 1965 to 1998 (purse seines).

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
2	0.124	0.124	0.124	0.124	0.124	0.109	0.095	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.122	0.122	0.122
3	0.179	0.179	0.179	0.179	0.163	0.173	0.168	0.163	0.163	0.161	0.179	0.197	0.179	0.161	0.218	0.217	0.215
4	0.201	0.201	0.226	0.226	0.201	0.196	0.193	0.190	0.203	0.216	0.219	0.221	0.196	0.242	0.238	0.236	0.275
5	0.238	0.238	0.269	0.256	0.225	0.235	0.234	0.232	0.224	0.234	0.230	0.225	0.244	0.263	0.262	0.276	0.288
6	0.232	0.232	0.277	0.283	0.252	0.281	0.280	0.315	0.267	0.263	0.263	0.259	0.279	0.301	0.292	0.343	0.342
7	0.237	0.237	0.262	0.297	0.278	0.276	0.294	0.285	0.278	0.273	0.273	0.267	0.331	0.335	0.351	0.367	0.395
8	0.240	0.240	0.329	0.294	0.303	0.316	0.280	0.298	0.330	0.267	0.272	0.277	0.314	0.345	0.360	0.460	0.411
9	0.266	0.266	0.328	0.317	0.301	0.335	0.299	0.301	0.303	0.345	0.312	0.278	0.315	0.355	0.332	0.424	0.401
10	0.287	0.287	0.349	0.348	0.315	0.307	0.328	0.334	0.331	0.339	0.335	0.335	0.335	0.337	0.382	0.455	0.480
11+	0.345	0.345	0.388	0.371	0.351	0.370	0.338	0.345	0.377	0.385	0.371	0.357	0.408	0.419	0.431	0.486	0.483

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
2	0.091	0.091	0.084	0.057	0.105	0.100	0.095	0.089	0.088	0.068	0.070	0.072	0.083	0.094	0.085	0.076	0.076
3	0.173	0.172	0.151	0.154	0.156	0.180	0.127	0.169	0.164	0.166	0.160	0.127	0.120	0.125	0.119	0.127	0.131
4	0.233	0.226	0.223	0.216	0.215	0.228	0.214	0.212	0.199	0.214	0.189	0.174	0.154	0.174	0.167	0.159	0.169
5	0.297	0.272	0.257	0.258	0.239	0.257	0.257	0.249	0.226	0.243	0.228	0.201	0.199	0.193	0.219	0.190	0.187
6	0.335	0.305	0.306	0.293	0.281	0.311	0.281	0.303	0.259	0.289	0.275	0.258	0.245	0.225	0.241	0.225	0.209
7	0.367	0.320	0.330	0.318	0.312	0.333	0.325	0.332	0.324	0.336	0.303	0.295	0.291	0.276	0.271	0.262	0.239
8	0.422	0.331	0.348	0.344	0.333	0.361	0.357	0.372	0.362	0.375	0.357	0.315	0.353	0.299	0.308	0.286	0.285
9	0.414	0.408	0.361	0.361	0.349	0.384	0.378	0.391	0.382	0.398	0.378	0.361	0.372	0.330	0.364	0.326	0.282
10	0.440	0.414	0.439	0.377	0.367	0.403	0.406	0.416	0.391	0.416	0.435	0.363	0.388	0.370	0.355	0.349	0.310
11+	0.473	0.474	0.483	0.441	0.428	0.499	0.425	0.456	0.431	0.441	0.434	0.415	0.420	0.421	0.436	0.391	0.402

Table 8a. Annual proportion mature at age for spring-spawning herring in NAFO division 4R from 1965 to 1998.

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
2	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	0.053
3	0.174	0.174	0.174	0.174	0.174	0.500	0.174	0.016	0.143	0.143	0.350	0.278	0.114	0.436	0.436	0.837	0.898
4	0.764	0.764	1.000	0.764	0.714	0.778	0.764	0.808	0.667	0.900	0.571	0.727	0.913	0.706	0.891	0.909	1.000
5	0.976	0.976	1.000	0.976	1.000	0.936	0.976	1.000	1.000	0.938	1.000	0.917	1.000	1.000	0.986	1.000	1.000
6	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
7	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
8	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
9	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
11+	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
2	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	0.000
3	0.625	0.130	0.167	0.052	0.500	0.286	0.429	0.436	0.667	0.429	0.300	0.438	0.652	0.714	0.533	0.546	0.533
4	1.000	0.940	0.706	0.875	0.918	0.813	0.857	0.891	0.818	0.844	0.583	0.938	0.929	0.905	0.836	1.000	0.836
5	1.000	0.968	0.961	0.996	1.000	0.991	0.962	0.986	1.000	1.000	0.818	1.000	1.000	1.000	1.000	1.000	1.000
6	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
7	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
8	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
9	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
11+	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table 8b. Annual proportion mature at age for autumn-spawning herring in NAFO division 4R from 1965 to 1998.

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
2	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	0.000
3	0.000	0.000	0.000	0.000	0.000	0.091	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.108	0.400
4	0.222	0.429	0.278	0.278	0.182	0.143	0.143	0.105	0.308	0.500	0.714	0.893	0.914	0.914	0.914	0.871	0.972
5	1.000	0.857	1.000	0.875	0.769	0.800	0.800	0.889	0.850	0.882	0.932	1.000	1.000	0.973	1.000	1.000	1.000
6	1.000	1.000	1.000	1.000	0.857	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
7	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
8	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
9	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
11+	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
2	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	0.000
3	0.400	0.048	0.154	0.000	0.000	0.143	0.000	0.047	0.048	0.069	0.325	0.077	0.500	0.500	0.208	0.273	0.327
4	0.969	0.867	0.732	0.543	0.649	0.867	0.563	0.682	0.727	0.880	0.824	0.947	0.694	0.884	0.810	0.778	0.824
5	1.000	0.990	0.979	0.990	0.985	1.000	0.938	0.857	0.667	0.944	1.000	1.000	1.000	0.959	1.000	1.000	0.929
6	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.974	1.000	0.941	1.000	1.000	1.000	1.000	1.000	1.000	1.000
7	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
8	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
9	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
11+	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table 9. Numbers at age ($x10^3$) for spring- and autumn-spawning herring estimated from the biennial acoustic survey in NAFO division 4R from 1991 to 1997.

SPRING-SPAWNERS

	1991	1993	1995	1997
2	5252	15591	1000	4053
3	14241	36865	4627	31460
4	78462	32008	5587	2199
5	216	26686	32838	4280
6	13484	41341	12184	7656
7	43972	1567	6786	17319
8	26318	6965	18560	3093
9	48683	6965	5301	236
10	8773	5398	12356	9335
11	44080	12879	14334	2317
2+	283480	186265	113573	81946

AUTUMN-SPAWNERS

	1991	1993	1995	1997
2	0	3054	0	3893
3	8841	42610	7365	18723
4	37546	25955	15411	31975
5	29664	33590	59905	12201
6	12515	14213	12296	10703
7	4207	36785	20719	69137
8	12515	9533	8609	5732
9	16616	5601	16702	10951
10	4101	8996	5713	1180
11	106938	31228	36515	36947
2+	232942	211566	183236	201440

Table 10. Spring- and autumn-spawner catch rate at age (arbitrary units) from herring gillnet logbook data for NAFO division 4R from 1985 to 1998 and 1984 to 1997, respectively.

SPRING-SPAWNERS

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
3	0.8	0.0	0.0	0.0	1.0	2.5	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0
4	11.1	46.4	6.5	0.8	16.3	8.8	7.9	28.1	2.8	5.6	2.2	0.9	0.3	3.3
5	1024.7	20.0	569.0	26.1	21.2	14.2	16.6	223.6	25.8	12.9	32.8	9.0	4.3	3.5
6	338.6	930.5	175.4	452.4	140.0	21.6	20.5	42.9	148.1	44.0	57.7	135.7	42.0	10.7
7	51.4	334.3	1187.0	140.0	599.6	76.3	113.1	47.9	45.6	145.8	22.3	84.1	293.4	21.9
8	91.4	38.4	107.4	538.9	92.1	340.5	244.1	114.9	105.2	29.3	135.2	25.8	116.8	101.6
9	57.0	34.2	10.6	95.6	227.4	87.3	394.2	144.5	98.8	56.5	16.0	115.2	41.7	21.0
10	78.1	24.4	0.4	14.7	30.2	166.2	77.0	230.3	109.3	71.1	36.6	8.9	97.5	13.8
11	334.2	175.6	54.3	34.5	21.8	12.5	356.8	138.6	154.9	85.3	115.2	44.7	67.2	91.5
3+	1987.1	1603.9	2110.6	1303.0	1149.5	729.7	1230.3	972.1	690.6	450.6	417.9	424.3	663.1	267.3

AUTUMN-SPAWNERS

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
4	284.5	214.2	81.1	84.1	29.1	20.0	0.0	400.9	478.8	176.9	57.1	902.1	117.8	53.9
5	8612.4	5657.2	1755.0	2179.4	1155.4	235.3	398.2	1378.3	2429.9	1404.3	376.9	1746.3	399.3	424.0
6	1158.5	42650.9	4579.9	3073.3	3340.2	1246.6	384.4	1875.6	6636.0	2495.8	3395.1	3674.9	7264.6	481.1
7	1337.8	3217.2	29527.2	3148.8	3754.2	2823.7	463.1	948.8	3260.9	2943.1	3219.9	3337.0	2002.5	4934.3
8	77.0	2060.6	1139.3	16853.2	2749.2	3367.3	872.4	2738.5	5976.7	2050.9	2953.5	1948.4	4177.7	1014.5
9	94.3	459.0	1768.7	1409.0	13063.0	5208.0	1810.4	903.5	5986.0	3166.7	1202.9	1722.1	2020.6	2556.9
10	297.2	219.6	0.0	849.5	1038.0	3945.7	183.2	1255.3	2058.1	2933.8	824.3	936.4	1138.2	397.7
11	1400.1	5545.9	1933.4	1316.1	1378.6	2371.6	4389.0	9814.2	20544.7	13700.0	3640.1	1221.8	6438.8	1909.2
4+	11861.6	54478.7	38851.2	27597.3	25129.0	16846.7	4111.7	9501.0	26826.3	15171.5	12029.7	14267.1	17120.7	9862.3

Table 11. Instantaneous fishing mortality matrix and average for ages 5+, 6+ and 7+ (weighted on population numbers), estimated from SPA, for spring-spawning herring NAFO division 4R from 1965 to 1998.

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
2	0.006	0.002	0.000	0.001	0.005	0.001	0.000	0.005	0.134	0.004	0.003	0.004	0.000	0.000	0.009	0.017	0.001
3	0.002	0.003	0.000	0.003	0.015	0.010	0.004	0.001	0.010	0.025	0.040	0.037	0.005	0.002	0.002	0.061	0.030
4	0.000	0.007	0.006	0.009	0.060	0.003	0.007	0.017	0.005	0.004	0.052	0.043	0.038	0.023	0.011	0.011	0.210
5	0.027	0.007	0.004	0.009	0.038	0.012	0.011	0.037	0.074	0.002	0.003	0.031	0.026	0.018	0.171	0.023	0.017
6	0.096	0.092	0.005	0.008	0.010	0.009	0.025	0.024	0.094	0.032	0.008	0.014	0.061	0.055	0.068	0.344	0.029
7	0.218	0.386	0.247	0.011	0.013	0.002	0.038	0.054	0.067	0.015	0.037	0.026	0.018	0.062	0.116	0.059	0.386
8	0.173	0.650	0.474	0.120	0.017	0.007	0.011	0.085	0.193	0.023	0.019	0.088	0.051	0.147	0.197	0.208	0.035
9	0.354	0.866	1.113	0.798	0.192	0.017	0.025	0.054	0.289	0.064	0.011	0.056	0.122	0.128	0.284	0.128	0.115
10	0.371	0.559	1.387	1.726	1.889	0.400	0.096	0.098	0.266	0.081	0.026	0.135	0.172	0.163	0.162	0.231	0.211
11	0.371	0.559	1.387	1.726	1.889	0.400	0.096	0.098	0.266	0.081	0.026	0.135	0.172	0.163	0.162	0.231	0.211
5+	0.103	0.118	0.105	0.046	0.046	0.022	0.029	0.051	0.098	0.026	0.024	0.070	0.098	0.138	0.165	0.234	0.208
6+	0.165	0.312	0.142	0.071	0.047	0.026	0.040	0.054	0.161	0.035	0.025	0.071	0.101	0.144	0.163	0.253	0.220
7+	0.247	0.515	0.457	0.097	0.073	0.029	0.045	0.073	0.177	0.045	0.032	0.075	0.102	0.149	0.168	0.218	0.242

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
2	0.002	0.000	0.000	0.004	0.005	0.009	0.030	0.002	0.003	0.011	0.001	0.003	0.001	0.003	0.024	0.003	0.002
3	0.041	0.011	0.007	0.014	0.033	0.006	0.014	0.030	0.021	0.076	0.029	0.020	0.016	0.026	0.067	0.022	0.077
4	0.064	0.080	0.035	0.016	0.053	0.050	0.009	0.024	0.045	0.128	0.077	0.117	0.041	0.075	0.163	0.045	0.176
5	0.401	0.141	0.114	0.130	0.085	0.076	0.057	0.013	0.016	0.114	0.156	0.215	0.136	0.119	0.373	0.049	0.159
6	0.071	0.313	0.102	0.169	0.255	0.121	0.100	0.093	0.036	0.038	0.122	0.179	0.388	0.389	0.230	0.191	0.134
7	0.244	0.065	0.406	0.104	0.347	0.174	0.180	0.173	0.217	0.144	0.063	0.272	0.129	0.400	0.536	0.309	0.414
8	0.545	0.119	0.060	0.338	0.150	0.185	0.279	0.224	0.224	0.526	0.191	0.184	0.533	0.426	0.166	0.407	0.487
9	0.176	0.524	0.157	0.096	0.242	0.080	0.444	0.378	0.471	0.511	0.307	0.290	0.206	0.102	0.355	0.262	0.339
10	0.320	0.309	0.240	0.125	0.135	0.077	0.271	0.238	0.402	0.615	0.603	0.825	0.307	0.770	0.351	0.509	0.765
11	0.320	0.309	0.240	0.125	0.135	0.077	0.271	0.238	0.402	0.615	0.603	0.825	0.307	0.770	0.351	0.509	0.765
5+	0.332	0.274	0.162	0.134	0.218	0.106	0.147	0.173	0.205	0.369	0.264	0.323	0.216	0.318	0.314	0.316	0.463
6+	0.326	0.295	0.203	0.149	0.252	0.153	0.163	0.200	0.233	0.392	0.341	0.344	0.246	0.483	0.304	0.342	0.481
7+	0.346	0.294	0.221	0.129	0.240	0.162	0.267	0.221	0.272	0.457	0.366	0.480	0.216	0.521	0.390	0.367	0.528

Table 12. Beginning-of-the-year population numbers at age ($x10^{-3}$), estimated from SPA, for spring-spawning herring in NAFO division 4R from 1965 to 1999.

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
2	123244	55247	78380	157441	74514	802105	335814	61105	16126	34659	25175	142617	31708	15529	19627	19298	79762	373655
3	52974	100335	45129	64172	128825	60676	655744	274941	49772	11551	28249	20560	116328	25952	12714	15918	15529	65268
4	101969	43306	81892	36932	52393	103911	49163	534595	224904	40358	9222	22230	16219	94759	21205	10387	12262	12338
5	28724	83473	35206	66633	29964	40388	84807	39977	430294	183176	32925	7171	17437	12790	75788	17169	8408	8136
6	19233	22891	67872	28698	54058	23607	32675	68674	31550	327148	149636	26867	5690	13906	10285	52296	13736	6768
7	7252	14302	17099	55282	23313	43807	19163	26101	54906	23512	259319	121551	21680	4384	10773	7864	30357	10926
8	4502	4774	7962	10938	44747	18848	35799	15101	20247	42046	18963	204701	96988	17436	3372	7851	6071	16891
9	1697	3100	2040	4059	7945	36001	15327	29003	11359	13666	33656	15239	153553	75470	12327	2268	5218	4800
10	1080	975	1067	549	1496	5371	28965	12233	22503	6964	10491	27252	11792	111331	54391	7601	1635	3809
11	1802	1628	1218	467	148	204	3060	23814	26764	30907	28602	31186	41784	36931	103079	109615	76171	51581
2+	342477	330031	337865	425171	417403	1134918	1260517	1085544	888425	713987	596238	619374	513179	408488	323561	250267	249149	554172
3+	219233	274784	259485	267730	342889	332813	924703	1024439	872299	679328	571063	476757	481471	392959	303934	230969	169387	180517
4+	166259	174449	214356	203558	214064	272137	268959	749498	822527	667777	542814	456197	365143	367007	291220	215051	153858	115249
5+	64290	131143	132464	166626	161671	168226	219796	214903	597623	627419	533592	433967	348924	272248	270015	204664	141596	102911
6+	35566	47670	97258	99993	131707	127838	134989	174926	167329	444243	500667	426796	331487	259458	194227	187495	133188	94775

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
2	84050	448561	97278	72253	53768	26539	137532	41075	58065	105921	27065	11453	4215	45939	15000	57000	57000
3	305386	68784	367071	79317	58864	43611	21094	112326	33526	47018	86639	22087	9364	3440	36395	12248	46597
4	51294	247351	55925	296390	62820	47896	35219	16752	90036	25434	37373	69497	17783	7444	2593	28889	9284
5	9476	38782	195496	45076	230243	48922	38851	28146	13111	64838	19284	27171	54555	13460	5054	2005	16908
6	4461	6740	28318	140550	33885	174742	37833	31393	22678	9576	45392	12720	19377	39482	7379	3903	1314
7	5161	2672	4982	19588	89184	24581	129482	28236	24802	17874	6940	31054	7038	10652	25385	4867	2697
8	7009	3961	1457	3677	11330	61351	16814	89163	18608	17587	13733	4325	22330	3831	4951	14854	2110
9	8021	5096	3054	851	2592	7713	37988	11001	58335	9007	11894	9350	2071	11891	2640	2543	5634
10	3296	3889	3566	2271	547	1958	4049	21308	5625	28657	5425	7287	6225	1529	6780	1640	1175
11	32938	21781	16535	14525	12020	9529	7171	7244	15643	9414	17055	8064	9241	5829	4214	5292	2143
2+	511092	847617	773682	674498	555253	446842	466033	386644	340429	335326	270800	203008	152199	143497	110391	133241	144862
3+	427042	399056	676404	602245	501485	420303	328501	345569	282364	229405	243735	191555	147984	97558	95391	76241	87862
4+	121656	330272	309333	522928	442621	376692	307407	233243	248838	182387	157096	169468	138620	94118	58996	63993	41265
5+	70362	82921	253408	226538	379801	328796	272188	216491	158802	156953	119723	99971	120837	86674	56403	35104	31981
6+	60886	44139	57912	181462	149558	279874	233337	188345	145691	92115	100439	72800	66282	73214	51349	33099	15073

Table 13 . Beginning-of-the-year population biomass (t), estimated from SPA, for spring-spawning herring in NAFO division 4R from 1965 to 1999.

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
2	15735	7053	10007	20100	11044	84970	41147	8501	1910	5114	3348	19717	4496	2202	2852	3551	12524	48590
3	8804	16676	7500	10665	24496	9981	94310	48483	9496	1950	5080	4306	23924	5863	2892	3645	3487	12906
4	27171	11539	21821	9011	12434	26445	10082	109787	46287	9008	1978	5085	3721	23103	5374	3025	3346	3493
5	8958	26033	10980	19488	7945	11132	21375	9896	102354	44065	7876	1810	5117	3927	22386	5739	3010	2676
6	6285	7480	22178	8825	15498	6893	8431	20224	8289	91798	40651	7249	1672	4627	3459	19982	5106	2709
7	2525	4980	5954	18432	7334	15688	5490	8431	17048	7520	81727	34038	7167	1552	3934	3235	12466	4529
8	1625	1724	2874	3717	14442	7292	10418	4772	7020	14121	6472	62565	31877	6256	1231	3491	2699	7047
9	656	1199	789	1455	2839	13981	4827	10365	3891	4874	11765	5184	54620	28347	4970	1050	2308	2250
10	459	414	453	211	553	2038	9816	4878	7852	2607	3794	8923	4416	44009	21518	3479	740	1762
11	766	692	518	182	58	80	1194	9289	10439	12116	11184	10760	16457	15814	44762	55452	36358	24864
2+	72984	77790	83075	92087	96644	178501	207090	234627	214586	193171	173874	159636	153467	135699	113378	102649	82045	110827
4+	48445	54061	65567	61321	61103	83550	71633	177642	203180	186107	165447	135613	125047	127635	107634	95453	66033	49331
5+	21275	42522	43747	52309	48669	57104	61550	67855	156893	177099	163468	130528	121326	104532	102260	92428	62688	45838
6+	12316	16489	32767	32821	40724	45973	40176	57959	54539	133034	155592	128718	116209	100605	79874	86689	59678	43162

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
2	12397	52939	10443	10225	7384	3831	18820	5024	9437	10890	3116	1272	468	4916	1607	4657	4657
3	57254	13096	68536	13719	12675	8942	4514	20563	6414	7284	14999	3300	1572	490	6748	1725	6561
4	14365	62357	14590	71383	15900	12819	8861	4498	22549	5880	7963	14680	3236	1670	546	5006	1609
5	3111	12022	58598	12772	69232	14095	11825	8633	3837	17643	4932	6441	13160	3436	1192	447	3769
6	1642	2380	9789	46054	12142	58282	12852	10888	8163	2976	13591	3800	5677	11850	2090	1028	346
7	2059	1070	1898	6872	34640	9166	49735	9908	9147	6593	2176	11996	2333	3676	7844	1251	693
8	3036	1750	591	1593	4401	24274	6831	35272	7927	6928	5372	1663	8549	1393	1705	4792	681
9	3503	2229	1437	379	1231	3100	16345	4504	25314	3830	5124	4066	877	4904	913	996	2207
10	1522	1732	1595	1040	262	1026	1825	9775	2339	12349	2376	3144	2858	639	2589	687	492
11	15993	10566	7801	6605	6324	4741	3669	3326	7563	4330	8150	4065	4555	2917	1712	2211	895
2+	114884	160142	175278	170641	164191	140276	135278	112391	102689	78703	67799	54426	43285	35890	26945	22801	21911
4+	45232	94106	96299	146698	144132	127503	111944	86804	86838	60528	49684	49854	41244	30485	18591	16419	10693
5+	30867	31749	81710	75315	128232	114683	103083	82306	64289	54648	41721	35174	38009	28815	18044	11413	9084
6+	27756	19727	23112	62543	59000	100589	91257	73674	60452	37005	36789	28733	24849	25379	16852	10966	5315

Table 14. Beginning-of-the-year population numbers at age ($x10^{-3}$), estimated from SPA, for autumn-spawning herring in NAFO division 4R from 1965 to 1998.

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
2	381901	76224	64516	21083	32615	25532	30748	34400	18282	18643	42098	12115	6309	17681	50771	76751	391013
3	77307	312659	62368	52821	17261	26673	20903	25138	28155	14968	15264	34467	9919	5166	14476	41568	62825
4	64470	62702	255914	50961	43093	13862	21417	17114	20495	21429	12237	12480	28176	8119	4220	11845	33869
5	42468	52354	50720	209361	41626	34639	11180	17433	13908	15715	17190	9983	9972	22916	6622	3351	9575
6	82724	34558	42576	40813	171222	33752	28330	8757	13091	10382	12388	13293	7911	8043	18270	5111	2666
7	246294	67483	27979	34525	32570	139394	27587	22619	5958	8356	8207	9308	10503	6113	6231	12536	4025
8	118261	201375	55041	22796	28066	26002	113899	20648	15949	3506	6307	6623	7115	7948	4007	4632	8706
9	91362	95912	163805	44673	18507	22798	21207	90107	14953	10689	2638	5022	5129	5459	4989	2127	3567
10	89333	74211	77685	133269	36319	15024	18601	15495	70545	8802	8473	2027	3883	3891	4016	2430	1136
11	181913	221104	238747	255353	315547	286210	245025	202113	150675	157761	131023	110969	88085	69038	53945	41367	30857
2+	1376033	1198582	1039351	865655	736826	623886	538897	453824	352011	270251	255825	216287	177002	154374	167547	201718	548239
3+	994132	1122358	974835	844572	704211	598354	508149	419424	333729	251608	213727	204172	170693	136693	116776	124967	157226
4+	916825	809699	912467	791751	686950	571681	487246	394286	305574	236640	198463	169705	160774	131527	102300	83399	94401
5+	852355	746997	656553	740790	643857	557819	465829	377172	285079	215211	186226	157225	132598	123408	98080	71554	60532
6+	809887	694643	605833	531429	602231	523180	454649	359739	271171	199496	169036	147242	122626	100492	91458	68203	50957

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
2	56441	97803	36587	46106	57825	28185	108932	40275	98119	47142	141907	33734	31351	29101	67895	41000	41000
3	320135	46118	80061	29955	37735	47312	23076	88749	32935	80309	38530	116183	27600	25668	23767	55588	33568
4	51407	261592	37684	65498	24313	30510	38595	18706	72120	26487	65000	31241	94933	22542	20934	17683	44976
5	27257	40442	212069	30250	52416	18614	24539	31137	14828	57632	20532	51912	24971	76827	17176	15913	12920
6	7618	21453	31887	167976	23046	40504	14019	19657	24660	11758	41988	15504	40735	17941	57345	11781	12237
7	2101	5778	16383	25071	128794	16802	31349	10359	15365	19913	9019	33261	11778	29715	11528	39226	8666
8	3030	1594	4274	12594	19712	97850	12198	24096	7806	12192	14950	6685	25733	6854	20810	7365	25229
9	6016	2141	1162	3301	9750	15422	74765	8485	18981	6044	9154	11749	4970	18872	4521	13503	4059
10	2782	4051	1333	820	2599	7636	12199	57454	6081	14782	4363	6792	8798	2607	12580	2956	6616
11	23044	18510	15371	10654	8939	9182	13445	19658	59654	49130	43978	35685	29834	26963	20015	22094	16222
2+	499831	499482	436811	392225	365129	312017	353117	318576	350549	325389	389421	342746	300703	257090	256571	227109	205493
3+	443390	401679	400224	346119	307304	283832	244185	278301	252430	278247	247514	309012	269352	227989	188676	186109	164493
4+	123255	355561	320163	316164	269569	236520	221109	189552	219495	197938	208984	192829	241752	202321	164909	130521	130925
5+	71848	93969	282479	250666	245256	206010	182514	170846	147375	171451	143984	161588	146819	179779	143975	112838	85949
6+	44591	53527	70410	220416	192840	187396	157975	139709	132547	113819	123452	109676	121848	102952	126799	96925	73029

Table 15. Instantaneous fishing mortality matrix and average for ages 5+, 6+ and 7+ (weighted on population numbers), estimated from SPA, for autumn-spawning herring in NAFO division 4R from 1965 to 1997.

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
2	0.000	0.001	0.000	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.009	0.000	0.002	0.004	0.019	0.019	0.000	0.004	0.073	0.001	0.001	0.002	0.000	0.002	0.001	0.005	0.001
4	0.008	0.012	0.001	0.002	0.018	0.015	0.006	0.007	0.065	0.020	0.004	0.024	0.007	0.004	0.031	0.013	0.017
5	0.006	0.007	0.017	0.001	0.010	0.001	0.044	0.086	0.092	0.038	0.057	0.033	0.015	0.027	0.059	0.028	0.028
6	0.004	0.011	0.010	0.026	0.006	0.002	0.025	0.185	0.249	0.035	0.086	0.036	0.058	0.055	0.176	0.039	0.038
7	0.001	0.004	0.005	0.007	0.025	0.002	0.090	0.149	0.330	0.081	0.014	0.069	0.079	0.222	0.096	0.164	0.084
8	0.009	0.006	0.009	0.008	0.008	0.004	0.034	0.123	0.200	0.084	0.028	0.056	0.065	0.266	0.433	0.061	0.169
9	0.008	0.011	0.006	0.007	0.009	0.003	0.114	0.045	0.330	0.032	0.063	0.057	0.076	0.107	0.518	0.426	0.048
10	0.004	0.013	0.014	0.008	0.007	0.007	0.066	0.167	0.138	0.040	0.029	0.049	0.087	0.101	0.137	0.150	0.127
11	0.004	0.013	0.014	0.008	0.007	0.007	0.066	0.167	0.138	0.040	0.029	0.049	0.087	0.101	0.137	0.150	0.127
5+	0.004	0.010	0.011	0.007	0.008	0.005	0.059	0.131	0.158	0.042	0.035	0.049	0.078	0.101	0.168	0.141	0.106
6+	0.004	0.010	0.011	0.009	0.008	0.005	0.059	0.133	0.162	0.042	0.033	0.050	0.083	0.118	0.176	0.147	0.121
7+	0.004	0.010	0.011	0.008	0.009	0.005	0.061	0.132	0.157	0.042	0.029	0.051	0.084	0.124	0.176	0.156	0.125

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
2	0.002	0.000	0.000	0.000	0.001	0.000	0.005	0.001	0.000	0.002	0.000	0.001	0.000	0.002	0.000	0.000
3	0.002	0.002	0.001	0.009	0.012	0.004	0.010	0.007	0.017	0.011	0.009	0.002	0.002	0.003	0.068	0.003
4	0.039	0.010	0.020	0.022	0.066	0.017	0.014	0.032	0.023	0.053	0.024	0.023	0.011	0.064	0.060	0.075
5	0.039	0.037	0.033	0.071	0.057	0.082	0.021	0.032	0.031	0.111	0.078	0.041	0.124	0.084	0.153	0.050
6	0.076	0.069	0.040	0.065	0.115	0.055	0.100	0.045	0.013	0.064	0.031	0.072	0.109	0.225	0.159	0.088
7	0.076	0.100	0.062	0.040	0.074	0.119	0.062	0.081	0.030	0.083	0.097	0.053	0.323	0.146	0.221	0.201
8	0.146	0.115	0.057	0.055	0.045	0.068	0.160	0.038	0.054	0.084	0.039	0.093	0.102	0.198	0.211	0.318
9	0.194	0.272	0.147	0.038	0.044	0.034	0.062	0.130	0.049	0.121	0.094	0.084	0.421	0.187	0.197	0.418
10	0.132	0.182	0.246	0.049	0.028	0.023	0.064	0.055	0.089	0.168	0.099	0.145	0.149	0.173	0.165	0.191
11	0.132	0.182	0.246	0.049	0.028	0.023	0.064	0.055	0.089	0.168	0.099	0.145	0.149	0.173	0.165	0.191
5+	0.095	0.090	0.049	0.062	0.069	0.065	0.066	0.053	0.057	0.124	0.070	0.079	0.149	0.138	0.173	0.199
6+	0.129	0.129	0.097	0.060	0.072	0.063	0.073	0.057	0.060	0.131	0.068	0.097	0.154	0.178	0.176	0.224
7+	0.140	0.170	0.144	0.045	0.066	0.065	0.071	0.059	0.071	0.139	0.087	0.101	0.176	0.169	0.190	0.243

Table 16. Beginning-of-the-year population biomass (t), estimated from SPA, for autumn-spawning herring in NAFO division 4R from 1965 to 1998.

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
2	47287	9438	7988	2610	4038	2787	2906	3864	2054	2094	4729	1361	709	1986	6184	9349	47629
3	13805	55832	11137	9432	2814	4624	3513	4092	4602	2405	2732	6802	1775	830	3160	8999	13508
4	12937	12582	57773	11504	8647	2722	4132	3244	4167	4638	2677	2759	5525	1967	1003	2791	9313
5	10109	12462	13644	53686	9369	8140	2611	4044	3118	3682	3947	2245	2433	6028	1738	924	2759
6	19180	8012	11782	11530	43121	9484	7932	2758	3491	2730	3258	3447	2211	2419	5337	1754	912
7	58278	15968	7341	10250	9038	38481	8111	6437	1659	2280	2240	2488	3482	2046	2185	4598	1590
8	28331	48241	18097	6706	8493	8212	31863	6157	5260	937	1716	1834	2235	2743	1442	2130	3578
9	24337	25549	53744	14156	5579	7637	6332	27145	4527	3685	822	1398	1615	1938	1658	903	1429
10	25619	21282	27120	46434	11438	4617	6101	5175	23319	2981	2842	680	1303	1312	1534	1106	545
11	62771	76294	92734	94721	110905	105935	82799	69676	56806	60765	48621	39617	35905	28947	23276	20116	14903
2+	302652	285661	301361	261030	213444	192640	156301	132594	109003	86198	73585	62632	57191	50216	47517	52671	96166
3+	255365	276223	293372	258420	209406	189853	153395	128730	106949	84104	68856	61271	56483	48229	41333	43322	48537
4+	241561	220391	282235	248988	206591	185229	149882	124638	102347	81699	66123	54469	54707	47400	38173	34322	35029
6+	218515	195347	210819	183797	188575	174367	143139	117349	95062	73379	59499	49465	46750	39405	35432	30607	22956

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
2	5142	8910	3091	2630	6090	2819	10315	3576	8609	3206	9933	2429	2599	2730	5763	3114	3114
3	55425	7955	12124	4627	5895	8537	2931	14999	5389	13329	6168	14777	3298	3215	2821	7056	4261
4	11971	59122	8422	14116	5237	6970	8272	3965	14326	5662	12284	5449	14610	3923	3491	2818	7168
5	8109	11008	54587	7792	12518	4790	6305	7741	3352	14004	4684	10412	4961	14797	3768	3029	2459
6	2553	6542	9753	49207	6477	12577	3937	5949	6382	3394	11540	3992	9963	4036	13804	2647	2749
7	772	1846	5401	7972	40170	5595	10181	3441	4984	6685	2735	9803	3425	8200	3123	10264	2268
8	1279	528	1487	4333	6569	35366	4349	8966	2826	4566	5331	2107	9089	2051	6406	2109	7225
9	2488	873	419	1192	3402	5923	28239	3317	7253	2403	3462	4237	1850	6226	1644	4398	1322
10	1225	1676	585	309	954	3079	4957	23880	2380	6152	1898	2462	3413	963	4466	1032	2309
11	10908	8779	7423	4699	3824	4585	5709	8959	25738	21685	19093	14796	12541	11343	8718	8640	6343
2+	99871	107240	103293	96876	91135	90241	85195	84791	81239	81086	77128	70465	65749	57483	54003	45107	39220
3+	94729	98330	100201	94246	85045	87422	74880	81216	72630	77880	67194	68036	63150	54753	48240	41993	36105
4+	39304	90376	88077	89619	79150	78885	71949	66217	67241	64551	61026	53258	59852	51539	45419	34937	31844
6+	19224	20245	25068	67711	61395	67125	57372	54511	49563	44885	44059	37397	40281	32819	38161	29089	22217

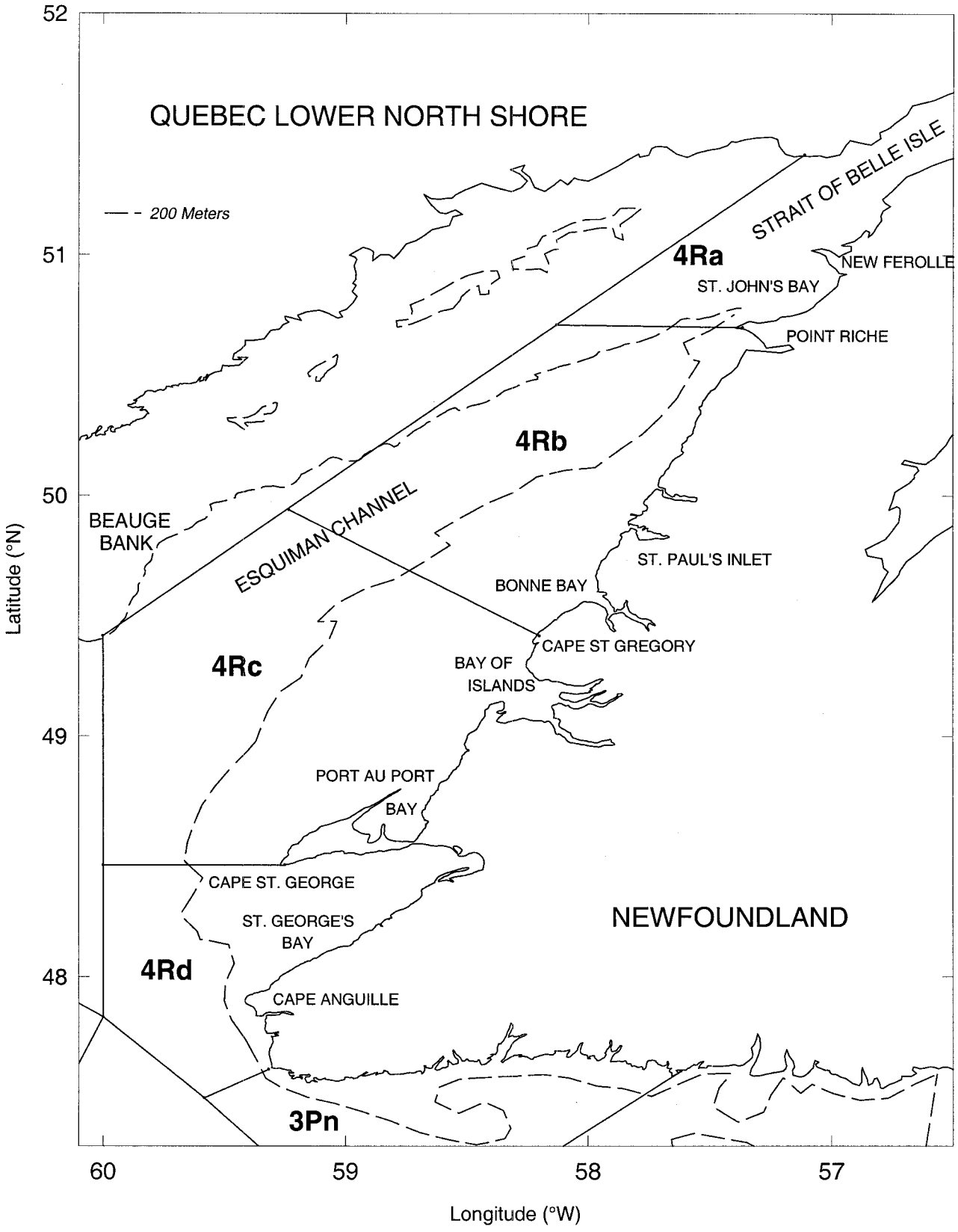

Figure 1. West coast of Newfoundland NAFO unit areas.

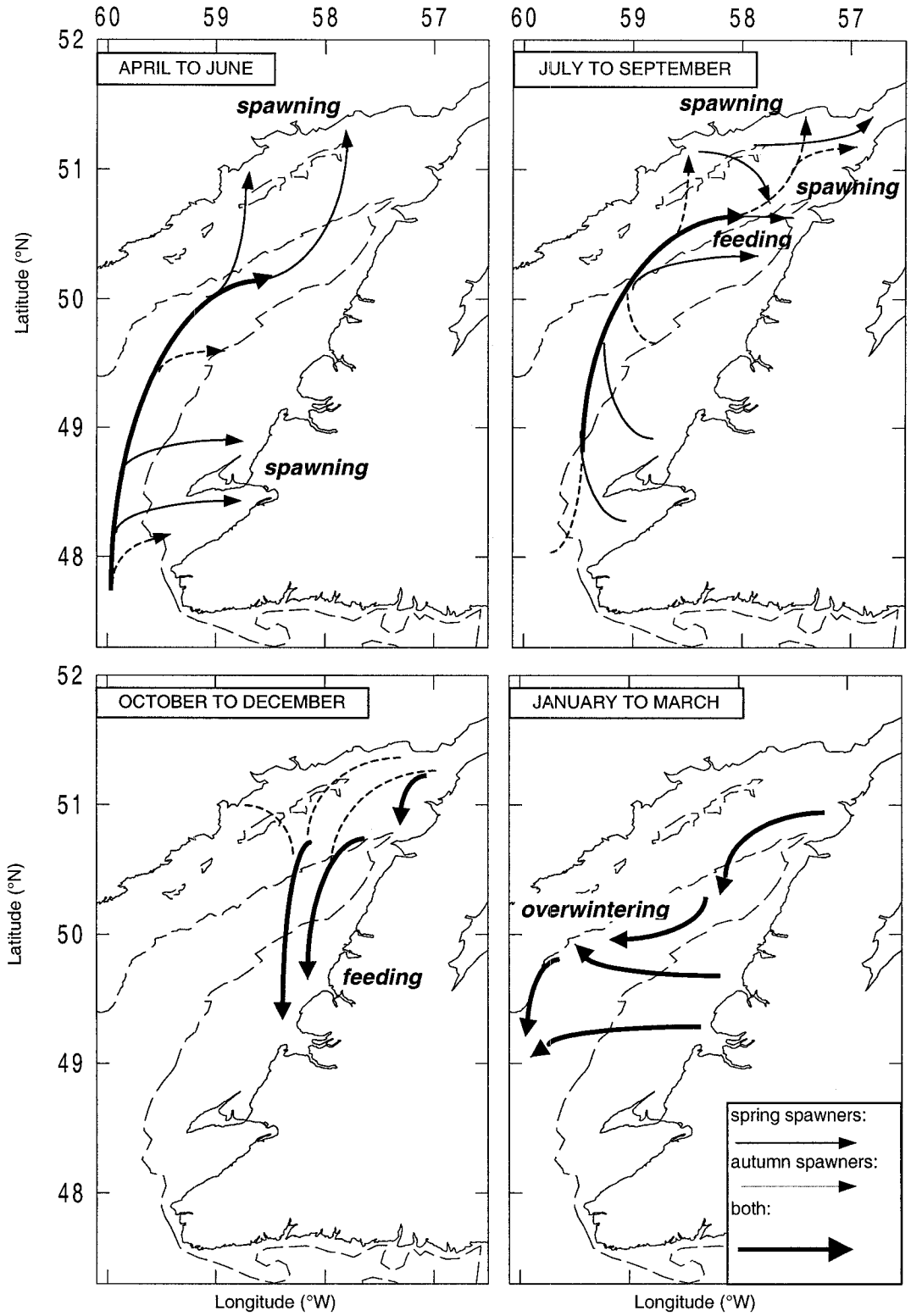

Figure 2. Probable annual migration pattern of spring- and autumn-spawning herring in the north-eastern Gulf of St. Lawrence.

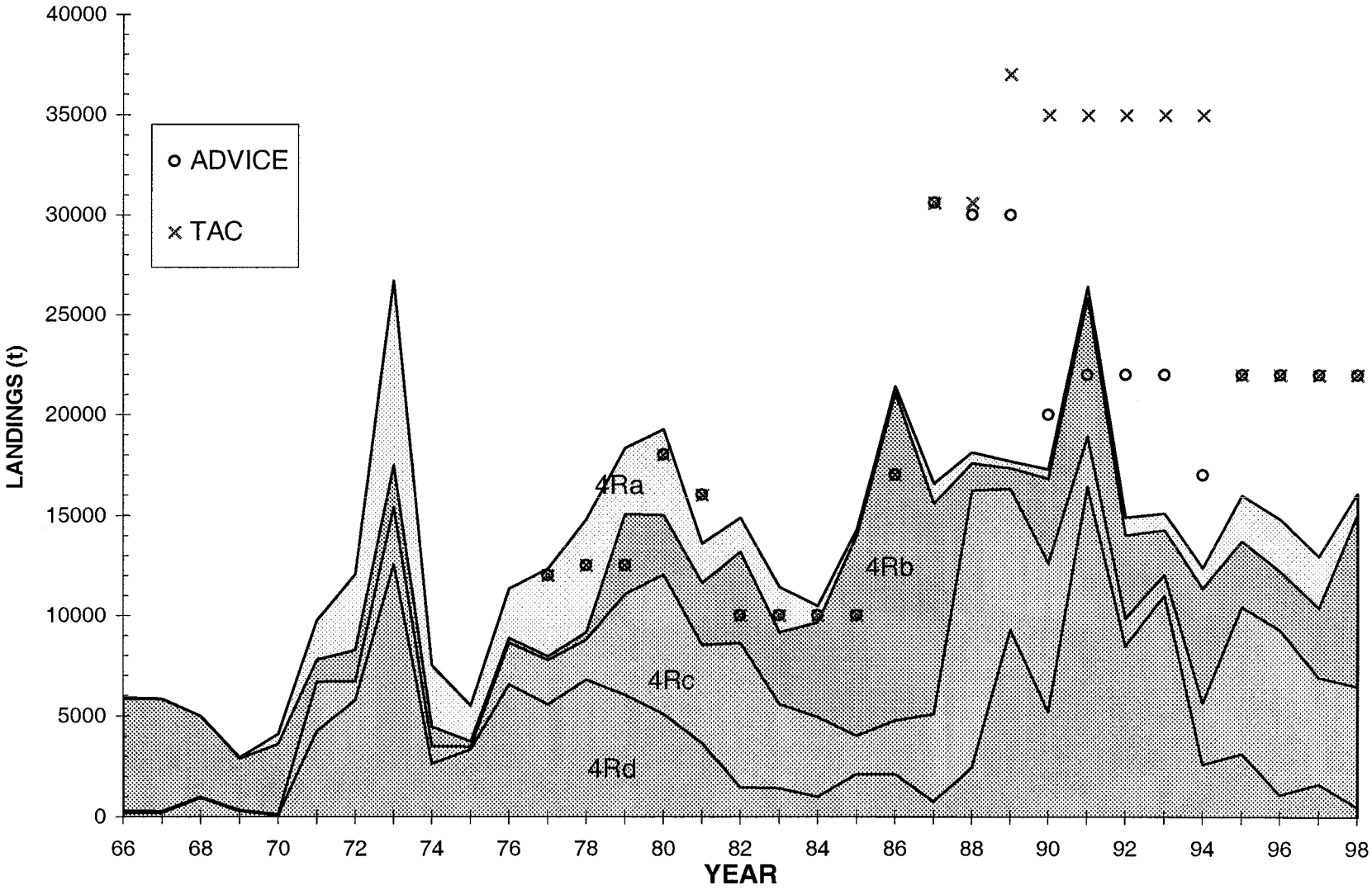

Figure 3. Cumulative commercial herring landings (t) by unit area in NAFO Division 4R from 1966 to 1998. (The advised catch level from the assessments and the final TAC are indicated).

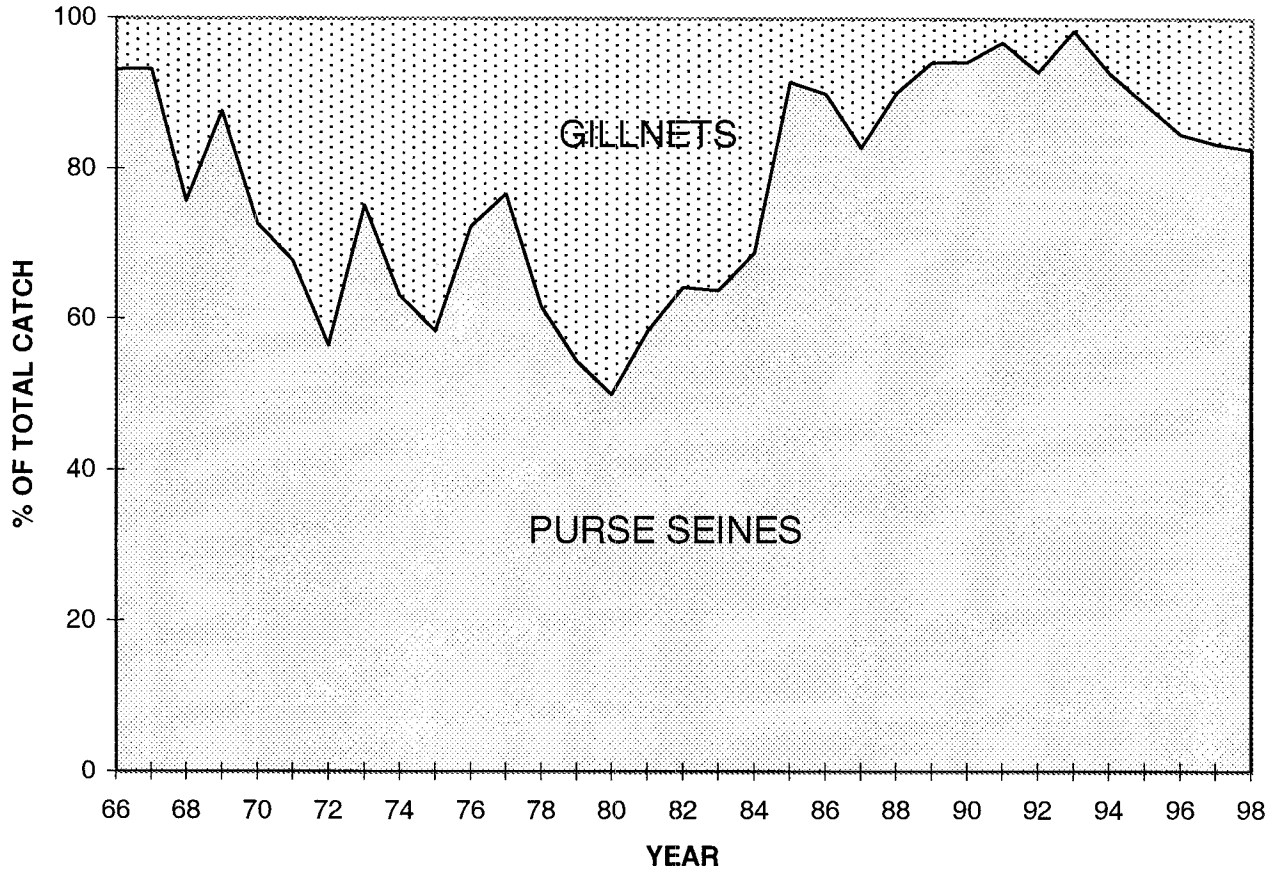

Figure 4. Proportion of total herring landings taken by gillnets and purse seiners in NAFO Division 4R from 1966 to 1998.

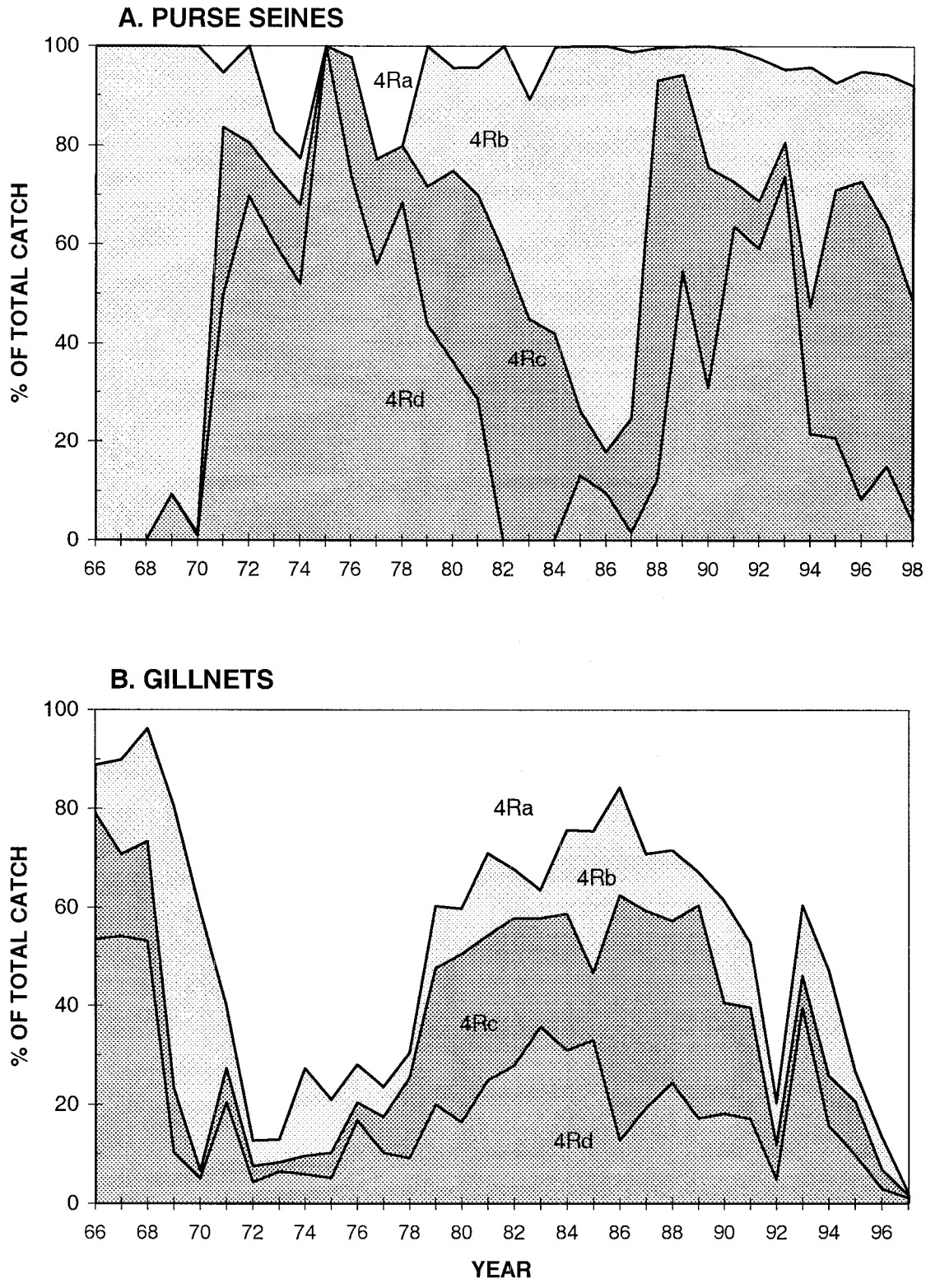

Figure 5. Proportion of purse seine (A) and gillnet (B) herring landings by fishing area in NAFO Division 4R from 1966 to 1997 for gillnets and to 1998 for purse seine.

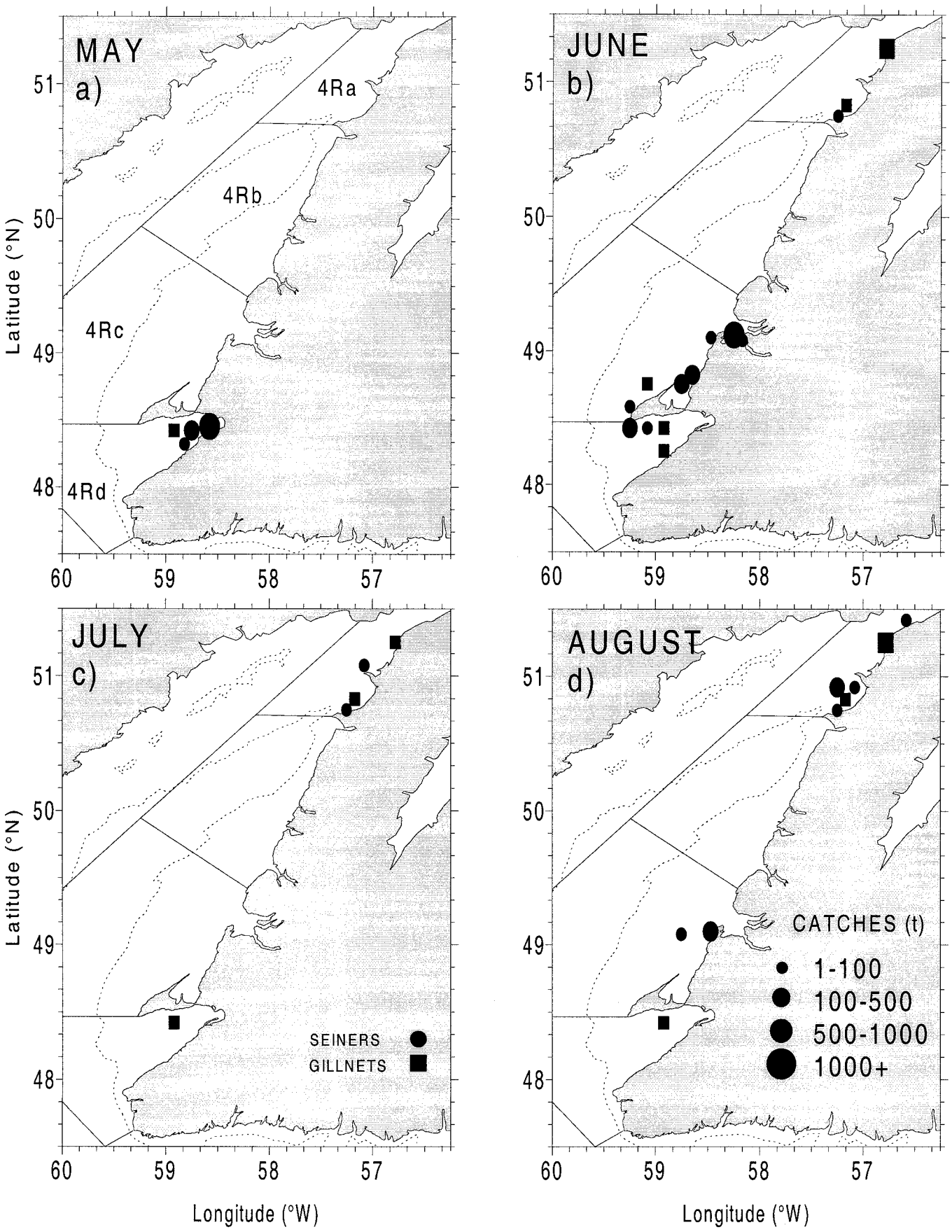

Figure 6a. Monthly distribution of purse seine and gillnet herring catches by 10-minute squares in NAFO division 4R in 1997.

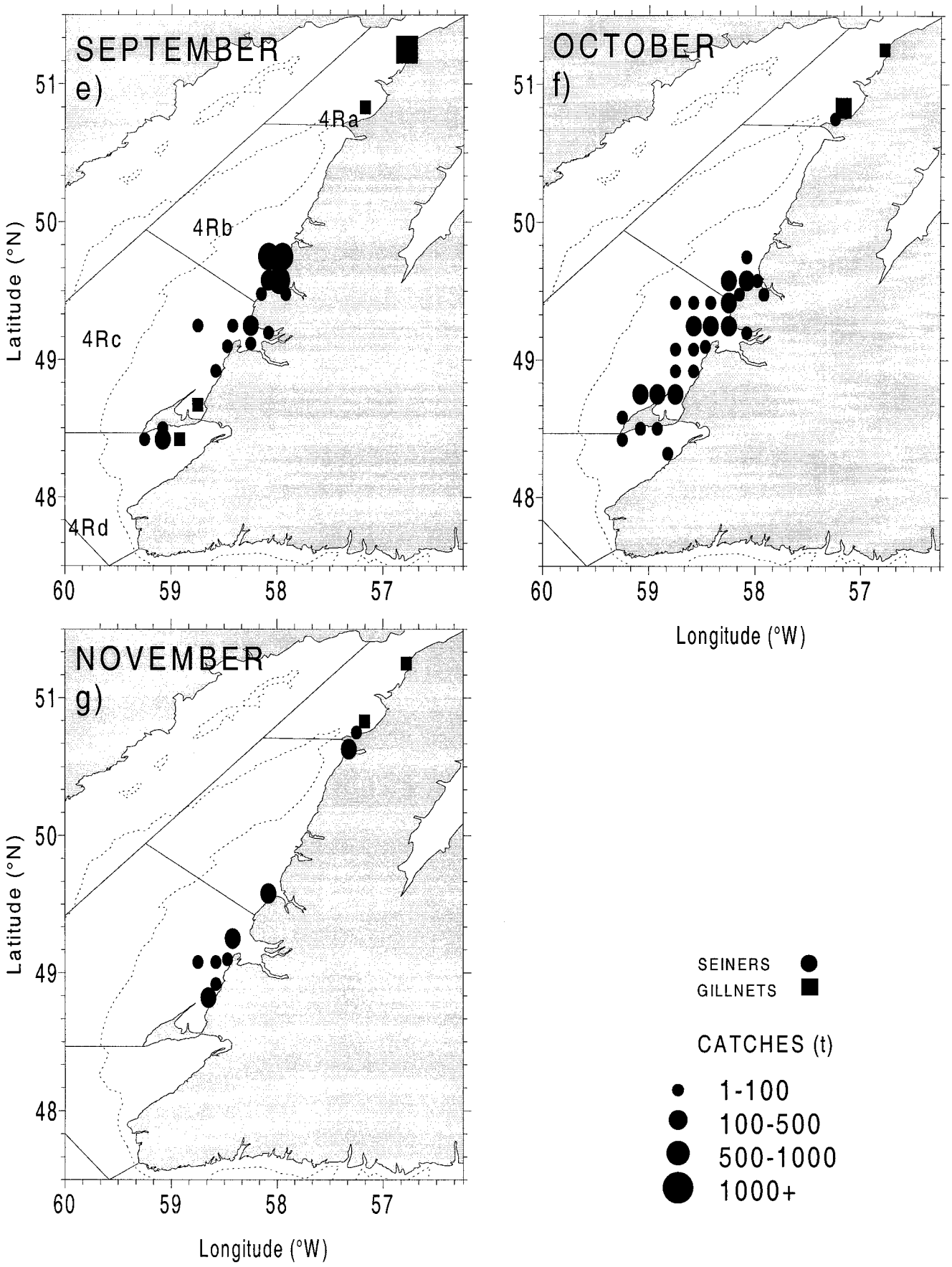

Figure 6b. Monthly distribution of purse seine and gillnet herring catch by 10-minute squares in NAFO division 4R in 1997.

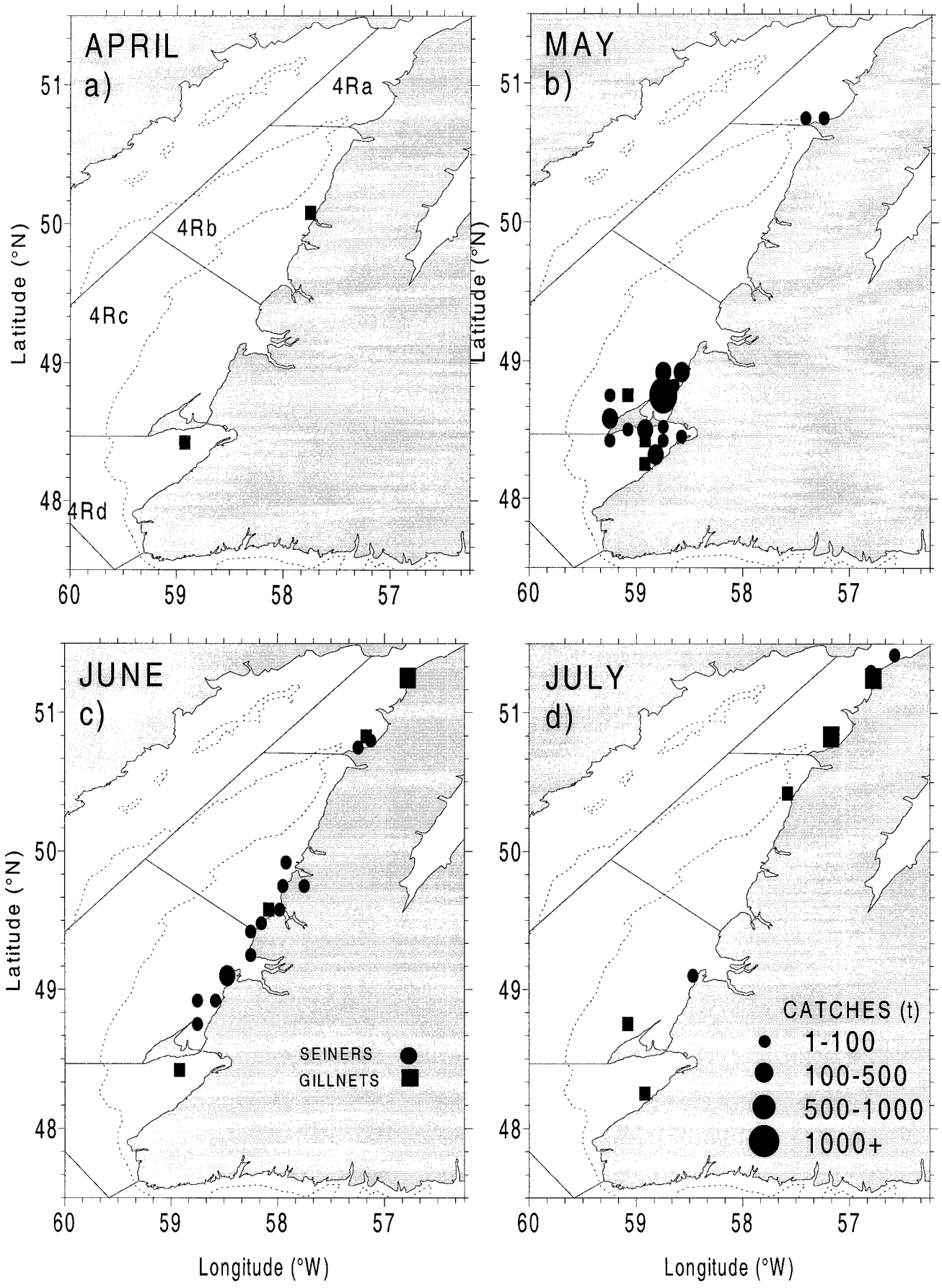

Figure 7a. Monthly distribution of purse seine and gillnet herring catch by 10-minute squares in NAFO division 4R in 1998.

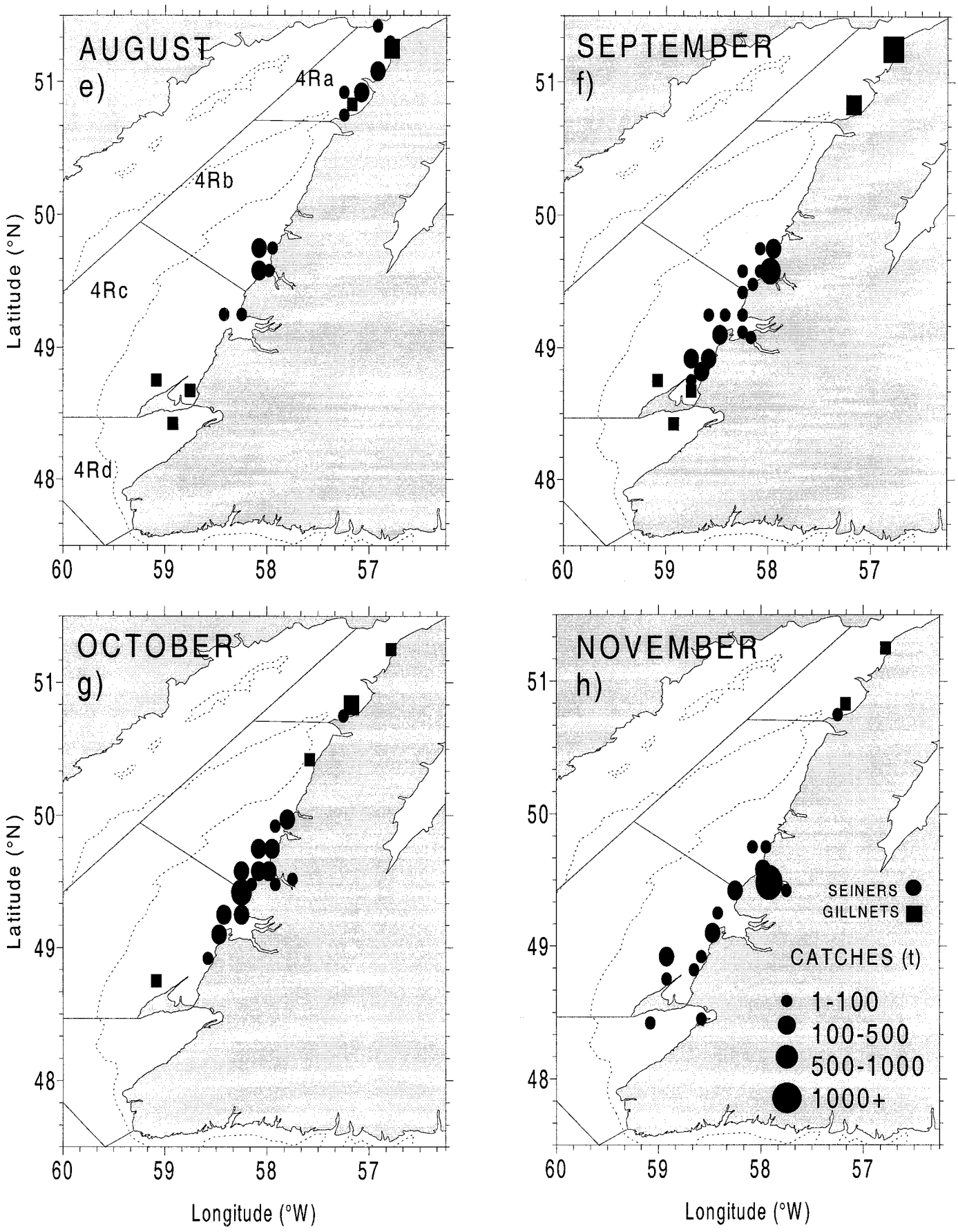

Figure 7b. Monthly distribution of purse seine and gillnet herring catch by 10-minute squares in NAFO division 4R in 1998.

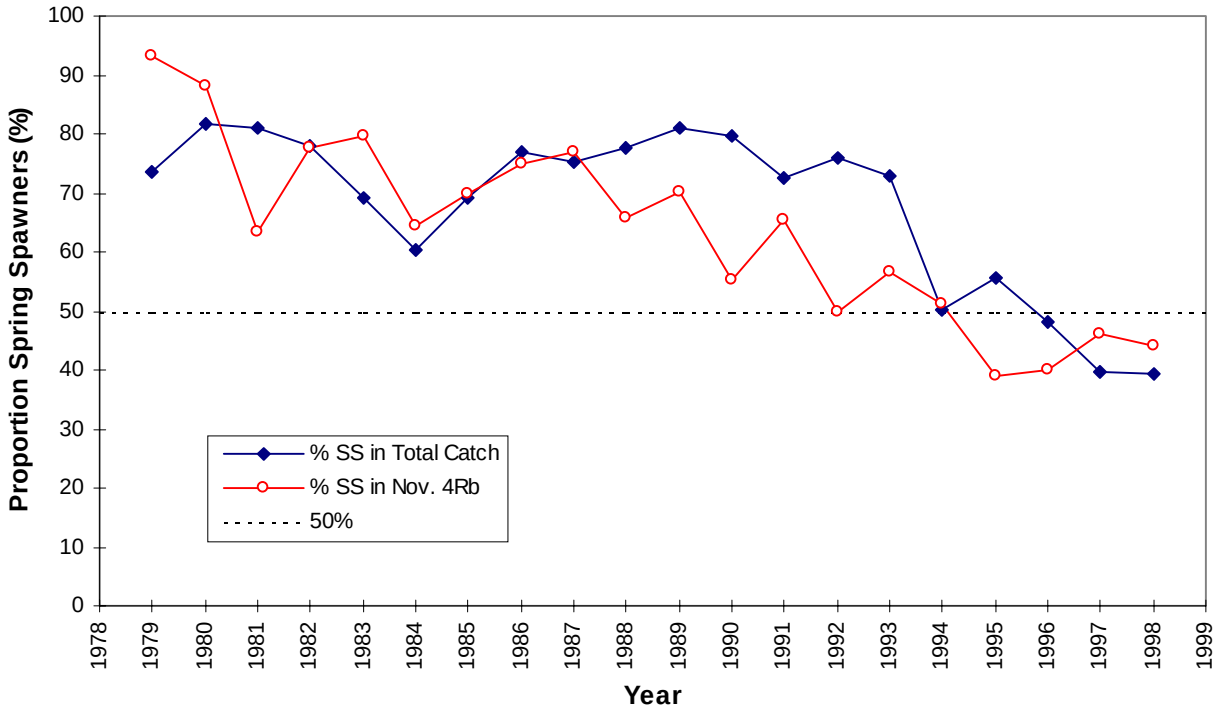

Figure 8. Proportion of spring-spawning herring in the total catch and in November catches in subarea 4Rb from 1979 to 1998.

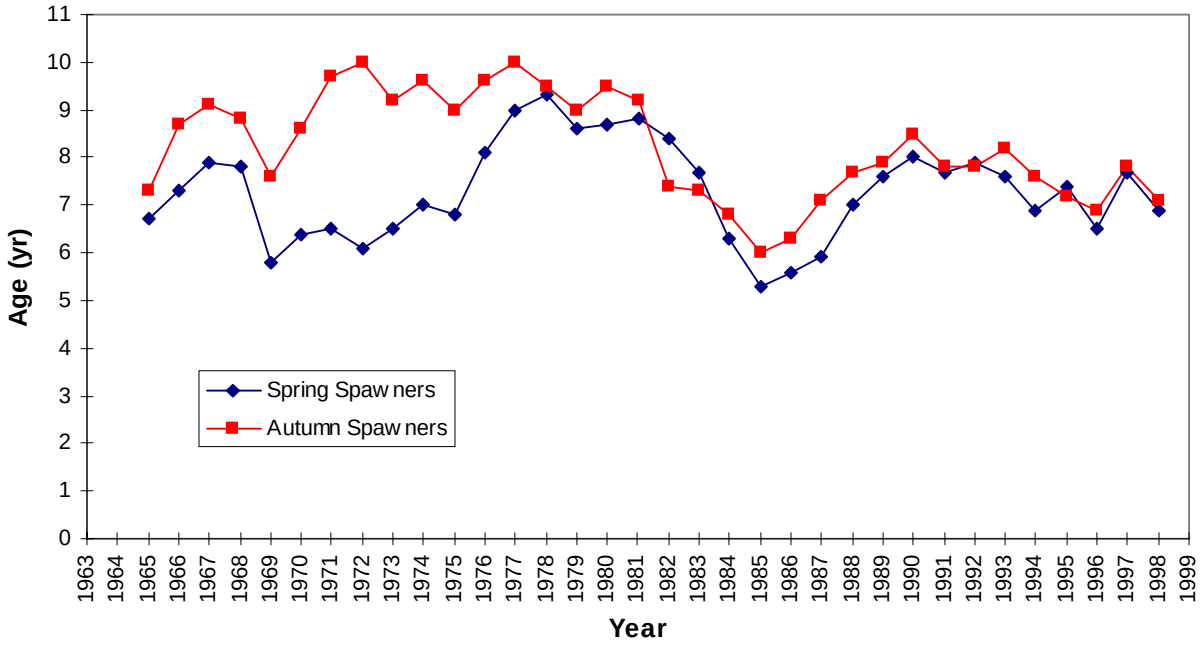

Figure 9. Mean age of spring- and autumn-spawning herring in NAFO division 4R herring landings from 1965 to 1998.

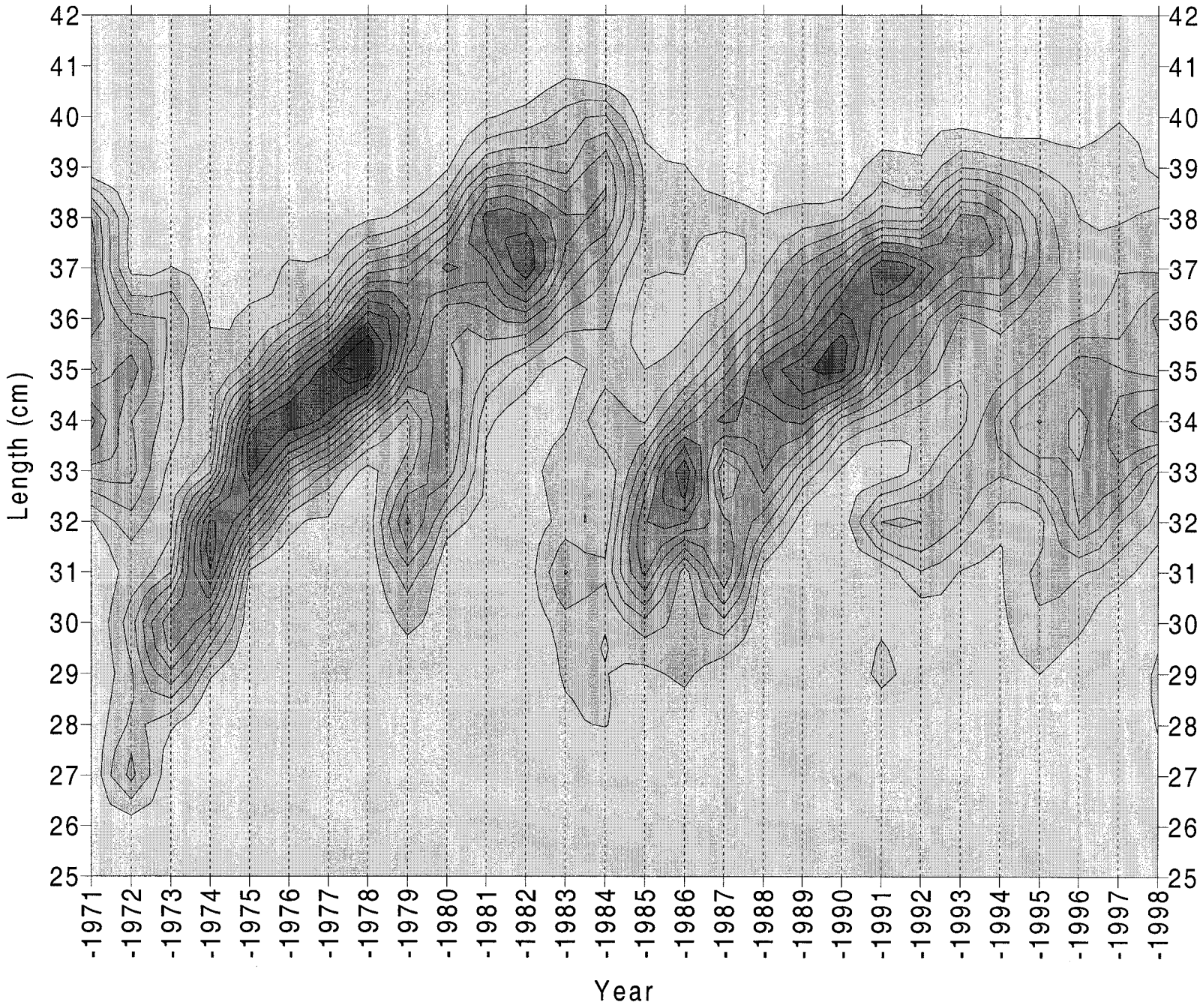

Figure 10a. Length frequency density contours of spring-spawning herring caught by purse seine in the spring fishery in 4Rcd between 1971 and 1998.

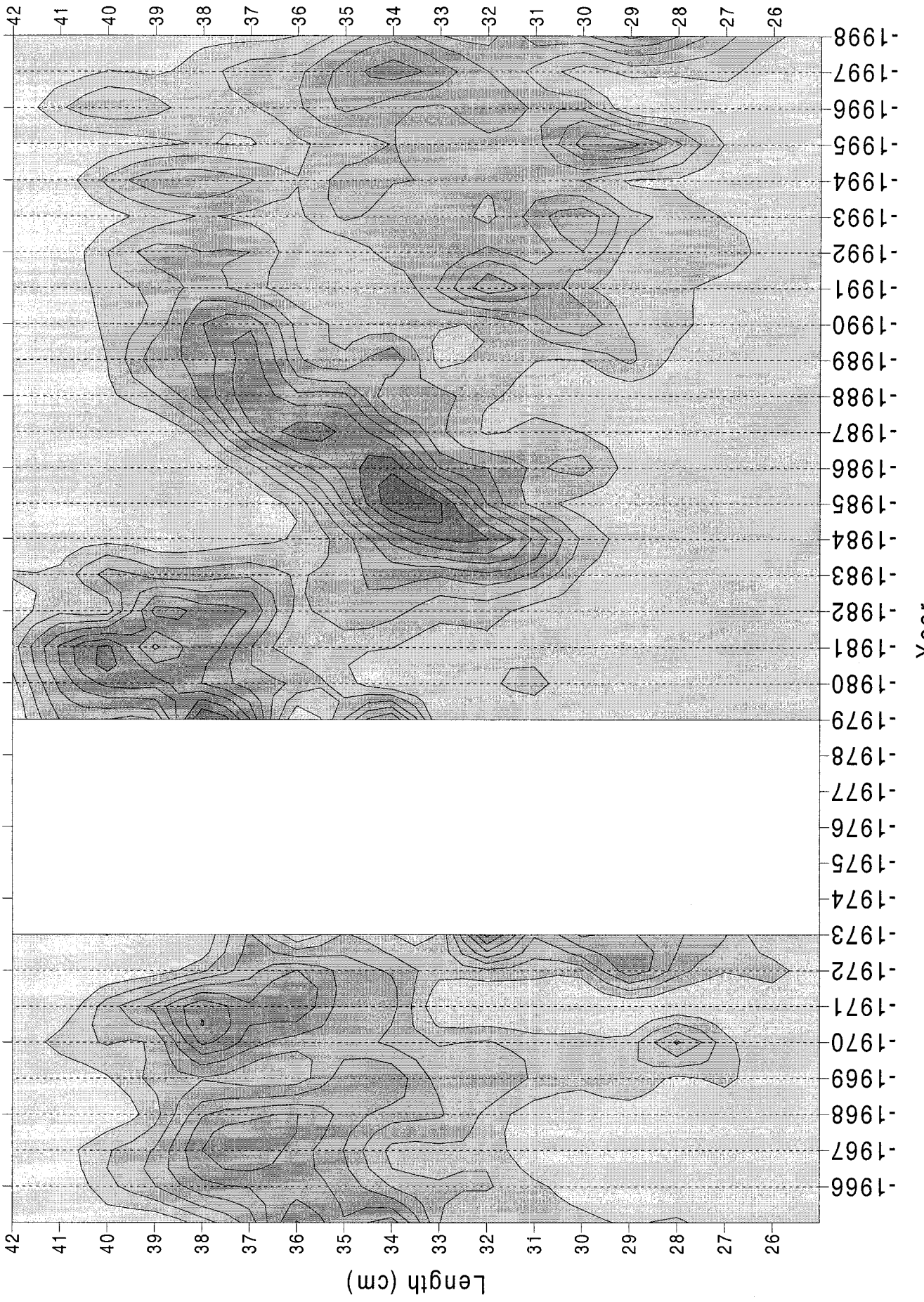

Figure 10b. Length frequency density contours of autumn-spawning herring caught by purse seine in the fall fishery in 4Rb between 1965 and 1999.

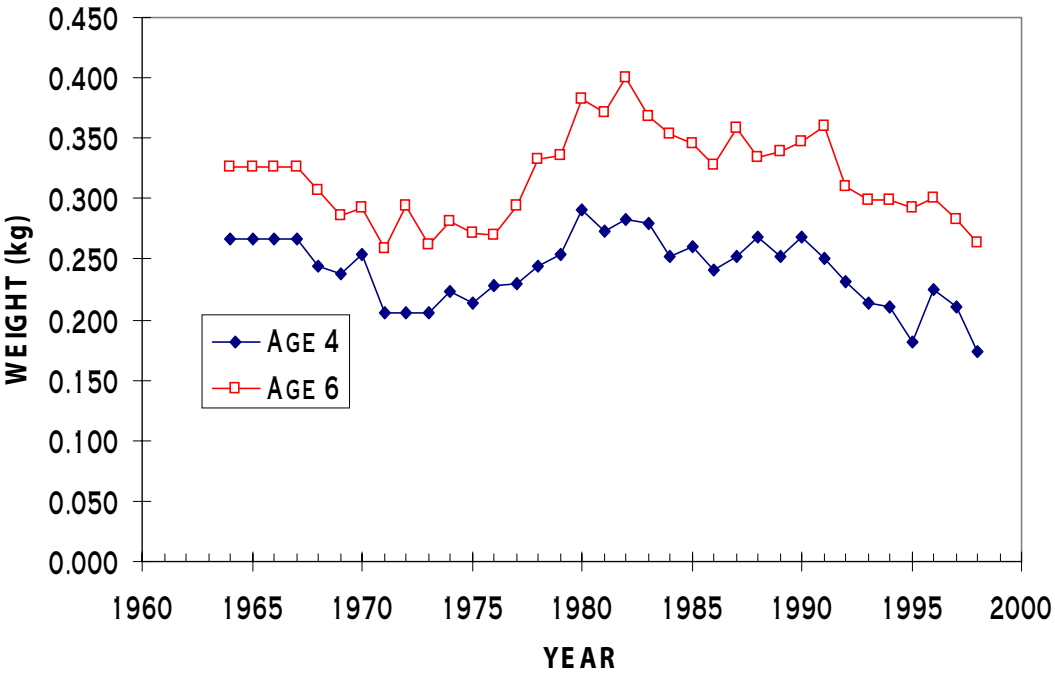

Figure 11a. Mean weight of spring-spawning herring at ages 4 and 6 from 1964 to 1998.

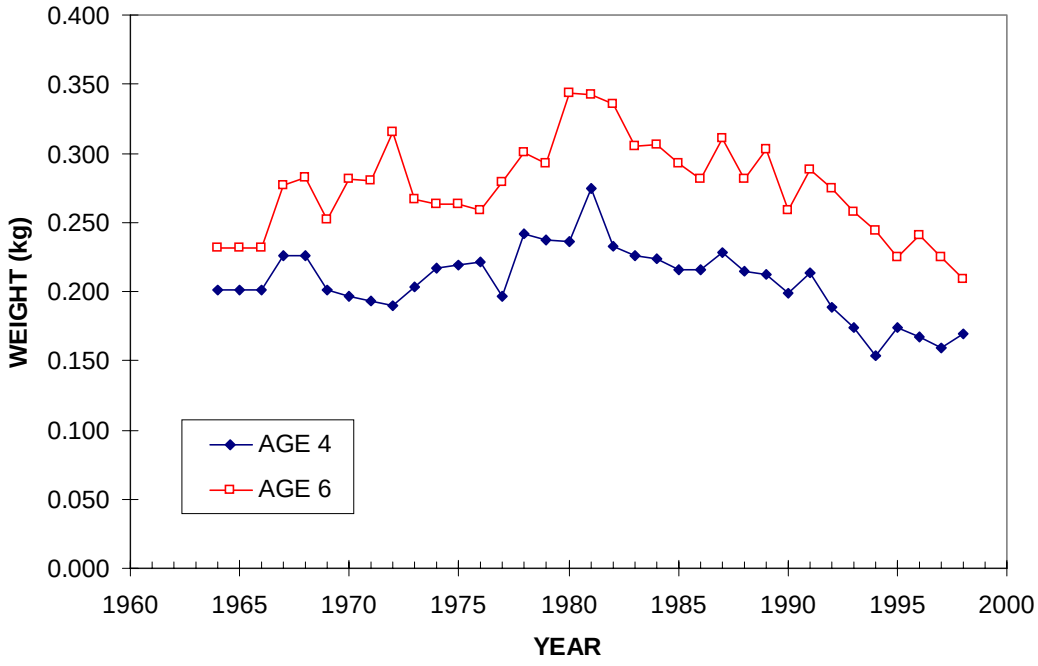

Figure 11b. Mean weight of autumn-spawning herring at ages 4 and 6 from 1964 to 1998.

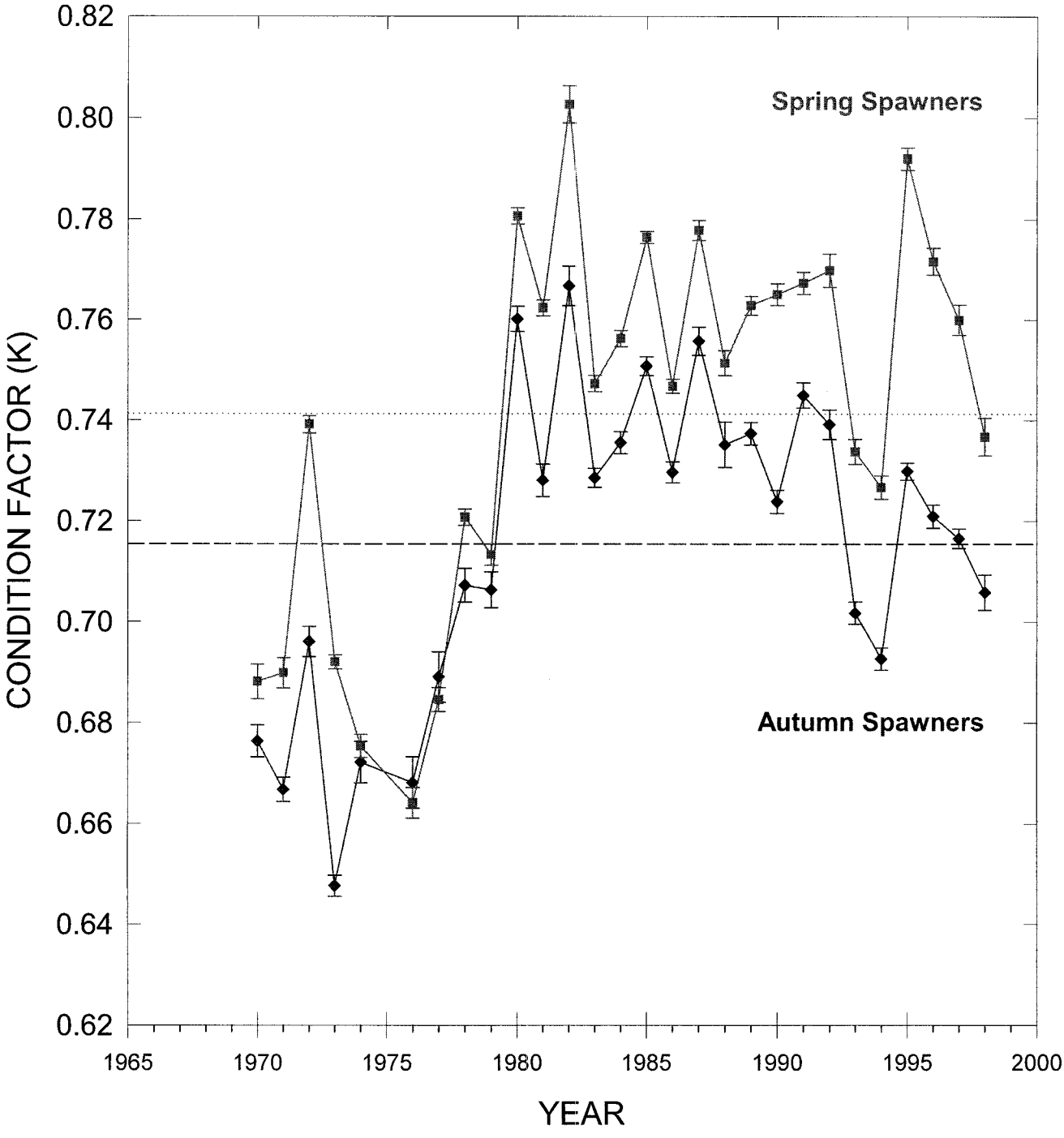

Figure 12. Mean condition factor (Fulton's K) and standard error for spring- and autumn-spawning 4R herring in late fall (Oct-Dec) from 1970 to 1998.

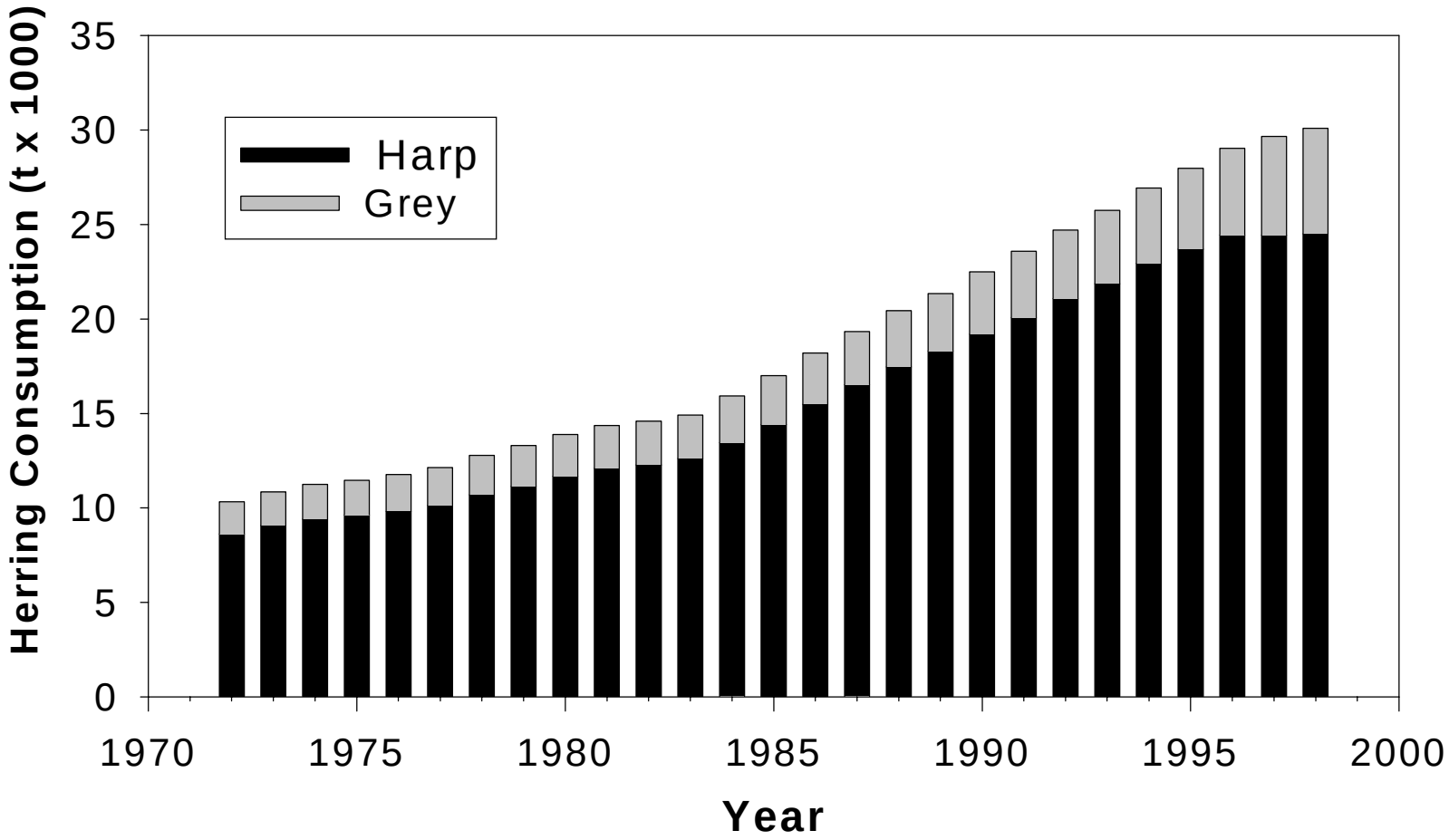

Figure 13. Estimated annual herring consumption by harp and grey seals between 1972 and 1998 in NAFO Division 4RS.

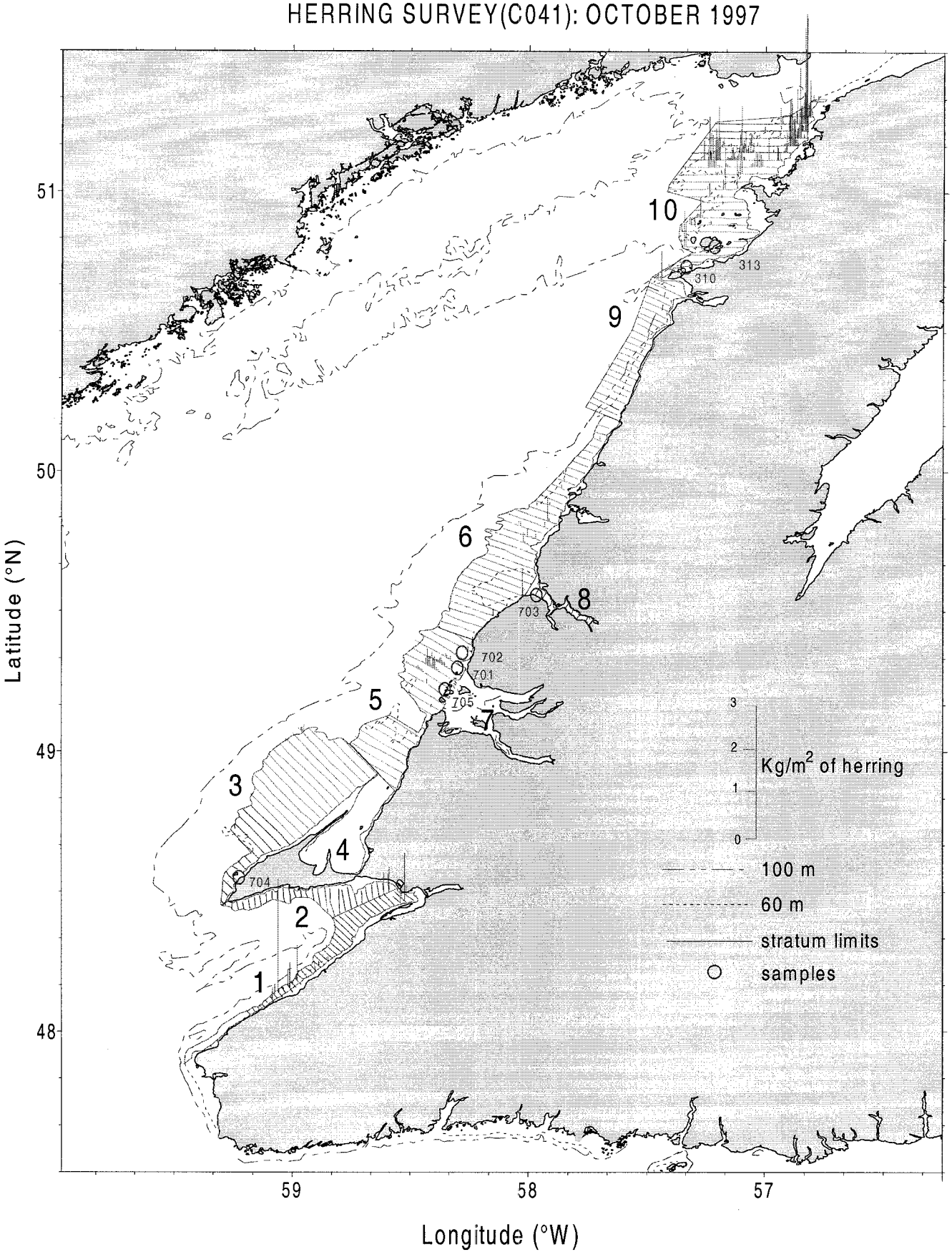

Figure 14. Distribution of herring density (kg/m^2) along the west coast of Newfoundland in October, 1997 (stratum numbers and completed transects are indicated).

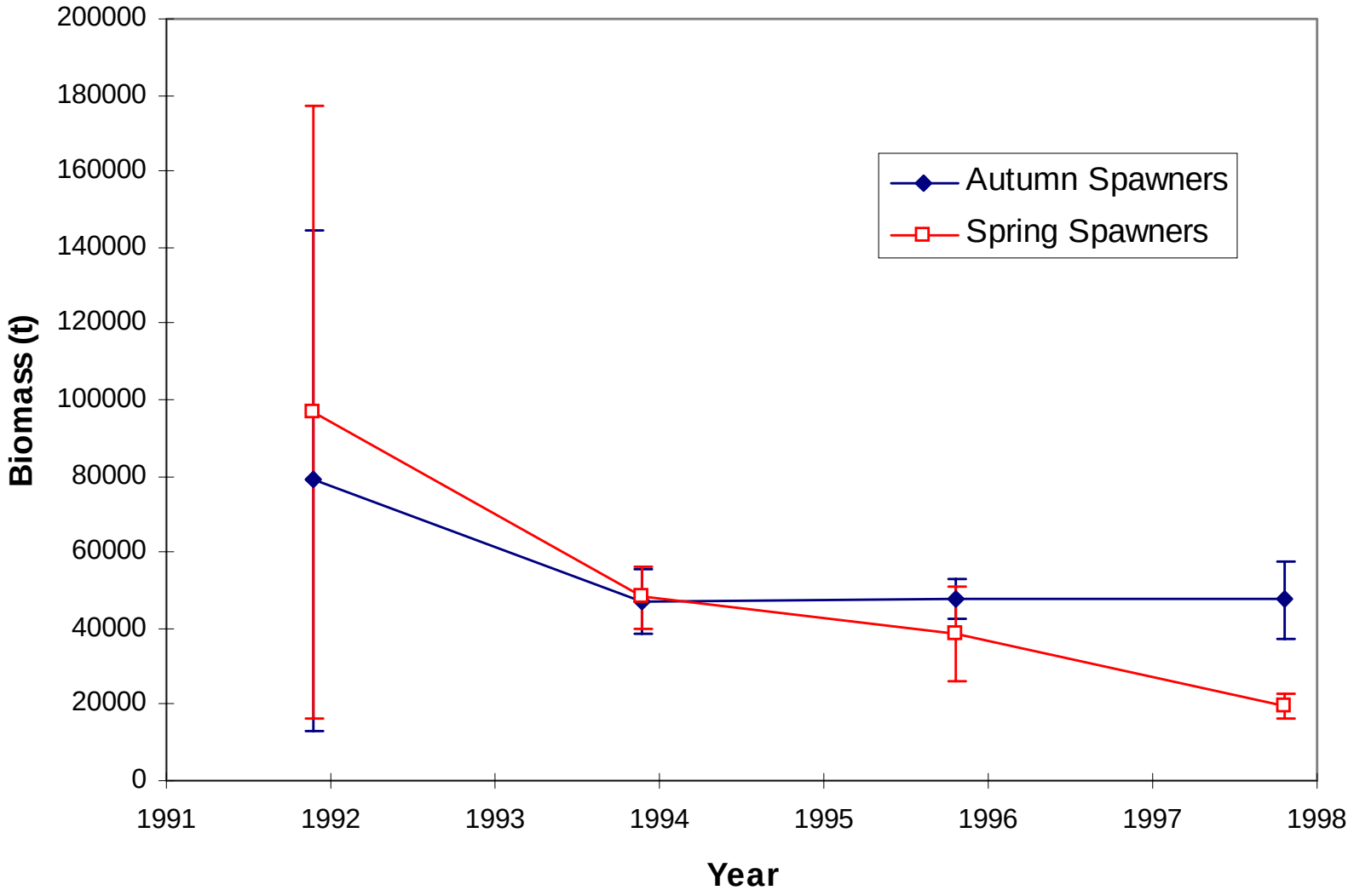

Figure 15. Spawning-stock biomass estimates and 95% confidence intervals for spring- and autumn-spawning herring in NAFO division 4R from 1991 to 1997 from the biennial acoustic survey.

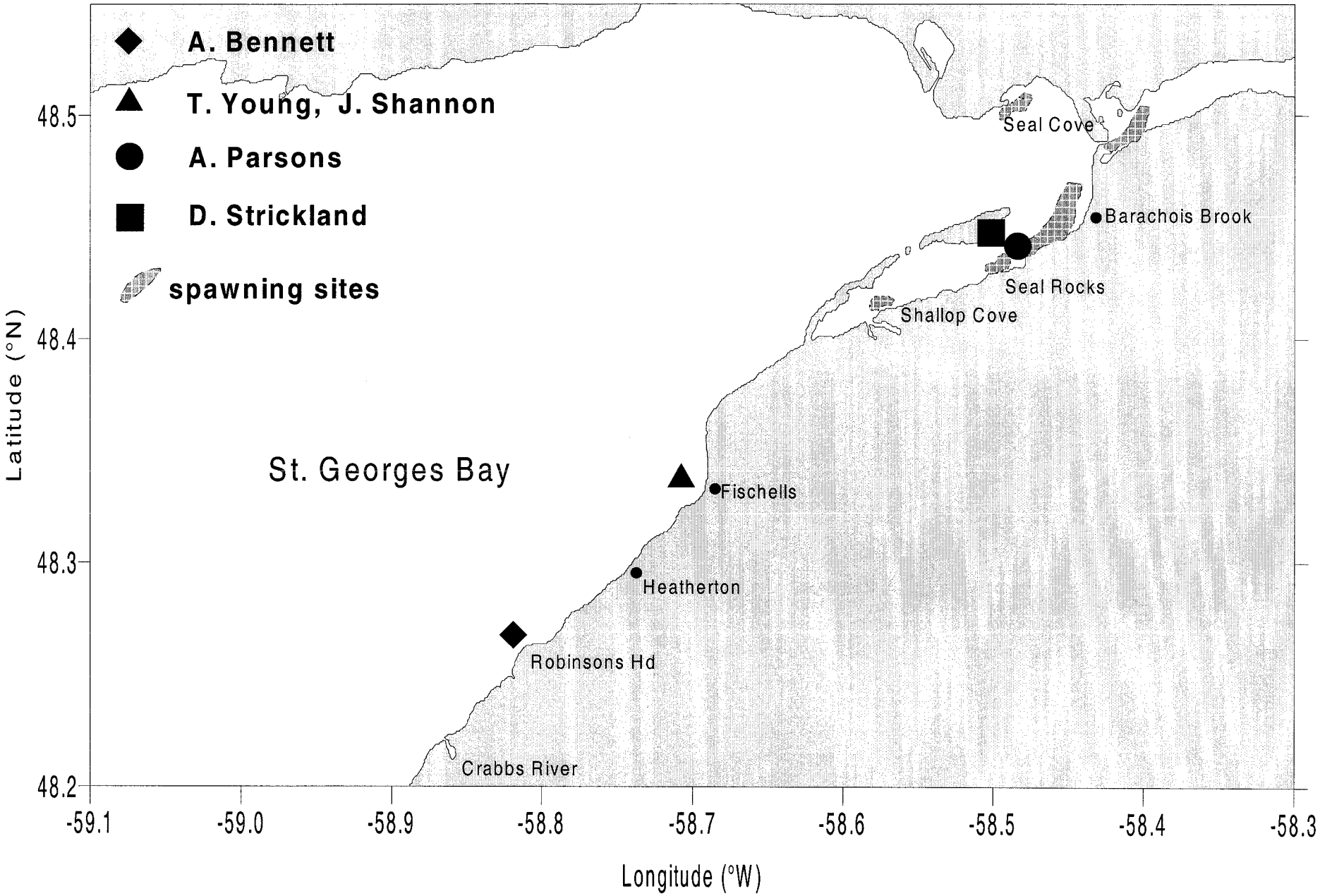

Figure 16. Location of the main spawning sites of spring herring and the fishing sites of index fishermen in and around St. Georges Bay.

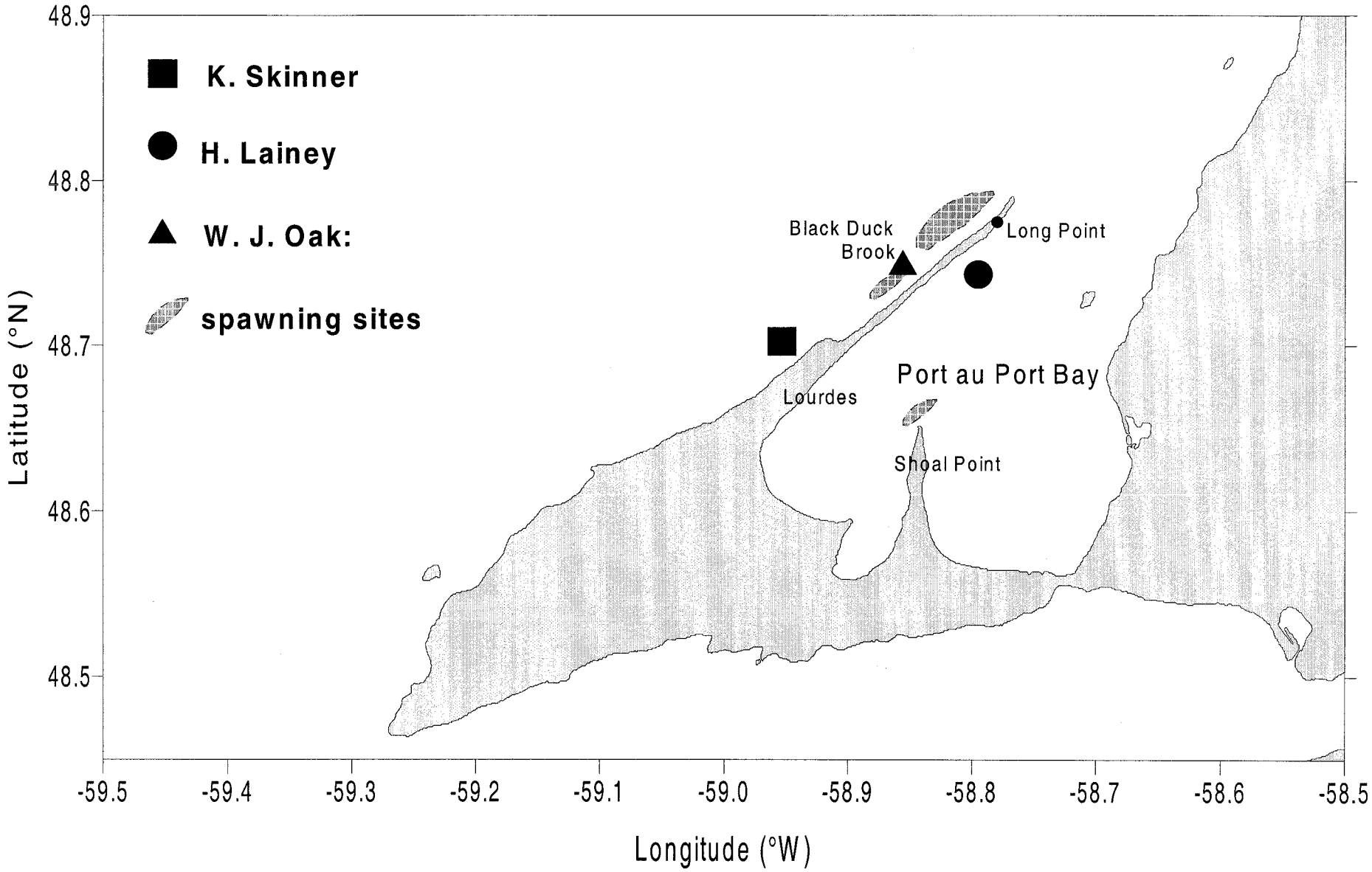

Figure 17. Location of the main spawning sites of spring herring and the fishing sites of index fishermen in and around Port au Port Bay.

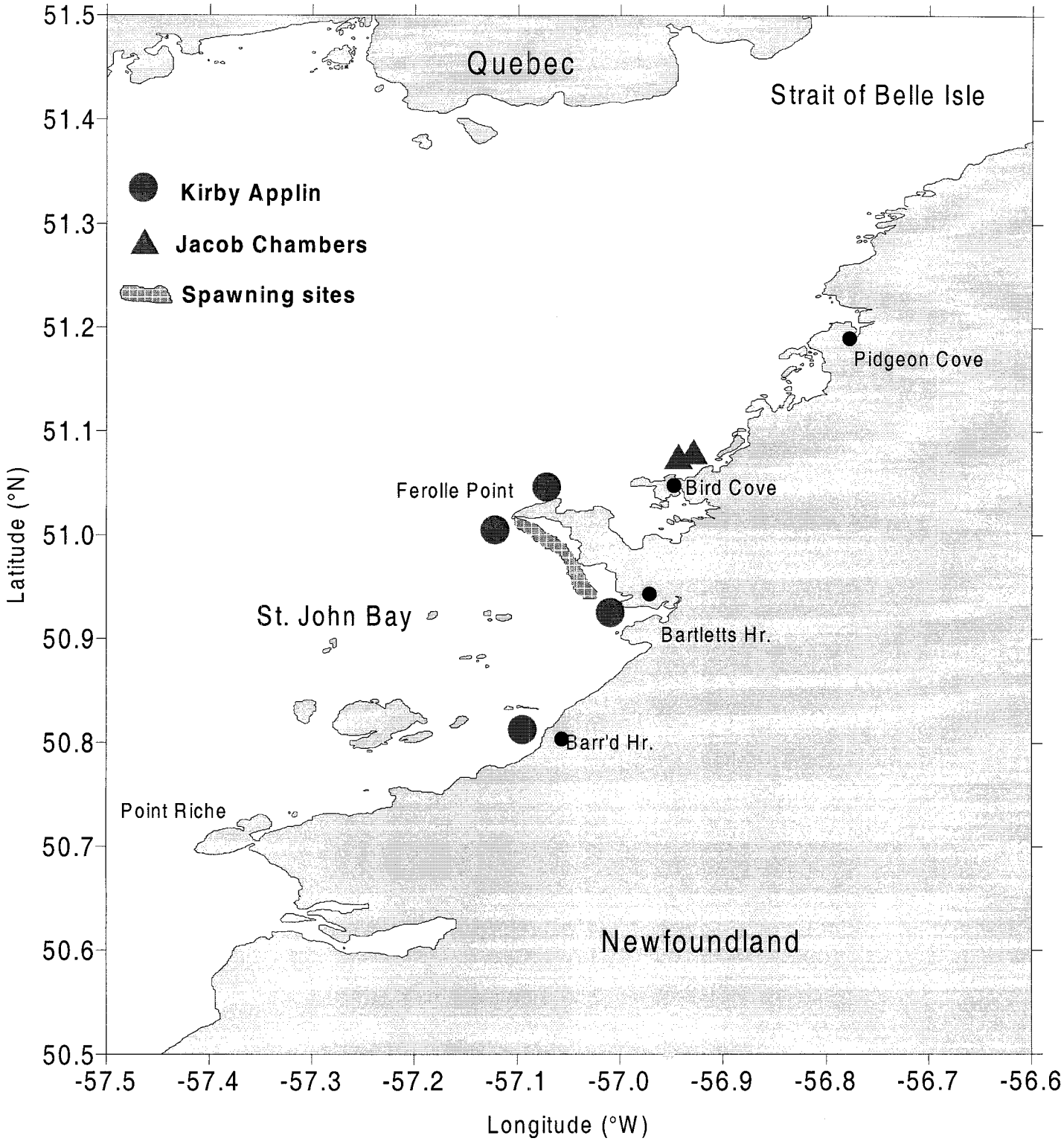

Figure 18. Location of the main spawning sites of fall herring and the fishing sites of index fishermen in and around St. John Bay.

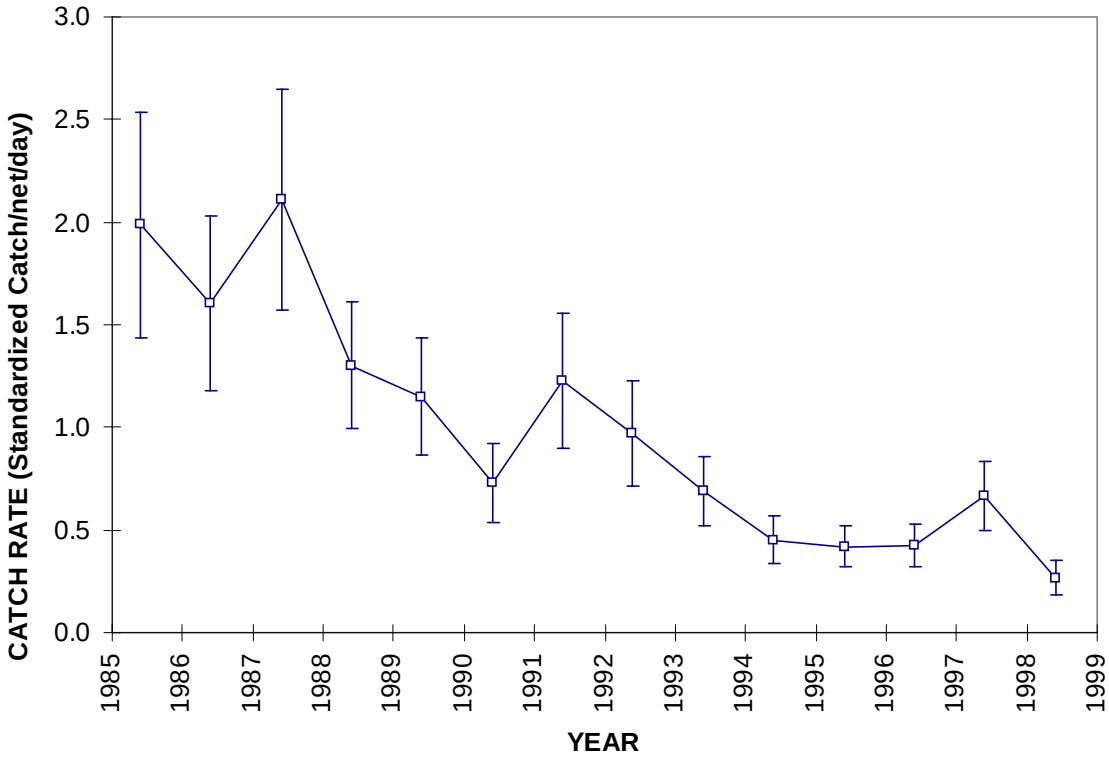

Figure 19. Standardized catch rates and 95% confidence intervals for spring-spawning herring from index-fisherman logbooks between 1985 and 1998.

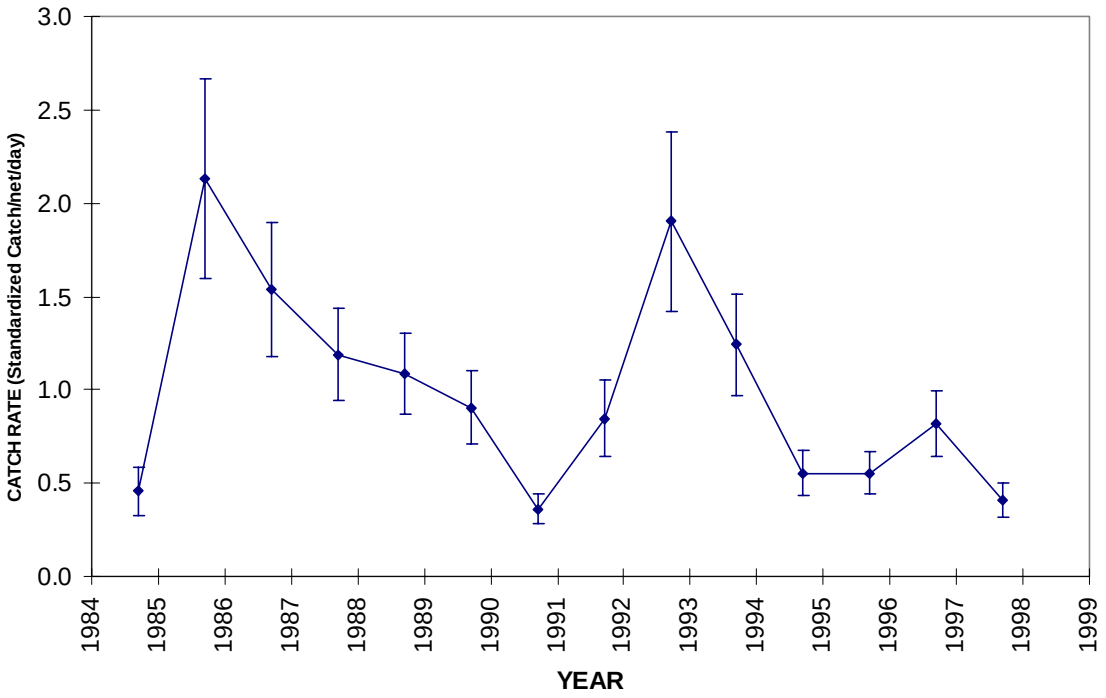

Figure 20. Standardized catch rates and 95% confidence intervals for autumn-spawning herring from index-fisherman logbooks between 1984 and 1997.

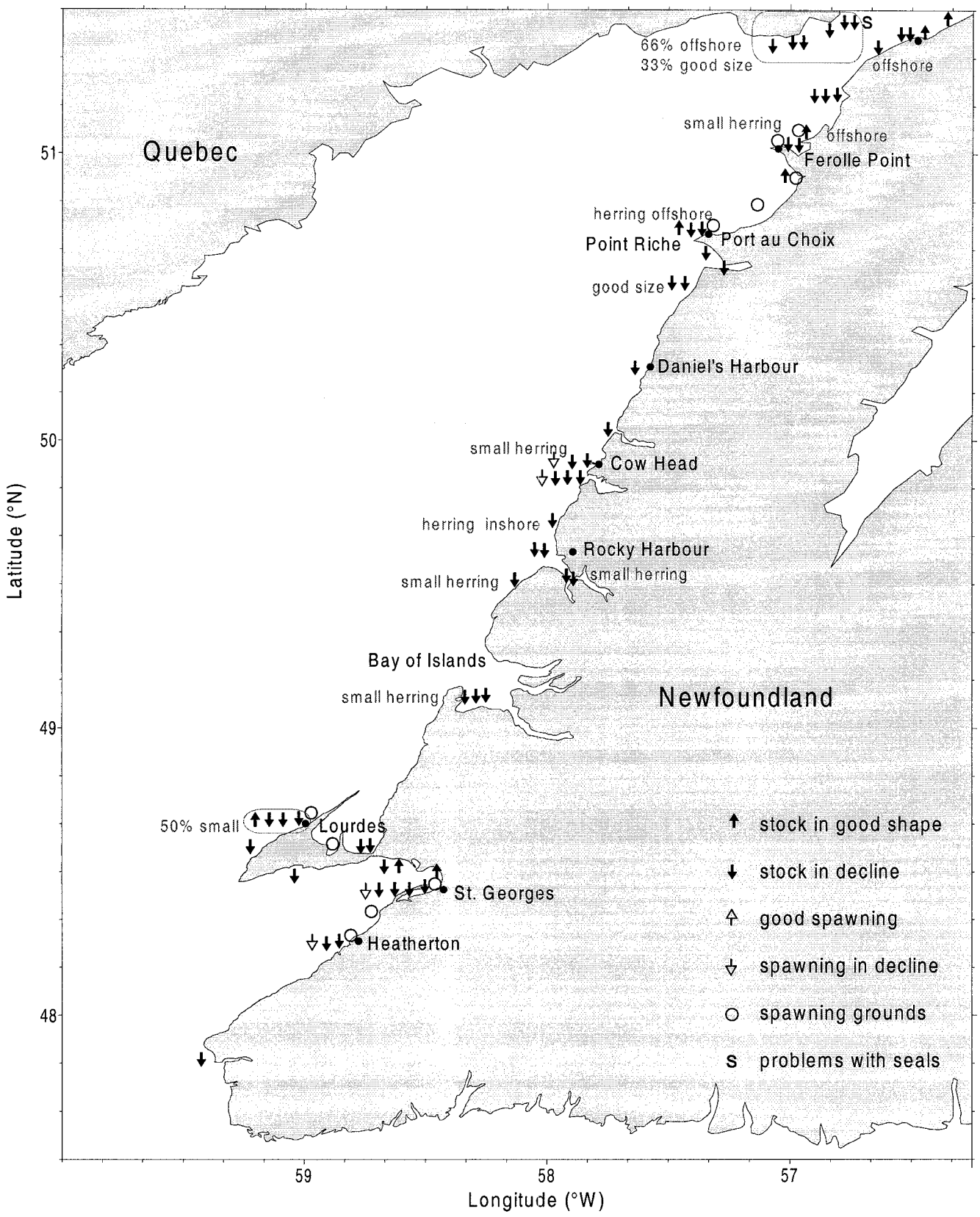

Figure 21. Distribution of inshore fishermen's opinions concerning the state of herring stocks and spawning in NAFO division 4R from 1997 written questionnaires.

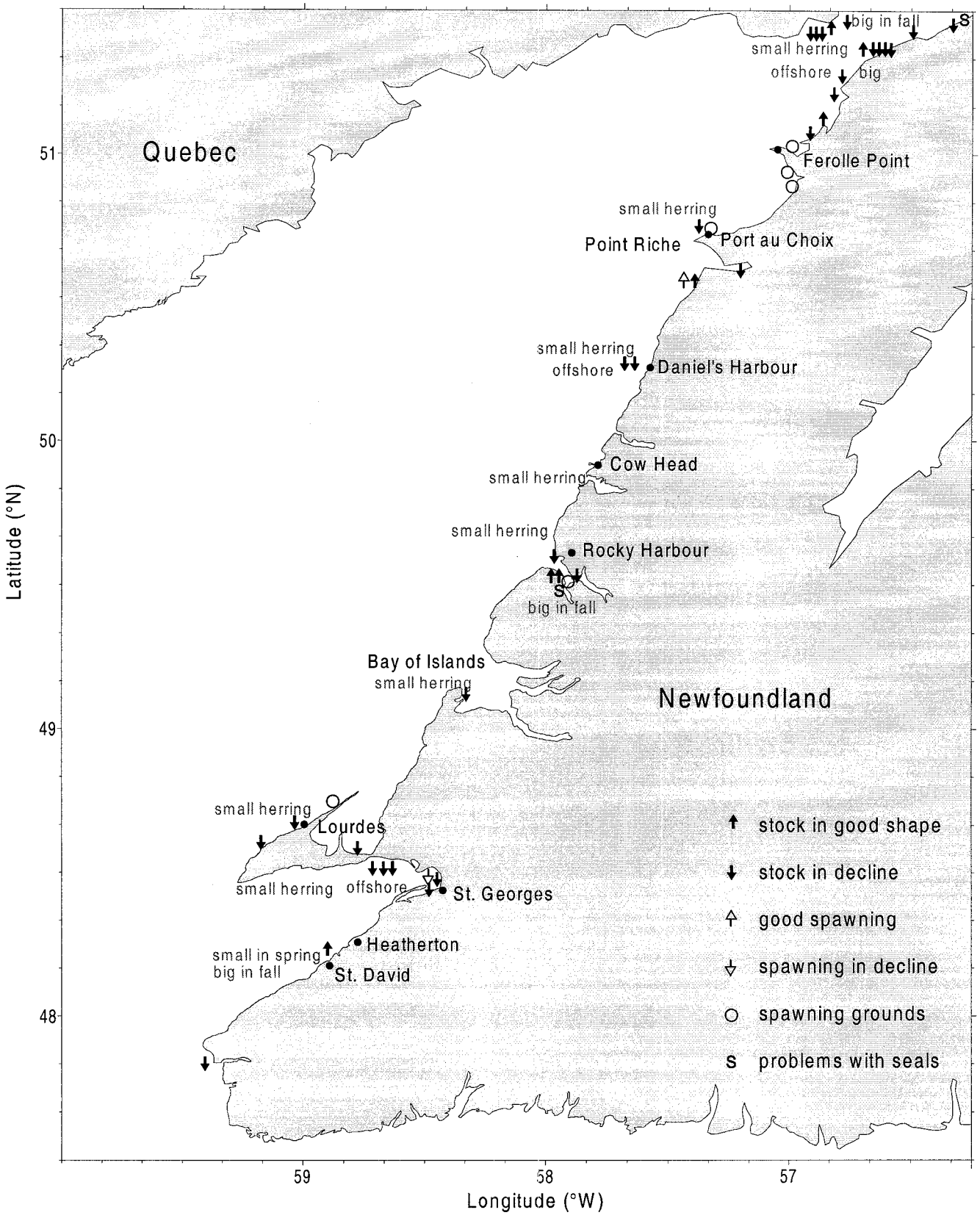

Figure 22. Distribution of inshore fishermen's opinions concerning the state of herring stocks and spawning in NAFO division 4R from 1998 written questionnaires.

Figure 23. Retrospective analysis of the SPA for spring-spawning herring from 1998 back to 1993.

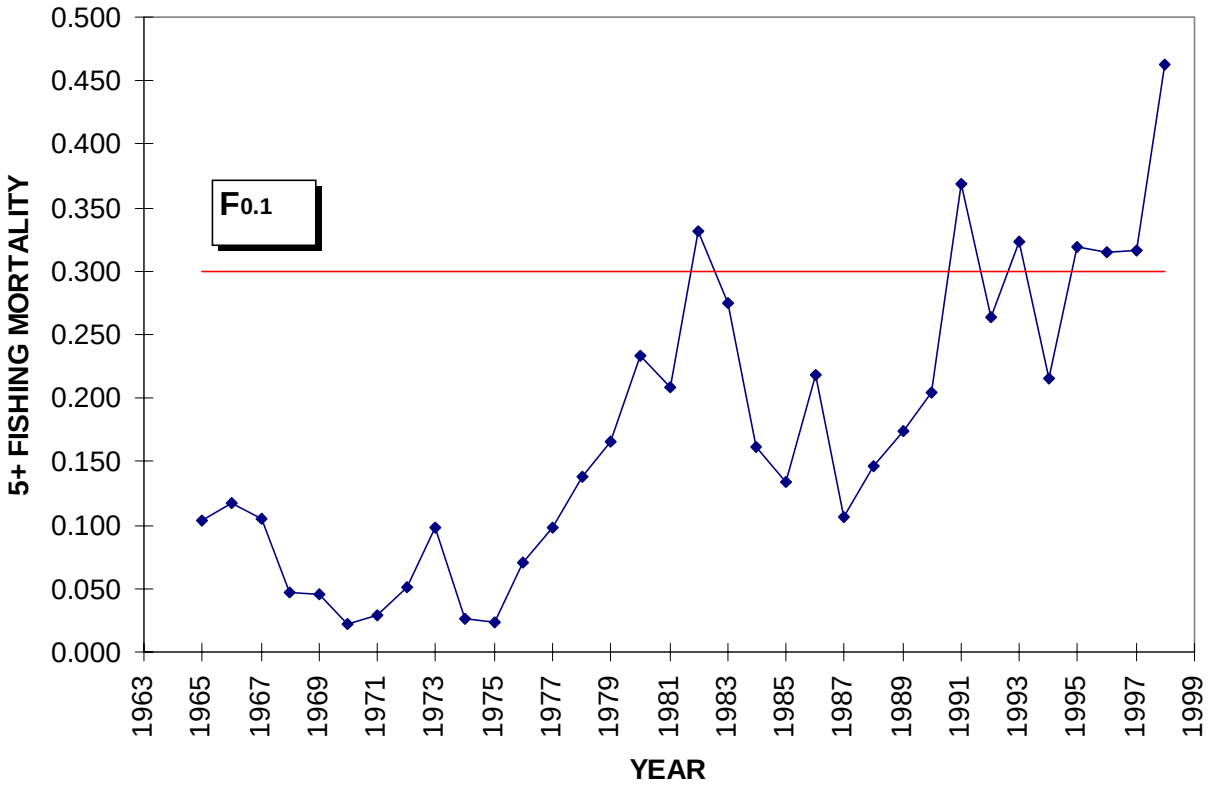

Figure 24. SPA estimates of annual instantaneous fishing mortality (5+) for spring-spawning herring from 1963 to 1998. The $F_{0.1}$ reference level is indicated.

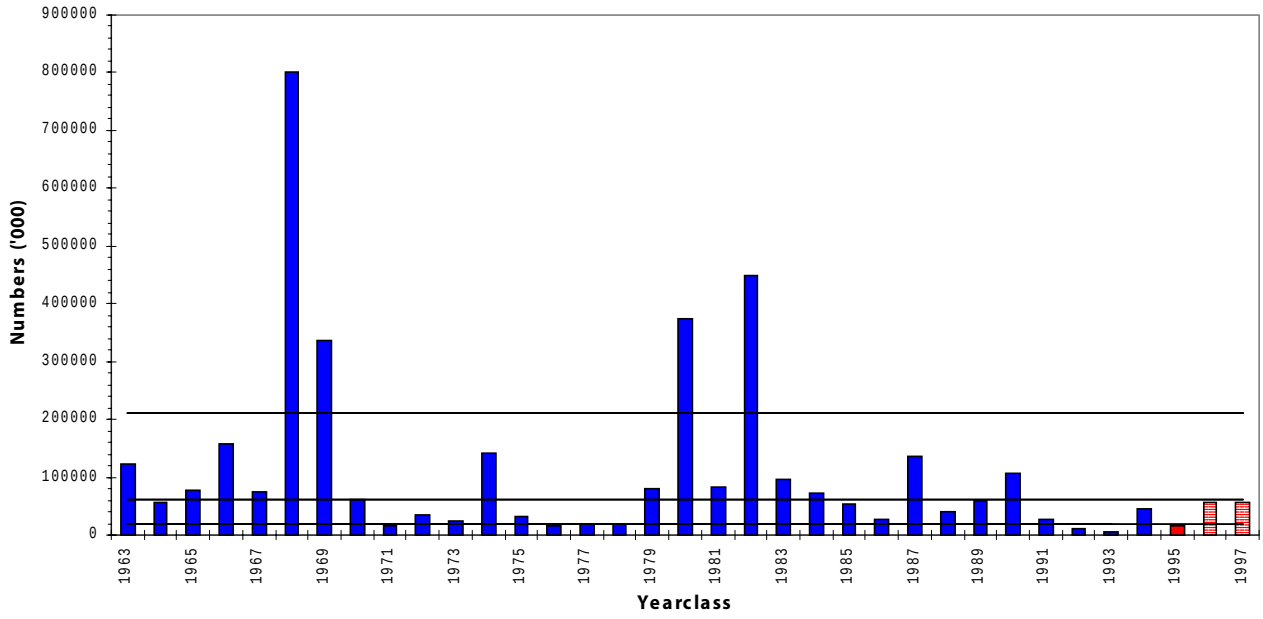

Figure 25. SPA estimates of recruitment at age 2 for spring-spawning herring for year-classes 1963 to 1994 (year-classes 1995 to 1997 are fixed at low or medium recruitment levels).

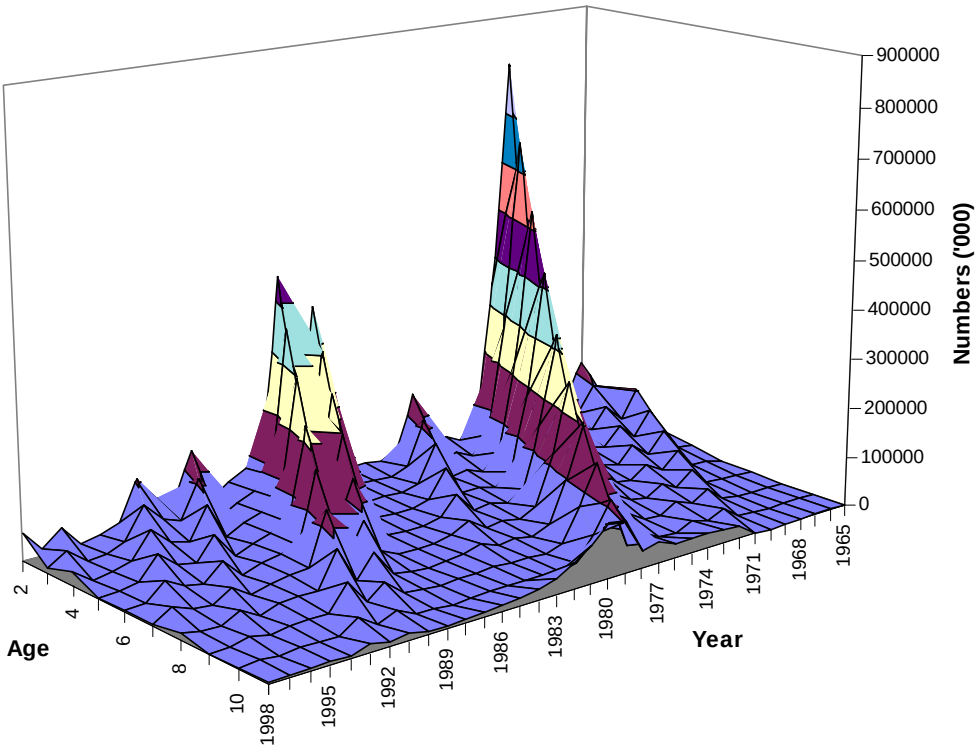

Figure 26. SPA estimates of population numbers at age for spring-spawning herring from 1965 to 1998.

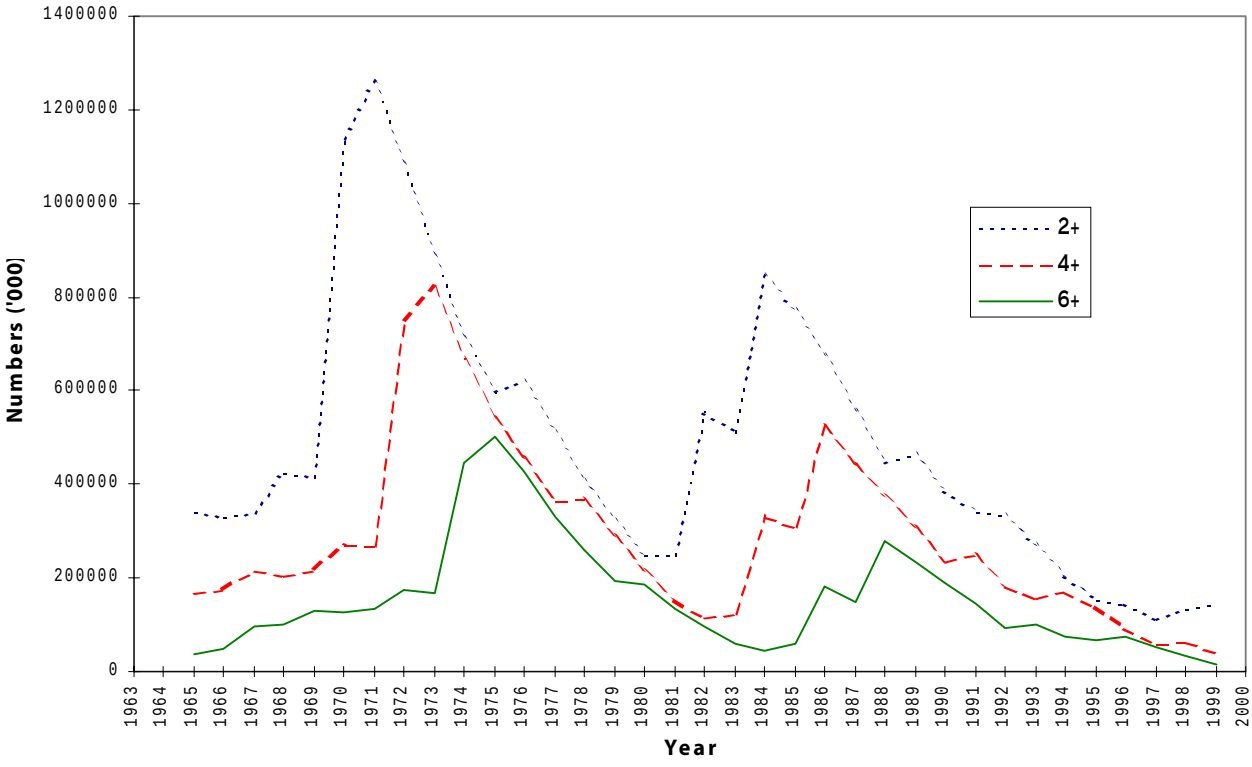

Figure 27. SPA estimates of population numbers for ages 2+, 4+ and 6+ for spring-spawning herring from 1965 to 1988.

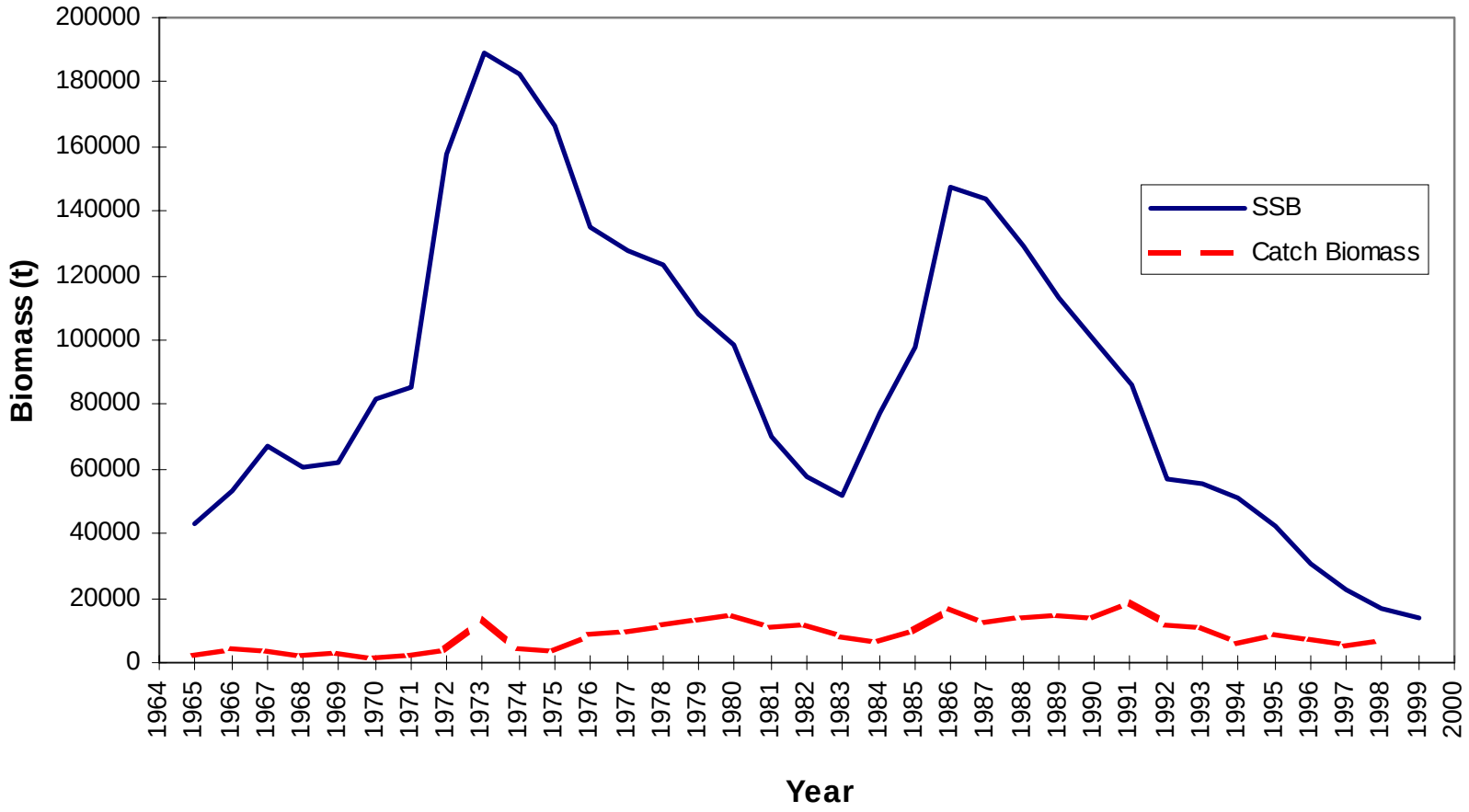

Figure 28. SPA spawning-stock biomass estimates and catch biomass for spring spawning herring from 1965 to 1999.

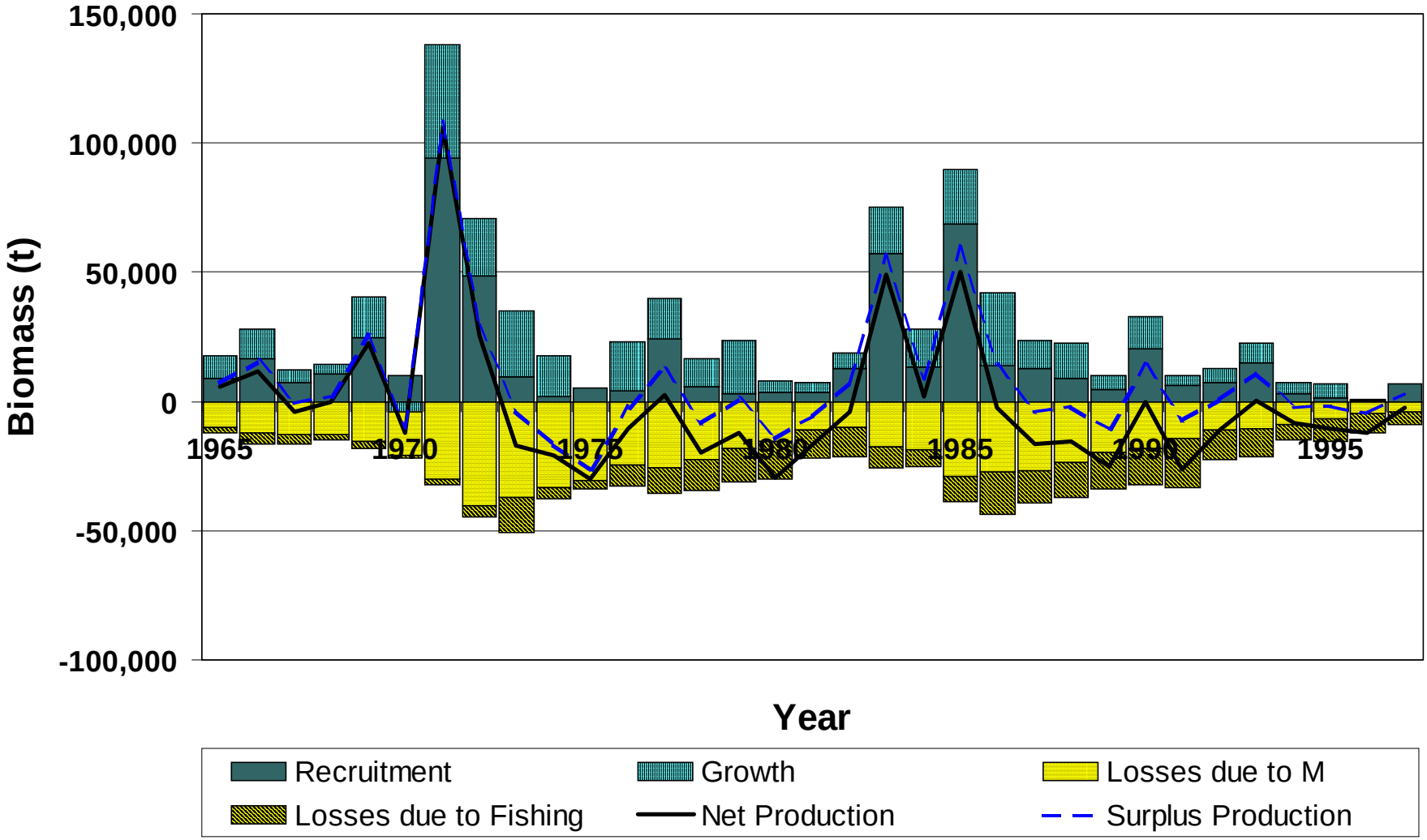

Figure 29. SPA estimates of biological production of west coast of Newfoundland spring-spawning herring from 1965 to 1997 showing gains through recruitment and growth and losses through natural mortality (M) and fishing. Surplus production (what is available to fishing) is expressed as gains minus losses due to M, and net production is expressed as surplus production minus losses due to fishing.

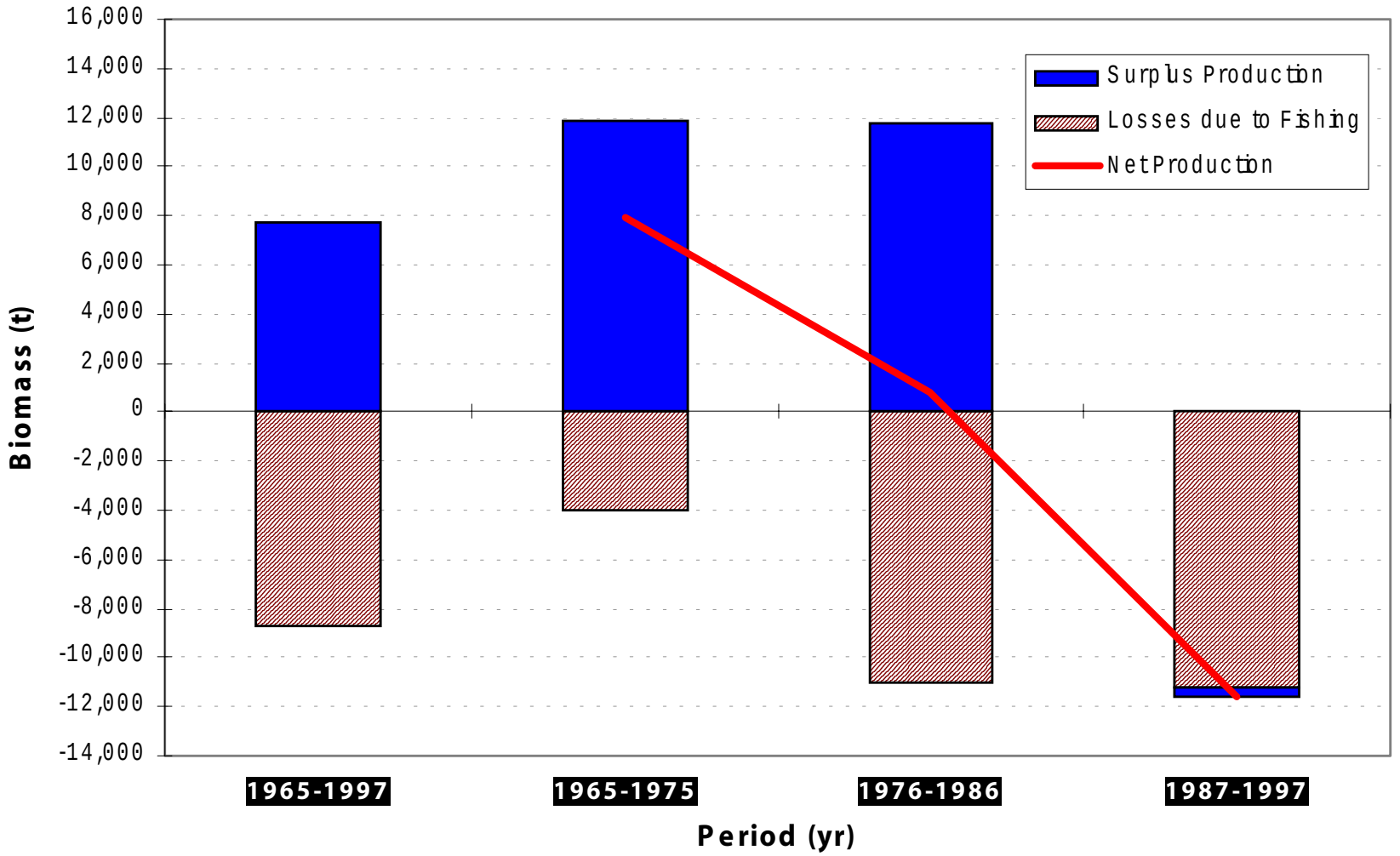

Figure 30. SPA estimates of biological production of west coast of Newfoundland spring-spawning herring for the period 1965-1997, and by three periods of 11 years (1965-1975, 1976-1986, 1987-1997) showing surplus production (what is available to fishing) and losses due to fishing. Net production is expressed as surplus production minus losses due to fishing.

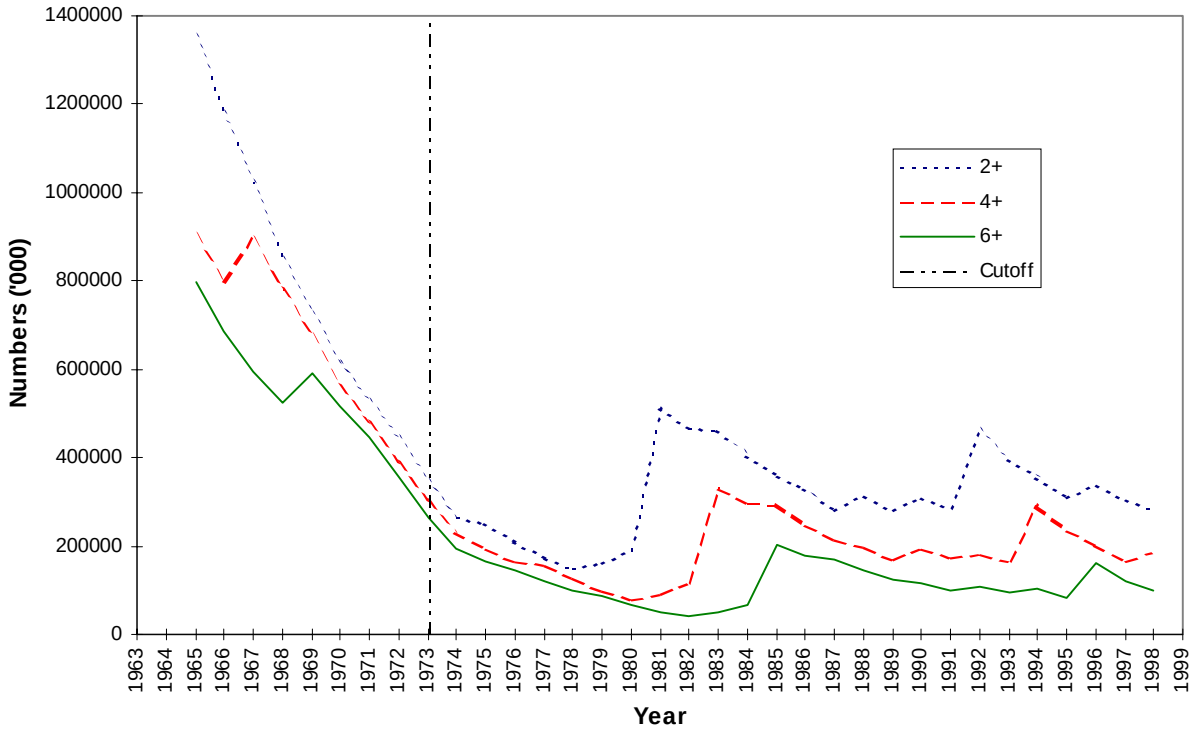

Figure 31. SPA estimates of population numbers for autumn-spawning herring from 1965 to 1998

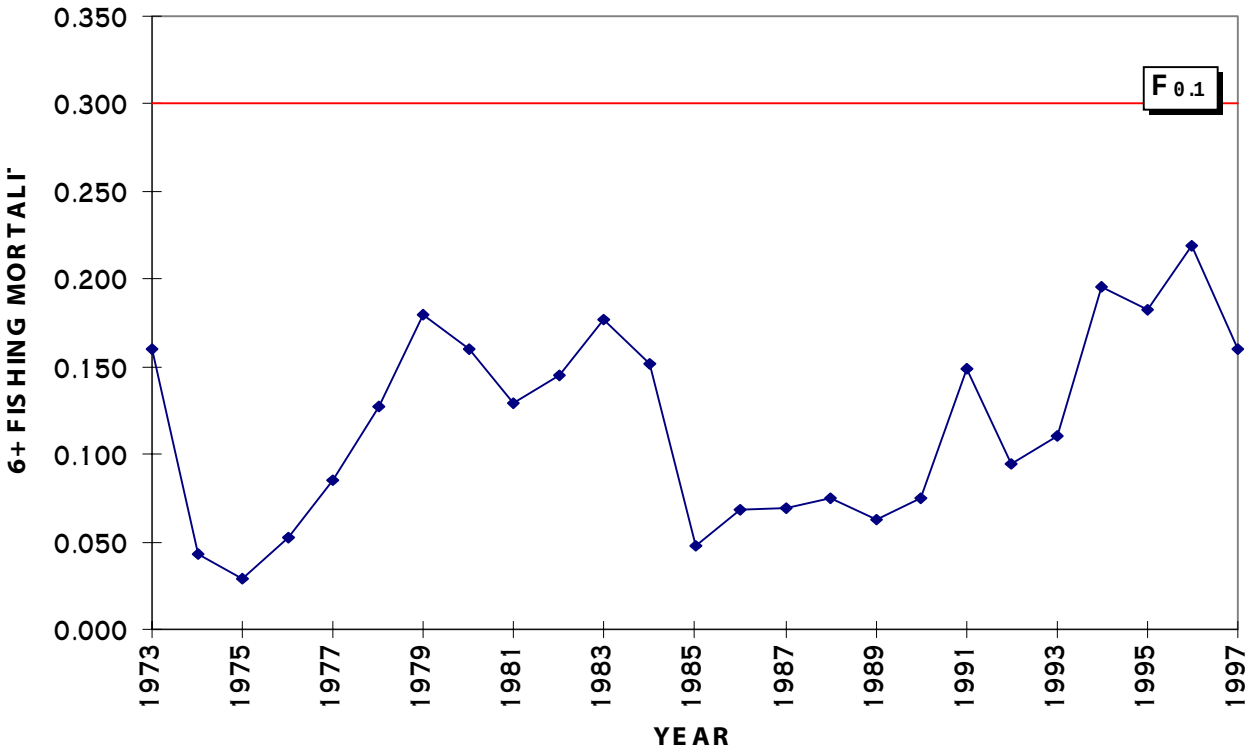

Figure 32. SPA estimates of annual instantaneous fishing mortality (6+ weighted) for autumn-spawning herring from 1973 to 1997.

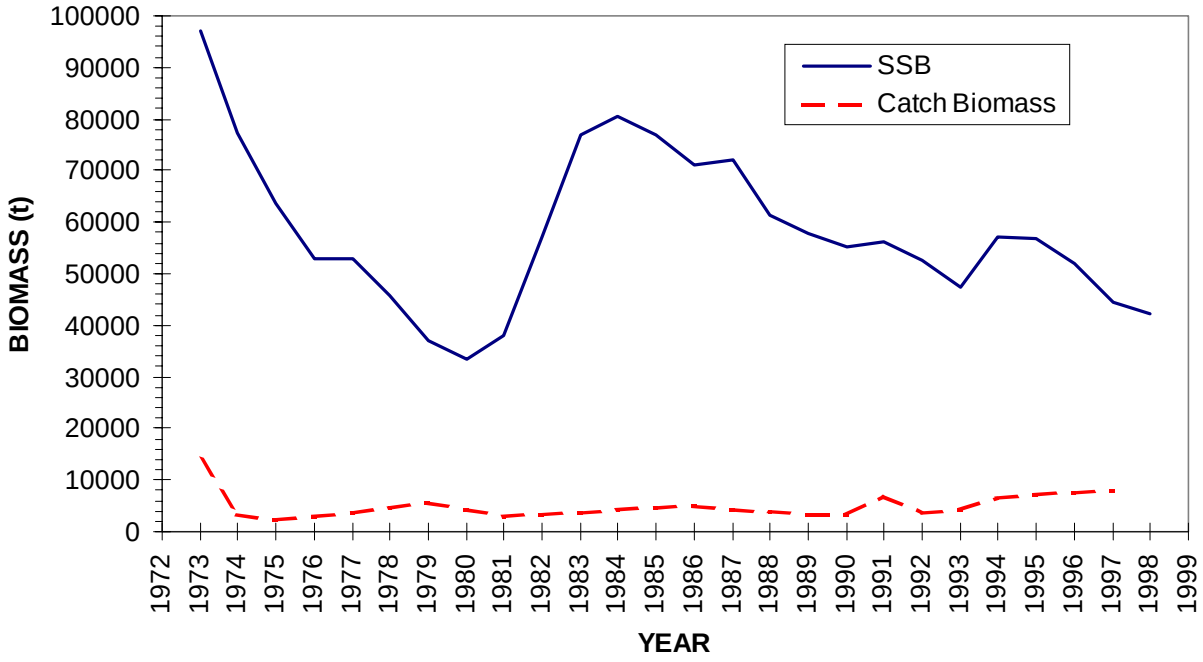

Figure 33. SPA spawning-stock biomass estimates and catch biomass for autumn-spawning herring from 1973 to 1998.

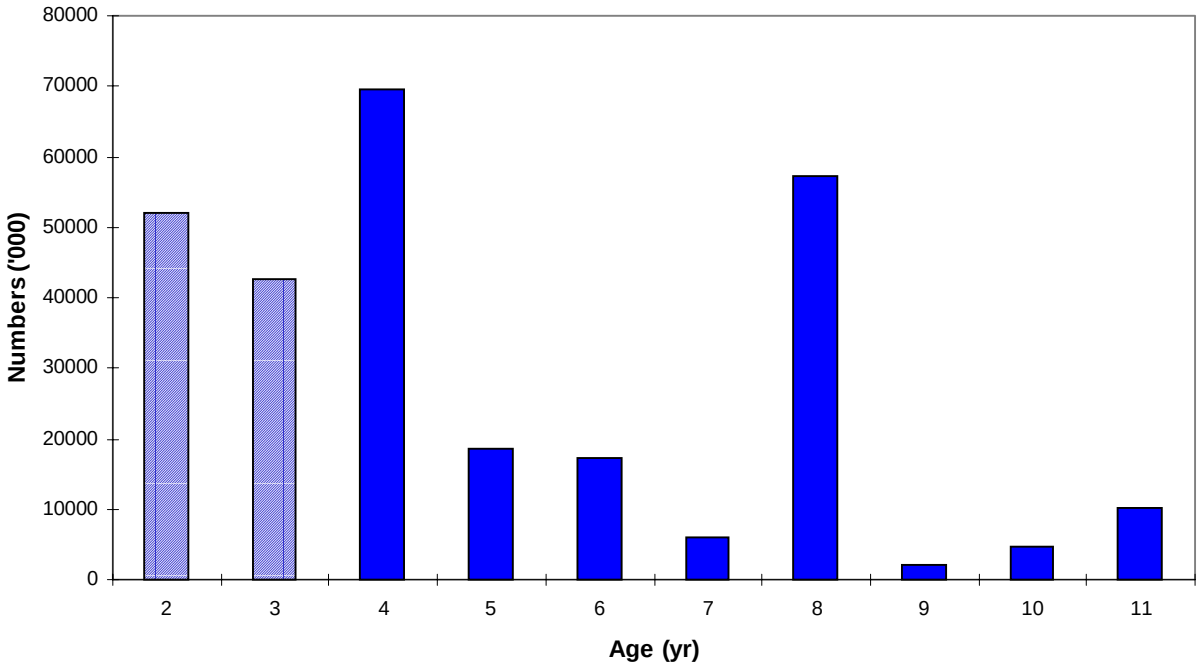

Figure 34. SPA estimates of population numbers at age for autumn-spawning herring in 1998 (ages 2 and 3 are assumed fixed at medium recruitment).

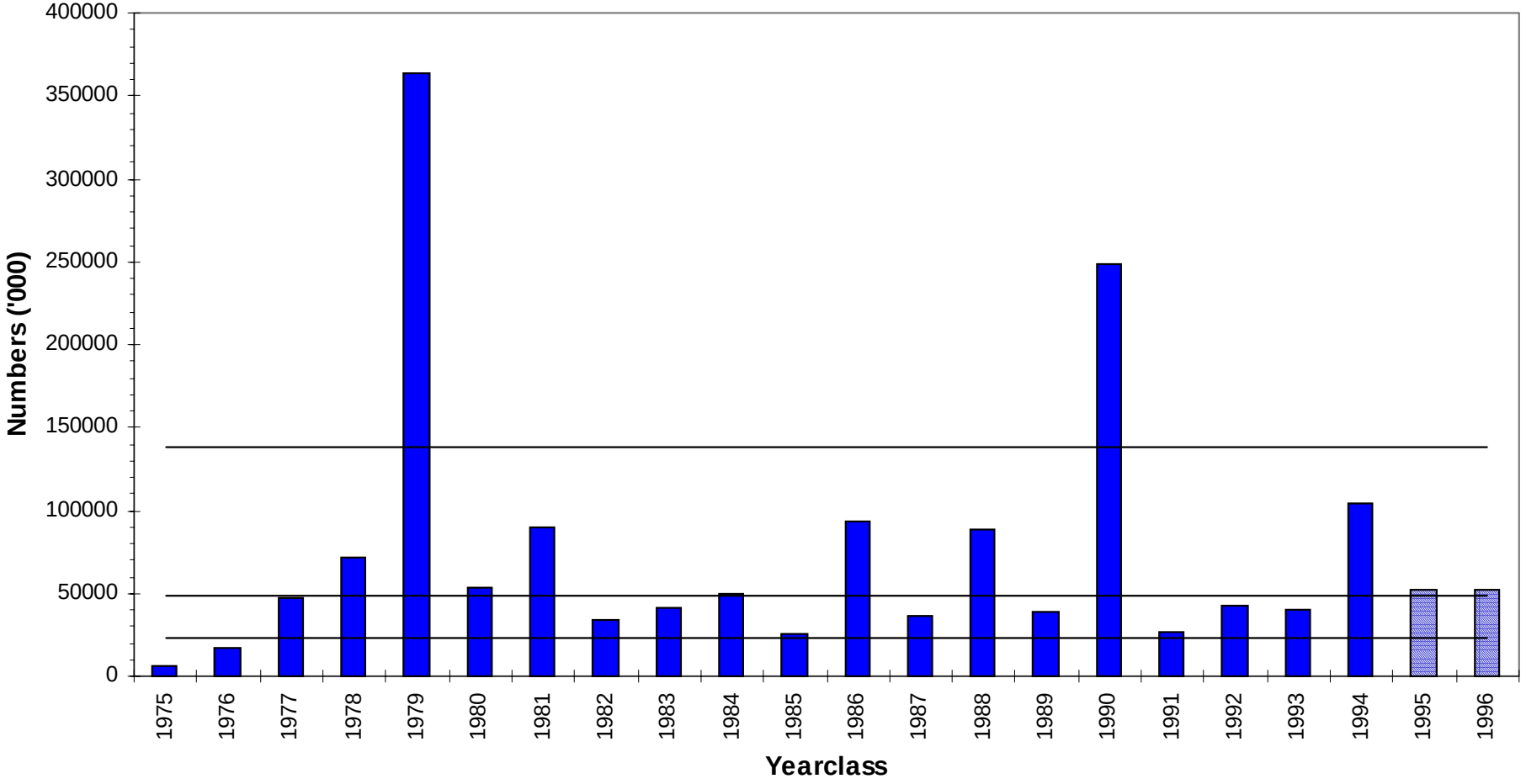

Figure 35. SPA estimates of recruitment at age 2 for autumn-spawning herring for year-classes 1975 to 1994 (year-classes 1995 to 1996 are fixed at medium recruitment).

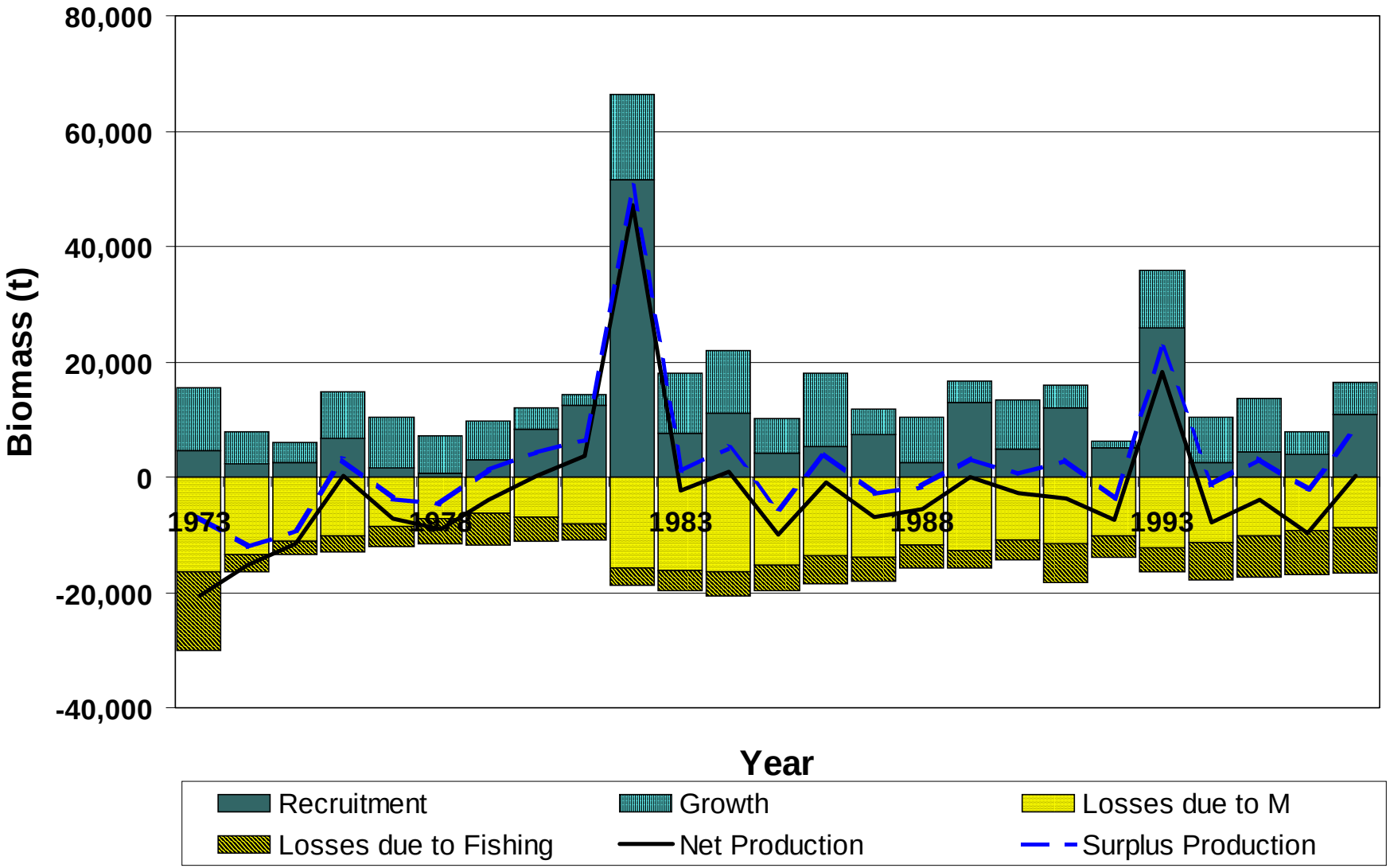

Figure 36. SPA estimates of biological production of west coast of Newfoundland autumn-spawning herring from 1973 to 1997 showing gains through recruitment and growth and losses through natural mortality (M) and fishing. Surplus production (what is available to fishing) is expressed as gains minus losses due to M, and net production is expressed as surplus production minus losses due to fishing

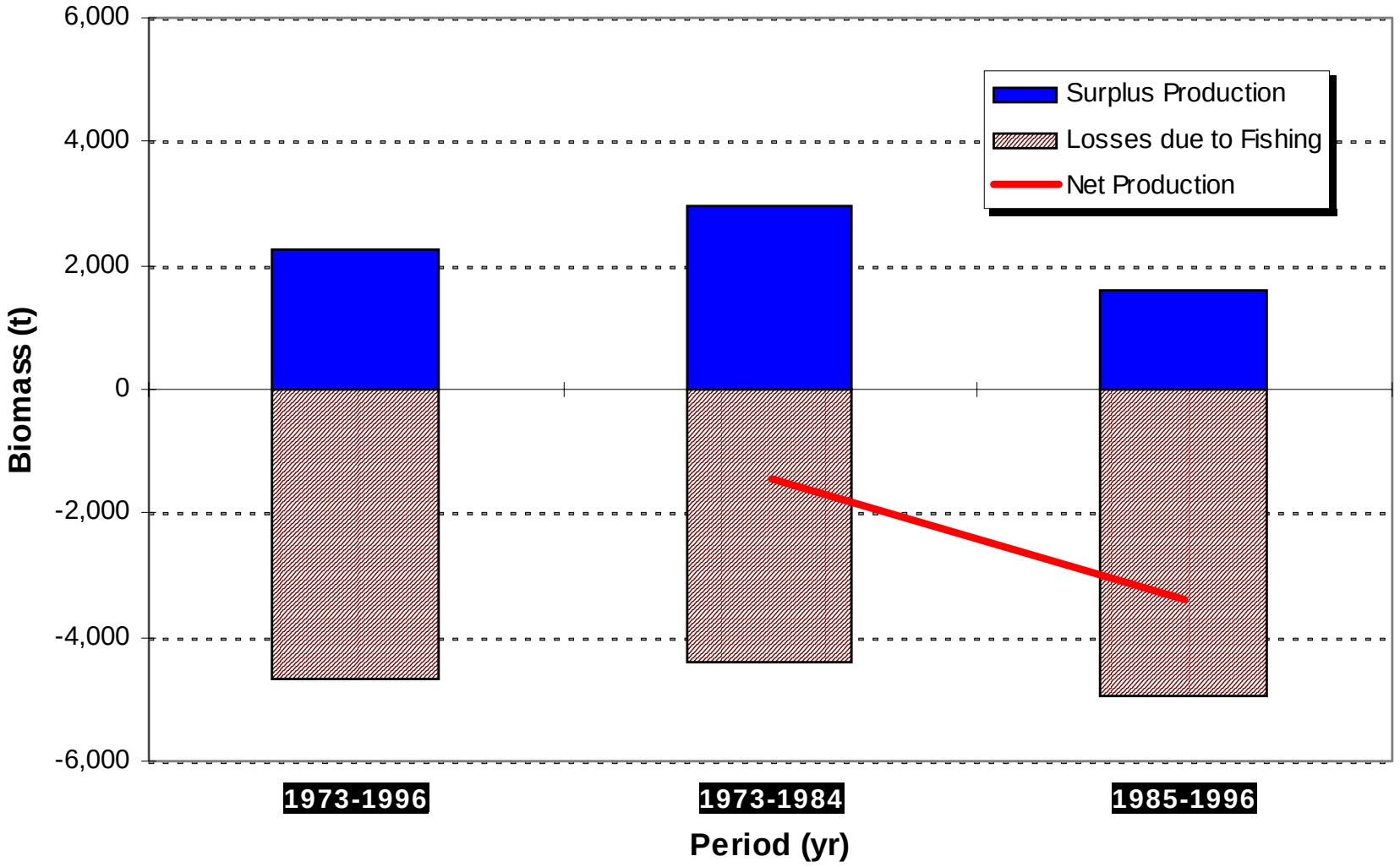

Figure 37. SPA estimates of biological production of west coast of Newfoundland autumn-spawning herring for the period 1973-1996, and by two periods of 12 years (1973-1984, 1985-1996) showing surplus production (what is available to fishing) and losses due to fishing. Net production is expressed as surplus production minus losses due to fishing.

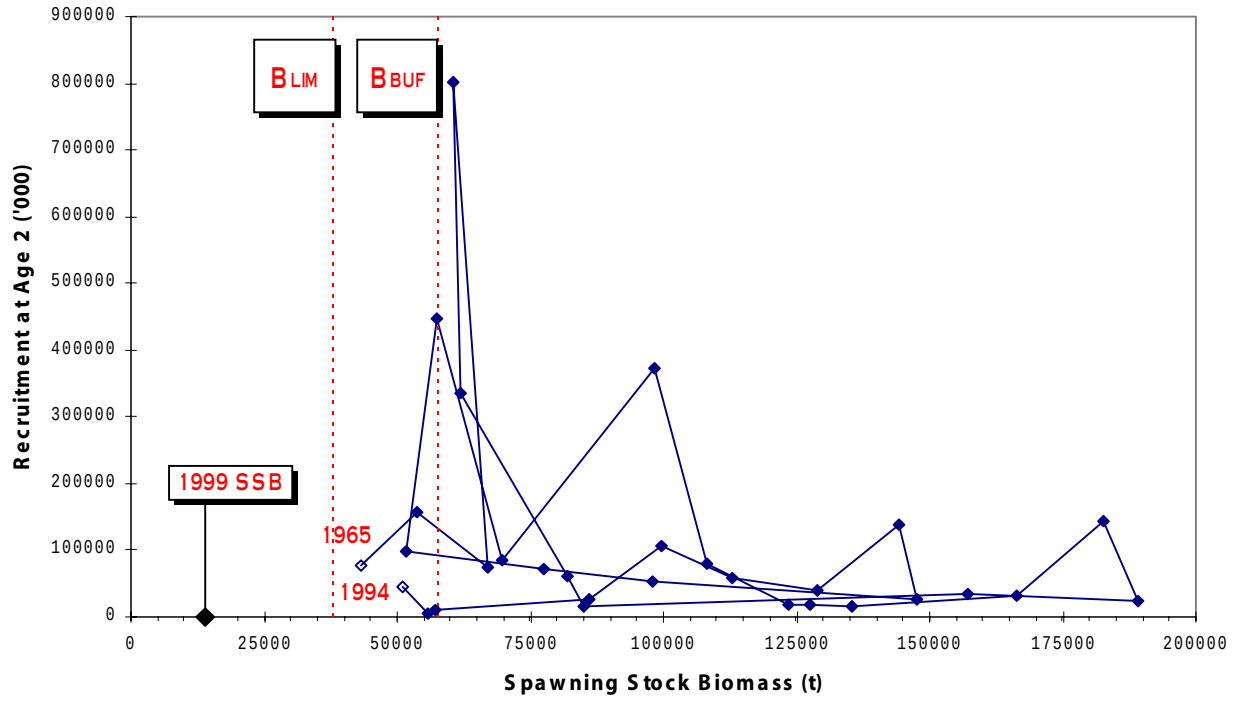

Figure 38. Stock-recruitment relationship and biological reference points (B_{LIM} and B_{BUF}) for spring-spawning herring from 1965 to 1994. Spawning stock biomass (SSB) in 1999 is indicated.

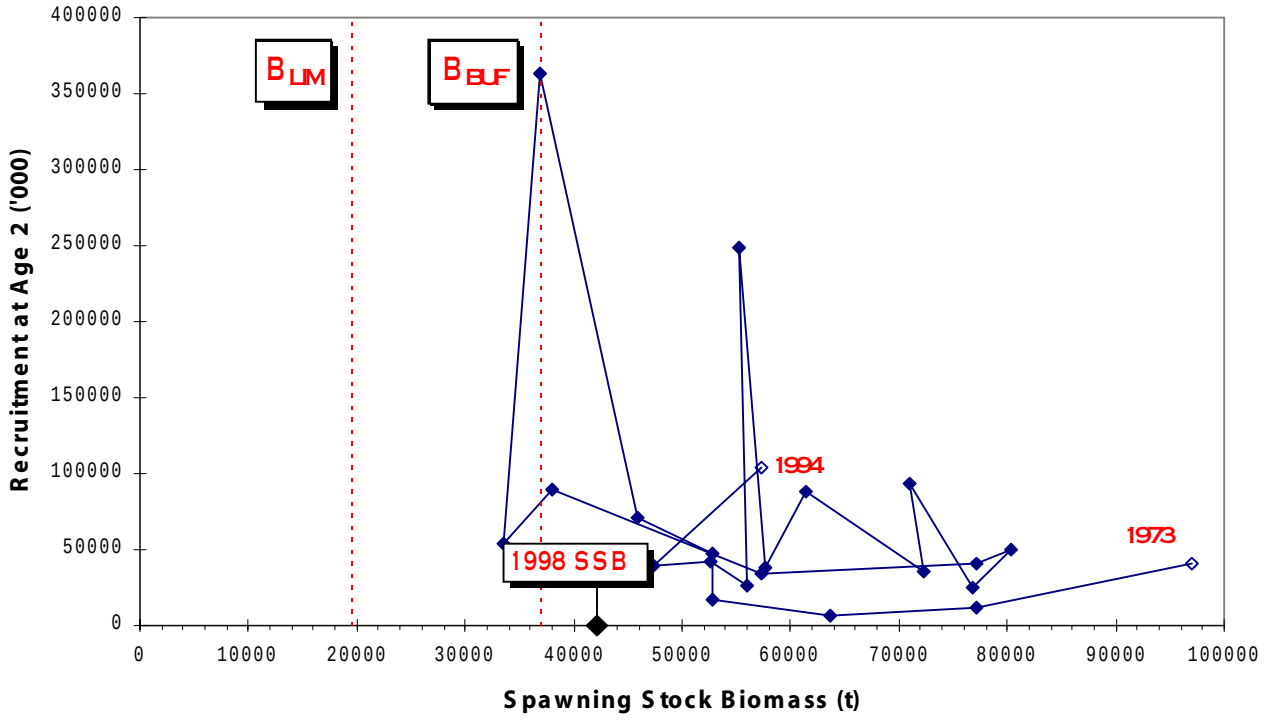

Figure 39. Stock-recruitment relationship and biological reference points (B_{LIM} and B_{BUF}) for autumn-spawning herring from 1973 to 1994. Spawning stock biomass (SSB) in 1998 is indicated.

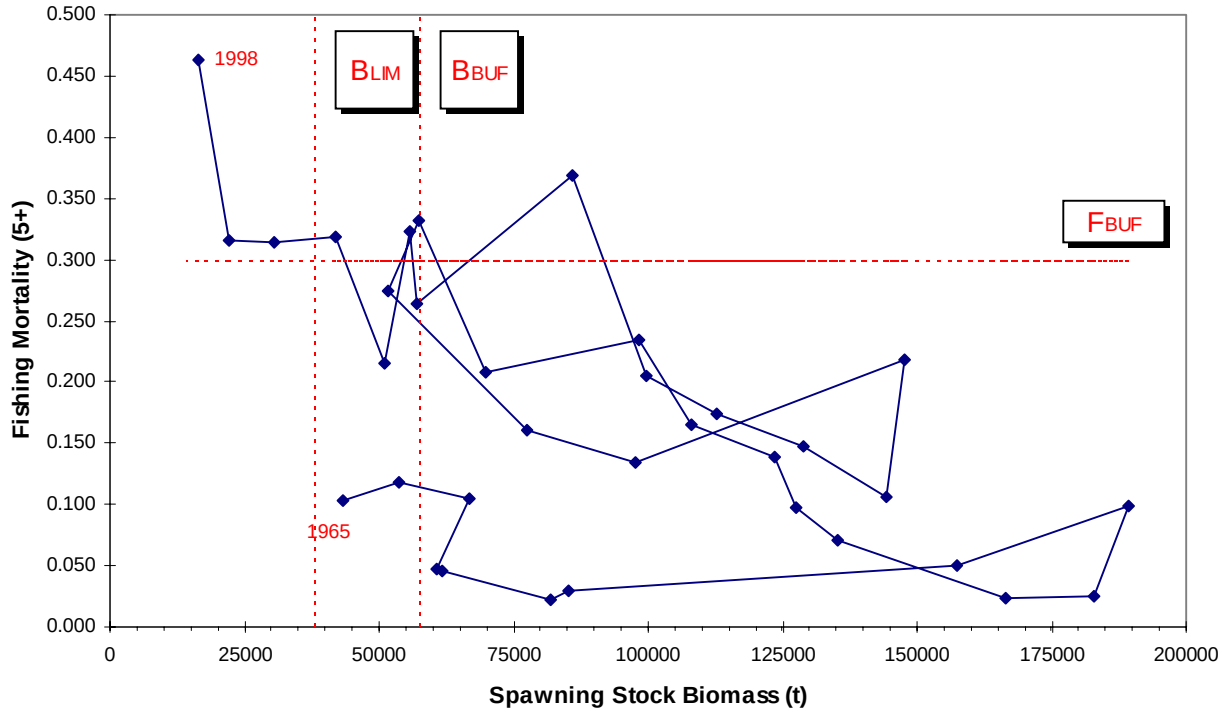

Figure 40. Spawning stock biomass versus 5+ fishing mortality with biological reference points for spring-spawning herring from 1965 to 1998

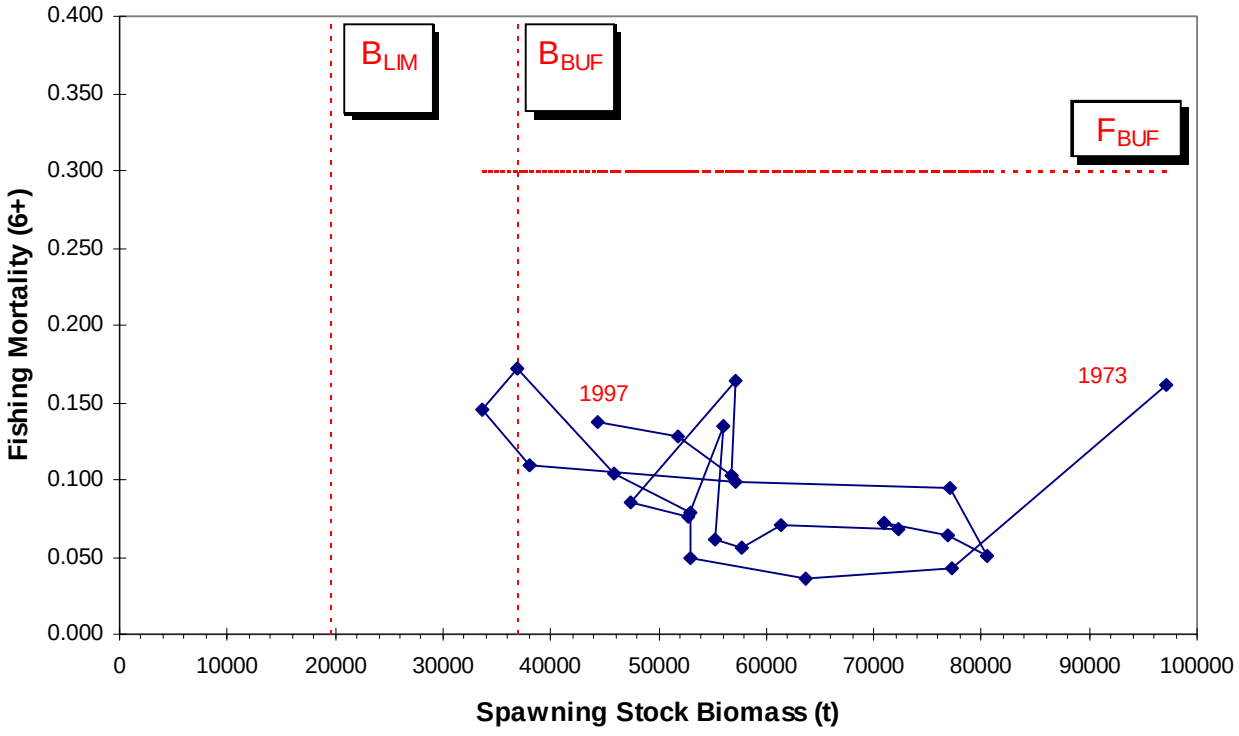

Figure 41. Spawning stock biomass versus 6+ fishing mortality with biological reference points for autumn-spawning herring from 1973 to 1997.

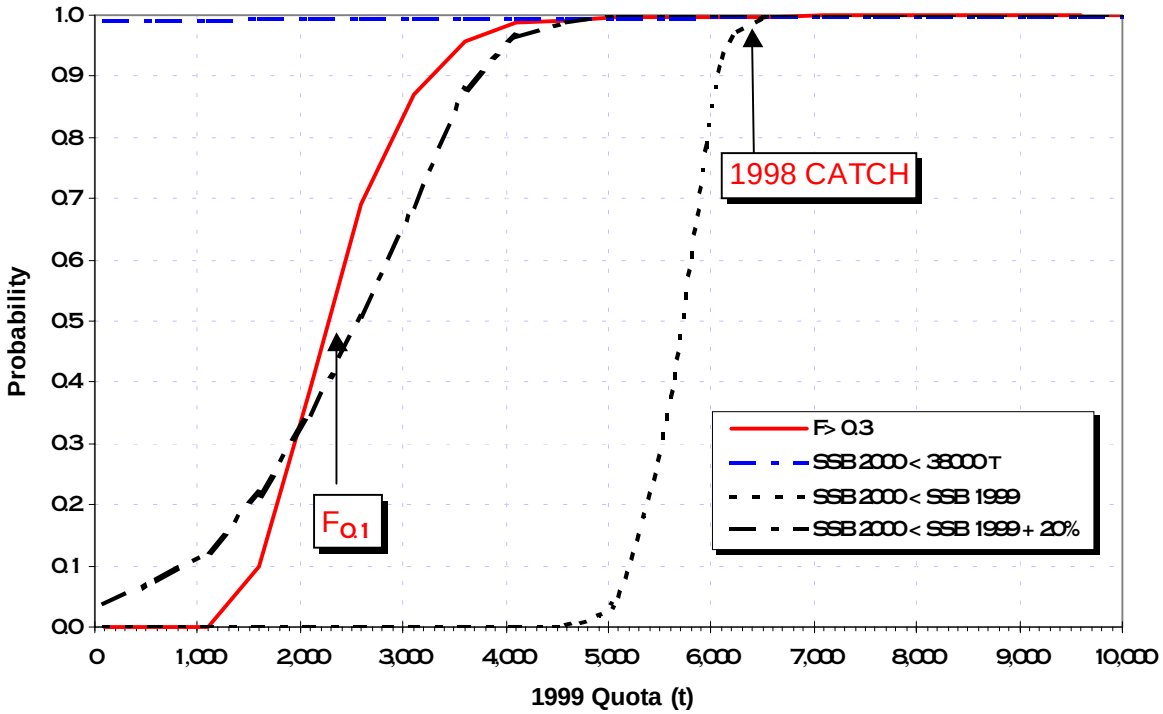

Figure 42. Risk Analysis for spring-spawning herring with the probability of not reaching various objectives given various quotas in 1999 assuming medium recruitment from 1997 to 2000.

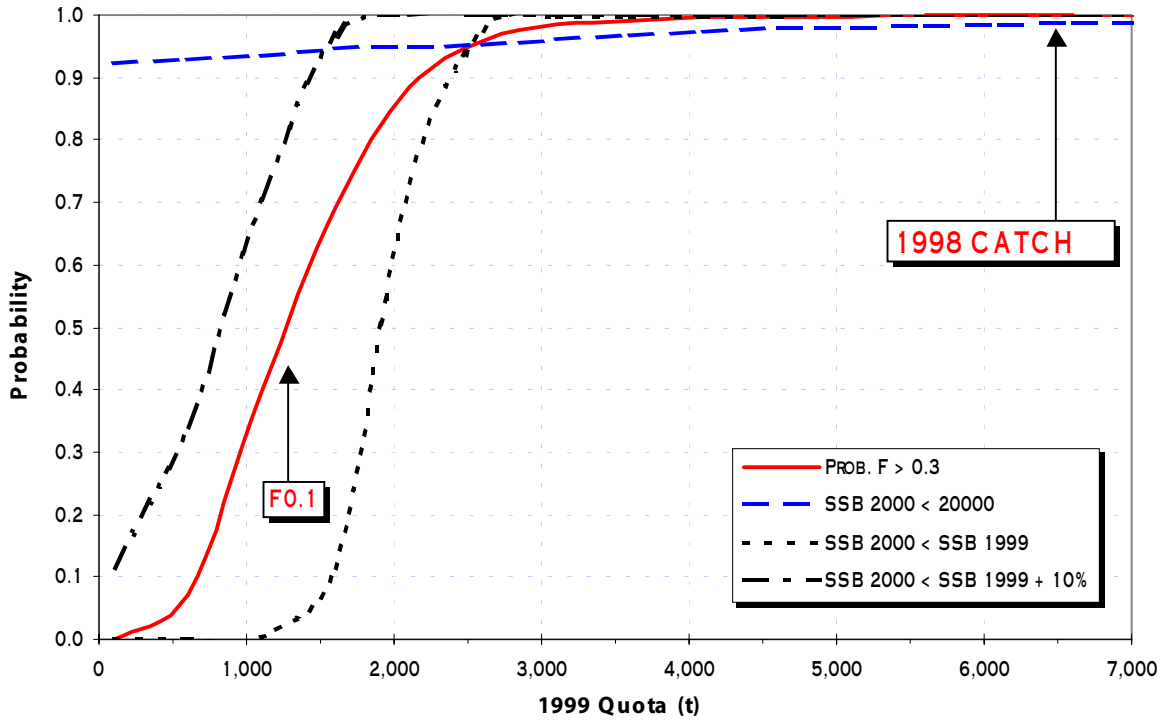

Figure 43. Risk Analysis for spring-spawning herring with the probability of not reaching various objectives given various quotas in 1999 assuming low recruitment from 1997 to 2000.

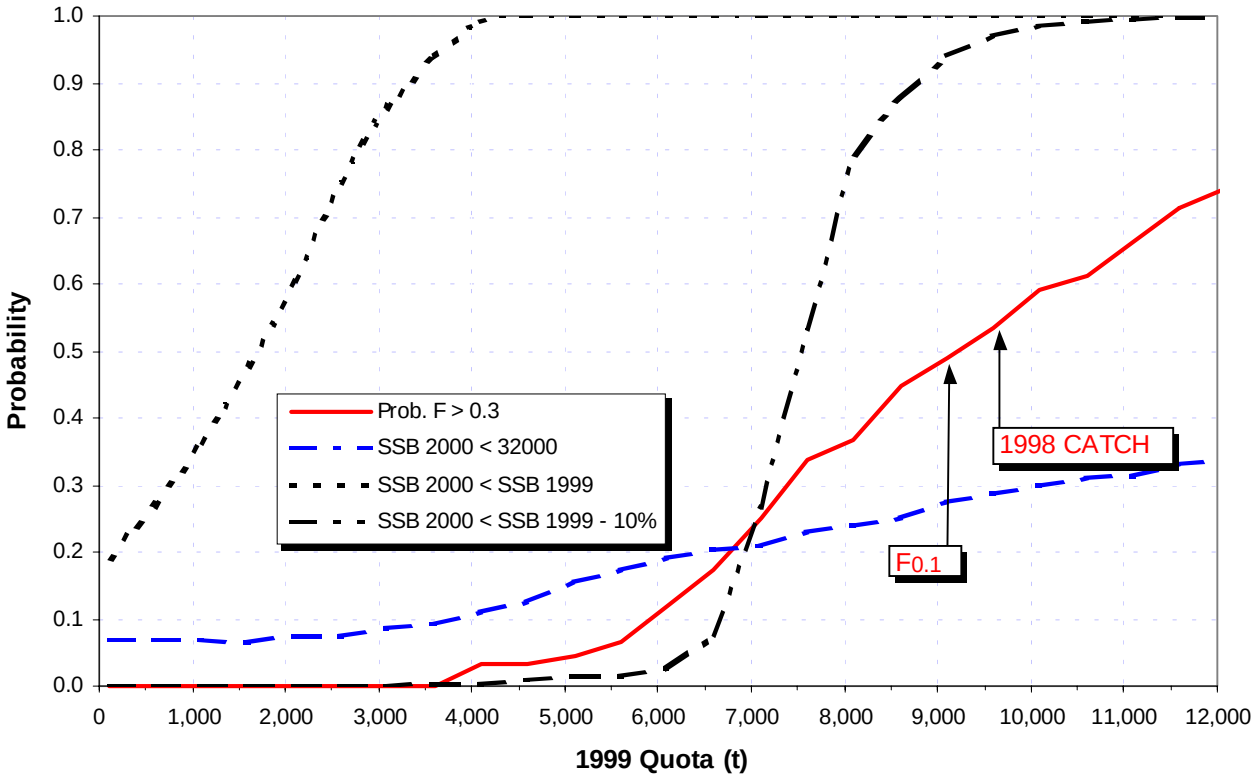

Figure 44. Risk Analysis for autumn-spawning herring with the probability of not reaching various objectives given various quotas in 1999 assuming medium recruitment.

Annex 1. Number of herring otoliths read (bold print) and commercial landings (t) in NAFO division 4R by gear, area and month in 1997. (Boxed areas indicate sample-landing combinations for the weighting of the catch at age).

GEAR	AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Gillnets	4Ra						[1] **150** 273 * 321		[2] **146** * 268	[3] **49** * 782	[4] **97** 245	57	
	4Rb								1			4	
	4Rc					[5] **299**	**49** 2		1	17			
	4Rd				[6] **48**	**348** 1	[7] **146** 13	1		4			

GEAR	AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Purse Seiners > 65'	4Ra												
	4Rb									[1] **100** 1610	[2] **50** 233	[3] **49** 350	
	4Rc						[4] **148** 1356		[5] **47** 169	[6] **98** 202	[7] **150** 2028	[8] **100** 483	
	4Rd					[9] **99** 743				[10] **150** 578			

GEAR	AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Purse Seiners < 65'	4Ra						[1] 83 20 **50** 408				[2] **50** 97	[3] **49** 8	
	4Rb									[4] **99** 850	248		
	4Rc						[5] P 250		[6] P 32	[7] P 247	[8] P 486	[9] P 17	
	4Rd					[10] P 114	31			[11] P 102	60		

P: Samples from large purse seiners

* Includes trap, hand line and beach seine

Annex 2. Number of herring otoliths read (bold print) and commercial landings (t) in NAFO division 4R by gear, area and month in 1998. (Boxed areas indicate sample-landing combinations for the weighting of the catch at age).

GEAR	AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Gillnets	4Ra						1 **97** 423.1	2 **53** 387.4	3 **100** 457.6	4 **150** 1213.2	291.9	19.9	
	4Rb						101.8	49.0	27.4	651.5	5 **50** 568.4		
	4Rc					**163** 0.2	**32**		0.3	4.2	0.1		
	4Rd				**147** 0.3	**234** 16	0.8	0.1	0.6	3.5			

GEAR	AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Purse Seiners > 65'	4Ra							1 **50** 88.4 488.9					
	4Rb								797.8	2 R 640.7	2152	3 **49** 1160	
	4Rc					4 **150** 1589	5 **50** 645.3	49.8		428.4	116.5	882.9	
	4Rd					6 **50** 428.4							

GEAR	AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Purse Seiners < 65'	4Ra					1 69.1	**47** 158.2		2 **49** 330.5	13.5	20.7	54.9	
	4Rb					3.3	122.7		175.6	3 487.8	**100** 357.5	4 **100** 308.0	
	4Rc					5 P 381.0	6 P 89.9		33.1	898.5	664.9	7 **49** 105.2	
	4Rd					8 P 52.7						9 107.1	**50**

P: Samples from large purse seiners

R: Samples from small purse seiners

Annex 3. Frequency of observations of index-fishermen catch and effort data by month, fishing area for spring-spawning herring in NAFO division 4R.

MONTH	Frequency	Percent	Cumulative Frequency	Cumulative Percent
4	134	3.5	134	3.5
5	1299	34.0	1433	37.5
6	731	19.1	2164	56.6
7	266	7.0	2430	63.6
8	923	24.1	3353	87.7
9	415	10.9	3768	98.6
10	44	1.2	3812	99.7
11	10	0.3	3822	100.0

FISHING AREA	Frequency	Percent	Cumulative Frequency	Cumulative Percent
FISCHELL	312	8.2	312	8.2
SANDY POINT	559	14.6	871	22.8
ST-GEORGES	117	3.1	988	25.9
BARACHOIS BROOK	134	3.5	1122	29.4
LOURDES	319	8.3	1441	37.7
BLACK DUCK BROOK	333	8.7	1774	46.4
LONG PT. (BAY)	413	10.8	2187	57.2
CASTOR RIVER	43	1.1	2230	58.3
FERROLE POINT	839	22.0	3069	80.3
WHALE ISLAND	12	0.3	3081	80.6
EDDIES COVE E	741	19.4	3822	100.0

YEAR	Frequency	Percent	Cumulative Frequency	Cumulative Percent
84	96	2.5	96	2.5
85	202	5.3	298	7.8
86	225	5.9	523	13.7
87	307	8.0	830	21.7
88	355	9.3	1185	31.0
89	303	7.9	1488	38.9
90	267	7.0	1755	45.9
91	227	5.9	1982	51.9
92	247	6.5	2229	58.3
93	290	7.6	2519	65.9
94	274	7.2	2793	73.1
95	337	8.8	3130	81.9
96	294	7.7	3424	89.6
97	268	7.0	3692	96.6
98	130	3.4	3822	100.0

Annex 4. Frequency of observations of index-fishermen catch and effort data by month, fishing area for autumn-spawning herring in NAFO division 4R.

MONTH	Frequency	Percent	Cumulative Frequency	Cumulative Percent
4	21	0.8	21	0.8
5	570	21.3	591	22.0
6	438	16.3	1029	38.4
7	261	9.7	1290	48.1
8	923	34.4	2213	82.5
9	415	15.5	2628	98.0
10	44	1.6	2672	99.6
11	10	0.4	2682	100.0

FISHING AREA	Frequency	Percent	Cumulative Frequency	Cumulative Percent
LOURDES	315	11.7	315	11.7
BLUE BEACH	236	8.8	551	20.5
LONG PT. (BAY)	496	18.5	1047	39.0
CASTOR RIVER	43	1.6	1090	40.6
FERROLE POINT	839	31.3	1929	71.9
WHALE ISLAND	12	0.4	1941	72.4
EDDIES COVE E	741	27.6	2682	100.0

YEAR	Frequency	Percent	Cumulative Frequency	Cumulative Percent
84	96	3.6	96	3.6
85	147	5.5	243	9.1
86	158	5.9	401	15.0
87	207	7.7	608	22.7
88	279	10.4	887	33.1
89	229	8.5	1116	41.6
90	209	7.8	1325	49.4
91	167	6.2	1492	55.6
92	167	6.2	1659	61.9
93	207	7.7	1866	69.6
94	197	7.3	2063	76.9
95	224	8.4	2287	85.3
96	194	7.2	2481	92.5
97	167	6.2	2648	98.7
98	34	1.3	2682	100.0

Annex 5. Analysis of variance and regression coefficients for the 1984 to 1998 spring-spawning 4R herring gillnet catch-rate data (catch/(surface*hours)).

Source	DF	Squares	Sum of Square	Mean F Value	Pr > F
Model	31	10211.90264	329.41621	138.41	0.0001
Error	3790	9020.03045	2.37996		
Corrected Total	3821	19231.93309			

R-Square	C.V.	Root MSE	CATRATE Mean
0.530987	-18.27418	1.54271	-8.442021

Source	DF	Type III SS	Mean Square	F Value	Pr > F
MONTH	7	684.782618	97.826088	41.1	0.0001
FISH	10	749.126294	74.912629	31.48	0.0001
YEAR	14	1020.290659	72.877904	30.62	0.0001

Parameter		Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		-18.29566981 B	-26.65	0.0001	0.68662658
MONTH	4	4.87857239 B	7.89	0.0001	0.61837540
	5	5.39917112 B	8.98	0.0001	0.60137816
	6	4.45720364 B	7.41	0.0001	0.60127920
	7	3.01791869 B	5.99	0.0001	0.50396839
	8	2.47054658 B	4.96	0.0001	0.49775140
	9	3.03942533 B	6.06	0.0001	0.50193947
	10	3.43935636 B	6.25	0.0001	0.55018104
	11	0.00000000 B	.		
FISH	BARACHOIS BROOK	4.55861910 B	7.75	0.0001	0.58847069
	BLACK DUCK BROOK	4.50296178 B	7.83	0.0001	0.57519343
	CASTOR RIVER	3.06968775 B	5.98	0.0001	0.51301939
	EDDIES COVE E	4.53172656 B	9.93	0.0001	0.45620410
	FERROLE POINT	4.21436284 B	9.22	0.0001	0.45693633
	FISCHELL	5.26201240 B	9.11	0.0001	0.57754552
	LONG PT. (BAY)	5.27983852 B	9.18	0.0001	0.57509484
	LOURDES	4.11903927 B	7.18	0.0001	0.57360159
	SANDY POINT	5.16748579 B	8.98	0.0001	0.57556312
	ST-GEORGES	5.48880605 B	9.26	0.0001	0.59248955
	WHALE ISLAND	0.00000000 B	.		
YEAR	84	1.30194130 B	6.01	0.0001	0.21649873
	85	2.00270029 B	10.96	0.0001	0.18269840
	86	1.78739627 B	10.23	0.0001	0.17473451
	87	2.06144907 B	12.11	0.0001	0.17019532
	88	1.57812280 B	9.61	0.0001	0.16420544
	89	1.45320675 B	8.74	0.0001	0.16630375
	90	0.99978761 B	5.85	0.0001	0.17093136
	91	1.52249929 B	8.75	0.0001	0.17400586
	92	1.28685143 B	7.51	0.0001	0.17143844
	93	0.94373025 B	5.67	0.0001	0.16649632
	94	0.51728305 B	3.08	0.0021	0.16809172
	95	0.44110050 B	2.71	0.0067	0.16248325
	96	0.45699694 B	2.75	0.0060	0.16630061
	97	0.90355693 B	5.40	0.0001	0.16737253
	98	0.00000000 B	.		

Annex 6. Analysis of variance and regression coefficients for the 1984 to 1998 autumn-spawning 4R herring gillnet catch-rate data (catch/(surface*hours)).

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	27	4049.95139	149.99820	79.56	0.0001
Error	2654	5003.83913	1.88540		
Corrected Total	2681	9053.79052			

R-Square	C.V.	Root MSE	CATRATE Mean
0.447321	-16.50107	1.37309697	-8.3212608

Source	DF	Type III SS	Mean Square	F Value	Pr > F
MONTH	7	263.3523942	37.6217706	19.95	0.0001
FISH	6	662.5898097	110.4316349	58.57	0.0001
YEAR	14	856.5685065	61.1834648	32.45	0.0001

Parameter		Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		-19.79543526 B	-30.5	0.0001	0.64897363
MONTH	4	4.85844381 B	7.65	0.0001	0.63477101
	5	4.16968448 B	7.46	0.0001	0.55929364
	6	4.18852377 B	7.49	0.0001	0.55908046
	7	4.87330537 B	10.82	0.0001	0.45059483
	8	4.91802630 B	11.05	0.0001	0.44510876
	9	4.80811017 B	10.71	0.0001	0.44896566
	10	4.25323915 B	8.64	0.0001	0.49224269
	11	0.00000000 B	.		
FISH	BLUE BEACH	4.54631983 B	8.43	0.0001	0.53918912
	CASTOR RIVER	3.24310071 B	7.07	0.0001	0.45903536
	EDDIES COVE E	4.92034116 B	12.06	0.0001	0.40785759
	FERROLE POINT	5.00921816 B	12.25	0.0001	0.40889953
	LONG PT. (BAY)	3.64298175 B	6.80	0.0001	0.53582583
	LOURDES	3.18146635 B	5.95	0.0001	0.53486869
	WHALE ISLAND	0.00000000 B	.		
YEAR	84	1.85391044 B	6.51	0.0001	0.28466019
	85	3.39244085 B	12.58	0.0001	0.26961153
	86	3.06645091 B	11.49	0.0001	0.26680567
	87	2.80768094 B	10.70	0.0001	0.26248185
	88	2.71795591 B	10.50	0.0001	0.25894217
	89	2.53638974 B	9.75	0.0001	0.26026327
	90	1.61834921 B	6.12	0.0001	0.26454863
	91	2.47109204 B	9.27	0.0001	0.26643227
	92	3.28039266 B	12.26	0.0001	0.26752963
	93	2.85396653 B	10.93	0.0001	0.26103364
	94	2.04644576 B	7.82	0.0001	0.26175311
	95	2.04665184 B	7.91	0.0001	0.25875083
	96	2.43532975 B	9.16	0.0001	0.26594255
	97	1.74496496 B	6.63	0.0001	0.26335890
	98	0.00000000 B	.		

Annex 7. Number of spontaneous comments received from questionnaires sent to inshore herring fishermen along the west coast of Newfoundland in 1997.

COMMENTS	4Rd	4Rc	4Rb	4Ra	TOTAL
Herring abundant	2	1		3	6
during fall				2	2
Herring stock in decline	8	4	7	11	30
during spring	1	1	4		6
during fall	0	2	3	1	6
Complaints against seiners:					
excessive catches and chasing	7	5	11	9	32
on spawning grounds	1	1	2	6	10
dumping at sea		1	2	3	6
should be limited	3	5	17	10	35
Others causes suggested:					
lack of food for herring				1	1
seals				1	1
herring offshore				6	6
herring inshore			1	1	2
technology				1	1
dirty water				2	2
Spawning:					
in decline	2		2		4
abundant					0
Size of herring					
small		4	3	2	9
small in fall		1	1	1	3
good size	1		1	3	5
Poor markets	1	1	1	10	13
Number of questionnaires received	42	48	95	124	309

Annex 8. Number of spontaneous comments received from questionnaires sent to inshore herring fishermen along the west coast of Newfoundland in 1998.

COMMENTS	4Rd	4Rc	4Rb	4Ra	TOTAL
Herring abundant			1	2	3
during fall			2	1	3
during summer	1				1
Herring stock in decline	2	2	1	8	13
during spring	1		1		2
Complaints against seiners:					
excessive catches and chasing	3	3	4	6	16
on spawning grounds			1	4	5
dumping at sea		3	4	5	7
should be limited	3	6	9	11	29
Others causes suggested:					
seals			1	2	3
herring offshore	1		1	1	3
technology		1			1
traps		1			1
Spawning:					
in decline	1				1
abundant in fall			1		1
Size of herring					
big				1	1
big in summer	1				1
big in fall			1	1	2
small	5	5	4	3	17
small in spring	1				1
small in fall			1		1
Poor markets		1	1	6	8
Number of questionnaires received	44	41	84	117	286

Annex 9. Summary of comments from Index Fishermen in St. Georges Bay and Port-au-Port Bay from 1996 to 1998.

1996

K. Skinner
The body of herring that do come is small. Herring is coming late each year. Years ago, we would be catching herring in March .
H. Lainey
Mixture of large and small herring, more spawn this year, covering a wider area, close to shore. Over all, this year hasn't been a bad year. Slow at first but picking up later.
A. Bennett
The herring were scarce in this area again this year, although slighty higher than 1995. Up until the last few years, we caught more than enough but the last few years we have had to buy most of our bait.
J. Shannon
Bad year, herring does not spawn in my area. A lot of wind, unable to haul, a lot of days.
A. Parsons
There was a nice sign of herring this summer.
D. Strickland
The herring appeared to come in a steadier flow, rather than hitting in really heavy schools, but the herring seemed to be smaller sized.

1997

K. Skinner
Herring still pass close to shore.
H. Lainey
Fishing season very poor. Poor weather. There seemed to be a lot of herring spawn, covering a area from the shoreline outward; it didn't seem to last for a long time. Big size.
W. J. Oak
The herring spawned about 4 miles North East of Black Duck Brook and it was a very small spawn.
A. Bennett
The past herring season in this area followed the trend of the last several seasons. The herring are getting fewer in number every year. (even scarcer than in 1996). I did not see any spawning activity in this area and I did not hear of any spawning activity from Fischells to Highlands. Fishermen who had nets out in July reported good catches of very large herring the 3, 4, 5, 6 of July.
J. Shannon
No herring this year. There was no spawning in the Fischells area. Herring was caught in deep by seiners. No chance to come inshore.
A. Parsons
The herring spawned down from Seal Rocks down along the Brook. It was not a big spawn like other years.
D. Strickland
This year, I saw no evidence of a herring spawn. I don't know if there was such a large body of herring as some years, but herring was avaliable for bait for a longer period.

1998

K. Skinner
This was the worst season yet for herring. There were a few along shore at first, but none anywhere, the last three weeks: also the weather was horrible during that time. It will be late in August or early September now, before you get any herring.
H. Lainey
I don't have many encouraging comments about this fishing season. So far, the herring have only spawned a small amount, one day. This could be because the spawning may have occured in deeper water which wasn't noticed by us.
Only spawned one day (11/05/98) and there wasn't very much.

A. Bennett

The herring were very scarce in this area again this year. Over the past several years, the herring are returning to this area in fewer and fewer numbers. I talked with many fisherman from Heatherton to Highlands and they all say the same thing: herring have been very scarce for the past several seasons and this season in particular. Maybe there are very few herring in Bay St. George in the spring or the migratory and feeding patterns of herring in Bay St. George have changed.

T. Young

The herring fishery this year was not at all that good. There are very few spawn herring. The size of herring varied. We had some really big ones and also very small ones.

D. Strickland

I found the schools of herring small this year. The herring seemed to be of average size but counts were down. I didn't see any spawn this year but there was never enough wind to really stirr the water enough to show where it was. The time the herring was here was also short.

A. Parsons

Awful year for herring and lobster.

18/05/98: the herring made a big spawn up in the Bay no one can fish up there, they are not bothered by anyone

Annex 10. Parameter estimates, standard errors, relative errors (CV), bias, relative bias and bias-corrected parameter estimates for the population numbers (N), and the index-fisherman (q(IF)) and research vessel (q(RV)) catchability coefficients in 1999 from the spring-spawning SPA as estimated from the adaptive framework.

Parameter		Age	Parameter Estimate	Standard Error	Relative Error	Bias	Relative Bias	Bias Corrected
N	1	5	22600	20700	0.913	5740	0.253	16860
	2	6	1630	1080	0.661	314	0.193	1316
	3	7	3040	1650	0.545	340	0.112	2700
	4	8	2570	1840	0.719	456	0.178	2114
	5	9	6210	4620	0.743	574	0.092	5636
	6	10	1450	1190	0.822	279	0.192	1171
	7	11+	2500	1650	0.662	356	0.142	2144
q(IF)	8	3	0.00002	0.00001	0.420	0.000001	0.056	0.00002
	9	4	0.00015	0.00004	0.232	0.000001	0.006	0.00015
	10	5	0.00113	0.00025	0.223	0.000004	0.004	0.00113
	11	6	0.00378	0.00080	0.213	0.000041	0.011	0.00374
	12	7	0.00710	0.00155	0.218	0.000070	0.010	0.00703
	13	8	0.01120	0.00251	0.224	0.000237	0.021	0.01096
	14	9	0.01200	0.00257	0.215	0.000154	0.013	0.01185
	15	10	0.01060	0.00229	0.216	0.000078	0.007	0.01052
	16	11+	0.01130	0.00248	0.220	0.000388	0.034	0.01091
q(RV)	17	2	0.270	0.113	0.419	0.012	0.043	0.259
	18	3	0.595	0.284	0.477	0.049	0.083	0.546
	19	4	0.804	0.337	0.420	0.049	0.061	0.755
	20	5	0.419	0.188	0.449	0.028	0.067	0.391
	21	6	1.040	0.480	0.462	0.094	0.090	0.946
	22	7	1.060	0.452	0.428	0.066	0.063	0.994
	23	8	1.250	0.548	0.438	0.096	0.077	1.154
	24	9	0.865	0.370	0.428	0.041	0.048	0.824
	25	10	2.990	1.280	0.427	0.239	0.080	2.751
	26	11+	2.420	1.020	0.421	0.187	0.077	2.233

Annex 11. Parameter correlation matrix for 4R spring-spawning herring as estimated from SPA using the adaptive framework.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
1	1.00	0.01	0.15	0.01	0.09	0.01	0.05	0.02	0.00	-0.03	-0.04	-0.02	-0.02	-0.01	-0.01	-0.01	-0.01	-0.52	-0.01	-0.06	-0.01	-0.03	-0.01	-0.01	0.00	0.00	0.00
2	0.01	1.00	0.04	0.11	0.03	0.07	0.02	0.05	0.00	-0.23	-0.03	-0.03	-0.02	-0.02	-0.01	-0.01	-0.01	-0.02	-0.36	-0.02	-0.04	-0.01	-0.02	-0.01	-0.01	-0.01	-0.01
3	0.15	0.04	1.00	0.05	0.12	0.04	0.06	0.05	-0.01	-0.17	-0.18	-0.03	-0.03	-0.02	-0.02	-0.02	-0.02	-0.29	-0.03	-0.28	-0.02	-0.04	-0.02	-0.02	-0.01	-0.01	-0.01
4	0.01	0.11	0.05	1.00	0.06	0.10	0.03	0.08	-0.01	-0.16	-0.16	-0.17	-0.03	-0.03	-0.02	-0.02	-0.02	-0.02	-0.24	-0.03	-0.26	-0.02	-0.03	-0.02	-0.02	-0.02	-0.02
5	0.09	0.03	0.12	0.06	1.00	0.06	0.08	0.08	-0.01	-0.11	-0.12	-0.14	-0.19	-0.03	-0.03	-0.03	-0.03	-0.18	-0.03	-0.17	-0.03	-0.25	-0.03	-0.03	-0.02	-0.02	-0.02
6	0.01	0.07	0.04	0.10	0.06	1.00	0.06	0.12	-0.01	-0.11	-0.10	-0.11	-0.13	-0.20	-0.03	-0.04	-0.04	-0.02	-0.15	-0.03	-0.16	-0.03	-0.24	-0.03	-0.03	-0.03	-0.03
7	0.05	0.02	0.06	0.03	0.08	0.06	1.00	0.12	-0.06	-0.06	-0.07	-0.08	-0.11	-0.14	-0.20	-0.04	-0.04	-0.09	-0.02	-0.09	-0.03	-0.12	-0.03	-0.26	-0.03	-0.03	-0.03
8	0.02	0.05	0.05	0.08	0.08	0.12	0.12	1.00	-0.06	-0.11	-0.11	-0.12	-0.15	-0.18	-0.22	-0.30	-0.30	-0.03	-0.08	-0.06	-0.11	-0.09	-0.18	-0.13	-0.26	-0.25	-0.25
9	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.06	-0.06	1.00	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01
10	-0.03	-0.23	-0.17	-0.16	-0.11	-0.11	-0.06	-0.11	0.01	1.00	0.07	0.06	0.05	0.04	0.03	0.03	0.03	0.07	0.12	0.07	0.06	0.04	0.04	0.03	0.03	0.03	0.03
11	-0.04	-0.03	-0.18	-0.16	-0.12	-0.10	-0.07	-0.11	0.01	0.07	1.00	0.06	0.05	0.04	0.03	0.03	0.03	0.07	0.05	0.07	0.06	0.04	0.04	0.03	0.03	0.03	0.03
12	-0.02	-0.03	-0.03	-0.17	-0.14	-0.11	-0.08	-0.12	0.01	0.06	0.06	1.00	0.05	0.05	0.04	0.04	0.04	0.03	0.06	0.04	0.06	0.05	0.04	0.03	0.03	0.03	0.03
13	-0.02	-0.02	-0.03	-0.03	-0.19	-0.13	-0.11	-0.15	0.01	0.05	0.05	0.05	1.00	0.06	0.05	0.04	0.04	0.04	0.03	0.04	0.04	0.06	0.05	0.04	0.04	0.04	0.04
14	-0.01	-0.02	-0.02	-0.03	-0.03	-0.20	-0.14	-0.18	0.02	0.04	0.04	0.05	0.06	1.00	0.06	0.06	0.06	0.02	0.04	0.02	0.05	0.03	0.07	0.05	0.05	0.04	0.04
15	-0.01	-0.01	-0.02	-0.02	-0.03	-0.03	-0.20	-0.22	0.02	0.03	0.03	0.04	0.05	0.06	1.00	0.07	0.07	0.02	0.02	0.03	0.03	0.04	0.04	0.07	0.06	0.05	0.05
16	-0.01	-0.01	-0.02	-0.02	-0.03	-0.04	-0.04	-0.30	0.02	0.03	0.03	0.04	0.04	0.06	0.07	1.00	0.09	0.01	0.02	0.02	0.03	0.03	0.05	0.04	0.08	0.07	0.07
17	-0.01	-0.01	-0.02	-0.02	-0.03	-0.04	-0.04	-0.30	0.02	0.03	0.03	0.04	0.04	0.06	0.07	0.09	1.00	0.01	0.02	0.02	0.03	0.03	0.05	0.04	0.08	0.07	0.07
18	-0.52	-0.02	-0.29	-0.02	-0.18	-0.02	-0.09	-0.03	0.01	0.07	0.07	0.03	0.04	0.02	0.02	0.01	0.01	1.00	0.01	0.11	0.01	0.05	0.01	0.03	0.01	0.01	0.01
19	-0.01	-0.36	-0.03	-0.24	-0.03	-0.15	-0.02	-0.08	0.01	0.12	0.05	0.06	0.03	0.04	0.02	0.02	0.02	0.01	1.00	0.02	0.08	0.01	0.05	0.01	0.02	0.02	0.02
20	-0.06	-0.02	-0.28	-0.03	-0.17	-0.03	-0.09	-0.06	0.01	0.07	0.07	0.04	0.04	0.02	0.03	0.02	0.02	0.11	0.02	1.00	0.01	0.05	0.01	0.03	0.02	0.01	0.01
21	-0.01	-0.04	-0.02	-0.26	-0.03	-0.16	-0.03	-0.11	0.01	0.06	0.06	0.06	0.04	0.05	0.03	0.03	0.03	0.01	0.08	0.01	1.00	0.02	0.05	0.02	0.03	0.03	0.03
22	-0.03	-0.01	-0.04	-0.02	-0.25	-0.03	-0.12	-0.09	0.01	0.04	0.04	0.05	0.06	0.03	0.04	0.03	0.03	0.05	0.01	0.05	0.02	1.00	0.02	0.04	0.02	0.02	0.02
23	-0.01	-0.02	-0.02	-0.03	-0.03	-0.24	-0.03	-0.18	0.01	0.04	0.04	0.04	0.05	0.07	0.04	0.05	0.05	0.01	0.05	0.01	0.05	0.02	1.00	0.03	0.05	0.04	0.04
24	-0.01	-0.01	-0.02	-0.02	-0.03	-0.03	-0.26	-0.13	0.02	0.03	0.03	0.03	0.04	0.05	0.07	0.04	0.04	0.03	0.01	0.03	0.02	0.04	0.03	1.00	0.03	0.03	0.03
25	0.00	-0.01	-0.01	-0.02	-0.02	-0.03	-0.03	-0.26	0.01	0.03	0.03	0.03	0.04	0.05	0.06	0.08	0.08	0.01	0.02	0.02	0.03	0.02	0.05	0.03	1.00	0.06	0.06
26	0.00	-0.01	-0.01	-0.02	-0.02	-0.03	-0.03	-0.25	0.01	0.03	0.03	0.03	0.04	0.04	0.05	0.07	0.07	0.01	0.02	0.01	0.03	0.02	0.04	0.03	0.06	1.00	0.06
27	0.00	-0.01	-0.01	-0.02	-0.02	-0.03	-0.03	-0.25	0.01	0.03	0.03	0.03	0.04	0.04	0.05	0.07	0.07	0.01	0.02	0.01	0.03	0.02	0.04	0.03	0.06	0.06	1.00

Annex 12. SPA standardized residuals (obs. - pred.) from the adaptive framework for 4R spring-spawning herring for (A) the index-fishermen catch rates and (B) the acoustic survey.

A) **INDEX FISHERMEN**

Year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
3	-1.94	0.00	0.00	0.00	1.10	0.35	0.00	0.49	0.00	0.00	0.00	0.00	0.00	0.00
4	0.35	0.13	-0.29	-2.13	1.20	1.33	-0.42	2.08	-0.59	-0.55	-0.18	-0.20	-0.30	0.00
5	1.67	-0.82	0.89	-0.65	-0.65	-0.73	0.23	1.25	0.32	-0.76	-0.52	-0.36	-0.27	0.38
6	1.30	0.74	0.44	-0.26	0.10	-1.61	-1.34	0.29	-0.01	0.13	-0.04	0.05	0.47	-0.28
7	0.50	1.10	0.78	-0.07	-0.28	-0.80	-0.31	-0.87	0.10	-0.30	-0.59	0.35	0.67	-0.28
8	1.93	0.07	-0.02	-0.05	-0.55	-0.91	0.44	-0.39	-0.24	-0.23	-0.39	-0.40	0.91	-0.18
9	0.56	1.39	-0.96	0.29	-0.46	-0.14	-0.29	0.49	-0.18	-0.53	-0.34	-0.02	0.42	-0.23
10	0.86	0.15	-2.46	-0.15	-0.18	-0.07	0.58	0.04	1.05	0.11	-0.22	-0.41	0.55	0.14
11	0.71	0.20	-0.80	-0.95	-1.14	-1.64	1.03	0.59	0.19	0.13	0.47	-0.19	0.59	0.80
SUM	5.94	2.96	-2.40	-3.97	-0.85	-4.22	-0.07	3.97	0.65	-1.99	-1.80	-1.17	3.03	0.36

B) **ACOUSTIC SURVEY**

Year	1991	1993	1995	1997
2	-0.87	0.94	-0.07	0.00
3	-0.10	-0.16	-0.08	0.34
4	0.37	0.33	-0.77	0.08
5	-2.96	1.55	0.60	0.81
6	-0.35	0.20	-0.07	0.22
7	0.82	-1.13	0.36	-0.05
8	0.77	-0.57	0.07	-0.28
9	0.60	0.04	1.30	-1.95
10	0.08	-0.19	0.35	-0.25
11	0.89	-0.25	0.31	-0.95
SUM	-0.74	0.77	2.00	-2.03

Annex 13. Parameter estimates, standard errors, relative errors (CV), bias, relative bias and bias-corrected parameter estimates for the population numbers (N), and the index-fisherman (q(IF)) and research vessel (q(RV)) catchability coefficients in 1999 from the autumn-spawning SPA as estimated from the adaptive framework.

Parameter		Age	Parameter Estimate	Standard Error	Relative Error	Bias	Relative Bias	Bias Corrected
N	1	4	108000	96200	0.894	38200	0.355	69800
	2	5	24400	19300	0.791	5780	0.237	18620
	3	6	23100	16200	0.703	5780	0.250	17320
	4	7	7380	4440	0.602	1410	0.191	5970
	5	8	78800	70500	0.894	21600	0.274	57200
	6	9	2830	2680	0.946	812	0.287	2018
	7	10	7880	11100	1.403	3220	0.408	4660
	8	11+	16700	24800	1.486	6520	0.391	10180
q(RV)	9	2	0.103	0.035	0.338	0.0028	0.027	0.100
	10	3	0.167	0.064	0.386	-0.0038	-0.023	0.171
	11	4	1.250	0.396	0.318	0.0076	0.006	1.242
	12	5	0.572	0.205	0.359	-0.0132	-0.023	0.585
	13	6	1.250	0.370	0.296	-0.0336	-0.027	1.284
	14	7	0.716	0.249	0.348	-0.0121	-0.017	0.728
	15	8	1.650	0.576	0.350	-0.0412	-0.025	1.691
	16	9	1.350	0.484	0.360	-0.0345	-0.026	1.385
	17	10	1.030	0.412	0.401	-0.0016	-0.002	1.032
	18	11+	1.970	0.831	0.422	0.0175	0.009	1.953

Annex 14. Parameter correlation matrix for 4R autumn-spawning herring as estimated from SPA using the adaptive framework.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1	1.00	0.04	0.20	0.06	0.17	0.07	0.15	0.13	-0.10	-0.11	-0.09	-0.10	-0.09	-0.10	-0.09	-0.09	-0.02	-0.54	-0.04	-0.12	-0.05	-0.10	-0.07	-0.09	-0.08	-0.08
2	0.04	1.00	0.10	0.17	0.12	0.16	0.13	0.20	-0.30	-0.13	-0.14	-0.13	-0.14	-0.14	-0.14	-0.14	-0.05	-0.07	-0.41	-0.09	-0.11	-0.10	-0.12	-0.11	-0.12	-0.12
3	0.20	0.10	1.00	0.15	0.26	0.17	0.25	0.29	-0.29	-0.30	-0.19	-0.20	-0.20	-0.21	-0.21	-0.21	-0.04	-0.37	-0.11	-0.38	-0.12	-0.17	-0.15	-0.18	-0.18	-0.18
4	0.06	0.17	0.15	1.00	0.19	0.24	0.21	0.33	-0.29	-0.29	-0.31	-0.22	-0.23	-0.23	-0.23	-0.23	-0.28	-0.11	-0.31	-0.14	-0.35	-0.16	-0.19	-0.18	-0.20	-0.20
5	0.17	0.12	0.26	0.19	1.00	0.24	0.32	0.42	-0.31	-0.33	-0.33	-0.36	-0.28	-0.29	-0.29	-0.29	-0.05	-0.31	-0.14	-0.34	-0.16	-0.40	-0.21	-0.25	-0.25	-0.25
6	0.07	0.16	0.17	0.24	0.24	1.00	0.28	0.46	-0.30	-0.32	-0.34	-0.36	-0.40	-0.32	-0.33	-0.33	-0.07	-0.13	-0.26	-0.18	-0.31	-0.22	-0.44	-0.25	-0.28	-0.28
7	0.15	0.13	0.25	0.21	0.32	0.28	1.00	0.52	-0.33	-0.35	-0.36	-0.38	-0.40	-0.44	-0.37	-0.37	-0.06	-0.27	-0.16	-0.31	-0.20	-0.36	-0.26	-0.47	-0.32	-0.32
8	0.13	0.20	0.29	0.33	0.42	0.46	0.52	1.00	-0.48	-0.54	-0.57	-0.60	-0.64	-0.68	-0.70	-0.71	-0.09	-0.24	-0.28	-0.34	-0.35	-0.43	-0.49	-0.53	-0.61	-0.61
9	-0.10	-0.30	-0.29	-0.29	-0.31	-0.30	-0.33	-0.48	1.00	0.31	0.31	0.32	0.32	0.34	0.34	0.34	0.08	0.19	0.24	0.23	0.21	0.25	0.26	0.28	0.29	0.29
10	-0.11	-0.13	-0.30	-0.29	-0.33	-0.32	-0.35	-0.54	0.31	1.00	0.34	0.35	0.36	0.37	0.38	0.38	0.08	0.20	0.19	0.25	0.23	0.27	0.28	0.30	0.33	0.33
11	-0.09	-0.14	-0.19	-0.31	-0.33	-0.34	-0.36	-0.57	0.31	0.34	1.00	0.36	0.38	0.39	0.40	0.40	0.09	0.17	0.20	0.23	0.24	0.28	0.30	0.32	0.34	0.34
12	-0.10	-0.13	-0.20	-0.22	-0.36	-0.36	-0.38	-0.60	0.32	0.35	0.36	1.00	0.40	0.42	0.42	0.43	0.06	0.18	0.18	0.24	0.23	0.30	0.31	0.34	0.37	0.37
13	-0.09	-0.14	-0.20	-0.23	-0.28	-0.40	-0.40	-0.64	0.32	0.36	0.38	0.40	1.00	0.44	0.45	0.45	0.06	0.17	0.19	0.23	0.24	0.29	0.34	0.35	0.39	0.39
14	-0.10	-0.14	-0.21	-0.23	-0.29	-0.32	-0.44	-0.68	0.34	0.37	0.39	0.42	0.44	1.00	0.48	0.48	0.06	0.18	0.19	0.25	0.24	0.31	0.33	0.38	0.41	0.41
15	-0.09	-0.14	-0.21	-0.23	-0.29	-0.33	-0.37	-0.70	0.34	0.38	0.40	0.42	0.45	0.48	1.00	0.50	0.07	0.17	0.19	0.24	0.25	0.30	0.34	0.37	0.43	0.43
16	-0.09	-0.14	-0.21	-0.23	-0.29	-0.33	-0.37	-0.71	0.34	0.38	0.40	0.43	0.45	0.48	0.50	1.00	0.07	0.17	0.19	0.24	0.25	0.30	0.34	0.37	0.43	0.43
17	-0.02	-0.05	-0.04	-0.28	-0.05	-0.07	-0.06	-0.09	0.08	0.08	0.09	0.06	0.06	0.06	0.07	0.07	1.00	0.03	0.09	0.04	0.10	0.05	0.05	0.05	0.06	0.06
18	-0.54	-0.07	-0.37	-0.11	-0.31	-0.13	-0.27	-0.24	0.19	0.20	0.17	0.18	0.17	0.18	0.17	0.17	0.03	1.00	0.08	0.22	0.09	0.18	0.12	0.16	0.14	0.14
19	-0.04	-0.41	-0.11	-0.31	-0.14	-0.26	-0.16	-0.28	0.24	0.19	0.20	0.18	0.19	0.19	0.19	0.19	0.09	0.08	1.00	0.11	0.17	0.13	0.17	0.15	0.17	0.17
20	-0.12	-0.09	-0.38	-0.14	-0.34	-0.18	-0.31	-0.34	0.23	0.25	0.23	0.24	0.23	0.25	0.24	0.24	0.04	0.22	0.11	1.00	0.13	0.22	0.17	0.22	0.21	0.21
21	-0.05	-0.11	-0.12	-0.35	-0.16	-0.31	-0.20	-0.35	0.21	0.23	0.24	0.23	0.24	0.24	0.25	0.25	0.10	0.09	0.17	0.13	1.00	0.16	0.21	0.19	0.21	0.21
22	-0.10	-0.10	-0.17	-0.16	-0.40	-0.22	-0.36	-0.43	0.25	0.27	0.28	0.30	0.29	0.31	0.30	0.30	0.05	0.18	0.13	0.22	0.16	1.00	0.21	0.26	0.26	0.26
23	-0.07	-0.12	-0.15	-0.19	-0.21	-0.44	-0.26	-0.49	0.26	0.28	0.30	0.31	0.34	0.33	0.34	0.34	0.05	0.12	0.17	0.17	0.21	0.21	1.00	0.26	0.30	0.30
24	-0.09	-0.11	-0.18	-0.18	-0.25	-0.25	-0.47	-0.53	0.28	0.30	0.32	0.34	0.35	0.38	0.37	0.37	0.05	0.16	0.15	0.22	0.19	0.26	0.26	1.00	0.32	0.32
25	-0.08	-0.12	-0.18	-0.20	-0.25	-0.28	-0.32	-0.61	0.29	0.33	0.34	0.37	0.39	0.41	0.43	0.43	0.06	0.14	0.17	0.21	0.21	0.26	0.30	0.32	1.00	0.37
26	-0.08	-0.12	-0.18	-0.20	-0.25	-0.28	-0.32	-0.61	0.29	0.33	0.34	0.37	0.39	0.41	0.43	0.43	0.06	0.14	0.17	0.21	0.21	0.26	0.30	0.32	0.37	1.00

Annex 15. SPA standardized residuals (obs. - pred.) from the adaptive framework for 4R autumn-spawning herring for (A) the index-fishermen catch rates and (B) the acoustic survey.

A) **INDEX FISHERMEN**

Year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
4	0.70	-0.14	-0.09	-0.33	-1.63	-1.26		1.40	0.64	0.38	-1.89	2.32	0.28	-0.38
5	0.15	1.71	-0.03	1.23	0.27	-1.56	-0.28	-0.35	1.23	-0.29	-0.82	-0.45	-0.41	-0.42
6	-1.03	0.93	0.72	-0.29	0.88	-0.48	-1.92	0.46	0.40	0.46	-0.19	0.78	0.25	-0.98
7	-0.49	-0.06	0.55	0.38	-0.12	0.72	-1.53	-1.04	1.01	-0.45	0.88	-0.15	0.32	-0.02
8	-2.13	0.08	-0.97	0.13	0.47	-0.10	-0.32	0.40	0.93	0.72	-0.28	0.69	0.34	0.03
9	-0.84	-0.38	-0.12	-0.81	-0.14	1.16	-0.76	-0.27	1.19	0.29	0.42	-0.74	0.85	0.15
10	0.57	0.61		-0.29	-0.53	-0.75	-1.55	-0.47	1.19	1.13	-0.40	0.95	-0.44	-0.03
11	-0.45	1.15	0.25	-0.16	-0.47	-0.32	-0.79	0.26	1.06	0.89	-0.26	-1.24	0.70	-0.60
SUM	-3.53	3.88	0.31	-0.13	-1.26	-2.59	-7.14	0.40	7.66	3.13	-2.53	2.17	1.90	-2.26

B) **ACOUSTIC SURVEY**

Year	1991	1993	1995	1997
2		-0.06		0.06
3	-0.66	0.51	0.15	
4	0.34	-0.25	-0.47	0.38
5	-0.17	-0.01	0.17	0.01
6	0.19	0.04	-0.18	-0.06
7	-1.24	0.38	-0.04	0.91
8	-0.11	0.23	0.14	-0.27
9	0.99	-0.8	-0.14	-0.05
10	-0.96	0.57	1.05	-0.66
11	0.45	-0.49	-0.08	0.13
SUM	-1.17	0.12	0.59	0.46

Annex 16. Summary of various stock status indicators related to data quality (knowledge status) and their inference on stock status for spring-spawning herring in NAFO division 4R.

Report Card **4R Spring-Spawning Herring**

Indicators			Knowledge Status			Observation	Interpretation	Uncertainties	Stock Status			
Rating	Type	Index	Poor	Medium	High		re: Reference Levels		Collapse	Danger	Pivotal	Healthy
Primary	Population No.	SPA				Historical low	Population in decline since 1984	Poor 11+ residual pattern				
		Acoustic Survey				Historical low	1994 yearclass not strong	Sampling poor / series short				
		IF Catch Rates				Historical low	Decline in 1998 after rise in 1997	Model r2 = .53				
	SSB	SPA				Historical low	Below 20% of virgin stock					
	Recruitment	SPA				Not sufficient to rebuild stock	Below medium since 1990	Not estimated from 95-97				
		S/R				Historical low	Increased chance of poor recruitment	Stock-recruitment relationship poorly known				
		Trawl Survey				Historical low	4R index below 4S index	Not sure what % of population is represented				
	Mortality	Fishing				Historical high	Well above F0.1	Highly variable depending upon yearclass				
		Natural				Assumed to be 0.2		May have increased in 1990's				
	Fishery	Catches				Significantly reduced since 1993	Increased in 1998 after decline since 1995					
		Effort (t-s)				More effort towards the north	Fewer herring in the south					
	Industry Preception	Questionnaires				General decline in south since 1996	Decline in spawning	Possibly biased responses				
		IF Logbooks				Unanimous: Population in decline	Shorter spawning season	Half-dozen fishermen				
		Purse Seine Catch Rates				Increase in 1998	Lots of small fish	Fishing high densities				
Secondary	Age Structure	SPA				Reduction in old ages / decline in mean age	Young ages are assumed average	Unknown recruitment after 1994				
	Maturity at Age	Commercial				Tendency towards younger age at maturity	Population under stress	Highly variable data				
	Growth	Condition Factor				Drop in condition over past 3 years	Poor feeding conditions					
		Weight at Age				Drop in weight at age	Poor growth conditions					
	Spatial Distribution	Fishing Distribution				Shift in distribution towards the north	Fewer herring in the south					
		Acoustic Survey				Few herring in central zone	CIL influence					
Auxiliary	Predators	Gulf Seal Model				Seal consumption possibly 10,000-20,000 t / year	Possibly inhibiting production of recruits	Seal distribution and diet				
	Prey Abundance											
	Oceanography	Temperature				Extremely cold inshore water in fall	Upwelling of CIL					
Overall												

The "Knowledge Status" does not refer only to the amount of data available, but also the reliability and the relevance of these data.

Annex 17. Summary of various stock status indicators related to data quality (knowledge status) and their inference on stock status for autumn-spawning herring in NAFO division 4R.

Report Card **4R Autumn-Spawning Herring**

Indicators			Knowledge Status			Observation	Interpretation	Uncertainties	Stock Status			
Rating	Type	Index	Poor	Medium	High		re: Reference Levels		Collapse	Danger	Pivotal	Healthy
Primary	Population No.	SPA				Wide age distribution	Stock declining slowly since 1992	Weak model fit / No 1998 index				
							Increase in 1997	Sampling poor / Series short				
		Acoustic Survey										
		IF Catch Rates				Near historical low	Declined in 1998 after rise in 1997	Model r2 =0.4 (2 fishermen)				
	SSB	SPA				Slow deline since 1985	Stock maintaining good SSB	Poor model fit				
	Recruitment	SPA				Four y.c. > medium in last 10 years	Recruitment above average	Not estimated from 95-97				
		S/R				Stock at high productivity level	High probability of good recruitment					
		Trawl Survey				Historical low	4R index below 4S index	Not sure what % of population				
	Mortality	Fishing				Increasing slowly since 1985	Still below F0.1					
		Natural				Assumed to be 0.2						
	Fishery	Catches				Increased in since 1992	Increased effort on autumn spawners					
		Effort (t/s)				More effort towards the north	Fewer herring in the south					
	Industry Preception	Questionnaires				General decline in north since 1996	Decline in spawning	Possibly biased responses				
		IF Logbooks				Shorter spawning season		2 fishermen				
		Purse Seine Catch Rates										
Secondary	Age Structure	SPA				Several y.c./ decline in mean age	Young ages are assumed average	Unknown recruitment > 1994				
	Maturity at Age	Commercial				Tendency towards older age at maturity	Population increasing	Highly variable data				
	Growth	Condition Factor				Drop in condition over past 3 years	Poor feeding conditions					
		Weight at Age				Weight at age stable	Normal growth conditions					
	Spatial Distribution	Fishing Distribution				More effort towards the north	Good density of as in north					
		Acoustic Survey				Most herring in the north	CIL influence					
Auxiliary	Predators	Gulf Seal Model				Seal distribution mostly in the south	No noticable decline in productivity	Seal distribution and diet				
	Prey Abundance											
	Oceanography	Temperature				Extremely cold inshore water in fall	Warmer water in north					
Overall												

The "Knowledge Status" does not refer only to the amount of data available, but also the reliability and the relevance of these data.