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**A Review of the West Coast Of Newfoundland (NAFO Division 4R)
Herring Fishery Data (1973 to 1994)**

by

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ABSTRACT

Herring catches in western Newfoundland are mainly taken by large and small purse seiners, and fixed gillnetters, although since 1988, the proportion of the total catch taken by the purse seines has ranged from 90 to 98%. In 1994, total landings were limited to 11,500 t due to a closure imposed in November when the cap of spring-spawning herring was reached. The spring-spawner catch-rate and questionnaire data indicate that the mature biomass in the southern spawning grounds has dropped steadily since 1987, primarily due to poor recruitment following the 1980 and 1982 year-classes. The decline in the local spring-spawning component in this area has come about mainly from: (1) the concentration of fishing effort on this local spawning component since 1988, combined with (2) the lack of a strong recruiting year-class over the past 10 years. Without a strong recruitment pulse, the biomass of the spring-spawning herring in the St. George's Bay/Port-au-Port area will continue to decline in the short term. However, detailed analyses of data collected from outside these southern spawning areas has allowed us to conclude that in general the 4R herring stocks are healthy. Both the spring- and autumn-spawning herring found in the Esquiman Channel in the spring, as well as those in the Bonne Bay/Bay of Islands area during the fall fishery are dominated by younger year-classes which have recruited to these stocks over the past five years. Available information suggests that many of these recruits may originate from the Quebec lower north shore and mix with local west coast of Newfoundland stocks in the fall. Given that the spring closure of St. George's Bay and Port-au-Port Bay should effectively limit directed catches of this spring-spawning component, a TAC of 22,000 t of spring- and autumn-spawning herring outside this area would not be excessive.

RÉSUMÉ

Les captures de hareng de la Côte ouest de Terre-Neuve sont principalement effectuées par les petits et grands senneurs, et les filets maillants, quoique depuis 1988 la proportion des prises totales des sennes-bourses se situait entre 90 et 98%. En 1994, les débarquements totaux furent limités à 11,500 t dû à une fermeture imposée en novembre lorsque le TPA des frayeurs de printemps fut atteint. Le taux de capture des frayeurs de printemps et les données des questionnaires indiquent que la biomasse des géniteurs dans les frayères du sud a constamment décliné depuis 1987, principalement dû au pauvre recrutement ultérieur aux classes d'âge de 1980 et 1982. Le déclin de la composante locale des frayeurs de printemps de cette région est survenu surtout de (1) la concentration de l'effort de pêche sur cette composante locale depuis 1988, combiné avec (2) l'absence d'une forte classe d'âge de recrutement depuis les dix dernières années. Sans une forte pulsion de recrutement, la biomasse des frayeurs de printemps dans la région de la Baie St-Georges et de Port-au-Port continuera à court terme de décliner. Toutefois, des analyses détaillées des données collectées à l'extérieur de ces aires de fraie du sud ont permis de conclure qu'en général les stocks de hareng de 4R sont en santé. Les deux groupes de fraie de printemps et d'automne retrouvés dans le Chenal Esquiman au printemps, aussi bien que ceux de Bonne Bay et de Baie des Isles durant la pêcherie d'automne, sont dominés par de jeunes cohortes qui se sont jointes à ces stocks durant les cinq dernières années. L'information disponible suggère que plusieurs de ces recrues peuvent provenir de la Basse Côte Nord du Québec et se mélanger à l'automne aux stocks locaux de la Côte ouest de Terre-Neuve. Etant donné que la fermeture printanière des baies St-Georges et Port-au-Port devrait limiter les captures dirigées sur la composante printemps, un TPA de 22,000 t de hareng des groupes de fraie de printemps et d'automne à l'extérieur de cette région ne devrait pas être excessif.

INTRODUCTION

Atlantic herring (*Clupea harengus* L.) in NAFO Division 4R (Figure 1) have been assessed by DFO as a single management unit since the stock limits were defined in 1977 (Moore and Winters 1977). The 4R herring management unit was delimited mainly on the basis of tagging studies conducted between 1975 and 1980 (Moore and Winters 1984). These studies indicated that herring tagged during the pre-spawning, spawning and overwintering seasons along the west coast of Newfoundland were primarily (99.2%) recaptured within Division 4R. This division was therefore considered to be "an appropriate reference for [herring] stock assessment purposes" (Moore and Winters 1984). Although there were indications from sampling and tagging data that herring concentrations exploited in St. George's Bay in the spring fishery between 1967 and 1972 were possibly a mixture of west coast and southern Gulf stocks, Moore (1983) concluded that herring caught in this area since 1973 were primarily of west coast origin.

Sympatric seasonal-spawning stocks of herring in the Northwest Atlantic have been shown to have similar attributes for certain population characteristics, e.g. both stocks may experience strong recruitment over two consecutive years (de Lafontaine *et al.* 1991). However, these stocks often show significant differences in other characteristics, e.g. growth rates, fecundity, age structure and physical features (Smith and Jamieson 1986). Most evidence suggests that seasonal-spawning stocks act somewhat independently as adults (McQuinn 1992). It is therefore necessary to follow the population dynamics of each stock separately. The two seasonal-spawning populations in western Newfoundland are therefore considered to be two separate stocks for management purposes.

In addition, within each spawning stock, there are local spawning components associated with specific spawning areas. Examples of spring-spawning components can be found in St. George's Bay, Port-au-Port Bay and St. Paul's Inlet. The interrelationship between these local components has yet to be established, although most evidence suggests that an individual that spawns in a given area will likely return to spawn in that area year after year. Therefore, the repeat spawners of a local spawning component are at risk of over-exploitation if the fishing effort concentrated on them is disproportionately high. Furthermore, a local component may not rebuild at the same rate as the overall stock if the recruitment to that component is not in proportion to the overall recruitment to the stock.

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, although in-season transfers from the fixed gear sector to the mobile fleet have been allowed since the early 1980's. In addition, the purse seine quota has been allocated proportionately 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 experimental, small-purse-seine fishery. The allocation for this gear sector has come from the inshore (fixed gear) quota and has increased from 2,000 to 4,800 t from 1989 to 1994. Neither the TAC nor the advised target fishing level have been exceeded since 1986 (Table 1; Figure 2). In 1994, a cap of 5,400 t of spring spawners was imposed to protect the St. George's Bay/Port-au-Port Bay spawning components.

Total Catches

Herring catches in western Newfoundland are mainly taken by the large (>85') purse seiners, and to a much lesser extent by the small (<65') purse seiners and fixed gillnetters from May to December on both spawning and overwintering concentrations. Since 1988, the proportion of the total catch taken by the purse seines has ranged from 90 to 98% (Figure 3).

Over the past decade, total 4R herring landings have increased from a low of 10,500 t in 1984 to a peak of 21,400 t in 1986 (Figure 2, Table 1) and have ranged from between 15,100 t and 19,400 t from 1987 to 1993. In 1994, total landings were limited to 11,500 t due to a closure imposed in November when the cap of spring-spawning herring (5,400 t) was reached.

The Purse Seine Fleet

Over the past decade, the traditional barrelled-product market for Newfoundland herring has been slowly replaced by an expansion in over-the-side sales (OSS) to the Russians, and by the development of a spring frozen-round market for the Japanese and Koreans. This, along with some quota sharing with the purse seine fleet based in the southern Gulf of St. Lawrence, explains the considerable increase in landings by the spring fishery in 4Rc and 4Rd (from approximately 2,000 t in 1987 to 12,400 t in 1991) (Table 2a). This spring fishery accounted for 71% of the total purse seine catch in 1993 (Figure 4a) and captured mainly spring spawners (Table 3) in the Bay St. George/Port-au-Port area. This proportion dropped to 20% in 1994 due to a cap of 5,400 t on spring-spawning herring. Annual landings from the smaller (<65') purse seiners gear sector had not exceeded 800 t until 1992, when they landed 2,200 t. In 1994, this fleet accounted for 3,400 t.

Mapping the set positions of the two purse seine fleets showed that the seiners were concentrated along the north shore and at the head of St. George's Bay in May (Figure 5). Fishing activity then moved towards the Bay of Islands in the summer, and concentrated more and more around Bonne Bay as the fall approached. There was a relatively important fishery around Cape St. George in October of 1994, which is quite uncommon, and some fishing in St. John's Bay in November.

The Gillnet Fleet

The inshore gillnet fishery is predominantly oriented toward supplying bait for the active lobster fishery. Since 1990, the market for gillnetted herring has been essentially moribund, with recorded landings ranging between 139 and 747 t (Table 2b).

From 1979 to 1989, almost equal proportions of the total gillnet catch were taken from spawning concentrations of spring spawners (Table 4) in St. George's Bay and Port-au-Port Bay (4Rd,4Rc), and north of Pointe Riche (4Ra,4Rb)(Figure 4b). A late fall fishery on mixed spring- and autumn-spawner concentrations (Table 4) has also occurred sporadically in areas 4Ra to 4Rc throughout this period. Since 1990, gillnet landings in St. George's Bay and Port-au-Port Bay have been minimal (Table 2b). In 1994, there was a slight resurgence in landings from the summer 4Ra fishery.

Industry Input

Index gillnet fishermen have been hired since 1984 to complete daily logbooks to record their catch and effort as well as their location, mesh-size, size of nets and water depth. These fishermen also supply biological samples and their comments on the extent of spawning in their area. Half of these fishermen set their nets in the

vicinity of the major spring-spawning sites in the St. George's Bay/Port-au-Port Bay area (Figures 6 and 7) while the other half fish autumn-spawners in the area north of Point Riche (4Ra) during the summer and fall.

The information recorded by these index-fishermen, as well as comments received from written questionnaires sent annually to all licensed inshore herring fishermen again confirmed observations made over the past three to four years that the abundance of the spring-spawning herring in the St. George's Bay/Port-au-Port Bay area continues to be low (Figure 8). A summary of these comments suggests a decrease in spawning activity in the southern unit areas, since the onset of spawning has been delayed, and that both the duration and geographic extent of spawning have contracted over the past several years (Table 5). Purse-seine fishing effort is the most commonly cited cause for the decline in the southern stock and for the disruption of normal spawning activity (Table 5).

North of Pointe Riche in unit area 4Ra (the major autumn-spawning area), comments varied, although the general opinion was that the abundance of herring ranged from average to good (Figure 8). In fact, during a recent seminar on 4R herring, several industry spokesmen from this area noted the re-establishment of certain spawning sites in 1994 where spawning had not occurred for several years.

BIOLOGICAL CHARACTERISTICS

Data collection and Analysis

Random samples covering most of the major commercial landings were collected by port samplers and by index gillnet fishermen (Annex 1). 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).

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 more were aggregated into an 11+ age-group. As in previous years, the 1994 catch at age (Table 6) was generated (CAT_AGE v1.0, Anon 1986) for spring and autumn spawners as described by McQuinn (1987b), weighting the age compositions by the corresponding landing as grouped in Annex 1.

Spawning Stock Proportions

Spring spawners have dominated the catch in every year since 1973 (Table 6), and exceeded 80% of the catch in numbers between 1988 and 1990 due to the active spring fishery in St. George's Bay, which traditionally exploits pre-spawning and spawning concentrations. Typically herring schools at the head of St. George's Bay near the spawning beds are predominately spring spawners while the autumn spawners are concentrated towards the mouth of the Bay or north of Cape St. George in 4Rc (McQuinn and Lefebvre 1994, McQuinn and Lefebvre 1995a). In 1994, most of the purse seine catches were inside the bay along the north shore (Figure 5), and as a result were again almost exclusively comprised of spring spawners.

Age Composition

Since the mid-1980's, the 1980 and 1982 year-classes have been the dominant contributors to the spring-spawner catch for both gillnets and purse seines (Table 7a). In 1991, the 1987 year-class recruited strongly to the purse seine fishery, making up 18% of the spring-spawner catch. Subsequently, the 1989 and 1991 year-classes became more and more prevalent in the overall spring-spawner catch. However, a closer look at these age composition data showed that the 1987, 1989 and 1991 year-classes were quite abundant in both the purse seine and gillnet catches during the fall fishery in the more northerly areas, although they were of only minor importance on the southern spawning grounds in the spring (McQuinn and Lefebvre 1995a).

In 1983, the 1979 autumn-spawning year-class strongly recruited into the fishery and contributed more than 24% of the catch in numbers at age 4 (Table 7b). In 1990, the 1986 year-class strongly recruited to the autumn-spawner purse-seine catch, but only became a significant contributor to the gillnet fishery in 1992 (Table 8). Since 1992, the 1988 year-class has also contributed significantly to the total autumn-spawner catch, with the 1989 and 1987 year-classes also appearing to be above average.

DISTRIBUTION

Distributional information is available from the winter (January), the spring (May) and the summer (August-September) bottom-trawl surveys, as well as the fall (November) acoustic survey (McQuinn and Lefebvre 1995a). Although capture data from the winter, spring and summer bottom-trawl surveys should only be considered qualitative for herring, catch/tow information was used as an indicator of geographic presence or absence. Catches from the summer survey from 1990 to 1993 showed herring to be consistently found in northern 4R where autumn spawning occurs. The 4R herring acoustic survey revealed that large concentrations had moved into the Bonne Bay/Bay of Islands area by November. Finally, catches from the winter and spring surveys consistently showed herring in the Esquiman Channel in January and in May.

These latter surveys also showed the 1987 and 1989 year-classes to be well represented in the Esquiman Channel since 1990, while the 1980 and 1982 year-classes were dominant inshore near the spawning grounds. The 1987 and 1989 year-classes were also abundant along the coast as determined from the fall acoustic survey (McQuinn and Lefebvre, 1995b) as well as from the fall purse seine fishery since 1991. However, these year-classes have not been detected spawning in large numbers anywhere along the west coast of Newfoundland in the gillnet catches, even though most of them have been mature since 1991 to 1993.

The most probable explanation for this pattern is that many of the spring herring from the 1987 and 1989 year-classes observed in 4R in the late fall originated from another area in the northern Gulf. An examination of the size composition from the inshore fishery along the Quebec lower north shore showed that the 1987 year-class has been present on the spawning grounds since 1992 and has been dominant since 1993 (McQuinn and Lefebvre 1995a). Given the presence of the 1987 and 1989 year-classes in the Esquiman Channel in January, and again in May, these may well be herring migrating to 4S where spring spawning occurs in late May and June. These same fish then appear to migrate to western Newfoundland in the fall where they are caught in the Bonne Bay fishery.

ABUNDANCE

Acoustic Surveys

Fall acoustic surveys conducted in 1989, 1991 and 1993 revealed that areas of herring concentrations vary from year to year both in intensity and expanse (McQuinn and Lefebvre 1995b). All of the surveys showed large concentrations of herring in the Bonne Bay/Bay of Islands area, although they were much more dispersed in 1993. Although the results of the 1989 survey did not yield useful biomass estimates due to technical problems, we were nonetheless able to confirm the presence of large herring schools in St. John's Bay in that year.

An estimate of the total biomass indicated the presence of approximately 127,000 t of herring in 4R in 1991 (70,000 t of spring spawners and 57,000 of autumn spawners), with 96% being in and around Bonne Bay. In 1993, the total biomass estimate was 66,000 t (31,000 t of spring spawners and 35,000 t of autumn spawners). However, this estimate is considered to be conservative since two northern strata were not surveyed due to bad weather, and fishing activity at that time confirmed the presence of herring schools in these strata (St. John's Bay) as in 1989. Biological samples from purse seines in 4Ra in November showed that the majority (80%) of these herring in the northern strata were autumn spawners although no data are available on their abundance.

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 (Table 9 and 10). These catch rates were standardized using a multiplicative model (Gavaris 1980). The categorical variables for this model were year, month and fishing site, and were chosen to account for spatial and temporal variability (Table 11 and 12). 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 4). 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 6 and 7) or the autumn-spawning areas north of Point Riche.

Spring-spawner catch rates calculated from the logbook data reflected the recruitment and subsequent decline of the contribution of the 1980 and 1982 spring-spawning year-classes to the gillnet fishery (Figure 9a; Table 13). Similarly, the passage of the 1979 year-class was equally obvious in the autumn-spawning series (Figure 9b). Furthermore, the recruitment of the 1986 autumn-spawning and the 1987 spring-spawning year-classes was also evident.

These catch rates indicate that the spring-spawning 1987 cohort was above average, but insufficiently strong to rebuild this spawning stock, as evidenced by its decline in importance at age five in the gillnet catch. The 1986 autumn-spawning cohort appeared quite strong in the index-fisherman catch rates in 1992 and seemed at that time to be well above the 10-year average. However, it has since declined sharply over the last two years and is now at a relatively low level.

ENVIRONMENTAL CONSIDERATIONS

It is believed that adverse environmental conditions may be having a detrimental effect on the general condition of the Gulf of St. Lawrence ecosystem. The average condition (weight vs length) of both of these herring stocks has declined in the past two years (Figure 10). However, when put into the perspective of the last 25 years, average condition was even lower from 1973 to 1976 (Figure 11). Furthermore, the lower fatness of

west coast herring in the last two years does not seem to have affected the reproductive output, since the gonadosomatic index (McQuinn 1989) of these fish has not changed over the last 11 years (Figures 12 and 13).

Parallel with these changes in fatness, purse seine operators have noted changes in fish schooling behaviour. For example, the traditional fall Bonne Bay fishery was curtailed in 1992 and 1993, when the typically large concentrations of herring left the bay area a month earlier than usual (end of November rather than the end of December). At the same time, they noted that these herring had not been feeding. The usual concentrations of krill were not present, the herring were not coming off the bottom at night to feed, and they were more widely distributed along the coast. All of these observations were confirmed during the fall 1993 acoustic survey which indicated a lack of adequate food in the Bonne Bay area, and a premature emigration into deeper waters (McQuinn and Lefebvre 1995b).

ASSESSMENT RESULTS AND DISCUSSION

Spring Spawners

The spring-spawner catch-rate data indicate that the mature biomass in the southern spawning grounds has dropped steadily since 1987, primarily due to poor recruitment following the 1980 and 1982 year-classes. Only the recruitment of the moderately strong 1987 year-class caused a slowing of this downward trend, which has continued to the present. This was not totally unexpected given the heavy fishing effort exercised during the spring St. George's Bay fishery over the past 6 years which has concentrated on pre-spawning herring.

Acoustic abundance estimates indicated a spring-spawner population biomass of 70,000 t in November, 1991 (McQuinn and Lefebvre 1995b). These herring were highly concentrated in the Bonne Bay area and were quite stationary since the fishery continued until mid-December. In 1993, the acoustic survey only found 31,000 t of spring spawners. However, since some fishing was taking place in the northern, un-surveyed strata, some important herring concentrations were missed. In addition, the herring in the Bonne Bay area were much more dispersed, and were apparently on the move, since they had left the area by the week following our survey. For these reasons the 1993 survey biomass (31,000 t) is undoubtedly an underestimate. The 1991 estimate (70,000 t) is considered to be more reliable and suggests that significant quantities of spring-spawners do concentrate in 4R during the fall fishery.

The present analyses point to (1) a decrease in the abundance of spring spawners in the St. George's Bay/Port-au-Port Bay spawning grounds and (2) an increase in the fishing effort and mortality on the spring-spawning stock in recent years. The decline in the local spring-spawning component in this area has come about mainly from two factors: (1) the concentration of fishing effort on this local spawning component since 1988, combined with (2) the lack of a strong recruiting year-class over the past 10 years. Even though the 1987 and 1989 year-classes are predominant in the northern areas later in the year, very little spawning by them has been detected in and around St. George's Bay and Port au Port Bay, or elsewhere in 4R. This situation could be explained by the contribution of spring-spawning herring from another major spring-spawning area in northern 4R not yet known or from spawning areas elsewhere in the north-eastern Gulf (i.e. 4S). Seasonal distribution and size composition data as well as comments from industry suggest that these 1987 and 1989 year-classes found in the fall catches are most likely from 4S (McQuinn and Lefebvre 1995a).

Autumn Spawners

The logbook catch-rate index indicated strong recruitment by the 1986 year-class in 1992, although this abundance index has declined sharply since then. However, the rather sharp decline in the 1993 and 1994 autumn-spawner catch rate was unexpected, and may be related to the observation made by inshore fishermen that the autumn spawners were farther offshore than usual in 1993, and thus less available to their gear. This possibility is substantiated by the higher catches of autumn spawners in the offshore by the summer groundfish survey in 1993 (McQuinn and Lefebvre 1994). This downward trend also contradicts other indices which show this stock to be in relatively good condition. These autumn spawners have been lightly exploited over the past decade, comprising less than 30% of the total catch since 1986. Responses to a written questionnaire also indicate that the status of this spawning component north of Point Riche (the major autumn-spawning zone) is relatively good but that the market for gillnetted herring is very limited. Finally, the presence of this year-class in the late fall purse seine fishery since 1990 and its dominance since 1991 (McQuinn and Lefebvre 1994) also points to a strong recruiting pulse. It is possible that this index-fisherman catch-rate series has become less reliable since it was estimated using data from only four logbooks in 1993 and three logbooks in 1994.

The 1991 acoustic estimate placed the fall autumn-spawning biomass at 57,000 t and, as with the spring-spawning stock, the majority was found in the Bonne Bay area. Although the 1993 estimate was considerably lower (35,000 t), the missed northern strata may well account for the difference, since the commercial fishery was catching mostly autumn spawners at that time.

Industry Feedback

The data described in this assessment were presented to industry delegates during a 4R herring seminar held in Corner Brook, Newfoundland the 1-2 February 1995. Representatives of all the principal gear sectors were present (i.e. large seiners, small seiners and gillnetters) as well as the major processors. There was a general agreement among the industry representatives present that the data presented were consistent with their observations. Therefore, in light of the concern for the St. George's Bay and Port au Port Bay spawning components, an Industry Working Group proposed the following management measures:

1. an experimental co-management group representing industry and DFO will be established to monitor future events surrounding the spring spawners in St. George's Bay and Port-au-Port Bay and to take appropriate action as the fishery unfolds.
2. the spring herring fishery in these areas normally taking place in early May will be delayed until June 15.
3. prior to June 15, purse seine fishing will be restricted inside the line drawn from Cape St. George to Cape John in St. George's Bay and from Long Point to Broad Cove in Port-au-Port Bay. A bait fishery with gillnets will not be subject to these closed areas but the issue of the sale for bait will be addressed by the co-management group.
4. the co-management group will also address the issue of co-operative research.

The implementation of these management measures as suggested by the Industry Working Group was seen as a positive step towards the protection and conservation of these southern spawning stocks.

PROGNOSES

Northern Gulf Herring Stock Status

This year's review of the 4RS herring data has resulted in a greater understanding of herring population dynamics in the northern Gulf of St. Lawrence. Detailed analyses of all available commercial and research data has allowed us to conclude that these herring stocks are generally healthy. Both the spring- and autumn-spawning herring found in the Esquiman Channel in the spring, as well as those in the Bonne Bay/Bay of Islands area during the fall fishery are dominated by younger year-classes which have recruited to these stocks over the past five years (McQuinn and Lefebvre 1995a). Available information suggests that many of these recruits originate from the Quebec lower north shore and mix with local west coast of Newfoundland stocks in the fall. Unfortunately, the 1993 acoustic survey did not allow us to assess the total abundance of herring available along the west coast at that time, although at least 66,000 t of spring and autumn spawners were estimated in the southern strata. The 1995 fall acoustic survey will endeavour to estimate the total biomass of these herring.

St. George's Bay/Port-au-Port Bay

Although the status of the northern Gulf herring is generally good, the fishing mortality in recent years has been high on the spring spawners in St. George's Bay and Port-au-Port Bay and, at present, the biomass of this local component is low. Several indices suggest that the extent of spawning activities has been reduced in these areas. The gillnet catch-rate index continued to decline in 1994 and local inshore fishermen have not noted an improvement in the abundance of spawning herring.

Without a strong recruitment pulse, the abundance of the spring-spawning herring in the St. George's Bay/Port-au-Port area will continue to decline in the short term, with no forecast of rebuilding in the mid-term. Since the 1987 and 1989 year-classes are now fully recruited in other areas, it is unlikely that they will contribute significantly to this local spawning component. Fishing effort must therefore be reduced in these areas. The closure of St. George's Bay and Port-au-Port Bay to commercial fishing until 15 June 1995 is a necessary conservation measure and will help to limit the targeting of these spawners. Given these new conservation regulations, there is now less concern that other special restrictions will be needed for the 1995 fishing season to limit catches of spring-spawners outside of the St. George's Bay and Port au Port area. The dominance of the 1987 and 1989 year-classes among the spring-spawners in the Esquiman Channel in the spring and in the late fall Bonne Bay fishery will prevent the targeting of the 1980 and 1982 year-classes in these areas.

The situation in St. George's Bay must be watched closely. The continuation of the index-fisherman program in this area is essential for the monitoring of spawning activity and for the estimation of an abundance index for this local component. In addition, an acoustic survey undertaken this spring in co-operation with the large purse seine fleet will provide valuable information on the spawning type and size composition of the herring in the Esquiman Channel in early May.

With the concerns raised about the local 4R spring spawners, it is clear that the current TAC of 35,000 t is too high for these stocks. A catch of under 22,000 t of spring and autumn spawners has been advised for the past five years, and only the limited inshore market has kept total catches below this level. We reiterate that a TAC based on biological considerations would be more appropriate and in line with principles of conservation. Given that the spring closure of St. George's Bay and Port-au-Port Bay should effectively limit directed catches of this spring-spawning component, a TAC of 22,000 t of spring- and autumn-spawning herring outside this area would not be excessive.

The Management Unit

If, as suspected, the majority of herring from the 1987 and 1989 year-classes are local 4S spawners, the definition of 4R as a management unit must be revised. Although there is no indication that local 4R herring are caught in other management units, it would be appropriate to expand the 4R management unit to include the Quebec lower north shore (northeast of Beaugé Bank) if indeed the herring which spawn along that shore are subsequently caught along the west coast of Newfoundland. Although the available data do not allow us to confirm this at present, research efforts will be oriented towards verifying this hypothesis.

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Table 1. Herring catches (t) by gear type and fishing area and total allowable catches from NAFO Division 4R from 1966 to 1994.

YEAR	4Rd				4Rc				4Rb				4Ra				COMBINED				TAC
	Purse seine	Gill-net	Other gears*	Total	Purse seine	Gill-net	Other gears*	Total	Purse seine	Gill-net	Other gears*	Total	Purse seine	Gill-net	Other gears*	Total	Purse seine	Gill-net	Other gears*	Total	
1966	0	216	0	216	0	103	0	103	5491	39	0	5530	0	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	17415	37000
1990	5156	97	0	5253	7495	79	0	7574	3404	181	6	3591	28	323	133	484	16084	677	140	16903 ¹	35000
1991	11871	37	0	11918	1557	31	0	1588	5342	59	0	5401	98	323	54	377	18877	450	54	19381 ¹	35000
1992	8696	27	1	8724	1523	37	0	1560	4091	47	1	4139	346	440	115	901	14655	552	117	15324 ¹	35000
1993	10967	55	0	11022	1015	9	5	1029	2198	20	0	2218	694	55	103	852	14874	139	108	15121 ¹	35000
1994	2495	117	0	2612	2872	75	0	2947	4454	161	0	4615	779	394	145	1318	10600	747	145	11492 ¹	35000

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

¹ Preliminary

² Purse seine landings adjusted according to industry records

Table 2.a. Herring landings (t) by purse seines in NAFO division 4R by unit area and month from 1986 to 1994.

YEAR	AREA	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
1986	4Ra										3091	10608	2131	15830
	4Rb													1586
	4Rc					1400		186						1854
	4Rd				185	1669								
	Total				185	3069		186				3091	10608	2131
1987	4Ra											164		164
	4Rb					25			14		748	4426	4951	10164
	4Rc					1319	596			153	565	379	171	3183
	4Rd					222								222
	Total					1566	596		14	153	1313	4969	5122	13733
1988	4Ra							22	22					44
	4Rb									71	312	437	273	1093
	4Rc				639	5342	70		6		990	1985	4165	13197
	4Rd				1308	711								2019
	Total				1947	6053	70	22	28	71	1302	2422	4438	16353
1989	4Ra								13					13
	4Rb				33						81	347	486	947
	4Rc				35		51		6	514	776	3080	2127	6589
	4Rd				379	8587	145							9111
	Total				447	8587	196		19	514	857	3427	2613	16660
1990	4Ra						14	14						28
	4Rb						138				379			3404
	4Rc				6536	450	205	27	17	261	2888			7495
	4Rd				4799	335				23				5156
	Total				11335	798	357	27	17	662	2888			16084
1991	4Ra						62	36						98
	4Rb				8	42	113	18	45	501	3285	1330		5342
	4Rc				490	87	127		107	130	161	463		1567
	4Rd				6090	5567	214							11871
	Total				6090	6065	345	303	54	152	631	3446	1793	18877
1992	4Ra						86	258	2					346
	4Rb						18			87	3986			4091
	4Rc				23	779	43		51	56	567	4		1523
	4Rd				8297	124				2	273	1		8696
	Total				8320	1007	301	2	51	145	4825	5		14655
1993	4Ra					11	127	78	51	4		423		694
	4Rb		15						57	62	824	1241		2198
	4Rc				2	143	29		9	2	764	67		1015
	4Rd				1337	9122					78	431		10967
	Total		15		1339	9276	156	78	117	68	1666	2162		14874
1994	4Ra						84	12		25	57	601		779
	4Rb						35	629	1528	738	1524			4454
	4Rc				143	405	29	600	653	1043				2873
	4Rd				1565	63				866				2494
	Total				1708	552	76	1229	2206	2704	2125			10600

Table 2.b. Herring landings (t) by gillnets in NAFO division 4R by unit area and month from 1986 to 1994.

YEAR	AREA	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
1986	4Ra					65	84	19	48	28	68	14	11	337
	4Rb				6	48	46	14	9	8	136	171	30	468
	4Rc				132	319	105	21	10	8	141	319	14	1069
	4Rd				100	83	49	21	10	10				273
	Total				238	515	284	75	77	54	345	504	55	2147
1987	4Ra					19	21	14	142	65	192	353	23	829
	4Rb	1		1	15	22	23	11	7	5	87	135	20	327
	4Rc				146	580	96	77	52	13	55	117	1	1137
	4Rd				146	319	30	22	8	8	13	4		550
	Total	1		1	307	940	170	124	209	91	347	609	44	2843
1988	4Ra					14			18	5	208	225	38	508
	4Rb				11	15	23	7	4	2	60	114	21	257
	4Rc				34	61	227	186	10	4	7	18	45	592
	4Rd				108	113	43	142	8	8	11	1		434
	Total				153	203	293	335	40	19	286	358	104	1791
1989	4Ra					4	34	13			4	182	100	337
	4Rb		1	2	8	16	24	8	2	1	7			69
	4Rc				10	213	101	108		11		1		444
	4Rd				2	107	36	19	7	5		1		177
	Total		1	2	20	340	195	148	9	17	11	184	100	1027
1990	4Ra					4	9	3	13	49	28	216		323
	4Rb				10	13	23	14	3	1	1	117		181
	4Rc					4	19	46	3	2	5			79
	4Rd					34	11	40	9	2	1			97
	Total				10	55	62	102	28	54	35	333		679
1991	4Ra						21	169	40	23	24	45		323
	4Rb									1	12	46		59
	4Rc								6	19	5			31
	4Rd				2	4	1		9	12	6	4		37
	Total				2	4	22	169	56	56	47	95		450
1992	4Ra					9	16	179	34	12	107	84		440
	4Rb			2	3	15	20	1			3	3		47
	4Rc					22	2	5	3	1	2	2		37
	4Rd					15	3	3	2	1	1	2	1	27
	Total			2	3	62	41	188	39	14	113	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			395
	4Rb						3	5		116	26	10		160
	4Rc					21	42	7	2	4				76
	4Rd					34	59	16	3	6				118
	Total					55	104	260	56	233	31	10		749

Table 3. Proportion (%) of spring- and autumn-spawning herring in the purse seine catch by month and fishing area, NAFO Division 4R from 1973 to 1994.

SPAWNING GROUP	FISHING AREA																											
	4Rd			4Rc								4Rb								4Ra								
	SPRING	APR	MAY	NOV	JAN	APR	MAY	JUN	JUL	SEP	OCT	NOV	DEC	JAN	APR	MAY	JUN	AUG	SEP	OCT	NOV	DEC	JUL	AUG	SEP	OCT	NOV	DEC
1973	51.3				36.7	64.7							91.3							91.0	90.8							76.7
1974	68.3	39.1																			92.6							
1975	98.0	84.7																										
1976	90.4	97.8				52.3																						87.7
1977	95.4	99.0				32.4																			47.3	89.3		
1978	82.4				81.9																						85.8	84.4
1979	86.2				43.2	26.0															93.3						91.6	86.7
1980	95.2				98.0							73.4									88.2							
1981	96.4	92.0			97.3															87.3	63.5	55.7						
1982					99.8	98.0			65.0											78.8	77.7							
1983					61.0	54.5				73.8											79.8						74.7	62.7
1984				76.4	43.9									40.9							76.9	64.5	60.5				62.0	
1985		92.0				66.0	49.7			82.6							23.8			71.0	70.0	67.7						
1986	77.0	100.0				93.6		78.0												77.3	74.8	71.0						
1987		97.0			100.0	93.0	100.0		65.3	84.7							0.0			74.5	76.9	72.1					28.0	
1988	83.6	99.5				34.0	100.0							37.5				62.0		41.3	65.8	72.1	28.0	2.0				
1989		91.3				34.0				79.5	66.9									68.5	70.1	70.1						
1990		89.8						78.0			88.0									74.0	55.3	66.0						
1991		71.6						72.0	48.0	66.0		80.0								56.3	65.3	63.4						
1992		94.7	72.7			100.0	100.0		28.6		68.2									32.0	49.9							
1993	90.0	84.9								67.7					74.0					72.7	56.6			0.0			22.0	
1994		91.2					90.0		63.9	43.8								13.8	43.3	32.0	51.3							
AUTUMN																												
1973	48.7				63.3	35.3							8.7							9.0	9.2							23.3
1974	31.7	60.9																			7.4							
1975	2.0	15.3																										
1976	9.6	2.2				47.7																						12.3
1977	4.6	1.0				67.6																			52.7	10.7		
1978	17.6				18.1																						14.2	15.6
1979	13.8				56.8	74.0															6.7						8.4	13.3
1980	4.8				2.0							26.6									11.7							
1981	3.6	8.0			2.7															12.7	36.5	44.3						
1982					0.2	2.0			35.0											21.2	22.3							
1983					39.0	45.5				26.2											20.2	31.1					25.3	37.3
1984				23.6	56.1									59.1							23.1	35.5	39.5				38.0	
1985		8.0				34.0	50.3			17.4											29.0	30.0	32.3					
1986	23.0	0.0				6.4		22.0												22.7	25.2	29.0						
1987		3.0			0.0	7.0	0.0			34.7	15.3									25.5	23.1	27.9					72.0	
1988	16.4	0.5				66.0	0.0							62.5							58.7	34.2	27.9	72.0	98.0			
1989		8.7				66.0				20.5	33.1									31.5	29.9	29.9						
1990		10.2						22.0			12.0									26.0	44.7	34.0						
1991		28.4						28.0	52.0	34.0		20.0								43.7	34.7	36.6						
1992		5.3	27.0						71.4		31.8									68.0	50.1							
1993	10.0	15.1				0.0	0.0			32.1					26.0					27.2	43.4			100.0			78.0	
1994		8.8					10.0		36.1	56.3										86.2	56.7	68.0	48.7					

Table 4. Proportion (%) of spring- and autumn-spawning herring in the gillnet catch by month and fishing area, NAFO division 4R from 1973 to 1994.

SPAWNING GROUP	FISHING AREA																							
	4Rd			4Rc						4Rb						4Ra								
SPRING	APR	MAY	JUN	APR	MAY	JUN	JUL	SEP	OCT	MAY	JUN	JUL	SEP	OCT	NOV	DEC	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1973												32.3		29.0	81.2				14.4					62.4
1974											99.0					86.5				14.3				50.0
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														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											8.6	27.9	63.0	36.0	52.7
1985		97.7				86.5	90.0													9.5	15.7			28.0
1986	84.4	98.4			50.0	83.7			66.0	80.0					54.4				80.0					
1987	92.0	99.4			52.0	84.7	88.6							52.2					16.8	10.1	32.0	44.1	27.1	
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			
AUTUMN																								
1973												67.7		71.0	18.8				85.6					37.6
1974											1.0					13.5				85.7				50.0
1975		10.0									44.7	88.0												
1976		0.0									2.0													23.3
1977											16.7	82.0				14.0		34.0	67.2	92.0	74.3	43.4	22.0	
1978		1.0								14.3	2.0						48.0	66.4					21.1	
1979	16.0				7.2					5.0					16.0				61.3	88.2	56.0	44.0		
1980	3.6				8.9					0.0					18.2		36.7	44.4	65.9	97.0	57.1	28.0	34.0	
1981					4.2					17.6	9.0							63.0	75.1	99.3			56.3	
1982						2.8									35.1				97.3					
1983		4.3												20.0	53.9	58.2			60.4	98.6	53.7	43.1	43.7	31.8
1984		5.9				21.5			16.0											91.4	72.1	37.0	64.0	47.3
1985		2.3				13.5	10.0																	72.0
1986	15.6	1.6			50.0	16.3			34.0	20.0					45.6				20.0	90.5	84.3			
1987	8.0	0.6			48.0	15.3	11.4							47.8					83.2	89.9	68.0	55.9	72.9	
1988	2.0	0.4	4.0		26.5	21.7	18.6	24.0												85.8	74.0	50.5	62.5	
1989		1.0	8.9		14.0	14.7	20.4								29.0	43.3			72.0	88.2	73.0	58.7	47.2	58.0
1990		3.1	0.7			8.0	11.5	65.5							56.0				84.5	82.2	89.2	82.0	67.5	
1991		4.1	4.0			11.2	40.8						68.0	56.0	30.0				95.5	72.1	61.9	50.0	56.6	
1992		6.8	24.0			25.2	29.6	48.0										74.0	90.0	91.7	99.0	89.8		
1993		2.0				21.3	11.0											14.0	96.0	96.0	98.3			
1994		2.5	0.7			6.0	11.2	98.0											92.5	98.5	88.4			

Table 5. Comments from written questionnaires sent to inshore herring fishermen in 4R in 1994
(each value represents the number of comments which agree with the statement).

COMMENTS	3Pn	4Rd	4Rc	4Rb	4Ra	TOTAL
Herring abundant	1	1		4	9	14
- during summer-fall	1			2	9	12
- due to DFO control				1		1

Herring stock in decline	4	21	13	25	9	71
- during spring				1		1
- during fall		1				1
Complaints against seiners:	1	19	16	20	23	78
- catch everything, destroying	1	16	13	16	18	63
- on spawning grounds		6	5	5	4	20
- dumping at sea	1		3	6	10	20
Others causes suggested:		4	6	2	3	15
- draggers		1	1	2	1	5
- Russian vessels (OSS)		2	2		1	5
- seals			2		1	3
- no food for herring		1				1
- gillnets negligent			1			1

Spawning:						
- in decline		2		1	1	4
- late arrival on grounds				2		2
- absence of spawn in fish				1		1
- increasing					1	1
- herring full of spawn		1			1	2

Size of herring:						
- small		7	6	7	9	28
- big			1	3	6	10

Distribution:						
- Herring offshore			1		1	2
- Herring inshore			1			1

Markets are poor	1	2	5	2	34	43

Number of questionnaires returned	17	54	55	103	144	373 (42%)

Table 6. Spring- and autumn-spawner catch at age ($\times 10^3$) and proportion of spring spawners in NAFO division 4R herring landings from 1973 to 1994 (all gears).

SPRING SPAWNERS																						
	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0	0	0	0	45	0	0	3	13	0	4	39	48	265	323	183	0	0	0	0	0	0
2	1833	141	57	484	10	0	167	300	40	594	34	198	362	323	455	734	305	100	480	90	79	14
3	435	261	996	680	534	47	25	854	417	2374	2965	433	4587	2348	329	519	574	2056	1706	1243	1589	296
4	1063	130	420	846	541	1987	214	106	2114	693	3562	7773	787	13762	2781	417	763	610	7036	1708	3800	2522
5	27872	371	100	201	409	207	10828	355	129	2452	1131	3809	21642	3349	15257	2400	461	412	934	8377	3411	3040
6	2570	9445	1063	350	304	679	617	13872	354	421	1091	595	3993	28781	3507	14830	3036	983	631	997	6776	3689
7	3222	318	8431	2802	348	241	1075	407	8872	2153	293	814	445	5241	12952	4004	18705	5002	2072	998	1504	3379
8	3232	851	317	15567	4362	2162	547	1344	188	6488	713	209	381	465	1736	14606	3072	16049	4939	2783	2110	1616
9	2598	774	336	759	15959	8208	2772	247	515	704	2990	672	255	167	182	2734	10910	3782	15660	2168	2713	1620
10	4789	490	244	3136	1694	15260	7404	1427	283	950	798	755	380	260	37	480	779	6472	1649	11882	2798	1775
11+	5696	2175	665	3588	6003	5062	14032	20574	13181	12863	7975	4226	1764	1661	806	2123	1380	2130	4762	4064	8816	2080
1+	53310	14955	12629	28413	30210	33851	37681	39488	26106	29692	21556	19523	34645	56621	38365	43030	39985	37594	39869	34310	33597	20032
AUTUM SPAWNERS																						
	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	15	0	101	15	0	15	35	0	484	43	38	50	0	21	0
3	1798	20	19	48	3	10	7	181	33	567	83	55	235	426	156	207	599	463	719	337	210	52
4	1180	393	40	272	169	27	116	136	524	1824	2330	668	1340	1431	487	511	539	1391	949	1446	676	866
5	1114	530	865	290	134	545	345	86	245	956	1356	6259	1907	2671	1354	481	923	387	4279	1446	1955	2519
6	2626	325	925	422	404	393	2689	176	90	509	1309	1147	9678	2292	2009	1240	807	312	628	1235	1011	3773
7	1527	592	107	561	721	1108	520	1729	295	140	506	908	902	8421	1728	1740	749	466	1082	776	1651	3020
8	2631	258	157	325	405	1689	1287	250	1234	377	159	220	622	794	5927	1667	828	323	609	542	569	2399
9	3830	308	147	253	342	503	1847	675	153	972	467	146	115	384	474	4165	961	1027	485	777	918	1609
10	8265	313	218	88	293	341	468	308	124	315	618	268	36	66	163	705	2873	442	1658	389	884	1176
11+	17653	5610	3371	4818	6646	6051	6286	5243	3369	2609	2824	3091	468	227	196	777	983	4223	5543	3925	4592	3957
1+	40626	8348	5848	7076	9116	10668	13564	8799	6067	8371	9667	12762	15333	16745	12494	11977	9305	9072	16002	10873	12486	19371
TOTAL (SPRING AND AUTUMN)																						
YEAR	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
TOTAL	93937	23303	18477	35489	39326	44520	51245	48288	32173	38062	31223	32286	49978	73366	50859	53475	49292	46666	55871	45183	46084	39403
% SS	56.8	64.2	68.4	80.1	76.8	76.0	73.5	81.8	81.1	78.0	69.0	60.5	69.3	77.2	75.4	80.5	81.1	80.6	71.4	75.9	72.9	50.8

Table 7. Age composition (%) and mean age* of (A) spring and (B) autumn spawners in NAFO division 4R herring landings from 1973 to 1994. Dominant year-classes have been underlined.

A) SPRING SPAWNER AGE COMPOSITION (%)

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	.0	.0	.0	.0	.1	.0	.0	.0	.1	.0	.0	.2	.1	.5	.8	.4	.0	.0	.0	.0	.0	.0
2	3.4	.9	.5	1.7	.0	.0	.4	.8	.2	2.0	.2	1.0	1.0	.6	1.2	1.7	.8	.3	1.2	.3	.2	.1
3	.8	1.7	7.9	2.4	1.8	.1	.1	2.2	1.6	8.0	<u>13.8</u>	2.2	<u>13.2</u>	4.1	.9	1.2	1.4	5.5	4.3	3.6	4.7	1.5
4	2.0	.9	3.3	3.0	1.8	5.9	.6	.3	8.1	2.3	<u>16.5</u>	<u>39.8</u>	<u>2.3</u>	<u>24.3</u>	7.2	1.0	1.9	1.6	<u>17.6</u>	5.0	11.3	12.6
5	<u>52.3</u>	2.5	.8	.7	1.4	.6	<u>28.7</u>	.9	.5	8.3	5.2	19.5	<u>62.5</u>	5.9	<u>39.8</u>	5.6	1.2	1.1	<u>2.3</u>	<u>24.4</u>	10.2	15.2
6	4.8	<u>63.2</u>	8.4	1.2	1.0	2.0	1.6	<u>35.1</u>	1.4	1.4	5.1	3.0	11.5	<u>50.8</u>	9.1	<u>34.5</u>	7.6	2.6	1.6	2.9	<u>20.2</u>	<u>18.4</u>
7	6.0	2.1	<u>66.8</u>	9.9	1.2	.7	2.9	1.0	<u>34.0</u>	7.3	1.4	4.2	1.3	9.3	<u>33.8</u>	9.3	<u>46.8</u>	13.3	5.2	2.9	4.5	16.9
8	6.1	5.7	2.5	<u>54.8</u>	14.4	6.4	1.5	3.4	.7	<u>21.9</u>	3.3	1.1	1.1	.8	4.5	<u>33.9</u>	7.7	<u>42.7</u>	12.4	8.1	6.3	8.1
9	4.9	5.2	2.7	<u>2.7</u>	<u>52.8</u>	24.2	7.4	.6	2.0	2.4	<u>13.9</u>	3.4	.7	.3	.5	6.4	<u>27.3</u>	10.1	<u>39.3</u>	6.3	8.1	8.1
10	9.0	3.3	1.9	11.0	5.6	<u>45.1</u>	19.6	3.6	1.1	3.2	<u>3.7</u>	3.9	1.1	.5	.1	1.1	1.9	<u>17.2</u>	4.1	<u>34.6</u>	8.3	8.9
11+	10.7	14.5	5.3	12.6	19.9	15.0	<u>37.2</u>	<u>52.1</u>	<u>50.5</u>	<u>43.3</u>	<u>37.0</u>	<u>21.6</u>	5.1	2.9	2.1	4.9	3.5	5.7	11.9	11.8	<u>26.2</u>	10.4

MEAN AGE* OF INDIVIDUALS IN CATCH

YEAR	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
MEAN AGE	6.5	7.0	6.8	8.1	9.0	9.3	8.6	8.7	8.8	8.4	7.7	6.3	5.3	5.6	5.9	7.0	7.6	8.0	7.7	7.9	7.6	7.0

B) AUTUMN SPAWNER AGE COMPOSITION (%)

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0
2	.0	.0	.0	.0	.0	.0	.0	.2	.0	1.2	.2	.0	.1	.2	.0	4.6	.5	.4	.3	.0	.2	.0
3	4.4	.2	.3	.7	.0	.1	.1	2.1	.5	6.8	.9	.4	1.5	2.5	1.3	1.8	6.4	5.1	4.5	3.1	1.7	.3
4	2.9	4.7	.7	3.8	1.9	.2	.9	1.5	8.6	21.8	<u>24.1</u>	5.2	8.7	8.5	3.9	5.0	5.8	<u>15.3</u>	5.9	<u>13.3</u>	5.4	4.5
5	2.7	6.4	14.8	4.1	1.5	5.1	2.5	1.0	4.0	11.4	14.0	<u>49.0</u>	12.4	15.9	10.8	4.7	9.9	4.3	<u>26.7</u>	<u>13.3</u>	<u>15.7</u>	13.0
6	6.5	3.9	15.8	6.0	4.4	3.7	<u>19.8</u>	2.0	1.5	6.1	13.5	9.0	<u>63.1</u>	13.7	16.1	9.8	8.7	3.4	3.9	<u>11.4</u>	8.1	<u>19.5</u>
7	3.8	7.1	1.8	7.9	7.9	10.4	<u>3.8</u>	<u>19.7</u>	4.9	1.7	5.2	7.1	5.9	<u>50.3</u>	13.8	12.1	8.0	5.1	6.8	7.1	<u>13.2</u>	<u>15.6</u>
8	6.5	3.1	2.7	4.6	4.4	15.8	9.5	2.8	<u>20.3</u>	4.5	1.6	1.7	4.1	4.7	<u>47.4</u>	14.4	8.9	3.6	3.8	5.0	4.6	12.4
9	9.4	3.7	2.5	3.6	3.8	4.7	13.6	7.7	2.5	<u>11.6</u>	4.8	1.1	.7	2.3	3.8	<u>36.4</u>	10.3	11.3	3.0	7.1	7.4	8.3
10	20.3	3.8	3.7	1.3	3.2	3.2	3.5	3.5	2.0	3.8	6.4	2.1	.2	.4	1.3	4.8	<u>30.9</u>	4.9	10.4	3.6	7.1	6.1
11+	<u>43.5</u>	<u>67.2</u>	<u>57.6</u>	<u>68.1</u>	<u>72.9</u>	<u>56.7</u>	<u>46.3</u>	<u>59.6</u>	<u>55.5</u>	<u>31.2</u>	<u>29.2</u>	<u>24.2</u>	3.1	1.4	1.6	6.4	10.6	<u>46.5</u>	<u>34.6</u>	<u>36.1</u>	<u>36.8</u>	<u>20.4</u>

MEAN AGE* OF INDIVIDUALS IN CATCH

YEAR	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
MEAN AGE	9.2	9.6	9.0	9.6	10.0	9.5	9.0	9.5	9.2	7.4	7.3	6.8	6.0	6.3	7.1	7.7	7.9	8.5	7.8	7.8	8.2	7.7

* assuming ages 11+ to be 11.

Table 8. Spring- and autumn-spawner gillnet catch at age ($\times 10^3$) in NAFO division 4R herring landings from 1973 to 1994.

	SPRING-SPAWNER GILLNET CATCH AT AGE																					
	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	3	0	0	21	1	0	0	0	0	0	0	0	0	0	0
3	7	10	0	13	13	3	0	71	59	319	842	13	1	3	0	4	8	30	3	0	0	0
4	145	0	89	0	4	368	42	50	805	145	1770	1416	33	296	125	30	46	26	82	14	1	20
5	2148	76	10	0	39	82	2980	123	53	879	468	1486	1220	143	1714	600	58	35	7	50	10	164
6	228	1781	219	15	53	132	441	5485	163	106	513	242	391	2909	602	1436	349	75	4	18	36	71
7	1225	111	878	581	141	63	606	225	4038	340	57	469	67	662	2388	561	996	78	22	31	8	214
8	769	383	89	1790	1041	751	337	620	83	2495	19	67	75	78	418	1139	165	433	31	66	29	51
9	784	130	66	123	1680	1659	1597	146	192	229	1200	236	44	55	26	132	396	53	90	22	32	73
10	467	89	48	540	325	4228	3403	927	113	256	249	271	62	45	18	27	51	112	14	87	36	70
11	2830	1210	172	1336	1712	2408	6726	8291	3484	4144	3151	1892	290	261	175	98	53	36	47	26	48	104
1+	8603	3789	1573	4398	5007	9695	16131	15942	8988	8912	8290	6094	2183	4452	5466	4026	2121	880	300	316	201	767
	AUTUMN-SPAWNER GILLNET CATCH AT AGE																					
	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	3	0	0	0	0	16	24	0	0	0	0	0	0	0	1	0	0	0
4	32	106	6	0	39	9	11	43	342	405	1229	83	4	3	36	2	8	43	15	30	1	13
5	179	190	200	11	30	296	260	73	201	523	531	2319	49	102	178	102	32	70	55	32	10	47
6	766	49	586	178	90	193	1289	153	24	164	627	329	1211	189	354	251	63	119	63	178	18	358
7	331	207	46	191	467	463	218	1342	245	81	143	397	134	1596	473	202	108	79	82	80	27	401
8	639	38	134	228	228	708	504	120	876	199	78	74	93	135	1909	169	187	132	88	136	21	409
9	683	198	108	161	239	156	527	603	46	554	169	64	26	84	194	679	174	228	55	148	42	191
10	1862	80	201	88	140	147	315	272	71	220	199	95	2	31	74	89	182	51	68	51	44	141
11+	6941	2719	2683	2826	2647	3624	3018	4552	2396	1529	581	442	115	160	54	68	55	654	495	678	221	673
1+	11434	3586	3964	3684	3884	5595	6142	7159	4201	3708	3582	3803	1633	2299	3273	1561	809	1376	921	1334	385	2232

Table 9. Frequency of observations of index-fisherman catch and effort data by month, fishing area and year for spring-spawning herring in NAFO Division 4R.

MONTH	Frequency	Percent	Cumulative Frequency	Cumulative Percent
4	76	2.7	76	2.7
5	896	32.1	972	34.8
6	508	18.2	1480	53.0
7	185	6.6	1665	59.6
8	777	27.8	2442	87.4
9	310	11.1	2752	98.5
10	31	1.1	2783	99.6
11	10	0.4	2793	100.0

FISHING AREA	Frequency	Percent	Cumulative Frequency	Cumulative Percent
FISCHELL	167	6.0	167	6.0
SANDY POINT	328	11.7	495	17.7
ST-GEORGES	117	4.2	612	21.9
BARACHOIS BROOK	118	4.2	730	26.1
LOURDES	229	8.2	959	34.3
BLACK DUCK BROOK	267	9.6	1226	43.9
LONG PT. (BAY)	274	9.8	1500	53.7
CASTOR RIVER	43	1.5	1543	55.2
WHALE ISLAND	12	0.4	1555	55.7
EDDIES COVE E	1238	44.3	2793	100.0

YEAR	Frequency	Percent	Cumulative Frequency	Cumulative Percent
84	96	3.4	96	3.4
85	202	7.2	298	10.7
86	225	8.1	523	18.7
87	307	11.0	830	29.7
88	355	12.7	1185	42.4
89	303	10.8	1488	53.3
90	267	9.6	1755	62.8
91	227	8.1	1982	71.0
92	247	8.8	2229	79.8
93	290	10.4	2519	90.2
94	274	9.8	2793	100.0

Table 10. Frequency of observations of index-fisherman catch and effort data by month, fishing area and year for autumn-spawning herring in NAFO Division 4R.

MONTH	Frequency	Percent	Cumulative Frequency	Cumulative Percent
4	21	1.0	21	1.0
5	386	18.7	407	19.7
6	348	16.9	755	36.6
7	180	8.7	935	45.3
8	777	37.7	1712	83.0
9	310	15.0	2022	98.0
10	31	1.5	2053	99.5
11	10	0.5	2063	100.0

FISHING AREA	Frequency	Percent	Cumulative Frequency	Cumulative Percent
LOURDES	229	11.1	229	11.1
BLUE BEACH	205	9.9	434	21.0
LONG PT. (BAY)	336	16.3	770	37.3
CASTOR RIVER	43	2.1	813	39.4
WHALE ISLAND	12	0.6	825	40.0
EDDIES COVE E	1238	60.0	2063	100.0

YEAR	Frequency	Percent	Cumulative Frequency	Cumulative Percent
84	96	4.7	96	4.7
85	147	7.1	243	11.8
86	158	7.7	401	19.4
87	207	10.0	608	29.5
88	279	13.5	887	43.0
89	229	11.1	1116	54.1
90	209	10.1	1325	64.2
91	167	8.1	1492	72.3
92	167	8.1	1659	80.4
93	207	10.0	1866	90.5
94	197	9.5	2063	100.0

Table 11. Analysis of variance and regression coefficients for the 1984 to 1994 spring-spawning 4R herring catch rate data (catch/(surface*hours)).

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	26	6871.971001	264.306577	127.71	0.0001
Error	2766	5724.457733	2.069580		
Corrected Total	2792	12596.428734			

R-Square	C.V.	Root MSE	CATRATE Mean
0.545549	-17.29810	1.438603	-8.316540

Source	DF	Type III SS	Mean Square	F Value	Pr > F
MONTH	7	374.0483793	53.4354828	25.82	0.0001
FISH	9	908.5890649	100.9543405	48.78	0.0001
YEAR	10	474.7005680	47.4700568	22.94	0.0001

Parameter	Estimate	T for H0: Parameter=0	Pr > T	Std Error of Estimate	
INTERCEPT	-18.10227072 B	-28.64	0.0001	0.63197482	
MONTH	4	5.30758929 B	8.81	0.0001	0.60263060
	5	5.59966456 B	9.72	0.0001	0.57591247
	6	4.89686405 B	8.51	0.0001	0.57549640
	7	3.39521412 B	7.18	0.0001	0.47275251
	8	2.89283350 B	6.25	0.0001	0.46266325
	9	3.38660404 B	7.26	0.0001	0.46643162
	10	2.97160446 B	5.62	0.0001	0.52854253
	11	0.00000000 B	.	.	.
FISH	BARACHOIS BK	4.63146556 B	8.13	0.0001	0.56968893
	BLACK DUCK BK	4.37441696 B	7.86	0.0001	0.55630967
	CASTOR RIVER	3.08597702 B	6.45	0.0001	0.47880559
	EDDIES COVE E	4.57830630 B	10.79	0.0001	0.42440602
	FISCHELL	5.96484737 B	10.64	0.0001	0.56086561
	LONG PT. (BAY)	4.93434460 B	8.88	0.0001	0.55585886
	LOURDES	3.85709109 B	6.96	0.0001	0.55400245
	SANDY POINT	5.20166878 B	9.34	0.0001	0.55716477
	ST-GEORGES	5.65283294 B	9.89	0.0001	0.57128239
	WHALE ISLAND	0.00000000 B	.	.	.
YEAR	84	0.52233857 B	2.97	0.0030	0.17568572
	85	1.43682688 B	10.30	0.0001	0.13945924
	86	1.24103442 B	9.30	0.0001	0.13345785
	87	1.44729364 B	11.40	0.0001	0.12699867
	88	0.98747286 B	8.23	0.0001	0.11995414
	89	0.88757578 B	7.32	0.0001	0.12126335
	90	0.41828003 B	3.35	0.0008	0.12493833
	91	0.97068237 B	7.43	0.0001	0.13057968
	92	0.72446661 B	5.71	0.0001	0.12689139
	93	0.33445690 B	2.74	0.0061	0.12186667
	94	0.00000000 B	.	.	.

Table 12. Analysis of variance and regression coefficients for the 1984 to 1994 autumn-spawning 4R herring catch rate data (catch/(surface*hours)).

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	22	2550.951107	115.952323	66.06	0.0001
Error	2040	3580.873304	1.755330		
Corrected Total	2062	6131.824411			
	R-Square	C.V.	Root MSE	CATRATE Mean	
	0.416018	-16.28532	1.324889	-8.135477	

Source	DF	Type III SS	Mean Square	F Value	Pr > F
MONTH	7	313.5613072	44.7944725	25.52	0.0001
FISH	5	555.4372175	111.0874435	63.29	0.0001
YEAR	10	458.9295715	45.8929572	26.14	0.0001

Parameter	Estimate	T for H0: Parameter=0	Pr > T	Std Error of Estimate	
INTERCEPT	-17.56159675 B	-29.91	0.0001	0.58709067	
MONTH	4	4.48477455 B	7.11	0.0001	0.63078414
	5	3.90695463 B	6.97	0.0001	0.56026711
	6	3.75329245 B	6.70	0.0001	0.55979087
	7	4.74348077 B	10.86	0.0001	0.43674677
	8	4.96345065 B	11.61	0.0001	0.42757269
	9	4.56277956 B	10.59	0.0001	0.43082910
	10	3.72663023 B	7.63	0.0001	0.48837962
	11	0.00000000 B	.	.	.
FISH	BLUE BEACH	4.75651420 B	8.73	0.0001	0.54495314
	CASTOR RIVER	3.22451320 B	7.27	0.0001	0.44333607
	EDDIES COVE E	4.95170237 B	12.61	0.0001	0.39257390
	LONG PT. (BAY)	4.01224204 B	7.40	0.0001	0.54245922
	LOURDES	3.53097448 B	6.53	0.0001	0.54050395
	WHALE ISLAND	0.00000000 B	.	.	.
YEAR	84	-0.28209840 B	-1.67	0.0958	0.16928883
	85	1.17010027 B	7.86	0.0001	0.14889514
	86	0.81977361 B	5.60	0.0001	0.14646753
	87	0.59935018 B	4.42	0.0001	0.13545799
	88	0.53561138 B	4.18	0.0001	0.12815636
	89	0.37147017 B	2.81	0.0049	0.13197752
	90	-0.51589475 B	-3.83	0.0001	0.13462453
	91	0.28716722 B	2.02	0.0440	0.14247736
	92	1.13126985 B	7.97	0.0001	0.14186907
	93	0.64991912 B	4.91	0.0001	0.13231431
	94	0.00000000 B	.	.	.

Table 13. Predicted mean catch rate estimates for spring- and autumn-spawning herring in NAFO Division 4R.

YEAR	SPRING SPAWNERS		AUTUMN SPAWNERS	
	CATCH RATE	STANDARD ERROR	CATCH RATE	STANDARD ERROR
84	0.67440	0.10228	0.43110	0.06029
85	1.69153	0.19304	1.84695	0.21976
86	1.39218	0.14593	1.30244	0.14342
87	1.71257	0.16493	1.04612	0.10255
88	1.08186	0.09841	0.98214	0.08982
89	0.97835	0.09590	0.83280	0.08303
90	0.61169	0.06209	0.34279	0.03519
91	1.06195	0.11541	0.76439	0.08630
92	0.83013	0.09064	1.77726	0.20598
93	0.56272	0.05498	1.09993	0.11231
94	0.40263	0.04052	0.57408	0.06033

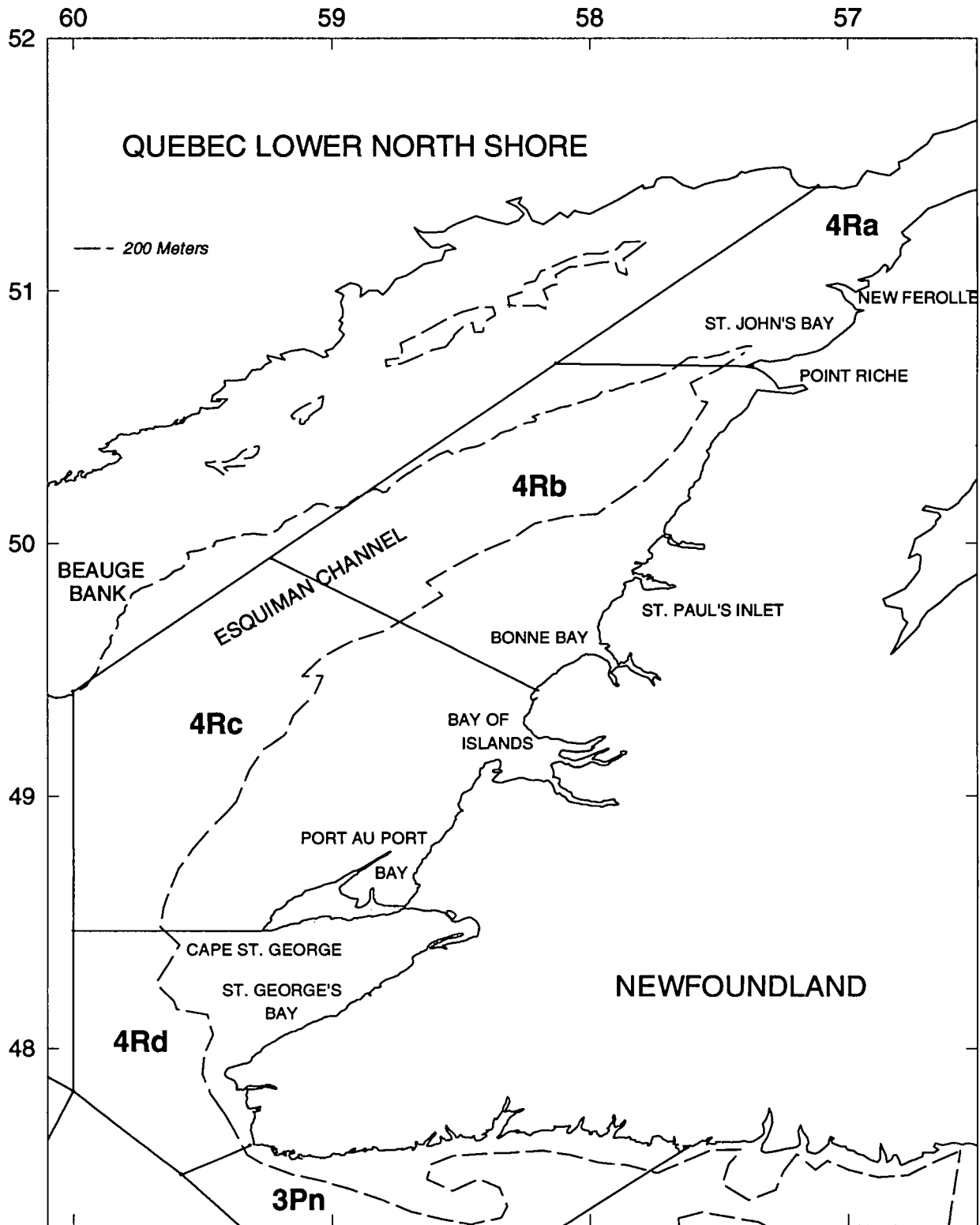


Figure 1. West coast of Newfoundland unit areas.

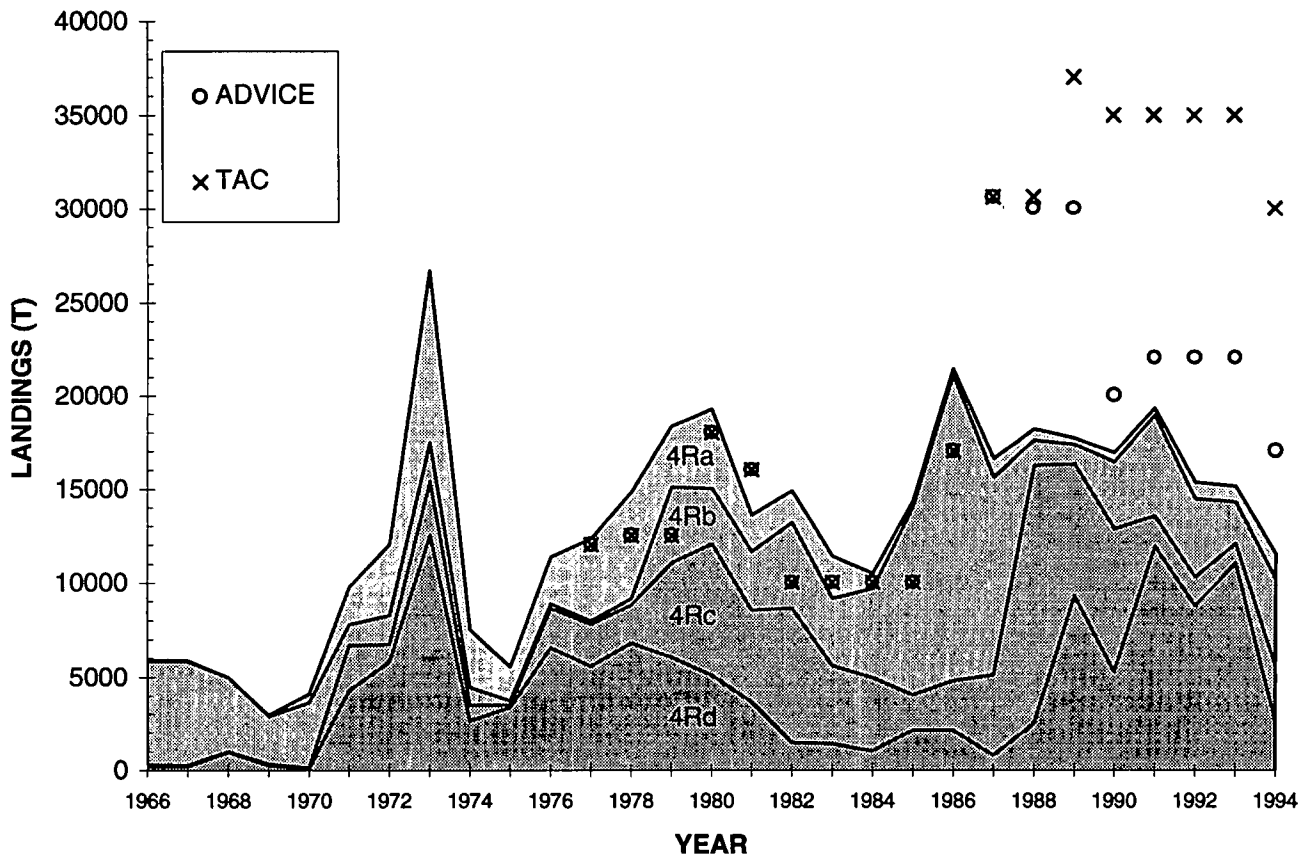


Figure 2. Cumulative commercial herring landings (t) by unit area in NAFO Division 4R from 1966 to 1994. (TAC and assessment advice are indicated).

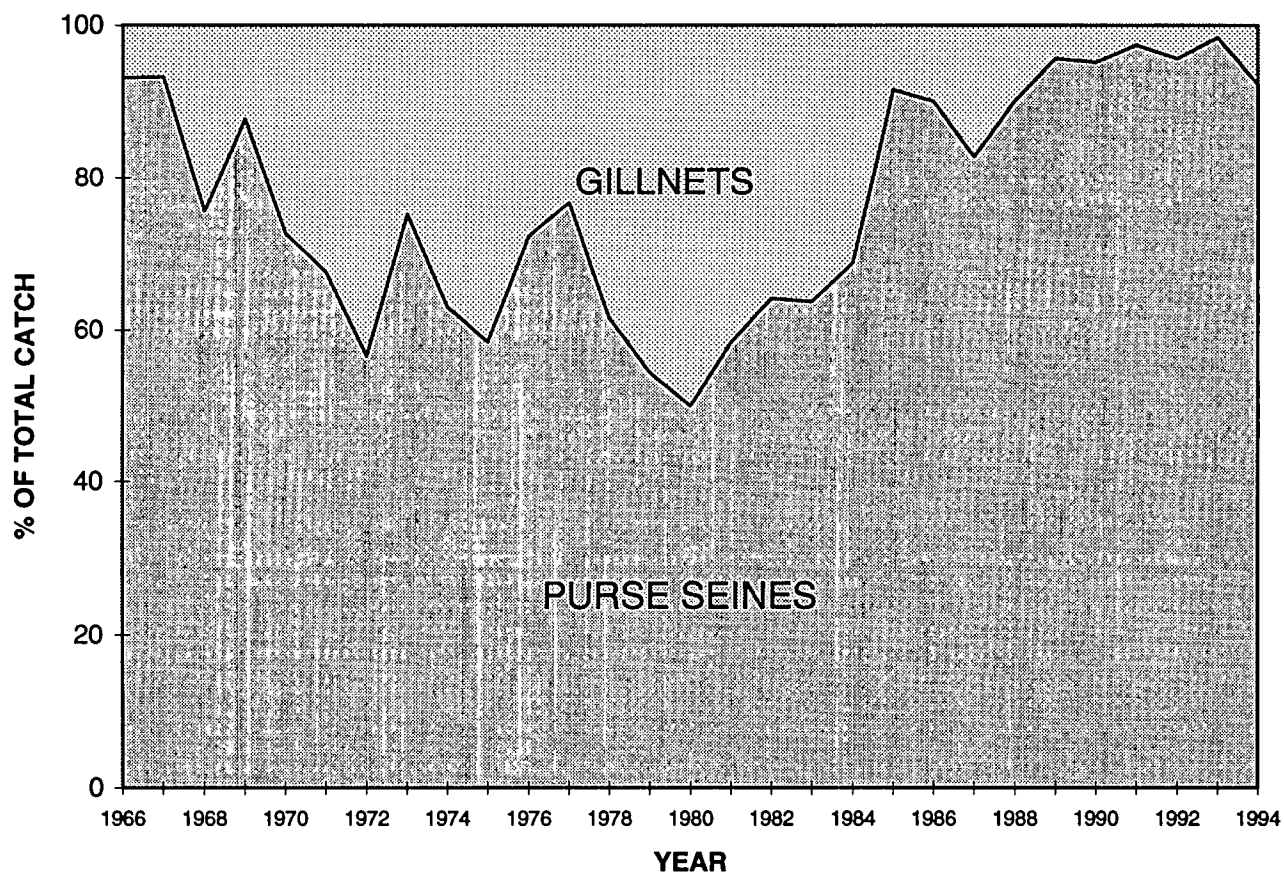


Figure 3. Proportion of total herring landings taken by gillnets and purse seiners in NAFO Division 4R from 1966 to 1994.

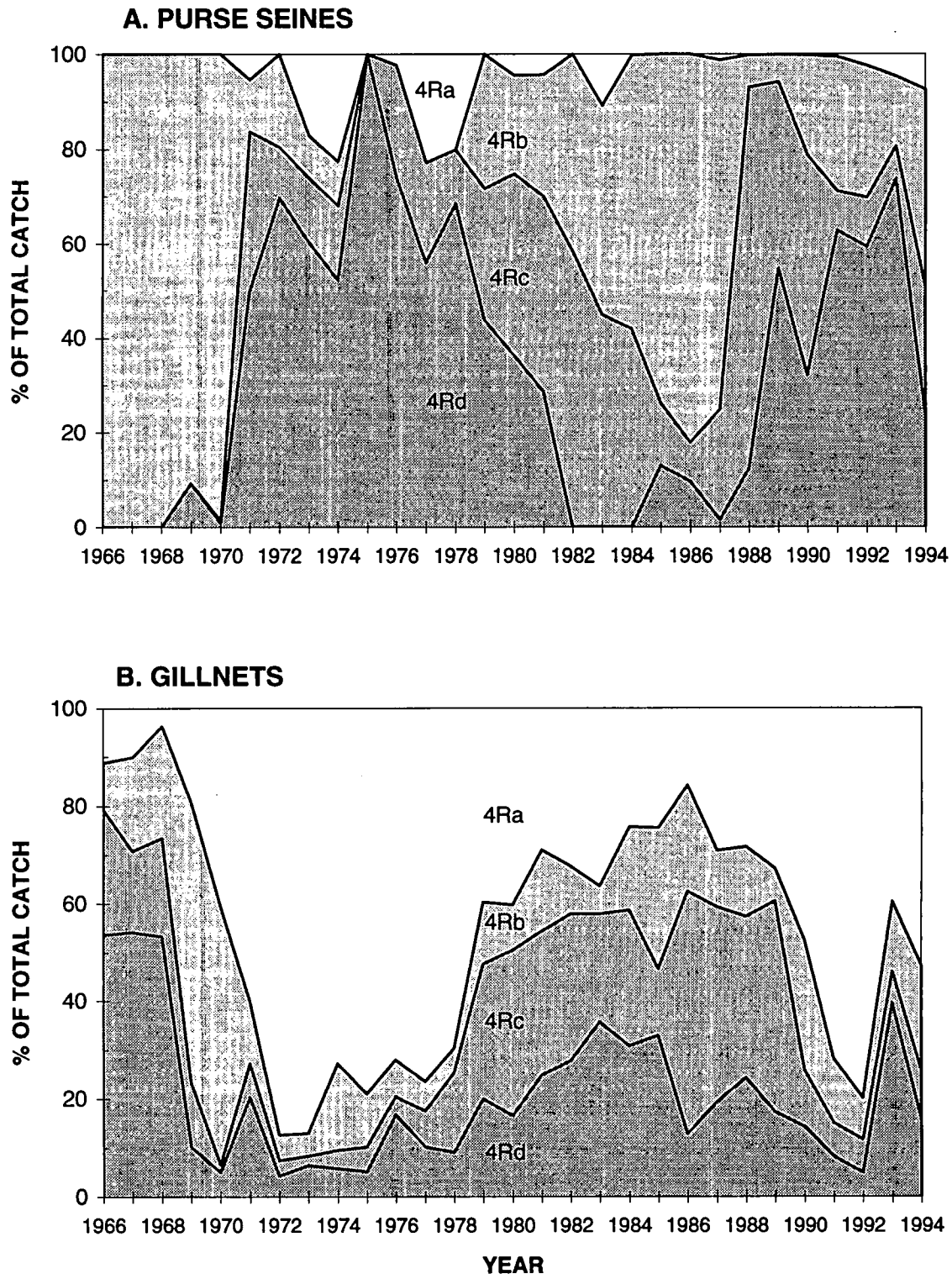


Figure 4. Proportion of purse seine (A) and gillnet (B) herring landings by fishing area in NAFO Division 4R from 1966 to 1994.

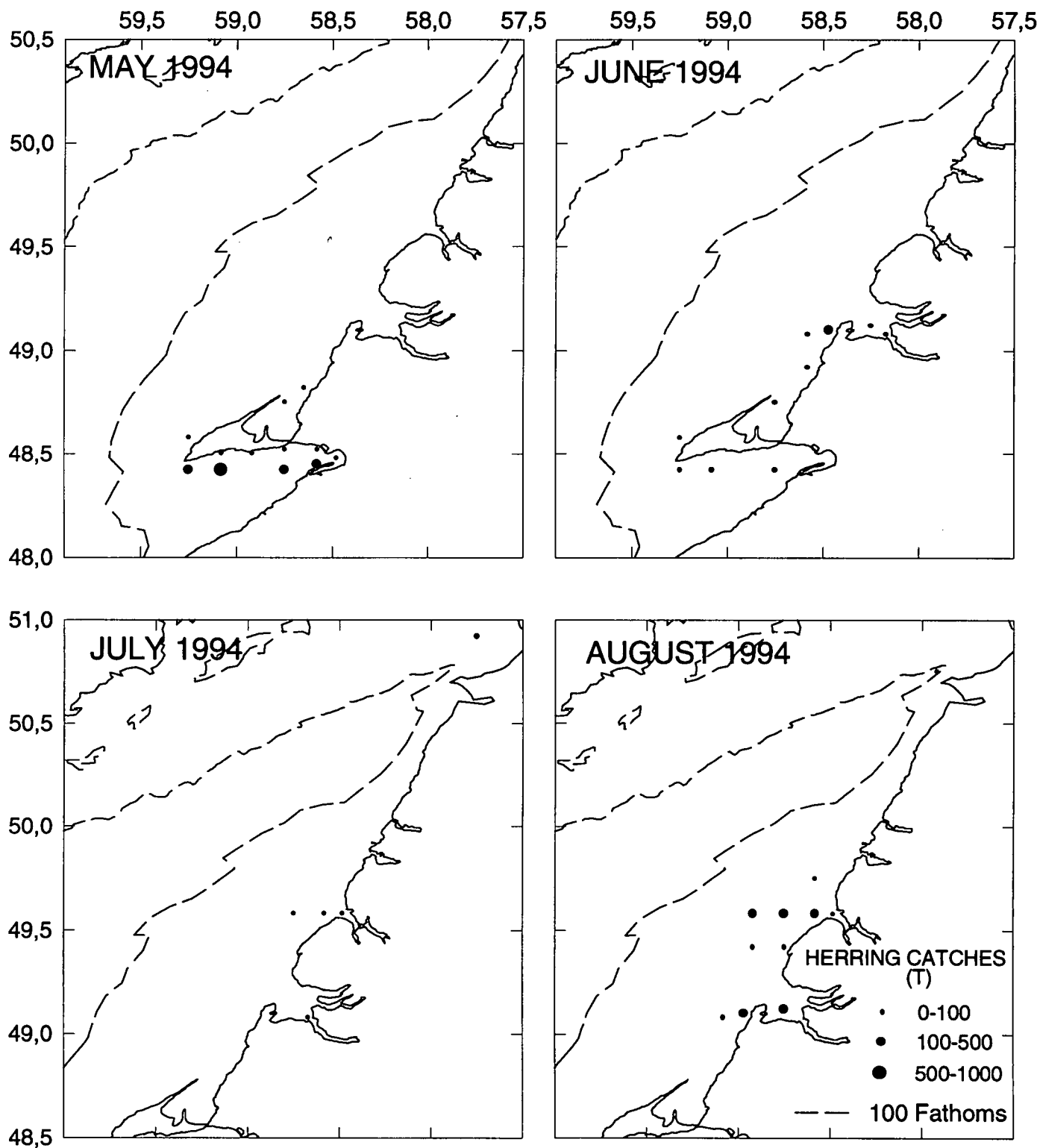


Figure 5. Monthly distribution of herring catches by 10-minute square from large and small purse seiners in 1994.

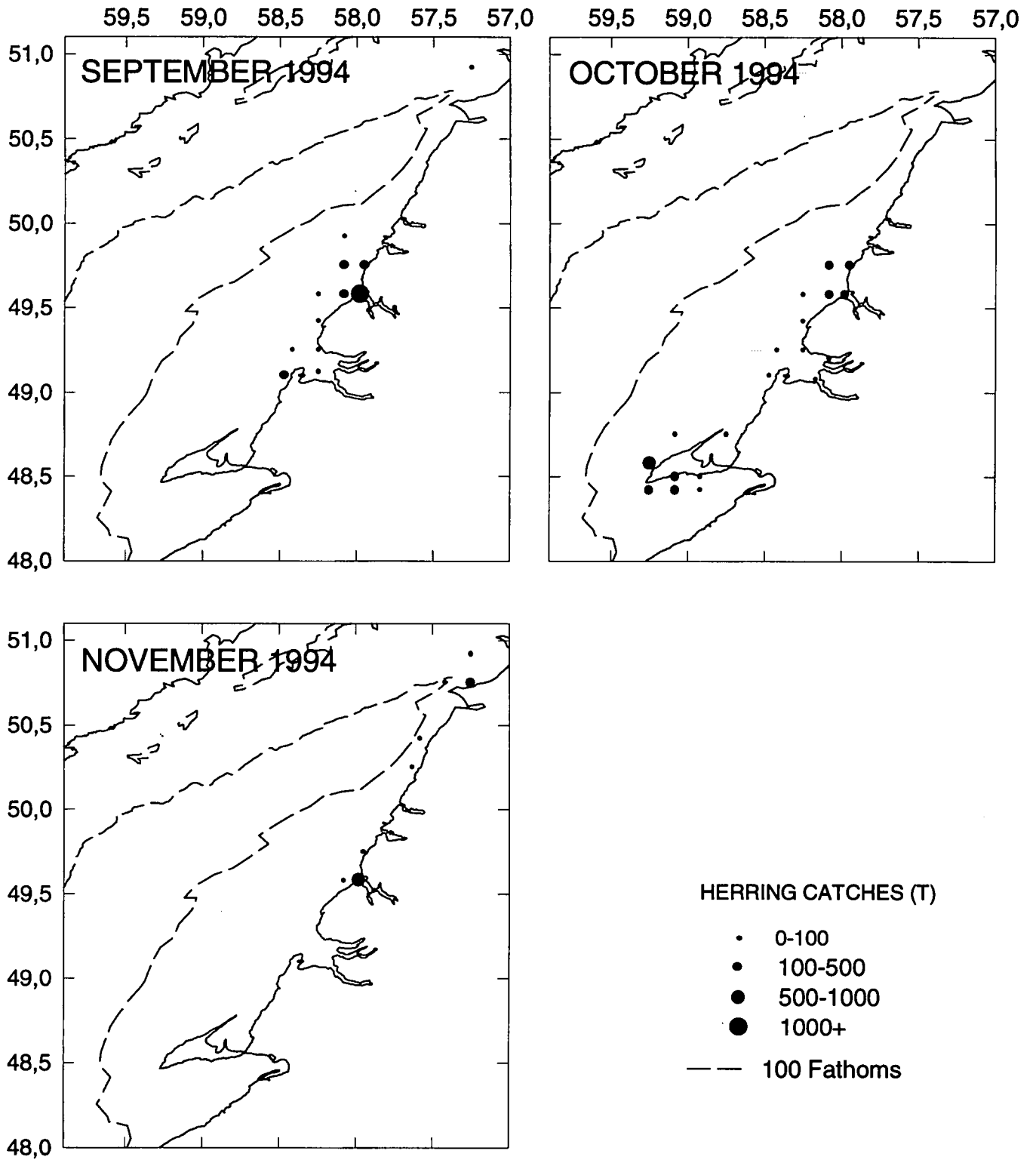


Figure 5. (Con't)

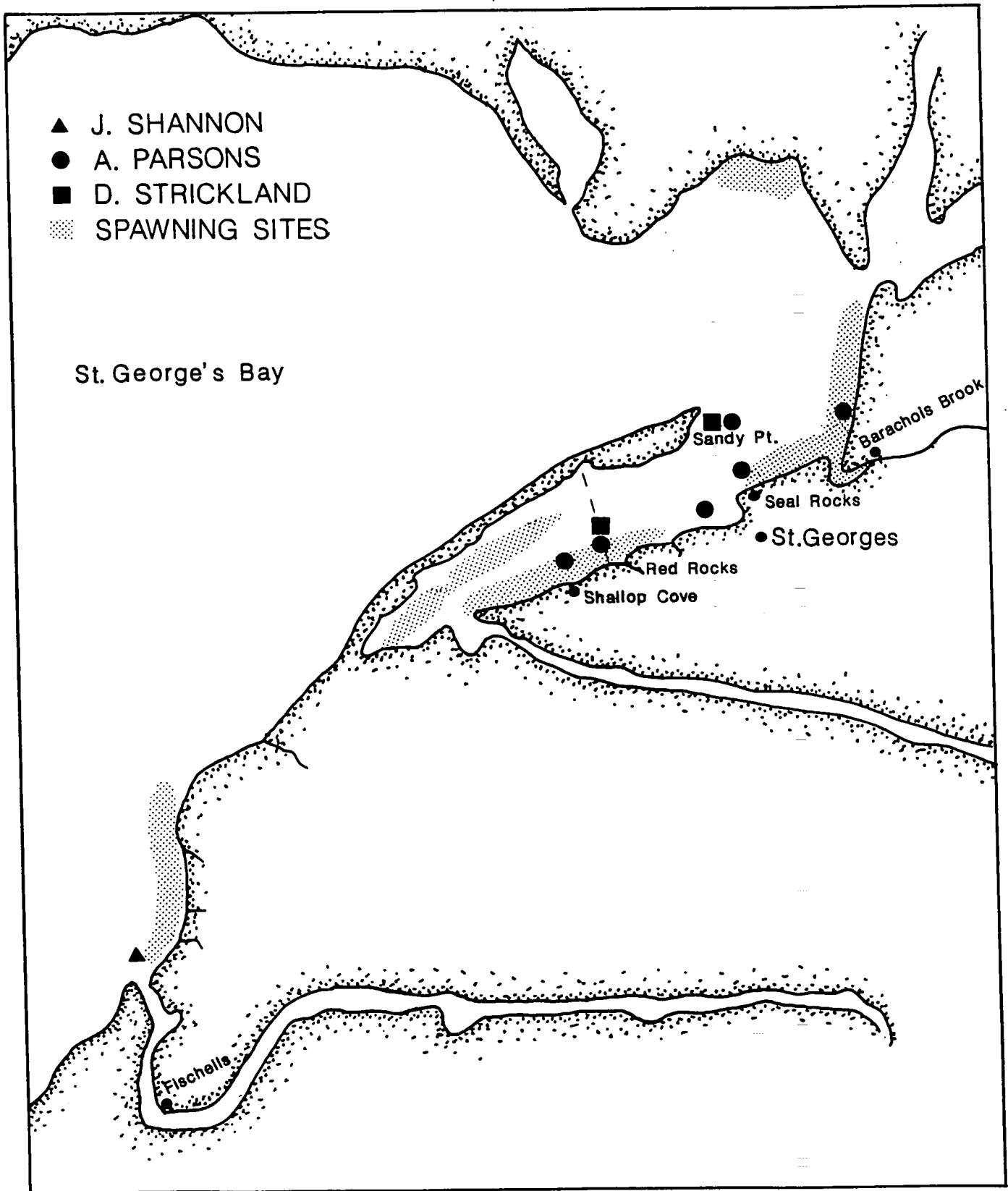


Figure 6. Location of the major spawning sites of spring herring and the fishing sites of index fishermen in St. Georges Bay.

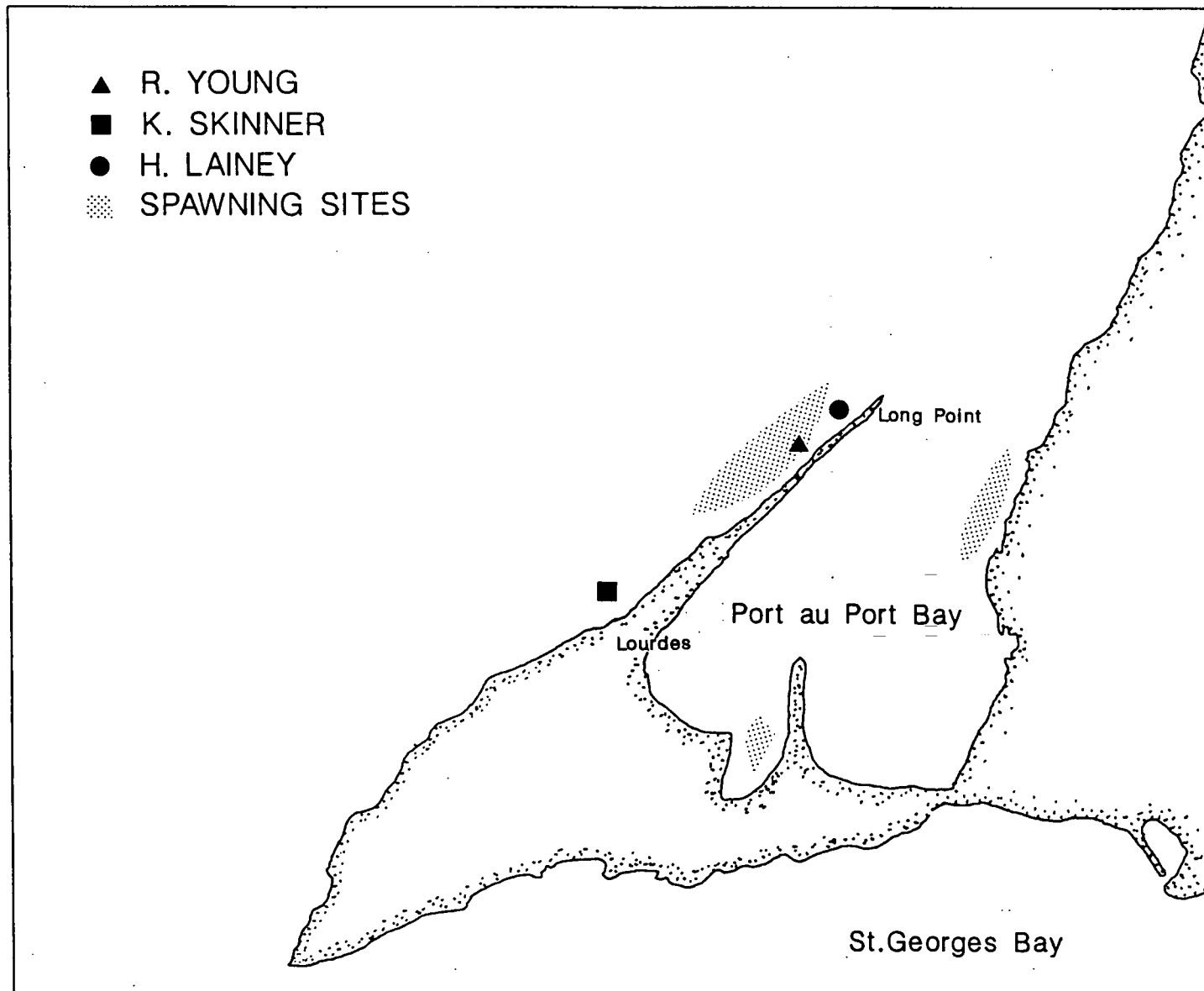


Figure 7. Location of the major spawning sites of spring herring and the fishing sites of index fishermen in and around Port-au-Port Bay.

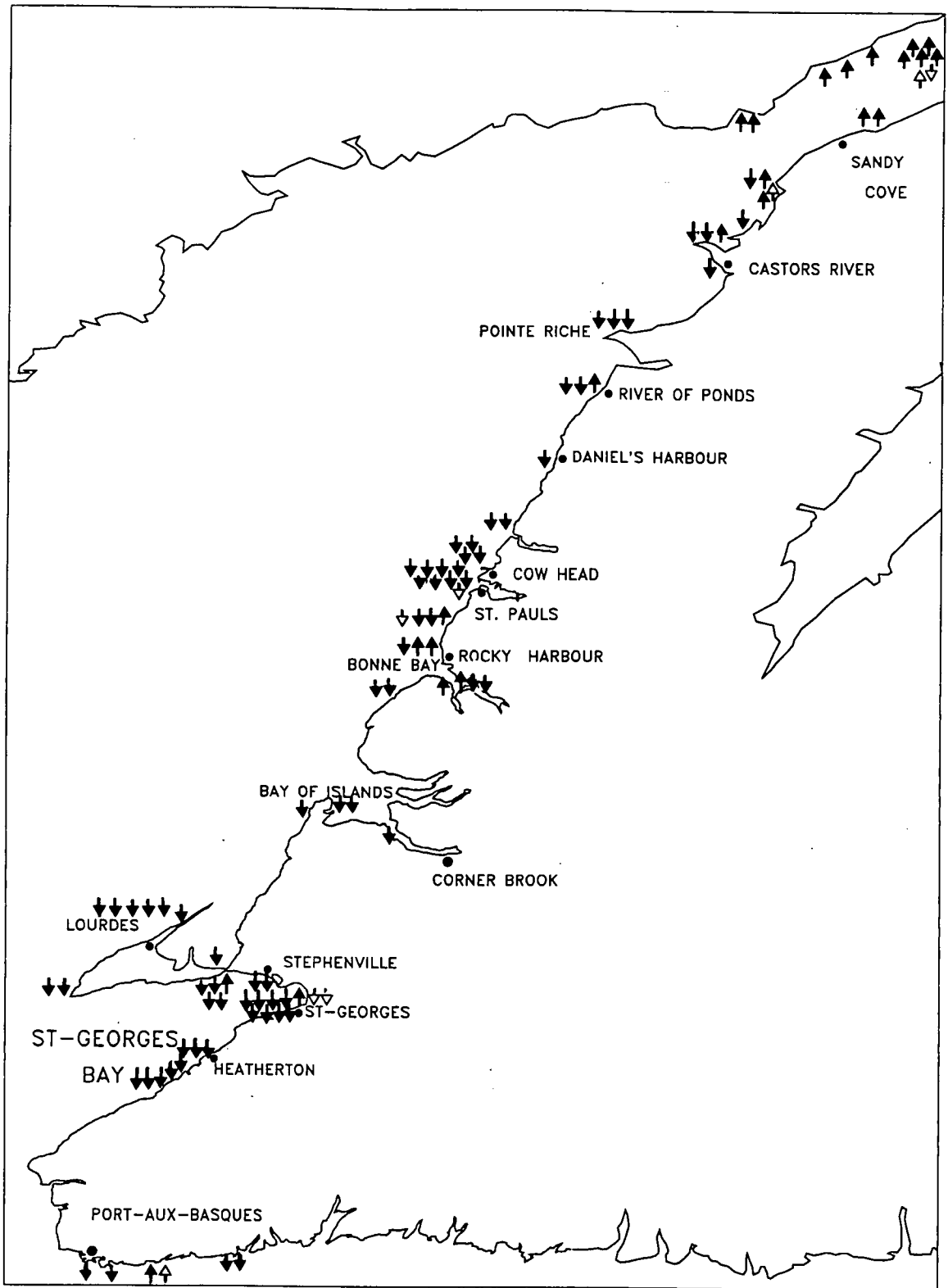


Figure 8. Distribution of inshore fishermen's opinions concerning the state of herring stocks and spawning in NAFO division 4R from 1994 written questionnaires [↑ = stock in good shape, ↓ = stock in decline, ⤴ = good spawning, ⤵ = spawning in decline].

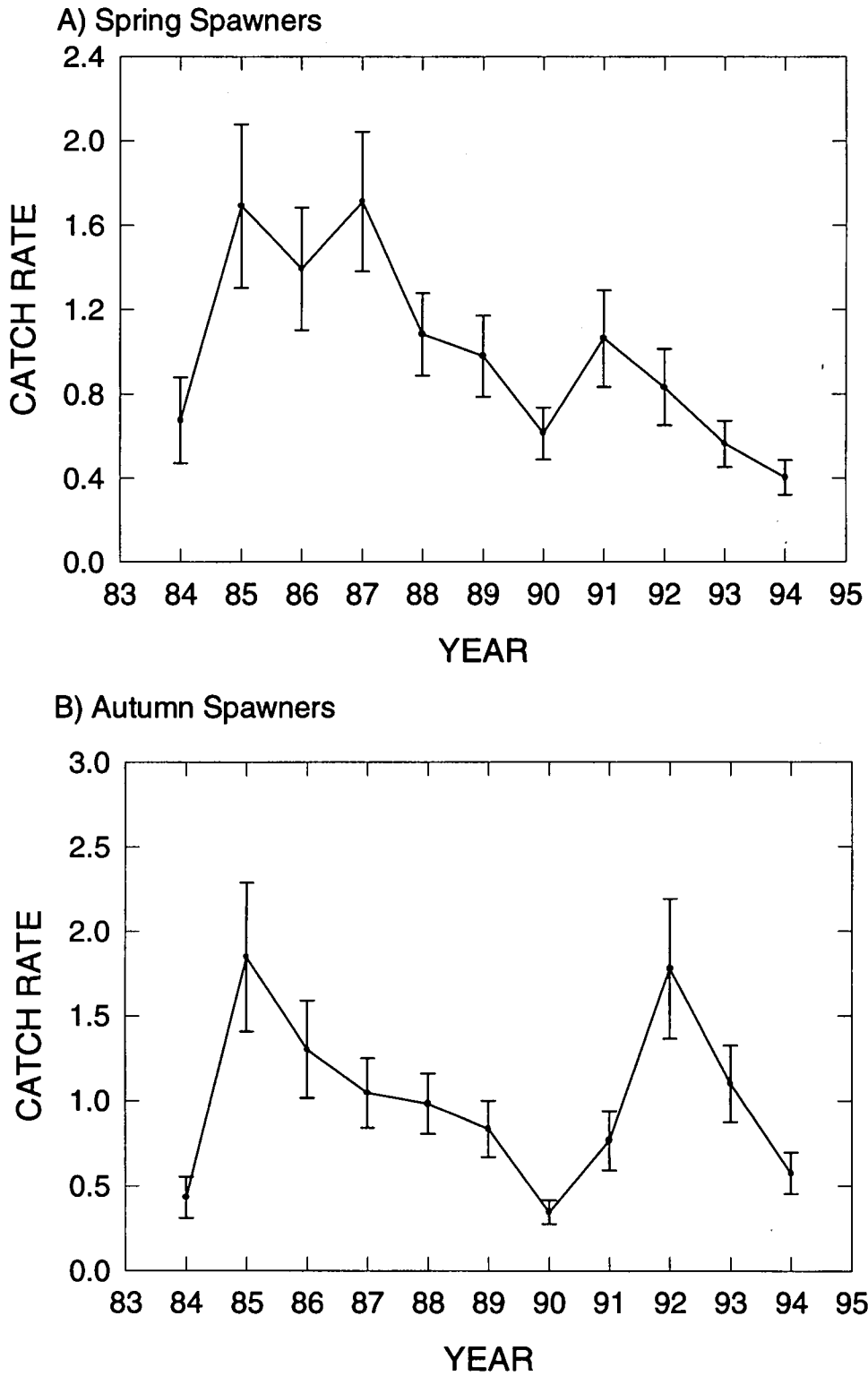


Figure 9. Standardized gillnet catch per unit effort and 2xs.e. for (a) spring-spawning and (b) autumn spawning herring in NAFO Division 4R as calculated from index-fisherman logbook data.

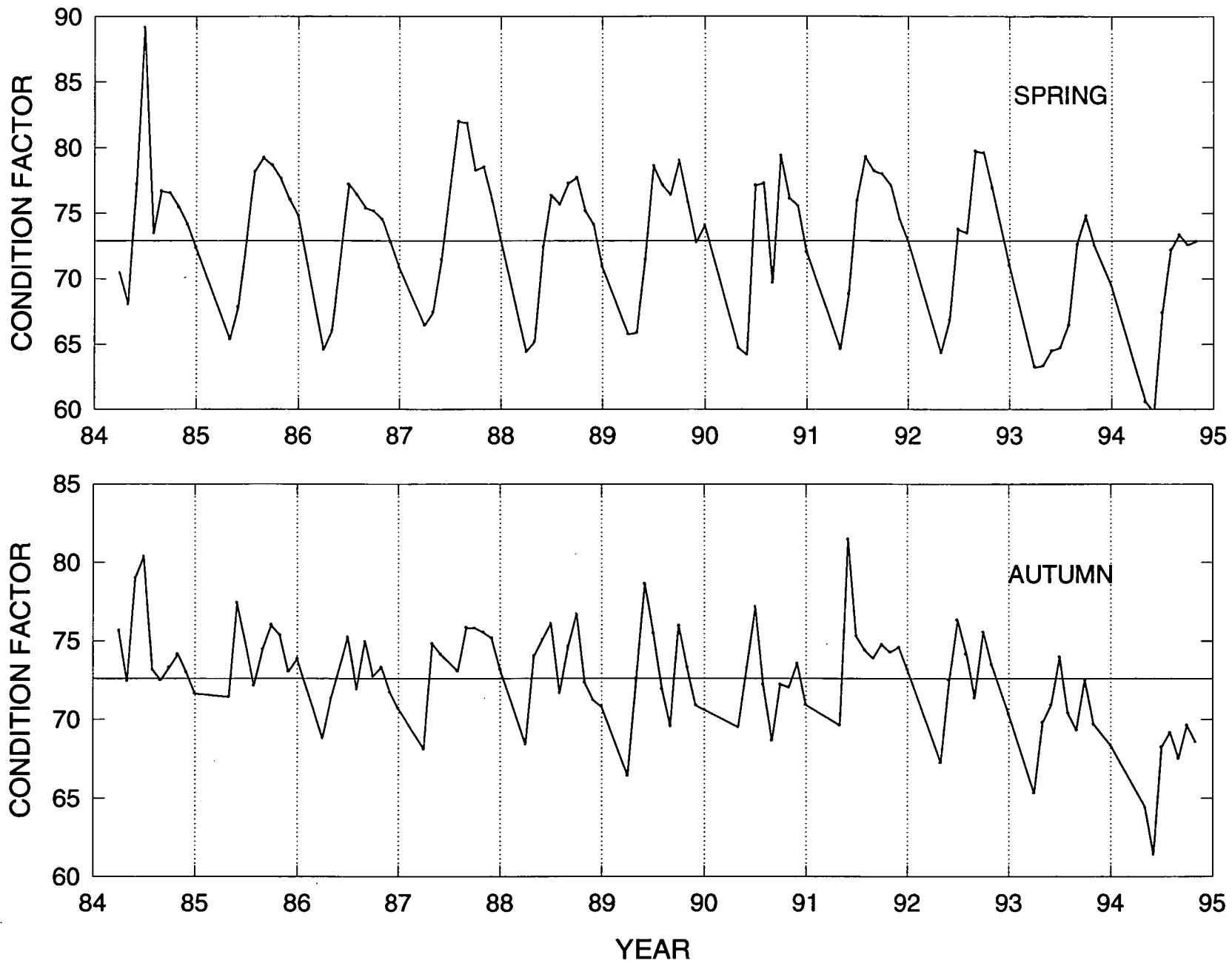


Figure 10. Monthly mean condition factor for spring and autumn spawning 4R herring from 1984 to 1994.

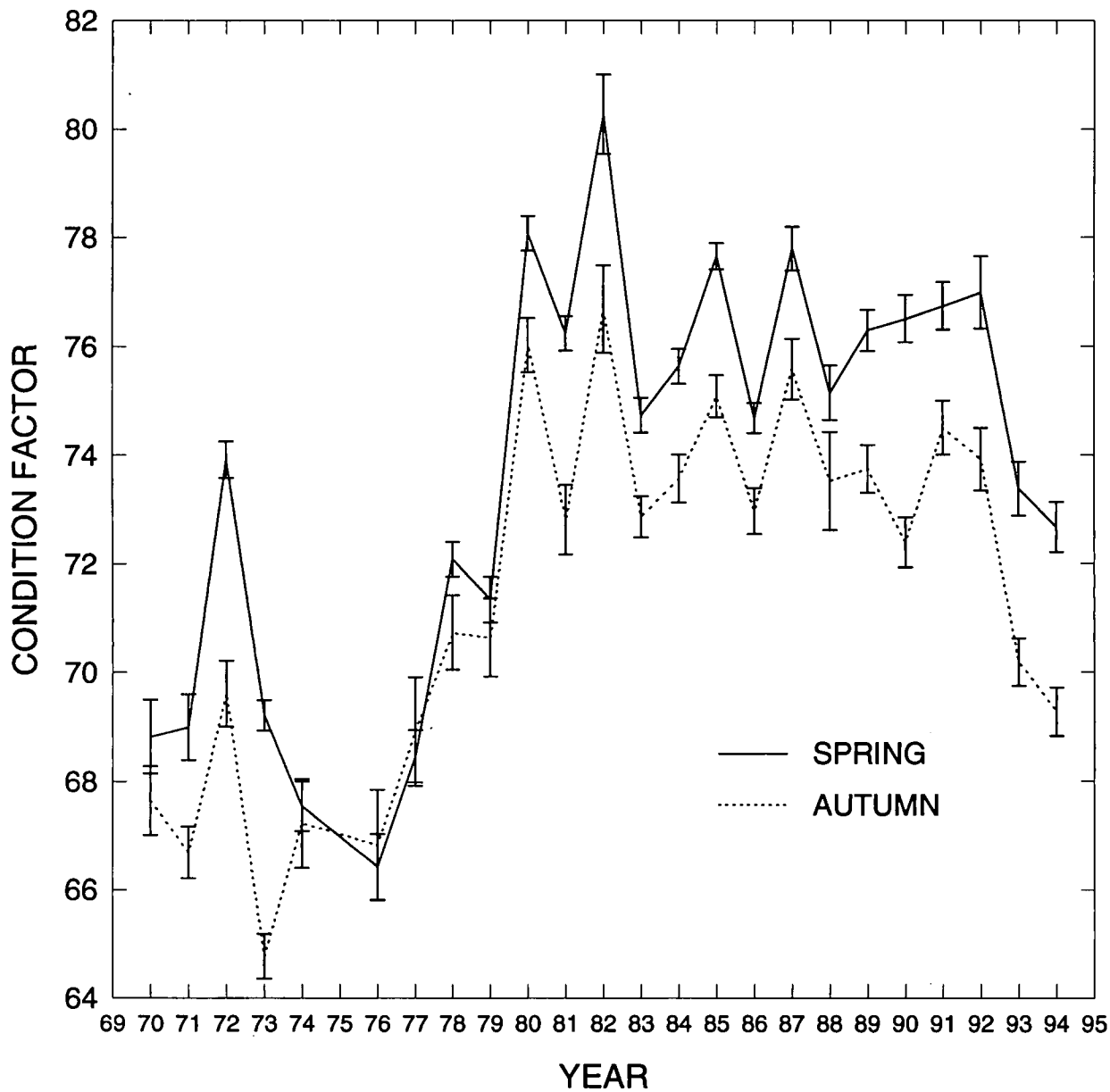


Figure 11. Mean condition factor for spring- and autumn-spawning 4R herring in late fall (Oct-Dec) from 1970 to 1994.

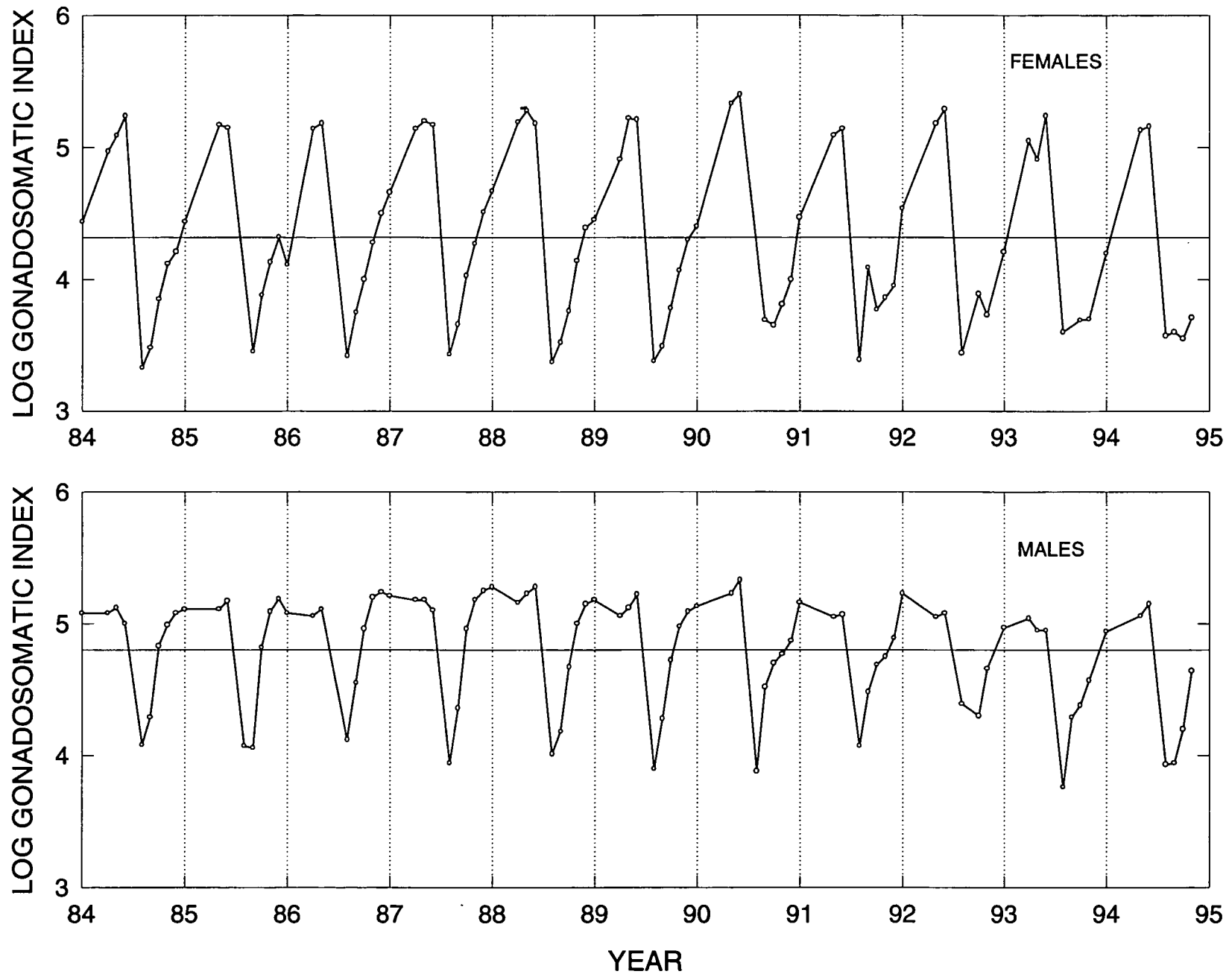


Figure 12. Monthly mean gonadosomatic index (stages 3-5) for female and male spring-spawning herring in NAFO division 4R from 1984 to 1994.

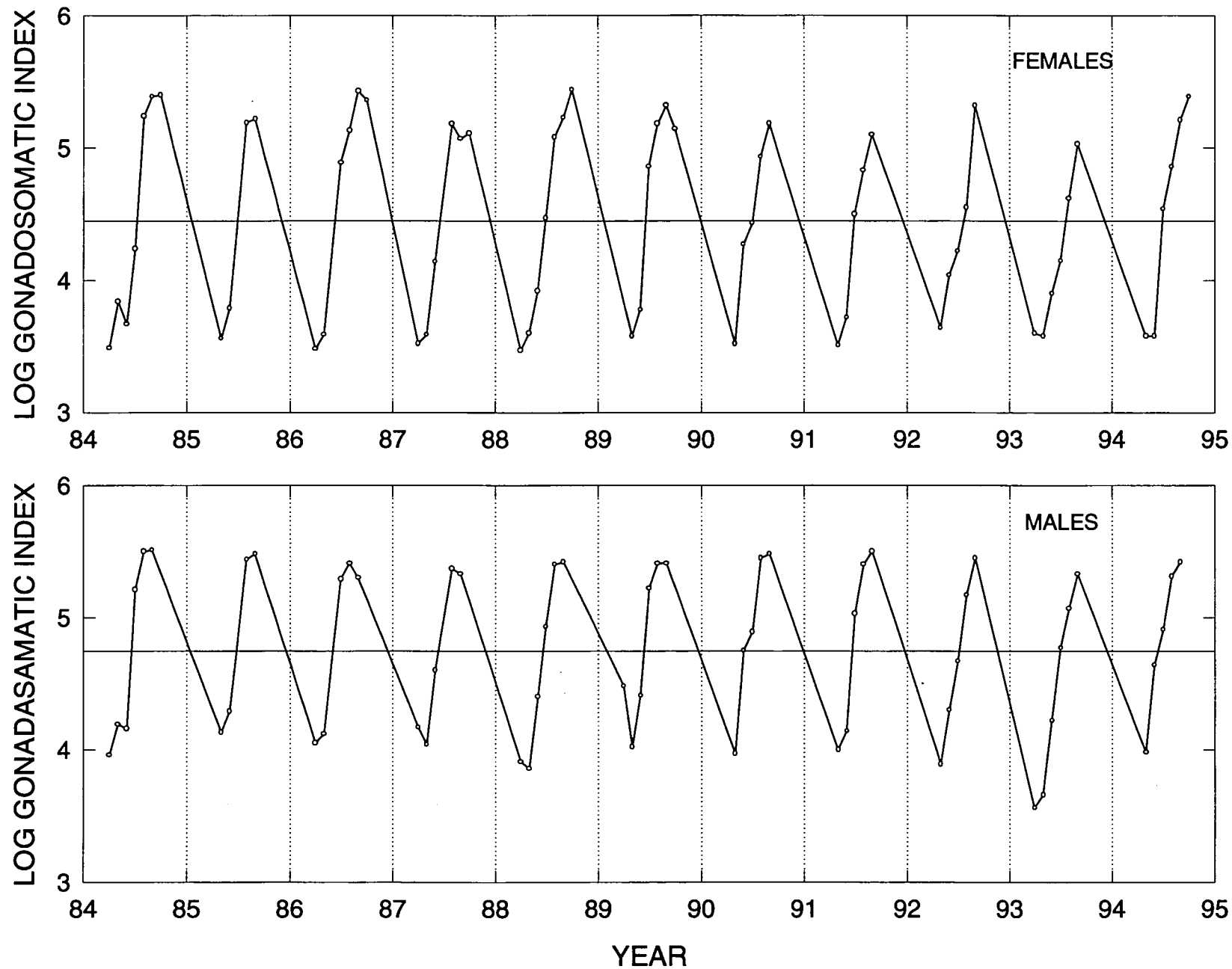


Figure 13. Monthly mean gonadosomatic index (stages 3-5) for female and male autumn-spawning herring in NAFO division 4R from 1984 to 1994.

Annex 1. Number of herring otoliths read (**bold print**) and commercial landings (t) in NAFO division 4R by gear, area and month in 1993. (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
GN	4Ra							1 182 251	2 149 110	3 97 166	12		
	4Rb						5 3	5		116	26	10	
	4Rc					4 88 21	124 42	6 45 7	2	4			
	4Rd					7 141 34	8 93 59	16	3	6			
PS >65'	4Ra											4 199	
	4Rb							1 177 532	2 90 747	3 97 527		130 447	
	4Rc					5 17	42 165	6 20	93 527	7 88 632	8 90 841		
	4Rd					9 139 1036	8				10 40 516		
PS <65'	4Ra						2 84	12		3 25	1 57	93 402	
	4Rb							35	45 97	97 781	4 96 211	9 77	
	4Rc					5 89 126	6 83 240	9	7 73	48 21	8 42 202	49	
	4Rd					10 92 530	55				11 92 350		