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An assessment of the west coast of Newfoundland (NAFO division 4R) herring fishery between 1973 and 1995.

by

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Abstract

Herring in western Newfoundland are mainly caught 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 and 1995, total landings were below 14,600 t due to the restrictions imposed on the capture of spring-spawning herring. The spring-spawner catch-rate and questionnaire data indicated that the mature biomass in the southern spawning grounds had dropped steadily since between 1987 and 1994, primarily due to poor recruitment over the last decade. The 1995 acoustic survey estimated a minimum biomass of 84,000 t (38,000 t of spring spawners and 46,000 t of autumn spawners) with 64% of the herring biomass being surveyed in the two northern most strata. Both the spring- and autumn-spawning herring found along the coast were dominated by younger year-classes which have recruited to these stocks over the past five years. In 1995, the 1987 year-class was for the first time as important on the southern spawning beds as the 1980 and 1982 year-classes. Comments from inshore fishermen indicated a slight improvement in spring-spawning activity in Port-au-Port. The delayed opening of St. George's Bay and Port-au-Port Bay in 1995 had the desired effect of concentrating fishing on the autumn spawners, of decreasing the quantity of spring spawners in the total catch and of allowing the remaining fish to spawn undisturbed. Fishing effort must continue to be restricted in these areas until there are indications of significant improvement in this local component. We conclude that in general the 4R herring stocks are healthy, and a TAC of 22,000 t of spring- and autumn-spawning herring outside closed areas would not be excessive.

Résumé

Le hareng de la Côte Ouest de Terre-Neuve est principalement capturé par les grands et les petits senneurs, et les filets maillants, quoique depuis 1988, la proportion des captures totales prises par les senneurs (senne-bourse) se situait entre 90 et 98 %. En 1994 et en 1995, les débarquements totaux furent inférieurs à 14,600 t dû aux restrictions imposées sur la capture des frayeurs de printemps. Le taux de capture des frayeurs de printemps et les données de questionnaires indiquent que la biomasse des géniteurs des frayères du sud a constamment décliné entre 1987 et 1994, principalement dû au pauvre recrutement des dix dernières années. Le relevé acoustique de 1995 a estimé une biomasse minimale de 84,000 t (38,000 t de frayeurs de printemps et 46,000 t de frayeurs d'automne avec 64 % de la biomasse de hareng se retrouvant dans les deux strates les plus septentrionales. Les deux groupes de fraie printemps et automne retrouvés le long de la Côte étaient dominés par de jeunes cohortes qui se sont jointes à ces stocks durant les cinq dernières années. En 1995, la classe d'âge 1987 fut pour la première fois aussi importante sur les frayères du sud que les classes d'âge 1980 et 1982. Des commentaires des pêcheurs côtiers indiquent une légère amélioration de la fraie du printemps dans la région de Port-au-Port. Le délai dans l'ouverture des baies St-Georges et Port-au-Port en 1995 ont eu l'effet désiré en concentrant la pêche sur les frayeurs d'automne, en diminuant la quantité de frayeurs de printemps dans la capture totale et en permettant aux poissons qui restent de frayer en paix. L'effort de pêche doit continuer d'être restreint dans ces zones jusqu'à ce qu'il y ait des indications d'une amélioration significative de cette composante locale. Nous concluons qu'en général les stocks de hareng de 4R sont en santé, et qu'un TPA de 22,000 t de frayeurs de printemps et d'automne à l'extérieur des zones fermées ne devrait pas être excessif.

Introduction

Atlantic herring (*Clupea harengus* L.) are found throughout the waters of the northwest Atlantic Ocean from Labrador to Cape Hatteras. In Canada, they are fished mainly within the Gulf of St. Lawrence, in eastern and southern Newfoundland, and in southwestern Nova Scotia and the Bay of Fundy. The herring is a migratory species which, over the course of a year, will travel extensively throughout its stock range from spawning grounds, to feeding and overwintering areas. These migration patterns are repeated year after year with considerable regularity. They are found nearshore in the spring and fall where they congregate around traditional spawning beds to reproduce. They also typically assemble in large concentrations in the late fall in preparation for their departure to over-wintering areas where the water temperatures are more stable.

Within most of the distributional range of northwest Atlantic herring, including the west coast of Newfoundland (NAFO Division 4R) we can find populations which spawn either in the spring (April to June) or in the autumn (July to October). Each seasonal-spawning population is considered to be a separate stock for fisheries management. In addition, within each seasonal-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 (Figure 1). The interrelationship between these local components has yet to be clearly established, although most evidence suggests that once an individual spawns in a given area, it will return to spawn in that area year after year (Blaxter 1985). Therefore, the repeat spawners of a local spawning component are subject to over-exploitation if fishing effort is concentrated on them disproportionately to the rest of the stock. 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.

The major spring-spawning areas 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. 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 mostly found in mixed schools in either feeding or overwintering areas. 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. They are believed to overwinter 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 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 small-purse-seine fishery. The allocation for this gear sector has come from the inshore (fixed gear) quota and was increased from 2,000 to 4,800 t from 1989 to 1994.

Since 1987, the advised target fishing level has been exceeded only in 1991 (Table 1; Figure 3). In 1994, a cap of 5,400 t of spring spawners was imposed as a conservation measure for the spring-spawning stock. In 1995, this spring-spawner cap was lifted, in favour of a delayed opening (June 1) of St. George's Bay and Port-au-Port Bay to fishing 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

Herring catches in western Newfoundland are mainly taken by large purse seiners (>85'), by small purse seiners (<65') and to a much lesser extent by fixed gillnetters from April 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 4).

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 3, Table 1) and have ranged between 15,300 t and 26,400 t from 1987 to 1993. In 1994 and 1995, total landings were below 14,600 t due to the restrictions imposed on the capture of spring-spawning herring.

The Purse Seine Fleet

From 1984 to 1987, up to 80% of the purse seine catches were taken in areas 4Rb and 4Rc from October to December from over-wintering concentrations of herring (Figure 5a). From 1988 to 1993, the purse seine fleet had redirected its fishing effort towards the spring fishery in St. George's Bay and Port-au-Port Bay, leading to a considerable increase in landings from 4Rc and 4Rd (Table 2a), from approximately 2,000 t in 1987 to 16,000 t in 1991. This spring fishery in the St. George's Bay/Port-au-Port area accounted for 71% of the total purse seine catch in 1993 (Figure 6). This proportion dropped to 20% in 1994 due to a cap of 5,400 t on spring-spawning herring but increased again to 40% in 1995 when the cap was lifted.

Concurrent with changes to the fishing pattern of the large purse seiners has been an increase in the activity of the small (<65') purse seiners along the west coast since 1989. Annual landings from this gear sector had not exceeded 800 t until 1992, when they landed 2,200 t. From 1993 to 1995, this fleet has landed from 3,100 t to 3,800 t per year.

In 1995, purse seine fishing was concentrated around Cape St. George and northwest of Cape Anguille in May (Figure 7). Fishing activity then moved towards the Bay of Islands in June as in 1994 (McQuinn and Lefebvre 1995a). In the late fall herring schools were less concentrated than in previous years and fishing was much more spread out along the southern part of the coast. As in 1994, relatively good catches were again recorded in St. George's Bay in October, as well as in St. John Bay in November.

The Gillnet Fleet

The inshore gillnet fishery is predominantly oriented toward supplying bait for the active lobster fishery. This has meant that recorded landings from 1990 to 1994 have ranged between only 140 and 840 t (Table 2b). There was a slight improvement in 1995 as landings increased to 1,250 t.

From 1979 to 1989, almost equal proportions of the total gillnet catch were taken from the south (4Rd and 4Rc), and from the north (4Ra and 4Rb, Figure 5b). A late fall fishery 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 and 1995, there was a slight resurgence in landings from the summer 4Ra fishery.

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 1995 catch at age was generated (CATDAGE v1.0, Anon 1986) for spring and autumn spawners as described by McQuinn (1987b), weighing the age compositions by the corresponding landing as grouped in Annex 1.

Spawning Stock Proportions

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 3). The 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 (Figure 8, McQuinn and Lefebvre 1994, 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 3) and are mixed in the southern regions (Table 4). 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 (Figure 8).

Spring spawners have dominated the catch in every year since at least 1973 (Table 5), averaging 72% in numbers. This percentage increased to over 80% between 1988 and 1990 due to the active spring fishery in St. George's Bay, which exploited mainly spring spawners nearshore (Table 4). With the 5,400 t cap on the TAC of spring spawners in 1994 and the delayed opening of St. George's Bay to commercial fishing in 1995, the percentage of spring spawners in the total catch has decreased to under 60%.

Age Composition

Since the mid-1980's, the 1980 and 1982 spring-spawner year-classes have been important contributors to the total catch (Table 5, Figure 9). In 1991, the 1987 year-class recruited strongly to the purse seine fishery (Table 6a). Since 1993, the 1989 year-class has increased in importance in the overall spring-spawner catch. However since 1994, it has become more and more difficult to distinguish these latter year-classes in the catch at age (Table 6a). This has lead us to suspect an error in the age attribution in the past couple of years. The distinction of the winter annuli seems to have degraded since 1992 or 1993 when these herring stocks were exposed to colder annual temperatures (Gilbert *et al.*, 1996). In this respect, the length frequency data appear more reliable, and it is easier to follow the major year-class with these data (Figure 9).

McQuinn and Lefebvre (1995b) noted that the 1987, 1989 and 1991 spring-spawning year-classes were more abundant in the fall fishery in the more northerly areas and were of only minor importance on the southern spawning grounds in the spring. In 1995, these recruiting year-classes were seen in the purse seine catches outside of St. George's Bay in the spring and all along the coast in the fall. Biological samples supplied by the index fishermen in St. George's Bay (4Rd) and Port-au-Port Bay (4Rc) showed that in 1995, the 1987 year-class was for the first time as important on the spawning beds as the 1980 and 1982 year-classes (Figure 10).

Since 1983, the 1979 autumn-spawning year-class has been the most important contributor to the fishery from this stock and is still dominant in some areas (Figure 11). Since 1990, the 1986 year-class has strongly recruited to the autumn-spawner purse-seine catch (Table 6b), but only became a significant contributor to the gillnet fishery in 1992 (Table 7). Since 1992, the 1988 year-class has also contributed significantly to the total autumn-spawner catch, with the 1990 year-class also appearing to be above average in recent years. These three year-classes have gradually increased in importance in the gillnet fishery since 1992.

Abundance Indices

Acoustic Surveys

Fall acoustic surveys have been conducted biannually since 1989. The 1995 survey was undertaken in close collaboration with the west coast large seiner fleet (McQuinn and Lefebvre, 1996). A scientific staff was invited aboard each of four purse seiners over a two week period to take temperature and salinity profiles and to collect biological samples while our research vessel, the *Frederick G. Creed*, collected the acoustic data.

The 1995 acoustic survey estimated a minimum biomass of 84,000 t (38,000 t of spring spawners and 46,000 t of autumn spawners) with 64% of the herring biomass being surveyed in the two northern most strata (Strata 9 and 10). The distribution of herring in the remaining strata was similar between 1993 and 1995, even though the survey was conducted three weeks earlier in 1995.

An additional acoustic survey was conducted in the first week of May, 1995 aboard the *CSS Teleost* (Figure 12). This survey was undertaken during a single night to locate schools of autumn-spawning herring outside of St. George's Bay (the bay itself was closed to commercial fishing). The survey area was defined from information supplied to us by purse seine operators fishing in this area as well as from our own explorations. In addition, a purse seine captain, Mr. John Hackett, was aboard the *Teleost* to assist in the design of the survey. This survey estimated the presence of approximately 12,400 t of herring (8,000 t of autumn spawners and 4,400 t of spring spawners) within a 390 km^2 area (Table 8). These herring were concentrated into schools in the mid-water (160-200 m) and were dominated by older (1979 year-class) fish. Most of the spring purse seine fishery was localised on these schools. Other herring schools were seen northward along the coast during that same week, although their abundance and composition were not estimated.

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) and 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 (McQuinn and Lefebvre 1995a) or the autumn-spawning areas north of Point Riche.

The standardized spring-spawner catch rates indicated that the 1987 year-class was above average, but not sufficiently abundant in the southern bays to rebuild this local spawning component given the heavy fishing effort exercised on it in the early 1990s. This catch-rate index declined again in 1995 to its lowest historical level (Figure 13a; Table 13).

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 (Figure 13b). However, it declined sharply in 1992 and 1993 and has now stabilised at a low level. Although this catch-rate index seemed to reflect the strong recruitment of the 1986 year-class, its sharp decline was unexpected given the low fishing effort on the autumn-spawning stock. In addition, the recent recruitment of the 1988 year-class has not been reflected in the index, which puts in doubt its usefulness as a measure of abundance. It is possible that this index is more a reflection of a change in availability, since it is known that autumn herring spawn farther offshore and are less available to inshore fixed gear than are the spring spawners.

Industry Input

Comments collected from written questionnaires sent to all licensed inshore herring fishermen in 4R (Table 14) as well as from our index fishermen indicated a slight improvement in spring-spawning activity in 4Rc. The index fishermen noted that in several areas, notably around Port-au-Port Bay, the main spawning period was again later than usual this year, i.e. first of June. This period corresponds to when the 1987 year-class was dominant in the samples and when the catch rates were the highest for the season. However, in St. George's Bay, spawning activity was again quite weak this year, and consisted mainly of a mixture of older (1980 and 1982 year-classes) and younger (1987 year-class) fish (Figure 10). This suggests that the 1987 year-class has not replaced the 1980 and 1982 year-classes in St. George's Bay, as it has done elsewhere, and therefore cannot be counted upon to rebuild this spawning component. The 1989 year-class, which has been captured in the fall gillnet fishery since 1994, has yet to be seen in large numbers in these southern bays. These observations are consistent with the catch rate data from index-fishermen in these areas.

North of Point Riche in 4Ra, the general opinion is that the abundance of herring is average to good especially in the summer and fall (Table 14). Spawning in the fall was noted mainly around Ferolle Point, but was not considered by our index fishermen to be extensive in this area nor around Forresters Point. They suggested that unfavourable winds from the southwest which dominated the season had moved the autumn herring offshore into deeper water, where they were less available to their gear.

Comments from the purse seine logbooks suggested that there was an abundance of herring along the coast throughout the year, but that they were often difficult to catch (Figure 14). In the spring, the herring outside of St. George's Bay were assembled into schools but were often too deep to fish (160-200 m). In the fall, the herring were found in shallower water, but were generally too thinly aggregated and too close to the bottom for purse seining. Both of these observations were confirmed during our two acoustic surveys.

Discussion

Spring Spawners

The minimum spring-spawning stock biomass of approximately 38,000 t from the 1995 fall acoustic survey was an increase over the 1993 estimate of 31,000 t of spring spawners. However, McQuinn and Lefebvre (1995c) considered the 1993 estimate to be low 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.

The spring-spawner catch-rate data indicated that the mature biomass in the southern spawning grounds had dropped dramatically in 1993, primarily due to (1) the lack of strong recruiting year-classes to this area over the past 10 years combined with (2) the concentration of fishing effort on this local spawning component between 1989 and 1993. In 1995, this catch-rate index suggested that this major component of the spring-spawning stock continued to be at a very low level.

Comments received from index fishermen and from the written questionnaires suggest little improvement over 1994 in St. George's Bay, although there are signs of more intensive spawning by the 1987 year-class around Port-au-Port Bay.

The present analyses support last years' conclusion (McQuinn and Lefebvre 1995a) that special measures must be taken to protect the spring spawners components in St. George's Bay and Port-au-Port Bay. The delayed opening of these bays in 1995 had the desired affect of concentrating fishing on the autumn spawners, of decreasing the quantity of spring spawners in the total catch and of allowing the remaining fish to spawn undisturbed.

Autumn Spawners

The 1995 acoustic survey results placed the minimum autumn-stock biomass at 46,000 t, the majority of which were located in the northern strata, and are normally not heavily fished. These herring were not formed into schools, but rather were in a relatively thick, dense layer close to the bottom (McQuinn and Lefebvre 1996). Although the 1993 estimate was considerably lower (35,000 t), as stated earlier, this survey undoubtedly underestimated a significant portion of the stock since commercial catch data showed that herring were in the two unsurveyed northern strata in 1993.

The logbook catch-rate data indicated strong recruitment by the 1986 year-class in 1992, although the index has declined sharply since then. This trend is in contradiction with other indices which show this stock to be in relatively good condition (1) the fall acoustic survey estimate of at least 46,000 t, (2) the light exploitation of this stock over the past decade, i.e. less than 28% of the total catch and (3) responses to a written questionnaire indicating that the situation with this spawning component north of Point Riche is relatively good but that the market for gillnetted herring is very limited. It is quite possible that the index-fisherman catch-rate series has become less reliable due to (1) a decrease in participation in the program (only three logbooks per year in 1992, 1994 and 1995) and (2) the decrease in availability to inshore gillnets as the herring have moved farther offshore (McQuinn and Lefebvre 1994).

Prognoses

Northern Gulf Herring Stock Status

The present analyses of the available commercial and research data has allowed us to confirm last years' assessment that the status of these herring stocks is generally healthy. Relatively young year-classes continue to dominate among both the spring- and autumn-spawning herring in both the purse seine fishery and in the research surveys. The 1995 fall acoustic survey estimated the minimum abundance of spring and autumn-spawning herring available along the west coast at that time at approximately 84,000 t.

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

Although the status of the northern Gulf herring is generally good, the fishing effort had been high on the spring spawners in St. George's Bay and Port-au-Port Bay between 1988 and 1993 and, at present, the biomass of this local component is low. 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. 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.

The 1994 closure of the spring commercial fishery (January 1- June 15) in St. George's Bay and Port-au-Port Bay has limited the targeting of these spawners and has increased the proportion of fall spawners in the total catch. Although covering a very small area (390 km^2), the spring survey, undertaken in co-operation with the large purse seine fleet, showed that a good quantity (12,400 t) of mainly autumn-spawning herring (65 %) were present in May at the mouth of St. George's Bay. This confirmed the observations made by both commercial and research fishing in 1993 and 1994 that St. George's Bay spring spawners can be avoided to a large extent by restricting fishing to outside of the bay in the spring.

The situation in St. George's Bay must be watched closely. Fishing effort must continue to be restricted in these areas until there are indications of improvement in this local component. The continuation of the index-fisherman program in this area is essential for the monitoring of spawning activity and as a local abundance index.

Given that the spring closure of St. George's Bay and Port-au-Port Bay has effectively limited directed catches of this spring-spawning component, and that several recruiting year-classes have entered the fishery elsewhere along the coast, the current TAC of 22,000 t of spring- and autumn-spawning herring outside the closed area would not appear to be excessive.

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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 1995.

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	
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	8896	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	0	11209	740	276	9	5	1029	1899	299	20	0	2218	362	332	55	103	852	11310	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	142	0	3099	5457	1662	133	0	7252	1377	903	75	104	2459	464	353	897	24	1739	10054	3119	1247	129	14549 [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.

Table 2.a. Herring landings (t) by purse seines in NAFO division 4R by unit area and month from 1987 to 1995.

YEAR	AREA	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
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													
	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						86	259	2					347
	4Rb						18			19	87	3994		4099
	4Rc					23	723				56	531		1353
	4Rd					8362	263				2	240	1	8868
	Total					8385	1091	259	2	19	145	4766	1	14667
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	9309					78	431		11154
	Total		15		1339	9463	156	78	116	68	1666	2162		15062
1994	4Ra						87	18	13	20		339		478
	4Rb							49	762	1971	937	1830		5550
	4Rc					299	474	17	471	501	1155	62		2977
	4Rd					1413	82			13	974			2483
	Total					1712	643	84	1246	2505	3066	2232		11488
1995	4Ra							68	51	8		692		818
	4Rb						391	1	38	646	487	297	420	2280
	4Rc					696	2753	41	430	915	1427	325	532	7119
	4Rd					1693	86			181	920	77		2957
	Total					2389	3231	110	519	1750	2833	1391	952	13173

Table 2.b. Herring landings (t) by gillnets in NAFO division 4R by unit area and month from 1987 to 1995.

YEAR	AREA	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
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	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	242	359	114	33	121	15	897
	4Rb				3	4	6	21	9	6	21	5		75
	4Rc			1	2	41	59	10	8	10	3			133
	4Rd					60	61	10	6	6				142
	Total			1	5	106	136	283	382	136	57	126	15	1247

Table 3. Proportion (%) of spring-spawning herring in the gillnet catch by month and fishing area, NAFO division 4R from 1974 to 1995.

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
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									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		97.5	89.7		90.5	84.9	66.0					45.2						72.9	10.1	2.3	8.5	45.2	47.2	34.5

Table 4. Proportion (%) of spring-spawning herring in the purse seine catch by month and fishing area, NAFO Division 4R from 1974 to 1995.

YEAR	FISHING AREA														
	4Rd					4Rc									
	APR	MAY	SEPT	OCT	NOV	JAN	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1974	68.3	39.1													
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								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	84.9											67.7		
1994		91.2							90.0			63.9	43.8		
1995		24.2	59.6	50.9				97.2	99.1		45.6	66.2	67.5	77.5	36.5

YEAR	4Rb									4Ra					
	JAN	APR	MAY	JUN	AUG	SEP	OCT	NOV	DEC	JUL	AUG	SEP	OCT	NOV	DEC
1974									92.6						
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					13.8	43.3	32.0	51.3							
1995				97.8		21.9	56.5	47.3	40.1					34.0	37.9

Table 5. Spring- and autumn-spawner catch at age ($x10^3$) and proportion of spring spawners in NAFO division 4R herring landings from 1973 to 1995 (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	1995
1	0	0	0	0	45	0	0	3	13	0	4	39	48	265	323	183	0	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	457	90	79	14	13
3	435	261	996	680	534	47	25	854	417	2374	2965	433	4587	2348	329	519	574	2056	2213	1243	1589	296	264
4	1063	130	420	846	541	1987	214	106	2114	693	3562	7773	787	13762	2781	417	763	610	10053	1708	3800	2522	3460
5	27872	371	100	201	409	207	10828	355	129	2452	1131	3809	21642	3349	15257	2400	461	412	1311	8377	3411	3040	6573
6	2570	9445	1063	350	304	679	617	13872	354	421	1091	595	3993	28781	3507	14830	3036	983	805	997	6776	3689	6243
7	3222	318	8431	2802	348	241	1075	407	8872	2153	293	814	445	5241	12952	4004	18705	5002	3063	998	1504	3379	6417
8	3232	851	317	15567	4362	2162	547	1344	188	6488	713	209	381	465	1736	14606	3072	16049	6967	2783	2110	1616	2330
9	2598	774	336	759	15959	8208	2772	247	515	704	2990	672	255	167	182	2734	10910	3782	21372	2168	2713	1620	2340
10	4789	490	244	3136	1694	15260	7404	1427	283	950	798	755	380	260	37	480	779	6472	2358	11882	2798	1775	2041
11+	5696	2175	665	3588	6003	5062	14032	20574	13181	12863	7975	4226	1764	1661	806	2123	1380	2130	6558	4064	8816	2080	359
1+	53310	14955	12629	28413	30210	33851	37681	39488	26106	29692	21556	19523	34645	56621	38365	43030	39985	37594	55156	34310	33597	20032	30038

AUTUMN SPAWNERS

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	1
2	0	0	0	0	0	0	0	15	0	101	15	0	15	35	0	484	43	38	46	0	21	0	31
3	1798	20	19	48	3	10	7	181	33	567	83	55	235	426	156	207	599	463	931	337	210	52	108
4	1180	393	40	272	169	27	116	136	524	1824	2330	668	1340	1431	487	511	539	1391	1312	1446	676	866	1942
5	1114	530	865	290	134	545	345	86	245	956	1356	6259	1907	2671	1354	481	923	387	5828	1446	1955	2519	4723
6	2626	325	925	422	404	393	2689	176	90	509	1309	1147	9678	2292	2009	1240	807	312	731	1235	1011	3773	4482
7	1527	592	107	561	721	1108	520	1729	295	140	506	908	902	8421	1728	1740	749	466	1467	776	1651	3020	3763
8	2631	258	157	325	405	1689	1287	250	1234	377	159	220	622	794	5927	1667	828	323	850	542	569	2399	1960
9	3830	308	147	253	342	503	1847	675	153	972	467	146	115	384	474	4165	961	1027	611	777	918	1609	1811
10	8265	313	218	88	293	341	468	308	124	315	618	268	36	66	163	705	2873	442	2079	389	884	1176	1158
11+	17653	5610	3371	4818	6646	6051	6286	5243	3369	2609	2824	3091	468	227	196	777	983	4223	6890	3925	4592	3957	1807
1+	40626	8348	5848	7076	9116	10668	13564	8799	6067	8371	9667	12762	15333	16745	12494	11977	9305	9072	20746	10873	12486	19371	21785

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	1995
TOTAL	93937	23303	18477	35489	39326	44520	51245	48288	32173	38062	31223	32286	49978	73366	50859	53475	49292	46666	75901	45183	46084	39403	51823
% 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	72.7	75.9	72.9	50.8	58.0

Table 6. Age composition (%) and mean age* of (A) spring and (B) autumn spawners in NAFO division 4R herring landings from 1973 to 1995. 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	1995
1	.0	.0	.0	.0	.1	.0	.0	.0	.1	.0	.0	.2	.1	.5	.8	.4	.0	.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	.8	.3	.2	.1	.0
3	.8	1.7	7.9	2.4	1.8	.1	.1	2.2	1.6	8.0	13.8	2.2	13.2	4.1	.9	1.2	1.4	5.5	4.0	3.6	4.7	1.5	.9
4	2.0	.9	3.3	3.0	1.8	5.9	.6	.3	8.1	2.3	16.5	39.8	2.3	24.3	7.2	1.0	1.9	1.6	18.2	5.0	11.3	12.6	11.5
5	52.3	2.5	.8	.7	1.4	.6	28.7	.9	.5	8.3	5.2	19.5	62.5	5.9	39.8	5.6	1.2	1.1	2.4	24.4	10.2	15.2	21.9
6	4.8	63.2	8.4	1.2	1.0	2.0	1.6	35.1	1.4	1.4	5.1	3.0	11.5	50.8	9.1	34.5	7.6	2.6	1.5	2.9	20.2	18.4	20.8
7	6.0	2.1	66.8	9.9	1.2	.7	2.9	1.0	34.0	7.3	1.4	4.2	1.3	9.3	33.8	9.3	46.8	13.3	5.6	2.9	4.5	16.9	21.4
8	6.1	5.7	2.5	54.8	14.4	6.4	1.5	3.4	.7	21.9	3.3	1.1	1.1	.8	4.5	33.9	7.7	42.7	12.6	8.1	6.3	8.1	7.8
9	4.9	5.2	2.7	2.7	52.8	24.2	7.4	.6	2.0	2.4	13.9	3.4	.7	.3	.5	6.4	27.3	10.1	38.7	6.3	8.1	8.1	7.8
10	9.0	3.3	1.9	11.0	5.6	45.1	19.6	3.6	1.1	3.2	3.7	3.9	1.1	.5	.1	1.1	1.9	17.2	4.3	34.6	8.3	8.9	6.8
11+	10.7	14.5	5.3	12.6	19.9	15.0	37.2	52.1	50.5	43.3	37.0	21.6	5.1	2.9	2.1	4.9	3.5	5.7	11.9	11.8	26.2	10.4	1.2

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	1995
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	6.5

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	1995
1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	.0	.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	.2	.0	.2	.0	.1
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	.5
4	2.9	4.7	.7	3.8	1.9	.2	.9	1.5	8.6	21.8	24.1	5.2	8.7	8.5	3.9	5.0	5.8	15.3	6.3	13.3	5.4	4.5	8.9
5	2.7	6.4	14.8	4.1	1.5	5.1	2.5	1.0	4.0	11.4	14.0	49.0	12.4	15.9	10.8	4.7	9.9	4.3	28.1	13.3	15.7	13.0	21.7
6	6.5	3.9	15.8	6.0	4.4	3.7	19.8	2.0	1.5	6.1	13.5	9.0	63.1	13.7	16.1	9.8	8.7	3.4	3.5	11.4	8.1	19.5	20.6
7	3.8	7.1	1.8	7.9	7.9	10.4	3.8	19.7	4.9	1.7	5.2	7.1	5.9	50.3	13.8	12.1	8.0	5.1	7.1	7.1	13.2	15.6	17.3
8	6.5	3.1	2.7	4.6	4.4	15.8	9.5	2.8	20.3	4.5	1.6	1.7	4.1	4.7	47.4	14.4	8.9	3.6	4.1	5.0	4.6	12.4	9.0
9	9.4	3.7	2.5	3.6	3.8	4.7	13.6	7.7	2.5	11.6	4.8	1.1	.7	2.3	3.8	36.4	10.3	11.3	2.9	7.1	7.4	8.3	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	30.9	4.9	10.0	3.6	7.1	6.1	5.3
11+	43.5	67.2	57.6	68.1	72.9	56.7	46.3	59.6	55.5	31.2	29.2	24.2	3.1	1.4	1.6	6.4	10.6	46.5	33.2	36.1	36.8	20.4	8.3

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	1995
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	7.7	7.8	8.2	7.7	6.8

* assuming ages 11+ to be 11.

Table 7. Spring- and autumn-spawner gillnet catch at age ($x10^3$) in NAFO division 4R herring landings from 1973 to 1995.

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	1995
1	0	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	0
3	7	10	0	13	13	3	0	71	59	319	842	13	1	3	0	4	8	30	3	0	0	0	19
4	145	0	89	0	4	368	42	50	805	145	1770	1416	33	296	125	30	46	26	92	14	1	20	60
5	2148	76	10	0	39	82	2980	123	53	879	468	1486	1220	143	1714	600	58	35	24	50	10	164	154
6	228	1781	219	15	53	132	441	5485	163	106	513	242	391	2909	602	1436	349	75	5	18	36	71	347
7	1225	111	878	581	141	63	606	225	4038	340	57	469	67	662	2388	561	996	78	39	31	8	214	277
8	769	383	89	1790	1041	751	337	620	83	2495	19	67	75	78	418	1139	165	433	163	66	29	51	218
9	784	130	66	123	1680	1659	1597	146	192	229	1200	236	44	55	26	132	396	53	338	22	32	73	134
10	467	89	48	540	325	4228	3403	927	113	256	249	271	62	45	18	27	51	112	39	87	36	70	106
11+	2830	1210	172	1336	1712	2408	6726	8291	3484	4144	3151	1892	290	261	175	98	53	36	361	26	48	104	11
1+	8603	3789	1573	4398	5007	9695	16131	15942	8988	8912	8290	6094	2183	4452	5466	4026	2121	880	1062	316	201	767	1327

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	1995
1	0	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	0
3	0	0	0	0	3	0	0	0	0	16	24	0	0	0	0	0	0	0	1	0	0	0	0
4	32	106	6	0	39	9	11	43	342	405	1229	83	4	3	36	2	8	43	16	30	1	13	210
5	179	190	200	11	30	296	260	73	201	523	531	2319	49	102	178	102	32	70	64	32	10	47	390
6	766	49	586	178	90	193	1289	153	24	164	627	329	1211	189	354	251	63	119	69	178	18	358	732
7	331	207	46	191	467	463	218	1342	245	81	143	397	134	1596	473	202	108	79	92	80	27	401	587
8	639	38	134	228	228	708	504	120	876	199	78	74	93	135	1909	169	187	132	99	136	21	409	355
9	683	198	108	161	239	156	527	603	46	554	169	64	26	84	194	679	174	228	65	148	42	191	251
10	1862	80	201	88	140	147	315	272	71	220	199	95	2	31	74	89	182	51	80	51	44	141	164
11+	6941	2719	2683	2826	2647	3624	3018	4552	2396	1529	581	442	115	160	54	68	55	654	544	678	221	673	225
1+	11434	3586	3964	3684	3884	5595	6142	7159	4201	3708	3582	3803	1633	2299	3273	1561	809	1376	1030	1334	385	2232	2912

Table 8a. Acoustic backscatter and biomass of herring per transect off St. George's Bay in May 1995.

Stratum	Transect Number	Transect Length (km)	Target Strength (dB/kg)	Average Sa (/m²)	Total Scattering (m2/sr)	Biomass Density (Kg/m²)	Set Number
St.Georges	67	13.134	-35.90	0.00000000	0	0.0000	
Bay	70	11.687	-35.90	0.00000271	120	0.0105	
	72	13.892	-35.90	0.00001089	575	0.0424	
	74	13.644	-35.90	0.00001147	594	0.0446	
	79	11.861	-35.90	0.00003013	1357	0.1172	502
	81	11.579	-35.90	0.00000110	49	0.0043	
	83	14.210	-35.90	0.00000930	502	0.0362	
	85	12.429	-35.90	0.00000000	0	0.0000	

Table 8b. Acoustic backscatter, biomass and variance estimates of herring off St. George's Bay in May 1995.

Stratum	Average TS (dB/Kg)	Stratum Area (km²)	Weighted Mean Sa (/m²)	Biomass Density (Kg/m²)	Total Biomass (metric tons) Total	S.E.	C.V.
St.George's	-35.9	389.00	0.00000822	0.0320	12438	5122	41.0
Spring spawners					4415		
Autumn spawners					8023		

Table 9a. 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	91	2.9	91	2.9
5	1019	32.6	1110	35.5
6	584	18.7	1694	54.1
7	212	6.8	1906	60.9
8	841	26.9	2747	87.8
9	341	10.9	3088	98.7
10	32	1.0	3120	99.7
11	10	0.3	3130	100.0

FISHING AREA	Frequency	Percent	Cumulative Frequency	Cumulative Percent
FISCHELL	218	7.0	218	7.0
SANDY POINT	380	12.1	598	19.1
ST-GEORGES	117	3.7	715	22.8
BARACHOIS BROOK	128	4.1	843	26.9
LOURDES	260	8.3	1103	35.2
BLACK DUCK BROOK	307	9.8	1410	45.0
LONG PT. (BAY)	307	9.8	1717	54.9
CASTOR RIVER	43	1.4	1760	56.2
FERROLE POINT	65	2.1	1825	58.3
WHALE ISLAND	12	0.4	1837	58.7
EDDIES COVE E	1293	41.3	3130	100.0

YEAR	Frequency	Percent	Cumulative Frequency	Cumulative Percent
84	96	3.1	96	3.1
85	202	6.5	298	9.5
86	225	7.2	523	16.7
87	307	9.8	830	26.5
88	355	11.3	1185	37.9
89	303	9.7	1488	47.5
90	267	8.5	1755	56.1
91	227	7.3	1982	63.3
92	247	7.9	2229	71.2
93	290	9.3	2519	80.5
94	274	8.8	2793	89.2
95	337	10.8	3130	100.0

Table 9b. Frequency of observations of index-fisherman catch and effort data by month, fishing area and year for spring-spawning herring in NAFO Division 4Rd (St. Georges Bay).

MONTH	**Frequency**	**Percent**	**Cumulative Frequency**	**Cumulative Percent**
4	70	8.3	70	8.3
5	574	68.1	644	76.4
6	194	23.0	838	99.4
7	5	0.6	843	100.0

FISHING AREA	**Frequency**	**Percent**	**Cumulative Frequency**	**Cumulative Percent**
FISCHELL	218	25.9	218	25.9
SANDY POINT	380	45.1	598	70.9
ST-GEORGES	117	13.9	715	84.8
BARACHOIS BROOK	128	15.2	843	100.0

YEAR	**Frequency**	**Percent**	**Cumulative Frequency**	**Cumulative Percent**
85	55	6.5	55	6.5
86	67	7.9	122	14.5
87	100	11.9	222	26.3
88	76	9.0	298	35.3
89	74	8.8	372	44.1
90	58	6.9	430	51.0
91	60	7.1	490	58.1
92	80	9.5	570	67.6
93	83	9.8	653	77.5
94	77	9.1	730	86.6
95	113	13.4	843	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	0.9	21	0.9
5	445	19.5	466	20.4
6	390	17.1	856	37.4
7	207	9.1	1063	46.5
8	841	36.8	1904	83.3
9	341	14.9	2245	98.2
10	32	1.4	2277	99.6
11	10	0.4	2287	100.0

FISHING AREA	Frequency	Percent	Cumulative Frequency	Cumulative Percent
LOURDES	260	11.4	260	11.4
BLUE BEACH	205	9.0	465	20.3
LONG PT. (BAY)	409	17.9	874	38.2
CASTOR RIVER	43	1.9	917	40.1
FERROLE POINT	617	27.0	1534	67.1
WHALE ISLAND	12	0.5	1546	67.6
EDDIES COVE E	741	32.4	2287	100.0

YEAR	Frequency	Percent	Cumulative Frequency	Cumulative Percent
84	96	4.2	96	4.2
85	147	6.4	243	10.6
86	158	6.9	401	17.5
87	207	9.1	608	26.6
88	279	12.2	887	38.8
89	229	10.0	1116	48.8
90	209	9.1	1325	57.9
91	167	7.3	1492	65.2
92	167	7.3	1659	72.5
93	207	9.1	1866	81.6
94	197	8.6	2063	90.2
95	224	9.8	2287	100.0

Table 11a. Analysis of variance and regression coefficients for the 1984 to 1995 spring-spawning 4R herring catch rate data (catch/(surface*hours)).

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	28	7768.716327	277.454155	122.64	0.0001
Error	3101	7015.460497	2.262322		
Corrected Total	3129	14784.176824			

R-Square	C.V.	Root MSE	CATRATE Mean
0.525475	-17.92151	1.504102	-8.392716

Source	DF	Type III SS	Mean Square	F Value	Pr > F
MONTH	7	502.5648252	71.7949750	31.74	0.0001
FISH	10	752.7994360	75.2799436	33.28	0.0001
YEAR	11	781.7109271	71.0646297	31.41	0.0001

Parameter		Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		-18.23772750 B	-27.66	0.0001	0.65937502
MONTH	4	5.08101116 B	8.32	0.0001	0.61103235
	5	5.66063298 B	9.64	0.0001	0.58741453
	6	4.91533955 B	8.37	0.0001	0.58724288
	7	3.45919152 B	7.02	0.0001	0.49253727
	8	2.77243499 B	5.73	0.0001	0.48350026
	9	3.41103083 B	7.00	0.0001	0.48707362
	10	3.05023835 B	5.54	0.0001	0.55044109
	11	0.00000000 B		.	
FISH	BARACHOIS BROOK	4.59314114 B	7.95	0.0001	0.57808402
	BLACK DUCK BROOK	4.44518827 B	7.88	0.0001	0.56428688
	CASTOR RIVER	3.11971414 B	6.23	0.0001	0.50045601
	EDDIES COVE E	4.50442512 B	10.15	0.0001	0.44358649
	FERROLE POINT	4.86791690 B	10.05	0.0001	0.48440467
	FISCHELL	5.51883556 B	9.70	0.0001	0.56898432
	LONG PT. (BAY)	4.81772017 B	8.52	0.0001	0.56521804
	LOURDES	3.93430726 B	6.99	0.0001	0.56307336
	SANDY POINT	5.14262864 B	9.08	0.0001	0.56608648
	ST-GEORGES	5.56578709 B	9.57	0.0001	0.58140974
	WHALE ISLAND	0.00000000 B		.	
YEAR	84	0.78307218 B	4.29	0.0001	0.18245136
	85	1.61397520 B	11.31	0.0001	0.14272633
	86	1.45417887 B	10.74	0.0001	0.13535434
	87	1.65478882 B	13.10	0.0001	0.12631373
	88	1.19505304 B	9.89	0.0001	0.12080097
	89	1.10734540 B	8.99	0.0001	0.12316235
	90	0.62240270 B	4.83	0.0001	0.12887209
	91	1.17306588 B	8.80	0.0001	0.13327326
	92	0.93539812 B	7.18	0.0001	0.13026391
	93	0.55373812 B	4.47	0.0001	0.12392794
	94	0.10920646 B	0.87	0.3865	0.12610163
	95	0.00000000 B		.	

Table 11b. Analysis of variance and regression coefficients for the 1984 to 1995 spring-spawning 4Rd herring catch rate data (catch/(surface*hours)).

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	16	838.4821460	52.4051341	21.74	0.0001
Error	826	1991.0478796	2.4104696		
Corrected Total	842	2829.5300256			

R-Square	C.V.	Root MSE	CATRATE Mean
0.296333	-23.19729	1.552569	-6.692888

Source	DF	Type III SS	Mean Square	F Value	Pr > F
MONTH	3	331.2842234	110.4280745	45.81	0.0001
FISH	3	96.8839994	32.2946665	13.40	0.0001
YEAR	10	307.6956477	30.7695648	12.76	0.0001

Parameter		Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		-9.387318281 B	-12.43	0.0001	0.75498577
MONTH	4	1.965273275 B	2.66	0.0080	0.73922256
	5	2.285410324 B	3.22	0.0013	0.70928844
	6	0.665920783 B	0.94	0.3485	0.70985596
	7	0.000000000 B		.	
FISH	BARACHOIS BROOK	-1.144299850 B	-4.86	0.0001	0.23530873
	FISCHELL	-0.097161945 B	-0.41	0.6798	0.23534609
	SANDY POINT	-0.440607601 B	-2.18	0.0293	0.20184180
	ST-GEORGES	0.000000000 B		.	
YEAR	85	1.242357580 B	4.44	0.0001	0.27969918
	86	1.584925229 B	6.33	0.0001	0.25040379
	87	1.930016207 B	7.56	0.0001	0.25539417
	88	0.800730785 B	3.30	0.0010	0.24288120
	89	1.425602979 B	6.04	0.0001	0.23589558
	90	1.785823574 B	6.92	0.0001	0.25805397
	91	1.732113005 B	6.89	0.0001	0.25155568
	92	1.879776740 B	8.10	0.0001	0.23218682
	93	0.909810835 B	4.00	0.0001	0.22769060
	94	0.787421271 B	3.38	0.0007	0.23273111
	95	0.000000000 B		.	

Table 12. Analysis of variance and regression coefficients for the 1984 to 1995 autumn-spawning 4R herring catch rate data (catch/(surface*hours)).

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	24	2772.440951	115.518373	60.10	0.0001
Error	2262	4347.449787	1.921950		
Corrected Total	2286	7119.890738			
	R-Square	C.V.	Root MSE		CATRATE Mean
	0.389394	-16.88286	1.386344		-8.211546

Source	DF	Type III SS	Mean Square	F Value	Pr > F
MONTH	7	281.7934774	40.2562111	20.95	0.0001
FISH	6	555.2709358	92.5451560	48.15	0.0001
YEAR	11	520.1848040	47.2895276	24.60	0.0001

Parameter		Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		-17.53021618 B	-28.34	0.0001	0.61862590
MONTH	4	4.75778326 B	7.40	0.0001	0.64284753
	5	4.22138915 B	7.45	0.0001	0.56663039
	6	4.10112612 B	7.24	0.0001	0.56646967
	7	4.73685232 B	10.35	0.0001	0.45751119
	8	4.86477730 B	10.81	0.0001	0.45009271
	9	4.57807801 B	10.05	0.0001	0.45548411
	10	3.73178291 B	7.24	0.0001	0.51553453
	11	0.00000000 B		.	
FISH	BLUE BEACH	4.37686384 B	7.98	0.0001	0.54842626
	CASTOR RIVER	3.24317545 B	6.99	0.0001	0.46376887
	EDDIES COVE E	4.94827641 B	12.01	0.0001	0.41192737
	FERROLE POINT	4.90640932 B	11.86	0.0001	0.41361489
	LONG PT. (BAY)	3.64892166 B	6.70	0.0001	0.54459236
	LOURDES	3.22113163 B	5.93	0.0001	0.54354914
	WHALE ISLAND	0.00000000 B		.	
YEAR	84	-0.24143548 B	-1.39	0.1650	0.17384409
	85	1.19790406 B	7.78	0.0001	0.15393980
	86	0.87462868 B	5.84	0.0001	0.14981444
	87	0.64383431 B	4.64	0.0001	0.13863971
	88	0.56491355 B	4.31	0.0001	0.13121418
	89	0.38510814 B	2.81	0.0049	0.13686277
	90	-0.48877817 B	-3.51	0.0005	0.13937513
	91	0.30126270 B	2.03	0.0427	0.14853961
	92	1.13800128 B	7.65	0.0001	0.14884901
	93	0.66868804 B	4.88	0.0001	0.13700508
	94	-0.13078158 B	-0.95	0.3417	0.13751458
	95	0.00000000 B		.	

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

	SPRING SPAWNERS		SPRING SPAWNERS 4Rd		AUTUMN SPAWNERS	
YEAR	CATCH RATE	STANDARD ERROR	CATCH RATE	STANDARD ERROR	CATCH RATE	STANDARD ERROR
84	0.75507	0.23856			0.45704	0.13679
85	1.74282	0.41369	0.83370	0.38068	1.93286	0.50679
86	1.48711	0.32381	1.18313	0.46025	1.40062	0.34134
87	1.81879	0.37128	1.66429	0.70790	1.11363	0.24272
88	1.14938	0.21642	0.54041	0.20696	1.02964	0.21473
89	1.05212	0.21309	1.00689	0.41092	0.85921	0.19700
90	0.64757	0.13600	1.43772	0.63857	0.35855	0.08256
91	1.12221	0.25286	1.36705	0.56702	0.78880	0.20204
92	0.88483	0.19926	1.58672	0.63804	1.82065	0.47486
93	0.60485	0.12231	0.60388	0.21903	1.14089	0.26217
94	0.38766	0.08069	0.53252	0.21128	0.51289	0.11816
95	0.34759	0.07177	0.24369	0.08209	0.58521	0.12292

Table 14. Number of comments received from questionnaires sent to inshore herring fishermen along the west coast of Newfoundland in 1995.

COMMENTS	4Rd	4Rc	4Rb	4Ra	TOTAL
Herring abundant			4	9	13
- during spring		1	1	1	3
- during summer			2	4	6
- during fall		1	3	6	10
Herring stock in decline	7	5	10	5	27
- during spring		2	4	1	7
- during fall			1		1
Complaints against seiners:					
- excessive catches	8	14	16	15	51
- on spawning grounds	2	2		2	6
- dumping at sea		1	3	6	10
Others causes suggested:					
- fishing on spawning grounds	2		2		4
- seals			1	2	3
- traps			1		1
Spawning:					
- in decline		1	1	1	3
- late arrival on grounds		1			1
Size of herring					
- small		5	3		8
- big			3	9	12
at fall		1	1	2	4
Poor markets	4	3	6	21	34
Number of questionnnaires received	41	57	90	117	306 (33%)

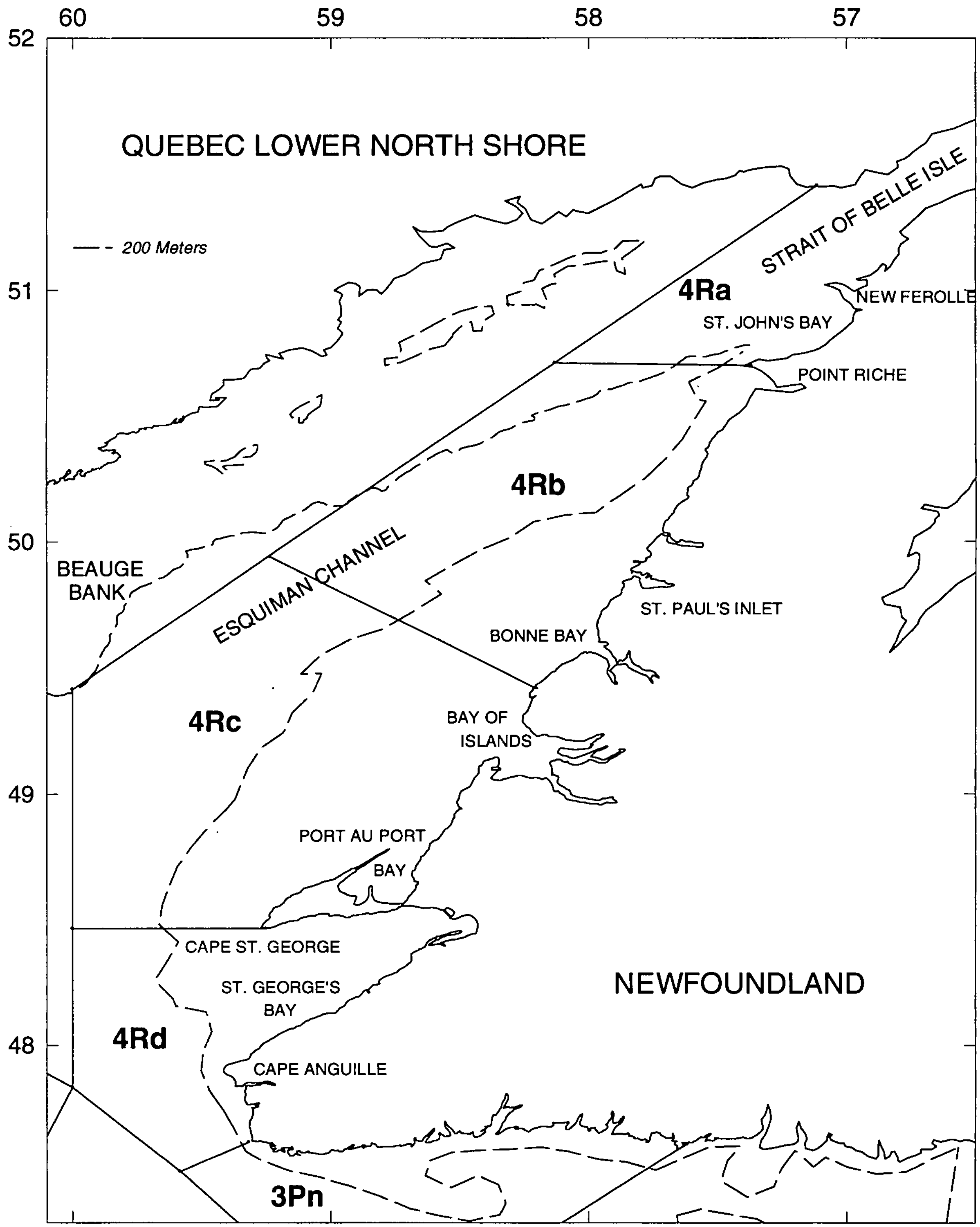


Figure 1. West coast of Newfoundland unit areas.

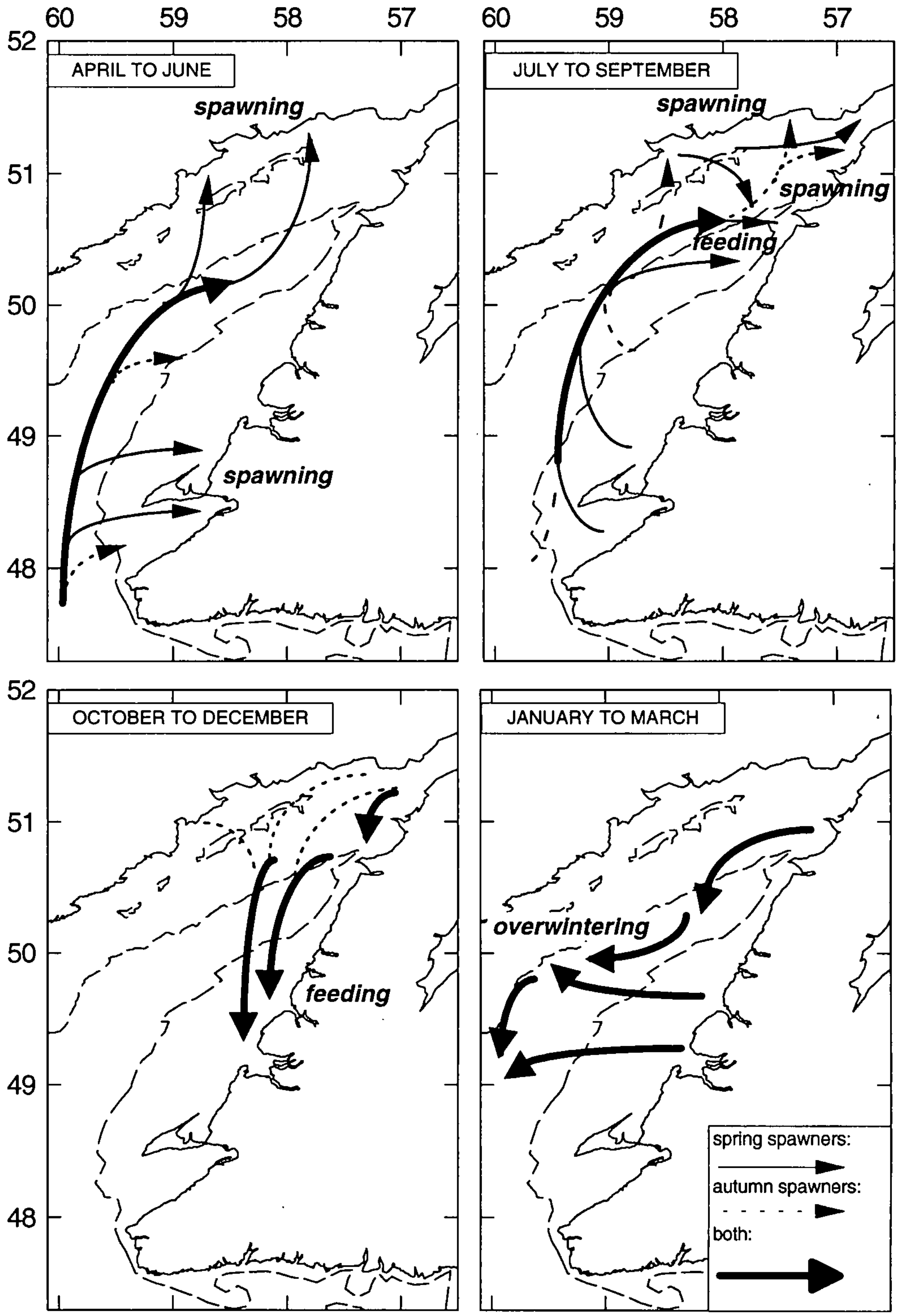


Figure 2. Probable annual migration pattern of spring- and autumn-spawning herring in the north-eastern Gulf of St. Lawrence.

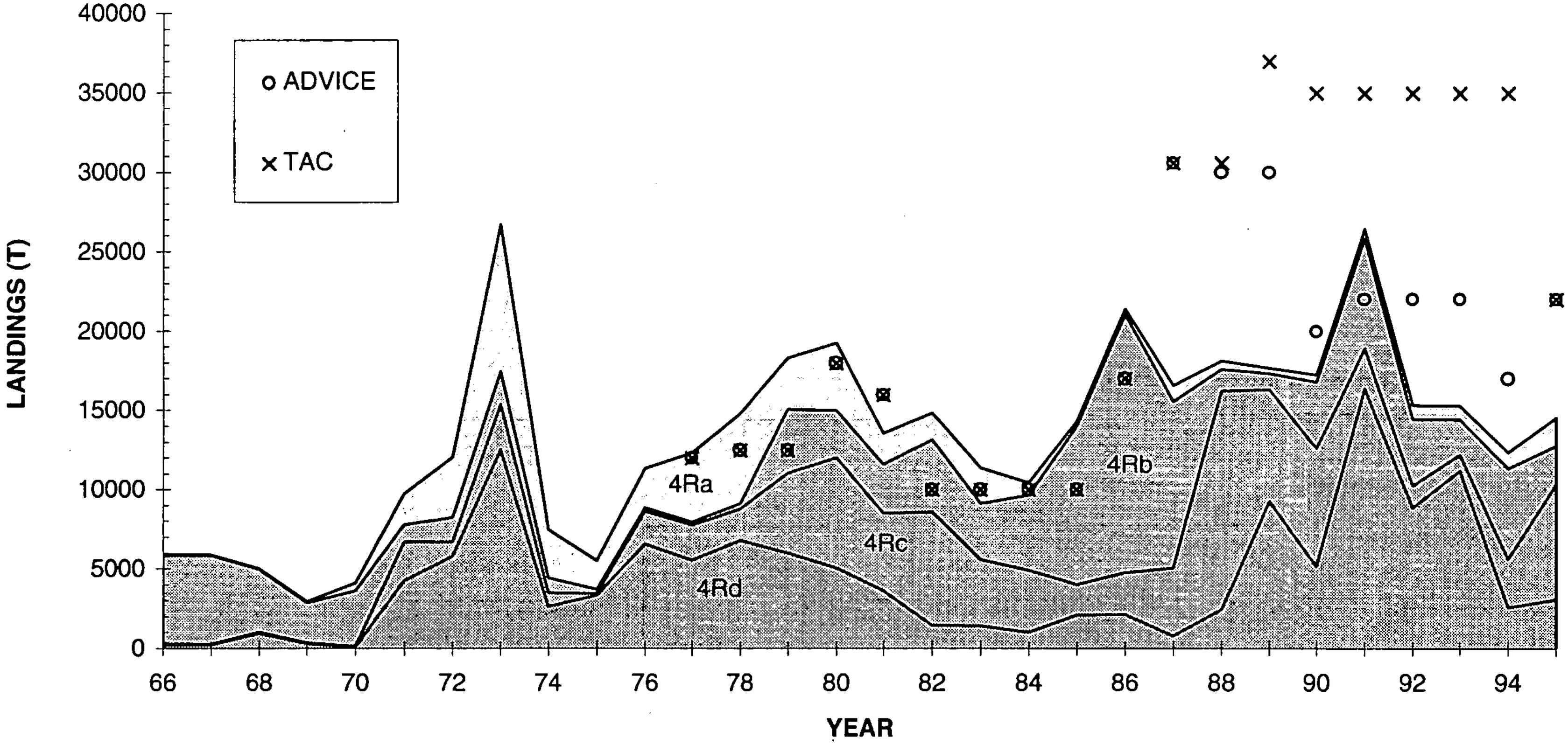


Figure 3. Cumulative commercial herring landings (t) by unit area in NAFO Division 4R from 1966 to 1995. (TAC and assessment advice are indicated).

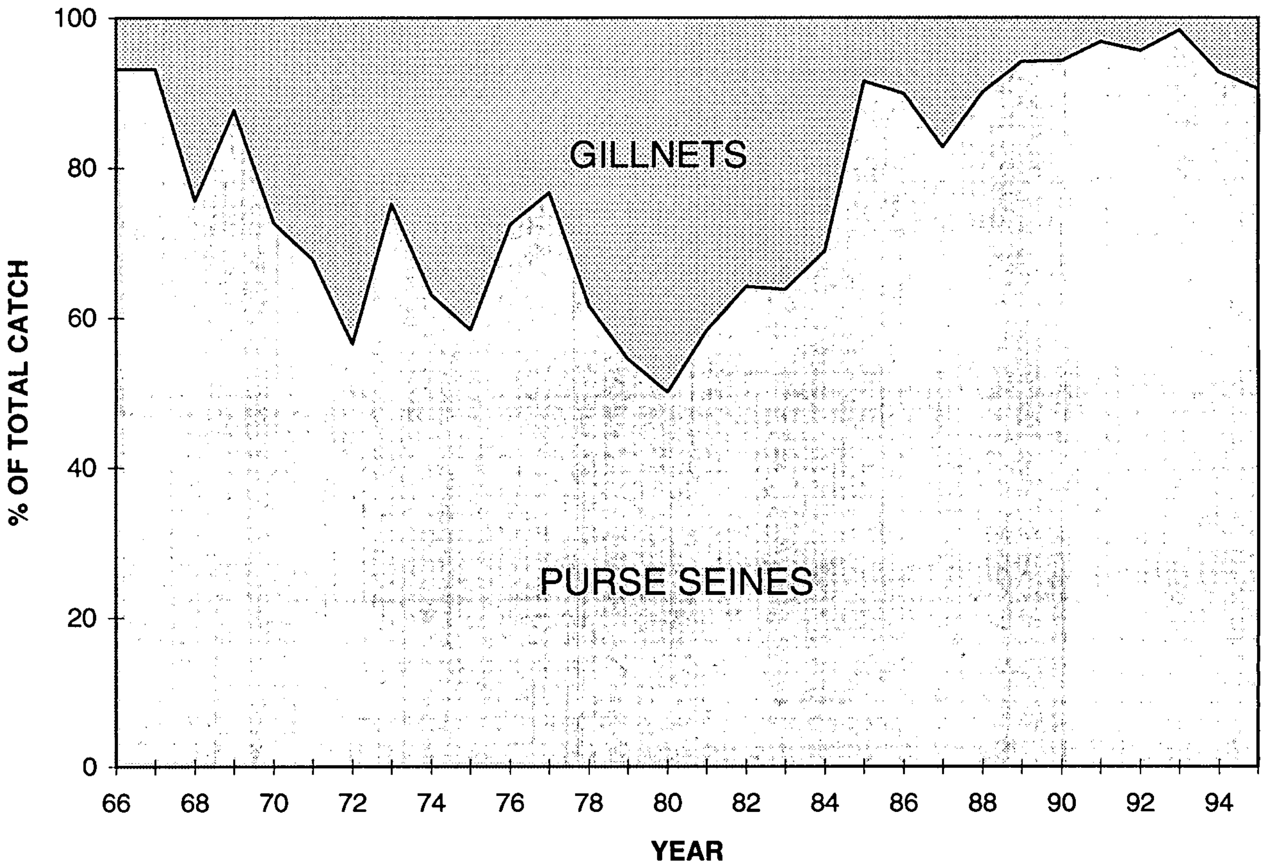
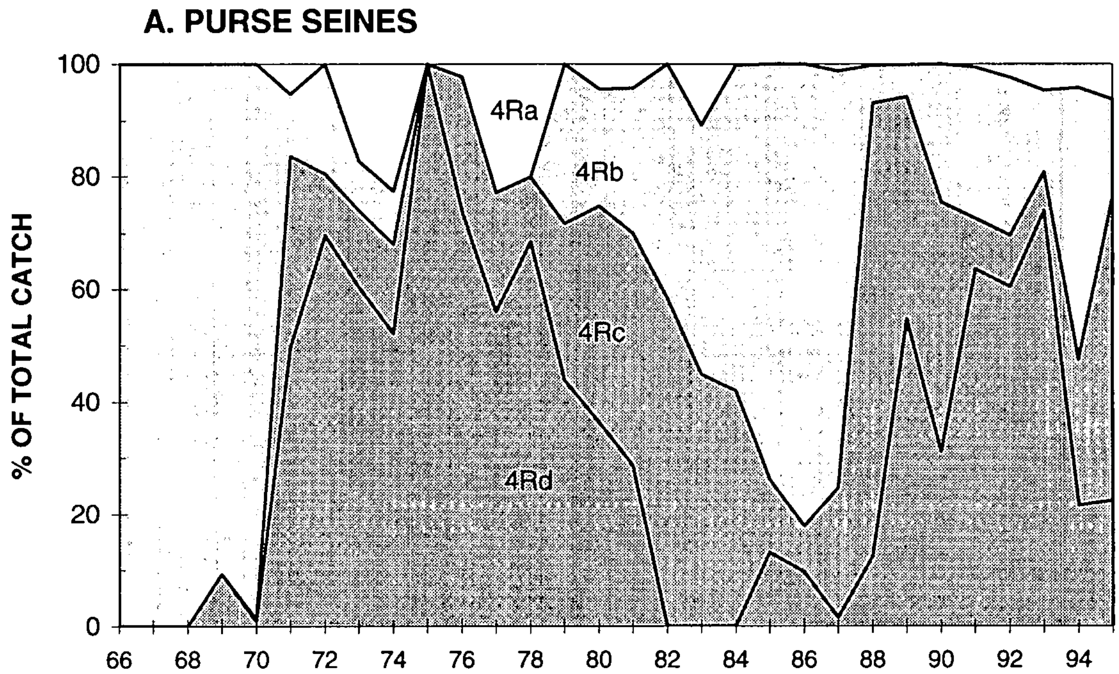


Figure 4. Proportion of total herring landings taken by gillnets and purse seiners in NAFO Division 4R from 1966 to 1995.



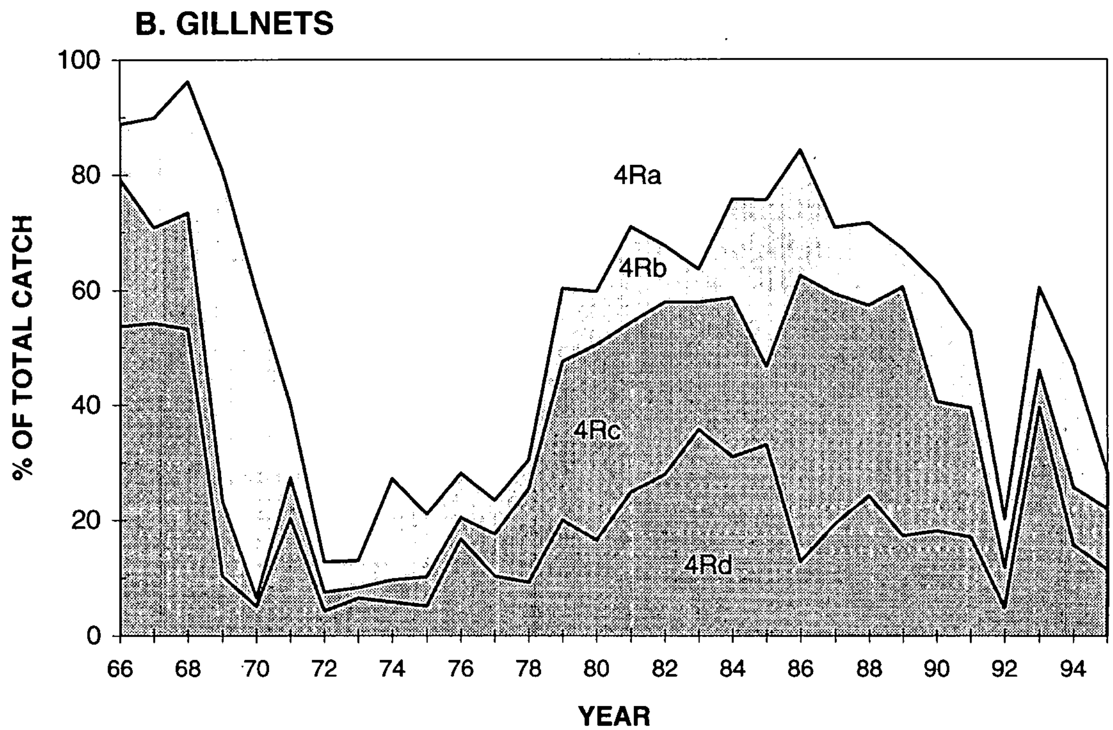


Figure 5. Proportion of purse seine (A) and gillnet (B) herring landings by fishing area in NAFO Division 4R from 1966 to 1995.

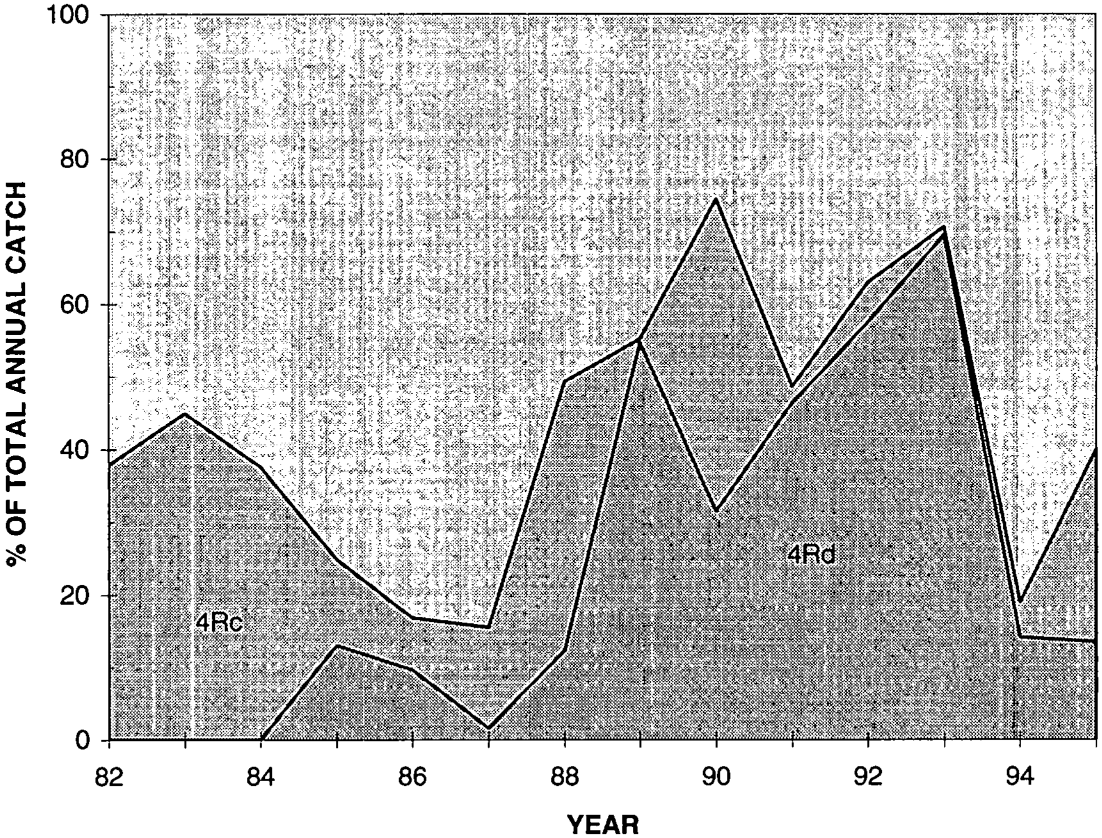


Figure 6. Proportion of total annual catch taken by purse seines in fishing areas 4Rc and 4Rd between 1982 and 1995.

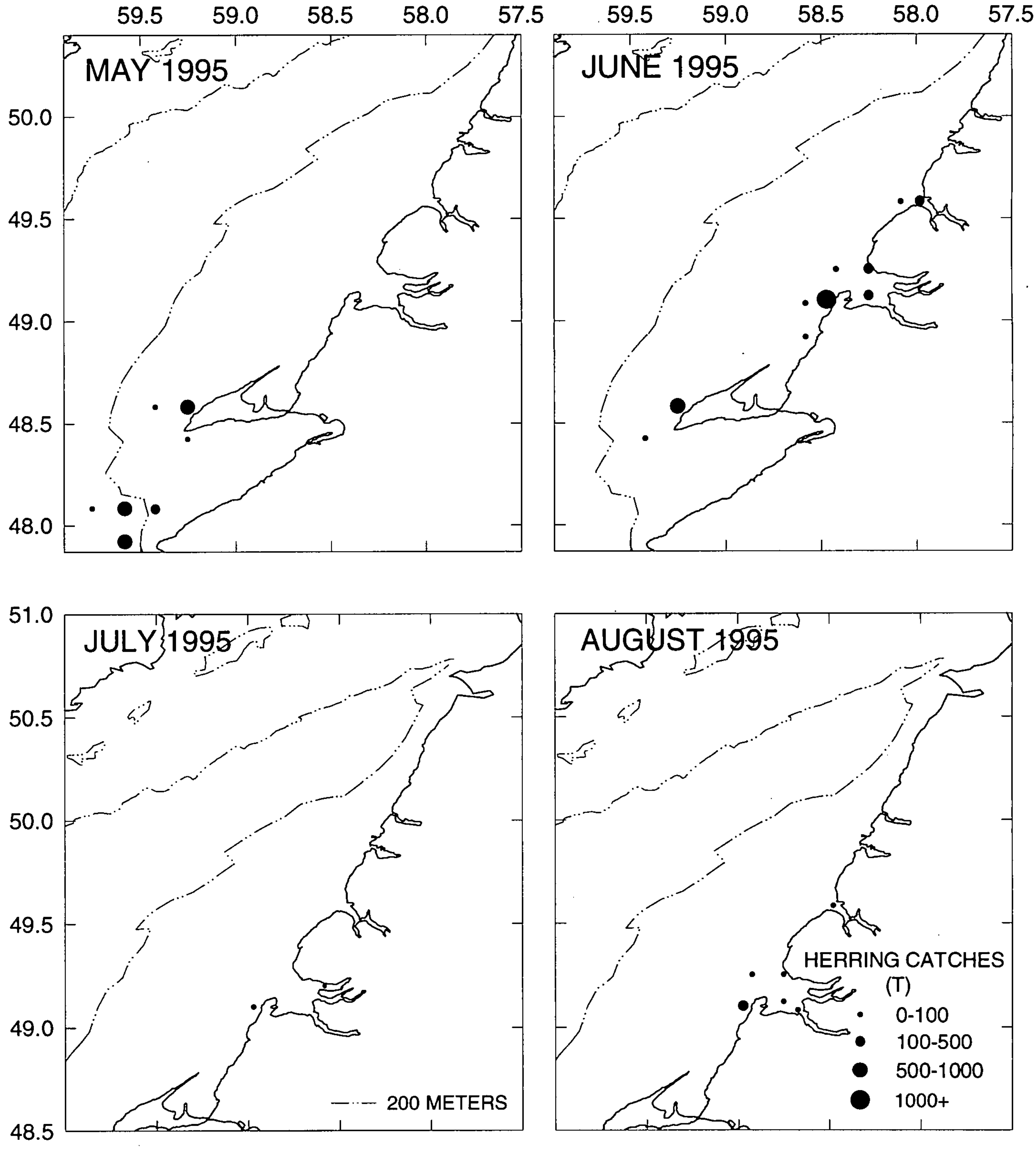


Figure 7. Monthly distribution of herring catches by 10-minute square from large and small purse seiners in 1995.

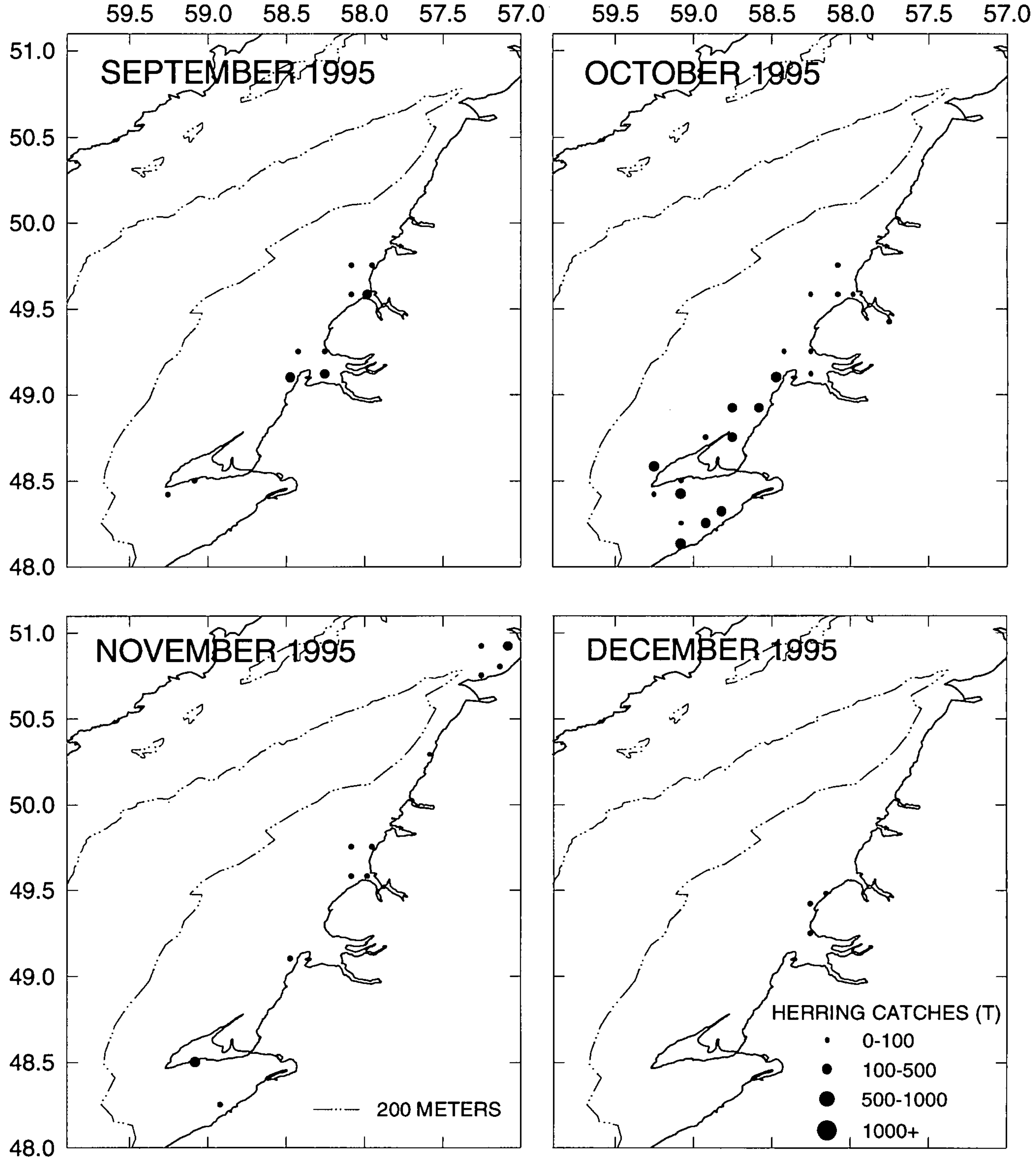


Figure 7. (Con`t)

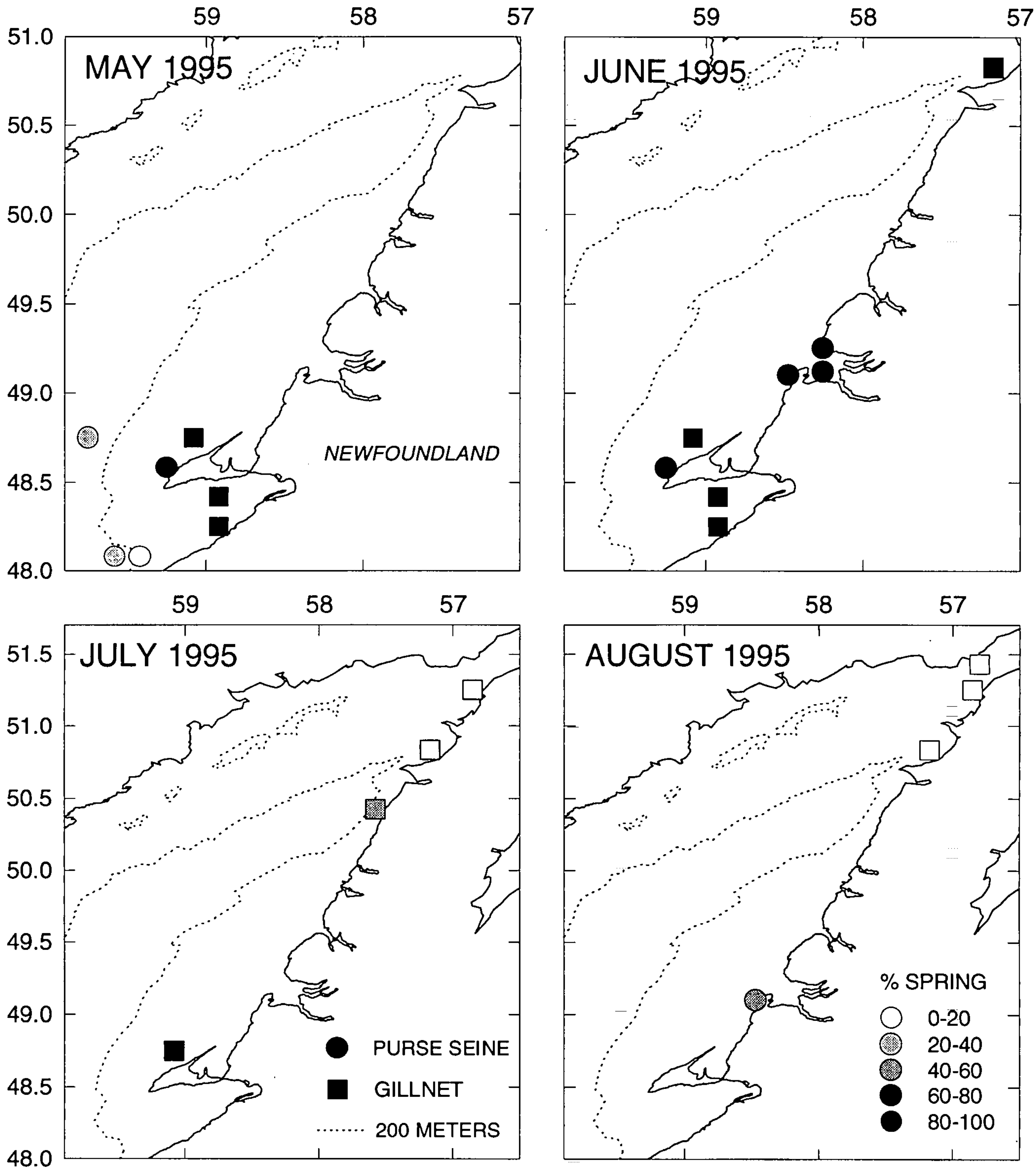


Figure 8. Percent of spring-spawning herring by 10 minute squares from May to December from all commercial and research data collected in 1995.

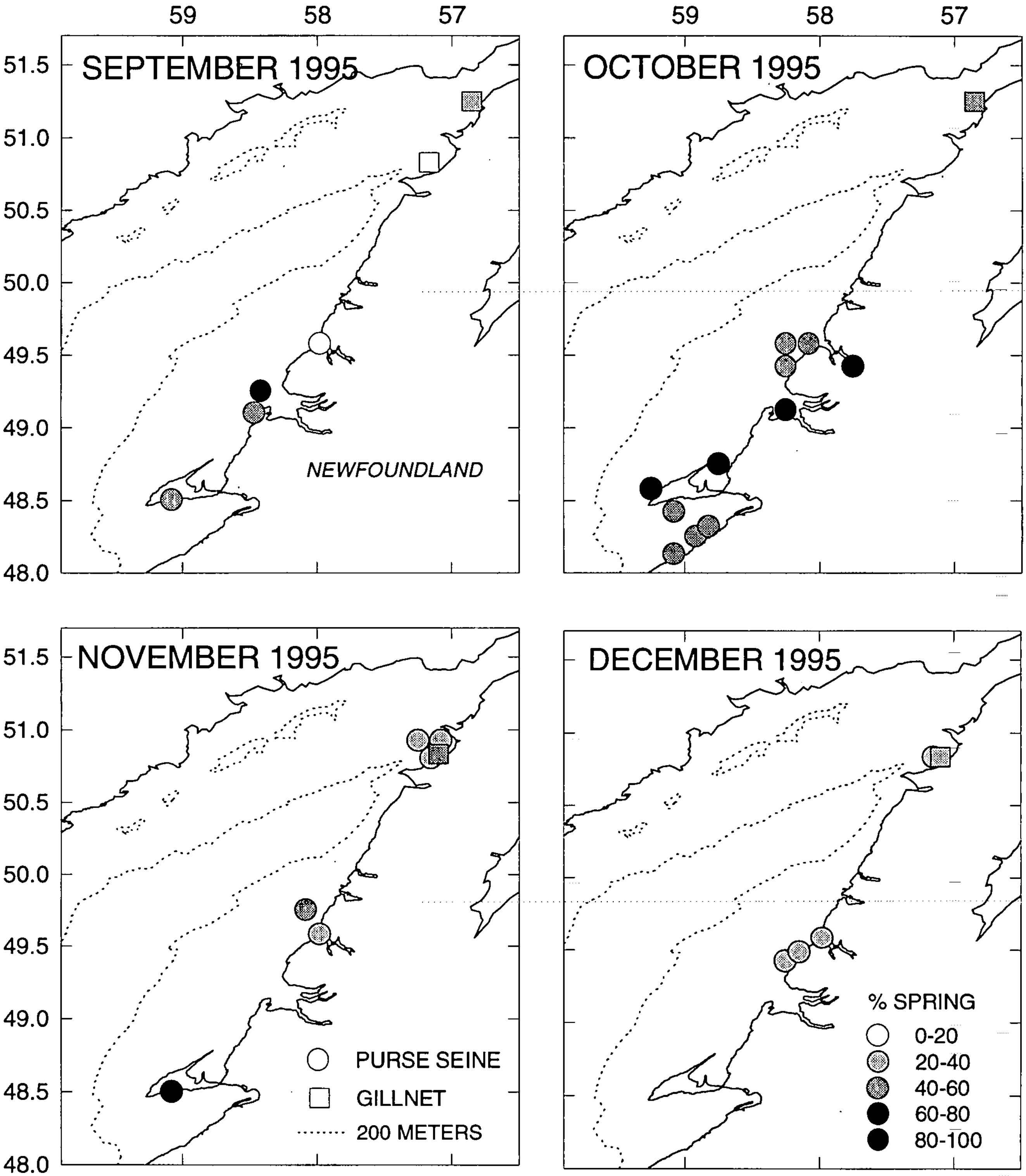


Figure 8. (Con't).

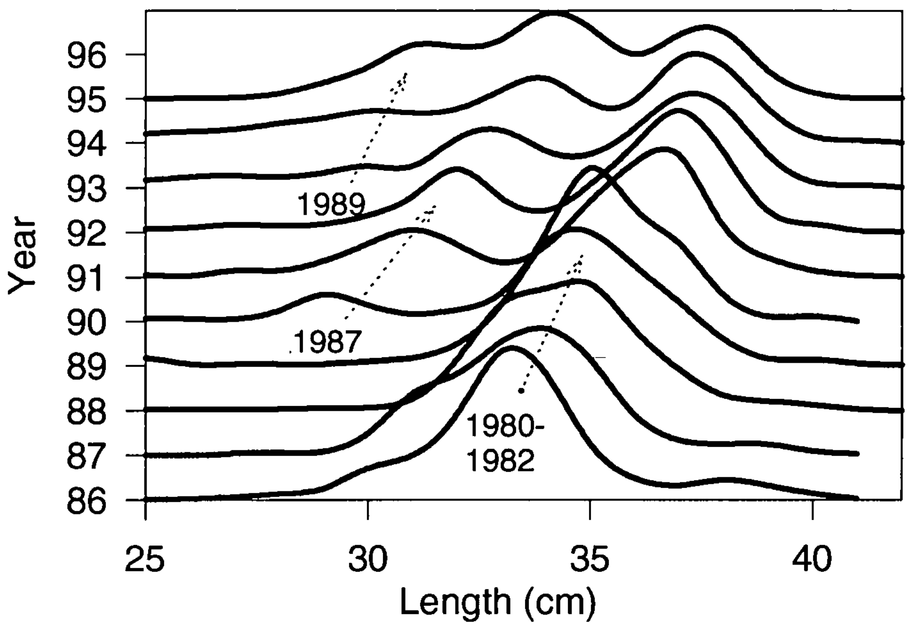


Figure 9. Annual length frequencies of spring-spawning herring from the 4R commercial fishery between 1986 and 1995 (major year-classes are indicated).

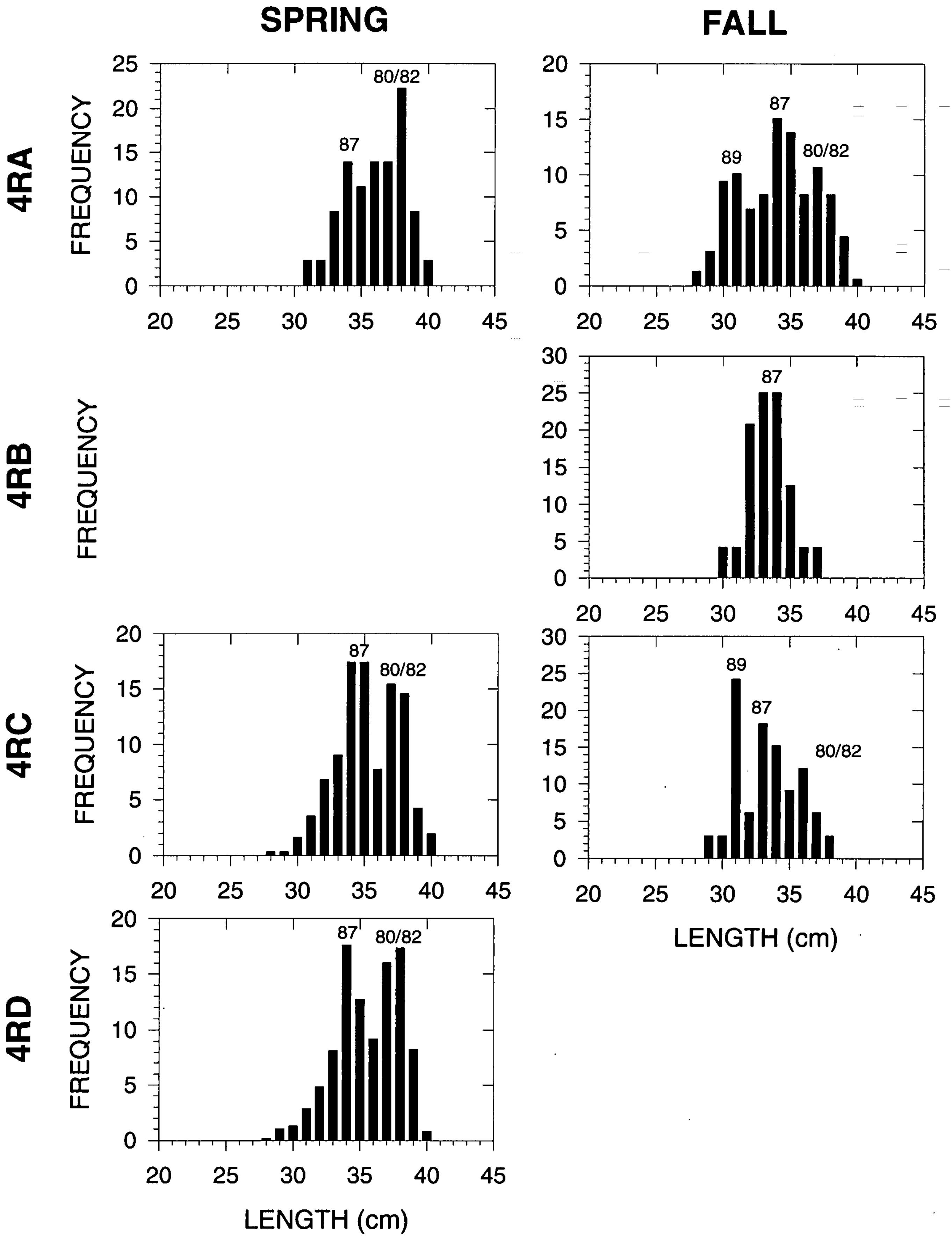


Figure 10. Length frequencies of spring-spawning herring from the spring and fall gillnet fisheries in 1995 (major year-classes are indicated).

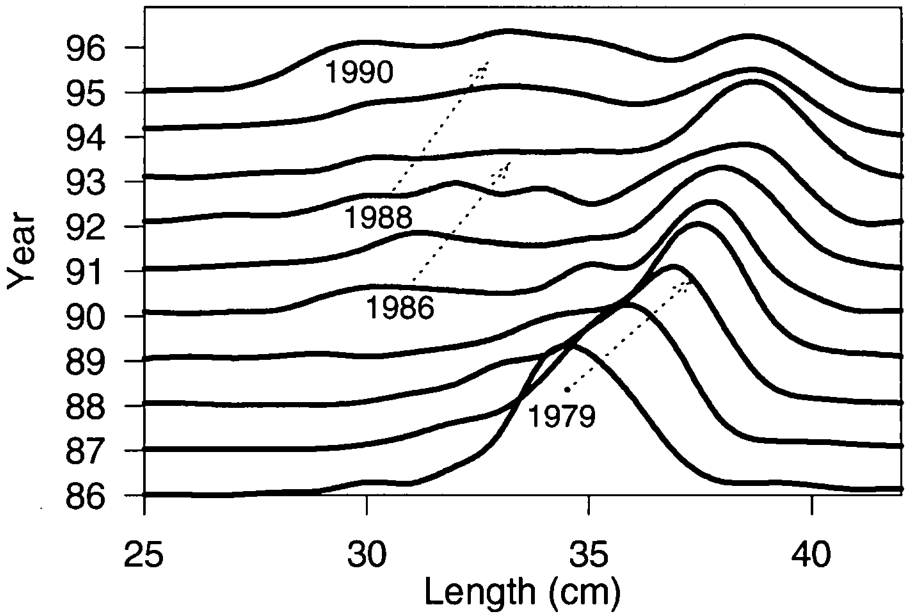
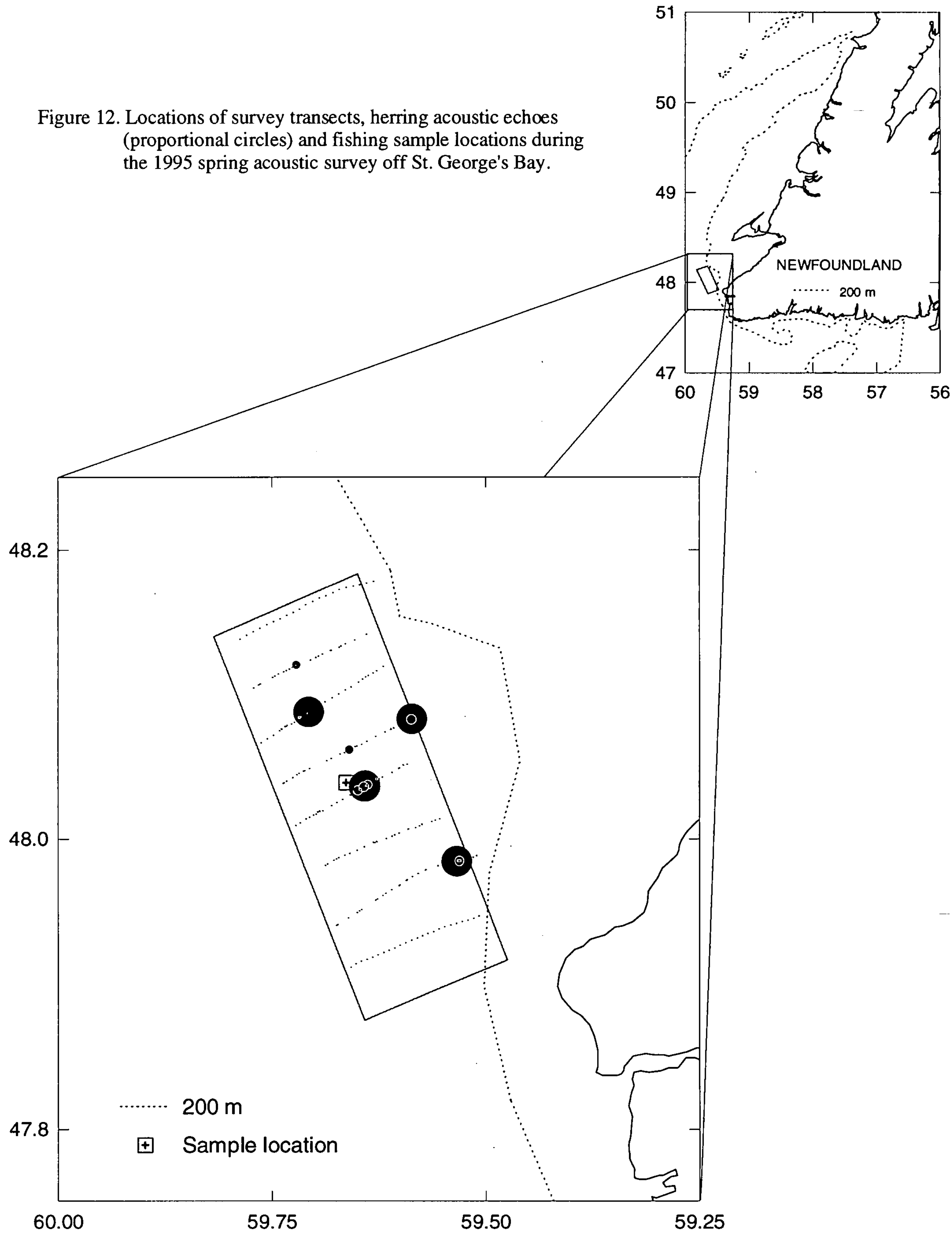


Figure 11. Annual length frequencies of autumn-spawning herring from the 4R commercial fishery between 1986 and 1995 (major year-classes are indicated).

Figure 12. Locations of survey transects, herring acoustic echoes (proportional circles) and fishing sample locations during the 1995 spring acoustic survey off St. George's Bay.



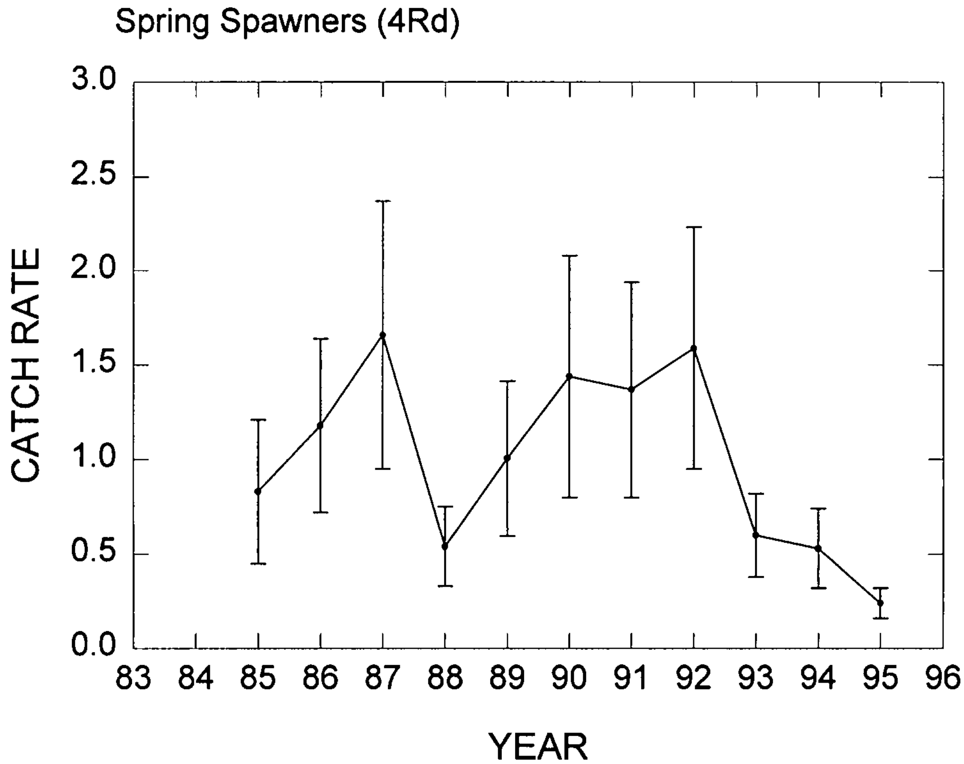


Figure 13a. Standardized gillnet catch per unit effort and 2xs.e. for spring-spawning herring in NAFO Division 4Rd as calculated from index-fisherman logbook data.

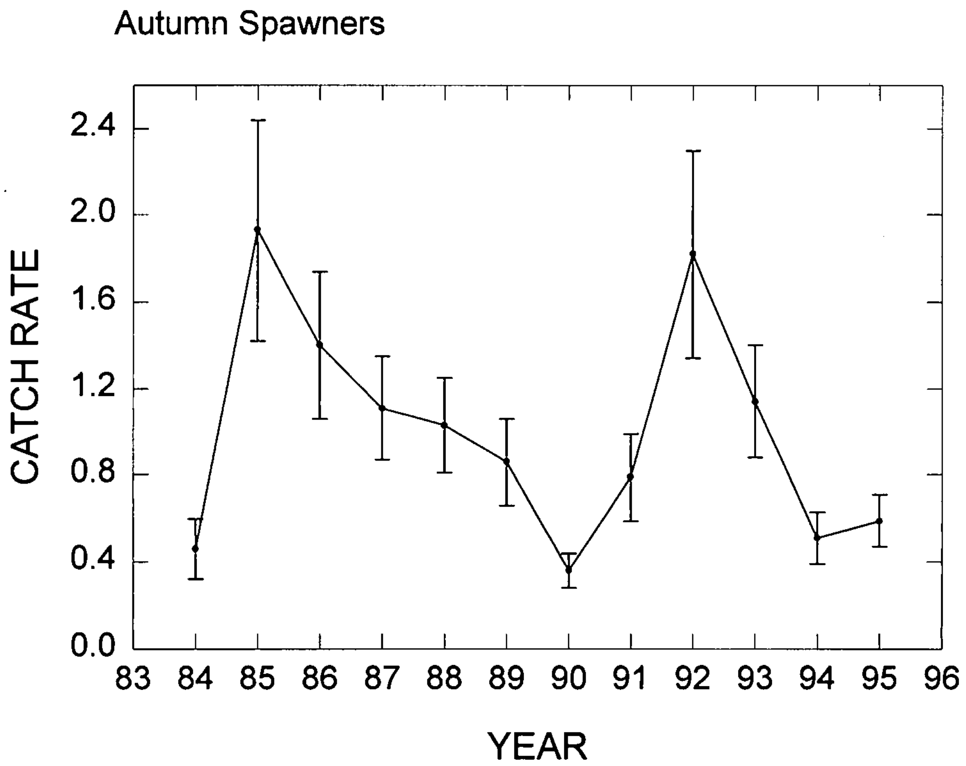


Figure 13b. Standardized gillnet catch per unit effort and 2xs.e. for autumn spawning herring in NAFO Division 4R as calculated from index-fisherman logbook data.

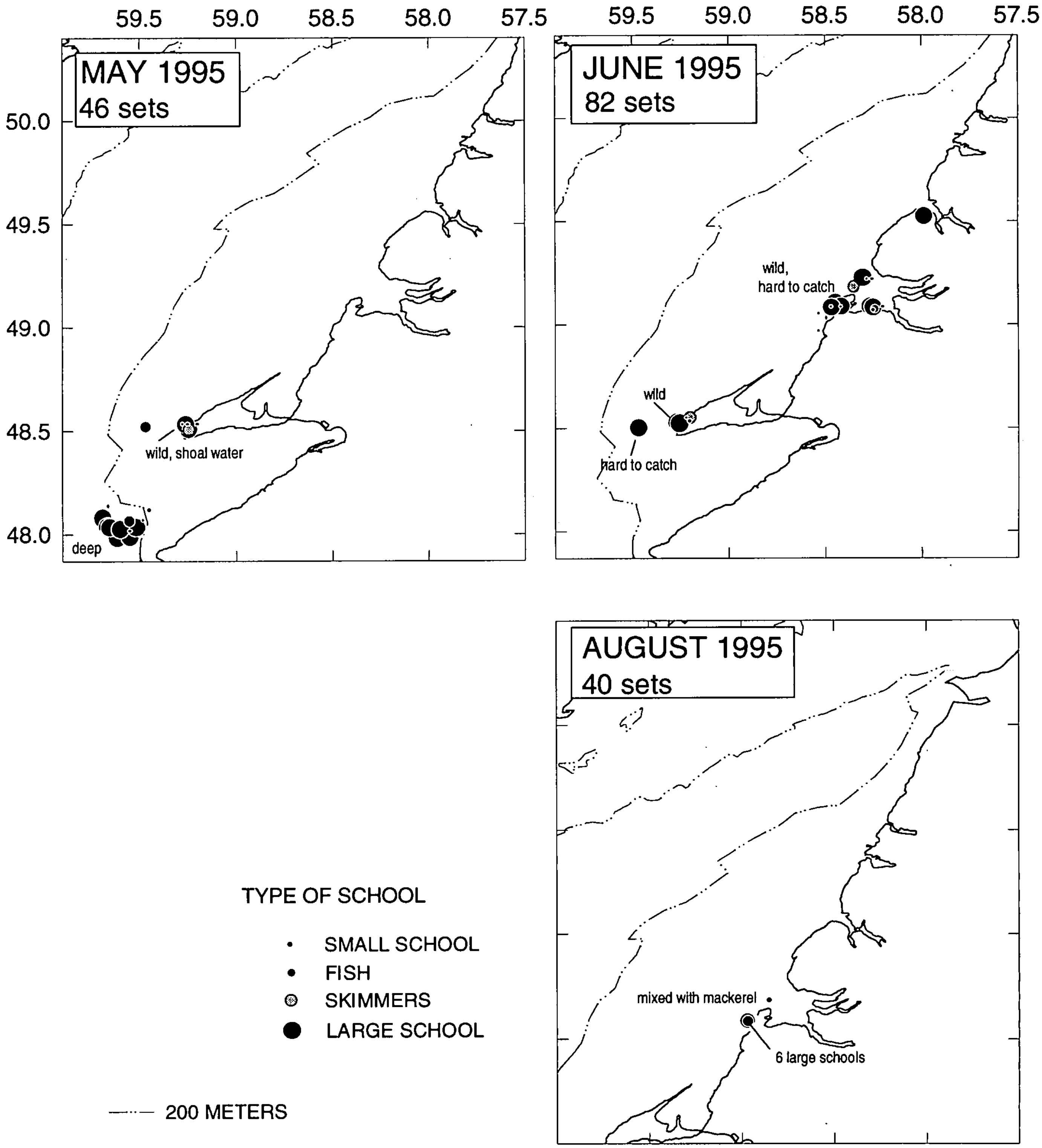


Figure 14. Monthly distribution of commentaries from available seiners logbooks in 1995.

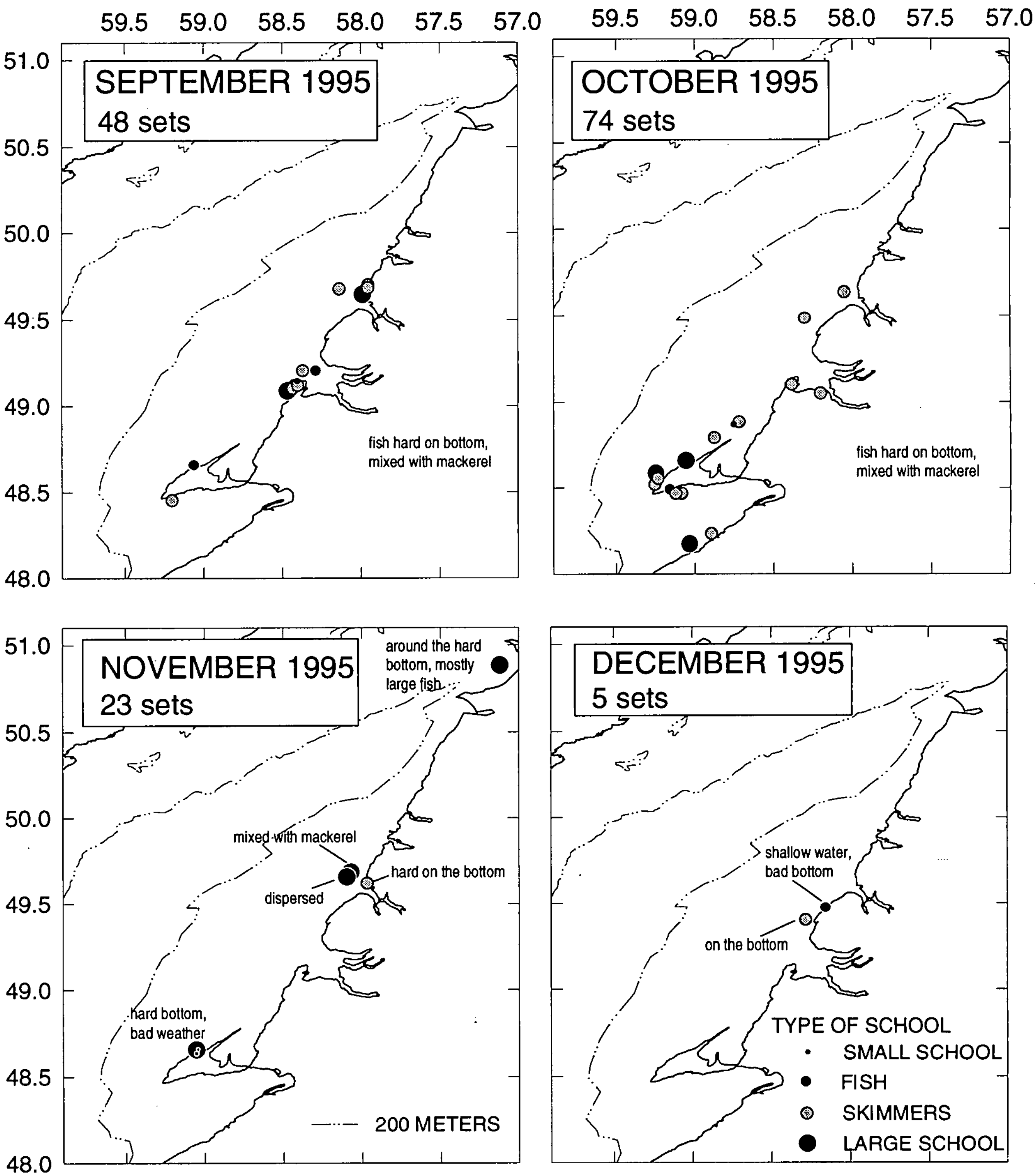


Figure 14. (Con`t)

Annex 1. Number of herring otoliths read **(bold print)** and commercial landings (t) in NAFO division 4R by gear, area and month in 1995. (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] 1	**49** / 10	[2] **129** / 242	[3] **419** / 359	[4] **183** / 114	[5] **50** / 33	[6] **94** / 121	[7] **49** / 15
	4Rb				3	4	6	[8] **48** / 21	9	6	21	5	
	4Rc			[9] 1	2	**233** / 41	[10] **93** / 59	[11] **49** / 10	8	10	3		
	4Rd					[12] **420** / 60	[13] **195** / 61	10	6	6			
PS > 65'	4Ra											[1] **44** / 464	
	4Rb									[2] **95** / 333	[3] **46** / 328	[4] **98** / 297	[5] **99** / 420
	4Rc					[6] **97** / 570	[7] **242** / 2445			[8] **50** / 514	1169	[9] **48** / 321	[10] **100** / 439
	4Rd					[11] **149** / 1693	69			[12] **49** / 181	[13] **49** / 736	77	
PS < 65'	4Ra							68	[*] 51	8		[1] **45** / 227	**45**
	4Rb						[2] **98** / 391	1	38	313	[3] 159	**47** / 1	
	4Rc					[4] 126	**48** / 309	[5] 41	**144** / 430	[6] **98** / 401	[7] **50** / 257	4	94
	4Rd						18				[8] **48** / 184		

* Samples from large purse seine.