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Changes in Distribution and Failure of the Winter Fixed Gear Cod (*Gadus morhua*) Fishery off Southwestern Newfoundland

Alain Fréchet and Pierre Gagnon
Institut Maurice-Lamontagne, Ministère des Pêches et Océans
C. P. 1000, Mont-Joli, Québec, Canada G5H 3Z4

Abstract

Catches in the fixed gear winter fishery (January to April) for cod (*Gadus morhua*) in NAFO Subdiv. 3Ps and Div. 4RS have plummeted from over 5 000 tons in the late-1970s to mid-1980s period to zero tons in 1991. This decline was investigated by an analysis of the distribution of cod from the winter groundfish surveys. Survey results showed a long term (14 years) trend of cod moving into deeper waters. By 1991, over 90% of the survey catch was in waters of more than 360 m. Examination of temperature recordings indicated that a cooling had occurred in waters less than 180 m but it did not explain the displacement of cod to depths of over 360 m. In order to verify if the decline of fixed gear catches were related to the size and abundance of cod, exploitable biomasses were calculated for both mobile and longline fleets. Results indicated no significant differences in availability.

Key words: Availability, cod, *Gadus morhua*, distribution, groundfish survey, longline, Newfoundland, temperature/depth

Introduction

Historically an important winter longline fishery for cod (*Gadus morhua*) has operated in the southwestern part of Newfoundland, in the southern part of NAFO Div. 4R and Subdiv. 3Pn (Fréchet *et al.*, MS 1991). The fishery has been dependent on the annual migration of the cod stock that leaves the Gulf of St. Lawrence and moves toward the southwestern part of Newfoundland (NAFO Subdiv. 3Pn). Landings from this fishery conducted from January to April ranged between 5 000 and 7 000 tons (Table 1). However, in recent years the fishery appears to have collapsed with 802 tons reported in 1989, 52 tons were reported in 1990 and no landings in 1991. This fixed gear fishery was carried out by a fleet of around 100 vessels, mostly small boats less than 35 feet. The fishery was confined to depths less than 180 m (100 fathoms) on account of unpredictable ice conditions.

The purpose of this paper is to investigate possible causes of the apparent collapse of this fishery with particular emphasis on the distribution of cod in the area.

TABLE 1. Landings (tons) of cod in Subdiv. 3Pn and Div. 4RS, January to April period, 1974-91.

	Fixed gear				Mobile gear
Year	Longline	Gillnet	Handline	Total	Otter trawl
1974	1 592	18	5	1 615	33 757
1975	1 537	11	13	1 561	31 475
1976	2 592	36	24	2 652	35 236
1977	4 050	48	31	4 129	30 719
1978	4 034	32	30	4 096	31 282
1979	5 070	308	53	5 431	27 507
1980	5 276	547	39	5 862	26 395
1981	5 626	176	25	5 827	25 630
1982	4 224	32	22	4 278	25 348
1983	6 650	1 098	138	7 886	24 065
1984	5 659	360	55	6 074	23 761
1985	4 200	5	24	4 229	25 778
1986	4 632	29	24	4 685	30 611
1987	5 436	23	7	5 466	19 124
1988	2 057	6	36	2 099	9 111
1989	790	12	0	802	15 774
1990[a]	42	1	9	52	10 124
1991[a]	0	0	0	0	9 512

[a] Preliminary.

Materials and Methods

The geographic area of the winter fishery in Subdiv. 3Pn and Div. 4RS under consideration is shown in Fig. 1. The cod biomass was estimated from 1978 to 1991 from annual January groundfish abundance surveys (Fréchet *et al.,* MS 1991). The surveys used a stratified-random sampling design. Stratified median depths and temperatures (of cod biomass) were calculated from the cumulative distributions. The cod preferences to temperatures and depths were analyzed in terms of cumulative frequency. The median depth and temperature corresponded to half the stock biomass. For comparison, similar median positions were calculated for witch flounder and redfish.

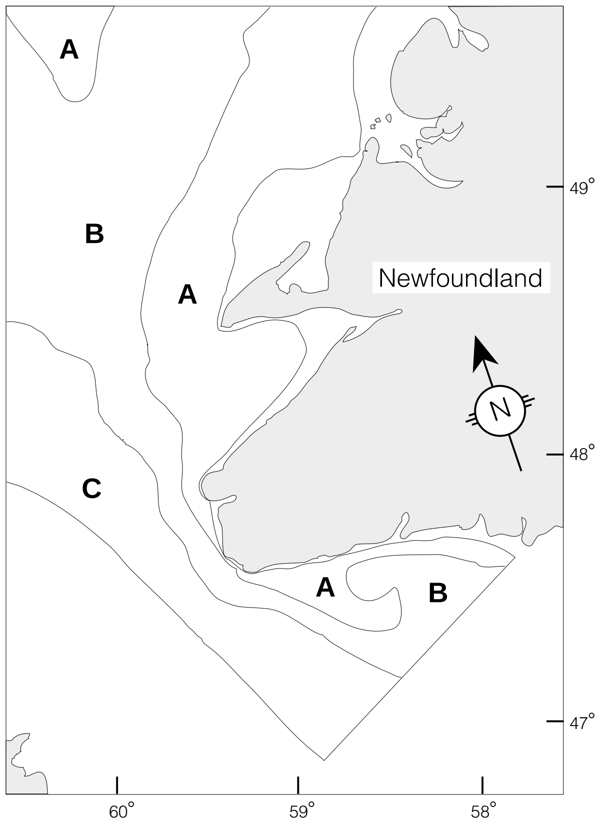

Fig. 1. Map of the area covered during the winter groundfish surveys. (**A** = less than 180 m, **B** = between 180 and 360 m, **C** = more than 360 m).

It is generally recognized that otter trawlers select smaller fish than longliners (Fréchet and Chouinard, MS 1987). Since this is currently a depleted stock, it may be argued that there is not enough older fish to sustain the longline fishery. In order to verify this, exploitable biomasses were calculated from the results of the most recent assessment (Fréchet *et al.*, MS 1991) using partial recruitment values from Fréchet and Chouinard, (MS 1987).

Maps of the distribution of the otter trawl fishery were done by extracting into units of 10 min. square, the data from Zonal Interchange File Format (ZIFF of the Department of Fisheries and Oceans, Canada) files for the 1986-89 period, where cod directed sets were done during the first 4 months of the year. A separate coding in depth zones was included in the ZIFF and presented for the same categories.

Results

Over a period of 14 years in which annual January groundfish surveys have been conducted, a gradual shift in the distribution of cod was observed (Fig. 2). In 1978 over 70% of the biomass was

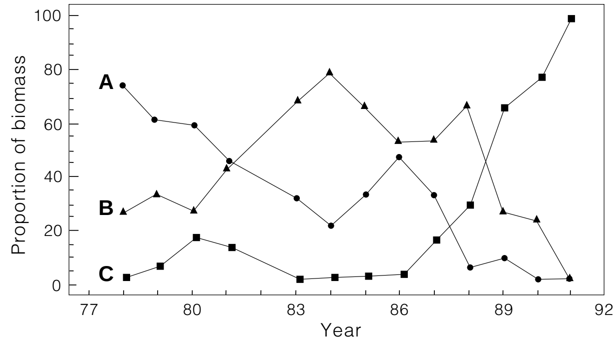

Fig. 2. Proportion of the cod biomass observed by depth area according to the winter groundfish surveys. (**A** = less than 180 m, **B** = between 180 and 360 m, **C** = more than 360 m).

observed in depths of less than 180 m, in 1984 over 80% of the biomass was observed in depths between 180 and 360 m, by 1991, 97% of the biomass was present in depths of over 360 m.

The temperature regime was highly variable through the study period, with the shallowest areas showing more variability from one year to the next (Fig. 3). Bottom temperatures at less than 180 m were on the average about 2°C cooler than the deeper stations, however, temperatures in depths of over 180 m showed similar general trends. The temperatures at 180 m and over 360 m for any given year were generally similar.

Most of the colder waters occurred only in shallow depths whereas temperatures greater than 5°C consistently occurred in depths of over 360 m. The median temperatures observed during these surveys occurred between the 4.7° to 6.3°C range.

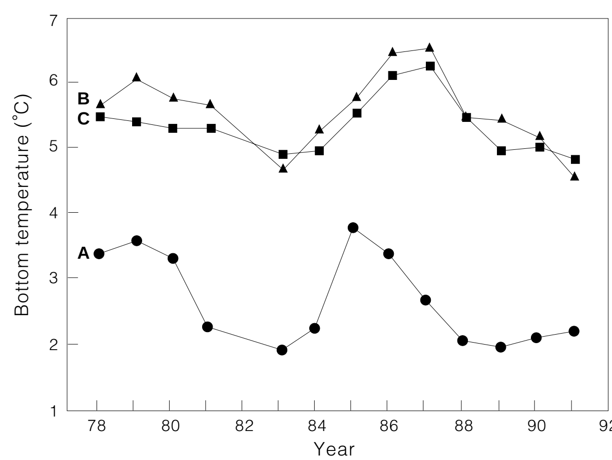

Fig. 3. Average temperature observed by depth area according to the winter groundfish surveys. (**A** = less than 180 m, **B** = between 180 and 360 m, **C** = more than 360 m).

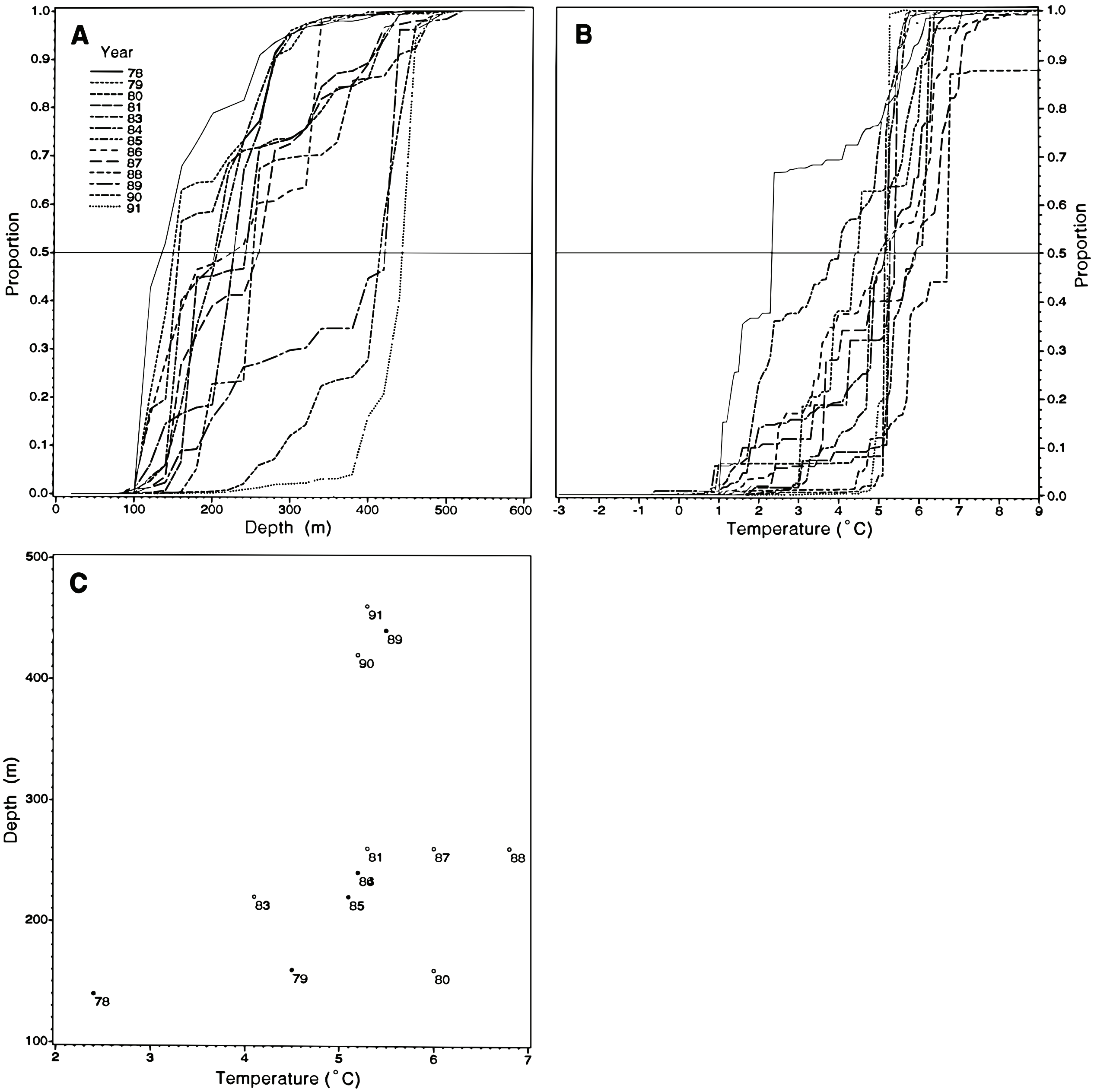

Fig. 4. Cumulative probability distribution of cod catches with (**A**) depth, (**B**) temperature, (**C**) a plot of the median temperature and depth, sampled where cod occurred during the winter groundfish surveys (1984 and 1986 positions are the same).

When the cumulative frequencies were done to test cod preferences to the observed temperatures and depths, a large scale displacement from shallow to deep waters was evident (Fig. 4). Similar examinations on two other species commonly found in this area, witch flounder and redfish, showed no large shift of preference (Fig. 5A and 5B). While these are deep water species, the indication was that the distribution observations were specific to cod. Cod showed a large range of depth preferences whereas preferences in terms of temperature was narrow. Specifically, Fig. 4A shows the 50 percentile preference ranged between depths of 180 and 360 m in all years of the surveys except 1989, 1990 and 1991; the period of collapse of the fishery. On the other hand, the temperature preference distribution (Fig. 4B) shows that 10 out of the 13 years had 50 percentile preference to a temperature range of 4.7°to 6.8°C, and less than 20% showed preference to temperature below 3.4°C.

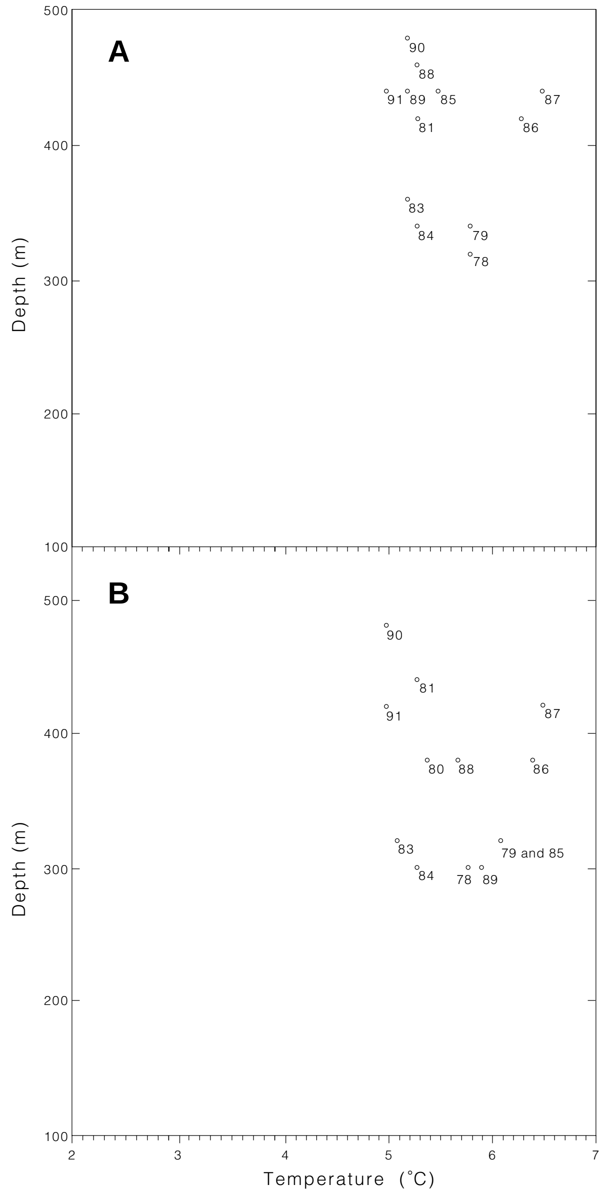

Fig. 5. Plot of the median temperature and depth of (**A**) witch flounder distribution, and (**B**) redfish distribution during the winter groundfish surveys.

Discussion

It is generally considered that two type of events can contribute to the success or failure of a fixed gear fishery. These are availability and abundance. According to results observed here from the winter groundfish surveys, as well as from the commercial otter trawler fleet, a gradual long-term shift in the distribution of cod had occurred.

The cod showed significant variations in distribution with depth through the years with a substantial shift to deeper waters in recent years. Waters in depths less than 180 m are highly influenced by the upwelling at the ice edge (Fréchet, 1990) and can at times show a homogenous very cold water column of -1°C from the surface to the bottom. These temperatures are not favourable to the preferences of cod. Other deep dwelling species like redfish and witch flounder have remained in the more stable water mass in the area.

From a management point of view, this shift of cod to deeper waters is causing some problems. Starting in 1989, following discussions with industry, a ceiling of 15% of cod as a by-catch (in weight) was set for the redfish directed fishery, since the winter groundfish survey had shown cod and redfish had traditionally occupied separate habitats. Cod being found in waters less than 300 m and redfish in waters more than 300 m (Fig. 4C and Fig. 5B). But since 1989, cod and redfish have been found in similar depths and it has been difficult to conduct a species specific fishery.

The displacement of the cod stock towards deeper waters is not related to stock size. In 1978 when the survey started, most of the biomass was in shallow waters (Fig. 2 and Fig. 4C), by 1983 the stock had doubled to reach its peak biomass and was found at average depths. Since 1983 the stock has declined to a level similar to 1978 but most of the biomass was in deep waters.

Average temperatures at depths greater than 180 m were generally similar ranging between 5° and 6°C since 1978 (Fig. 3), and as such could not explain the recent trend of cod moving to depths of over 360 m. However, shifts of cod biomass from the shallow depths can be explained by water temperatures. Most of the occurrences of cod were encountered in temperatures between 4.7° and 6.3°C. Bottom water temperature at depths of less than 180 m were cooler. Temperature can thus be assumed as a limiting factor to the presence of cod in traditional fixed gear fishing grounds. Cod was found in these areas only in years where the temperature was the warmest (Fig. 2, line A and Fig. 3, line A), from 1978 to 1980 and from 1985 to 1987. Notably, there is also a seasonal factor of cod distribution (Sinclair *et al.*, MS 1991). In the last few years, the ice cover has been extensive (Fréchet, 1990). The intense mixing that occurs at the ice edge may have cooled the shallow waters thus influencing the cod to move to deeper waters. It also appears that along with some colder years (1983 for example) that some warmer years also occurred (1979, 1986 and 1987), as seen in the ice forecast surveys (Bugden, 1991). Such years have had improved availability of cod.

Both fixed gear and mobile gear fleet sectors are present in the winter fishery (Table 1). Their performances have been quite different. Landings from the fixed gear sector increased steadily to peak in 1983 and then declined steadily thereafter. Landings from the mobile gear sector, however, have declined since 1974, except in 1985 and 1986 when substantial increases were noted. This declining pattern was more related to reductions in allocations given to that fleet sector for the winter fishery, while the low value for 1988 (9 111 tons) was caused by a strike. With respect to the decline of landings by the fixed gear since 1987, a significant advantage of the mobile gear was apparent. While the fixed gear sector could not find the cod in its shallower water operations, the otter trawler fleet

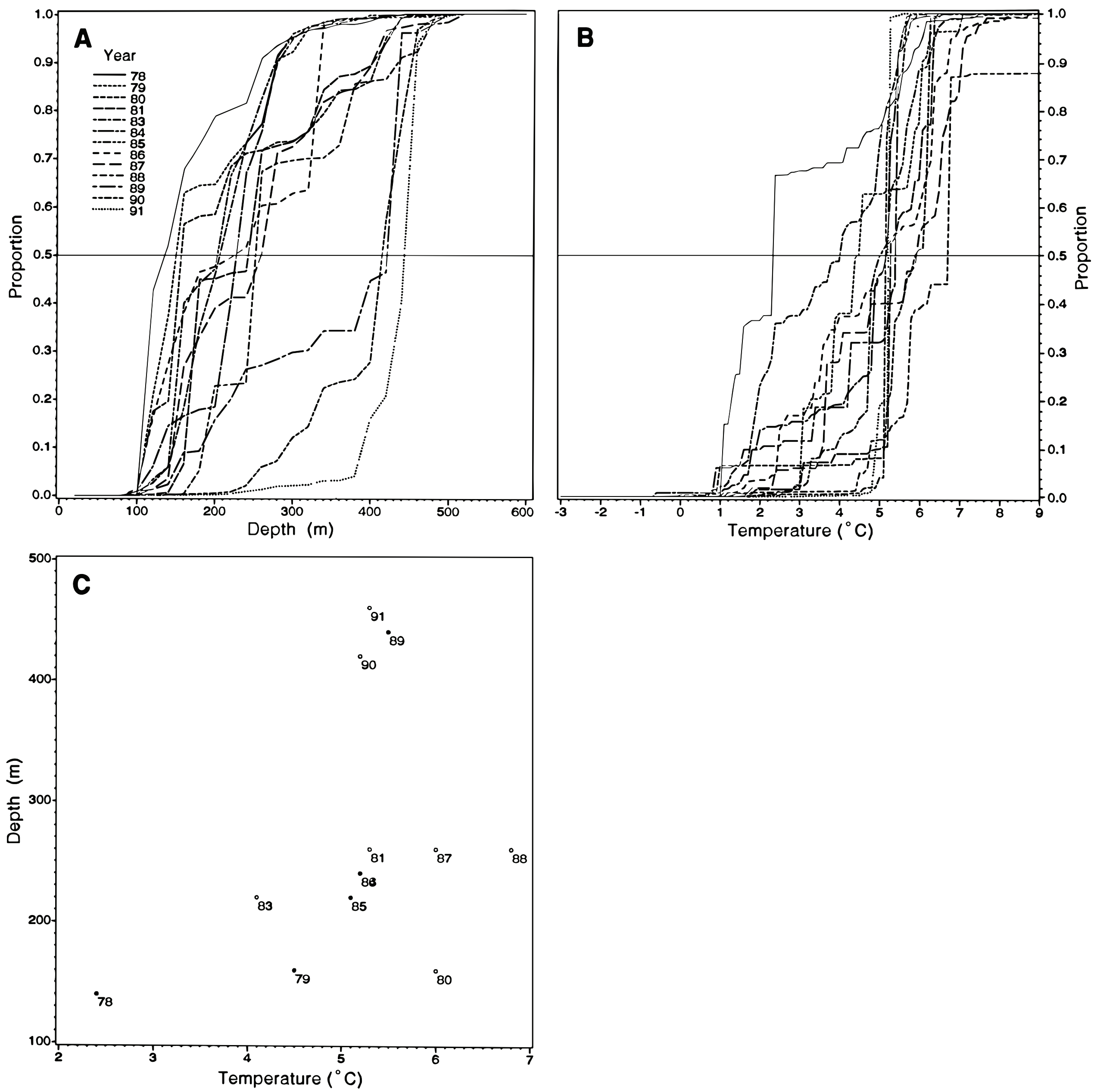

Fig. 6. Map of fishing intensity (number of sets) from the otter trawl commercial fishery in the period January to April, 1986-89.

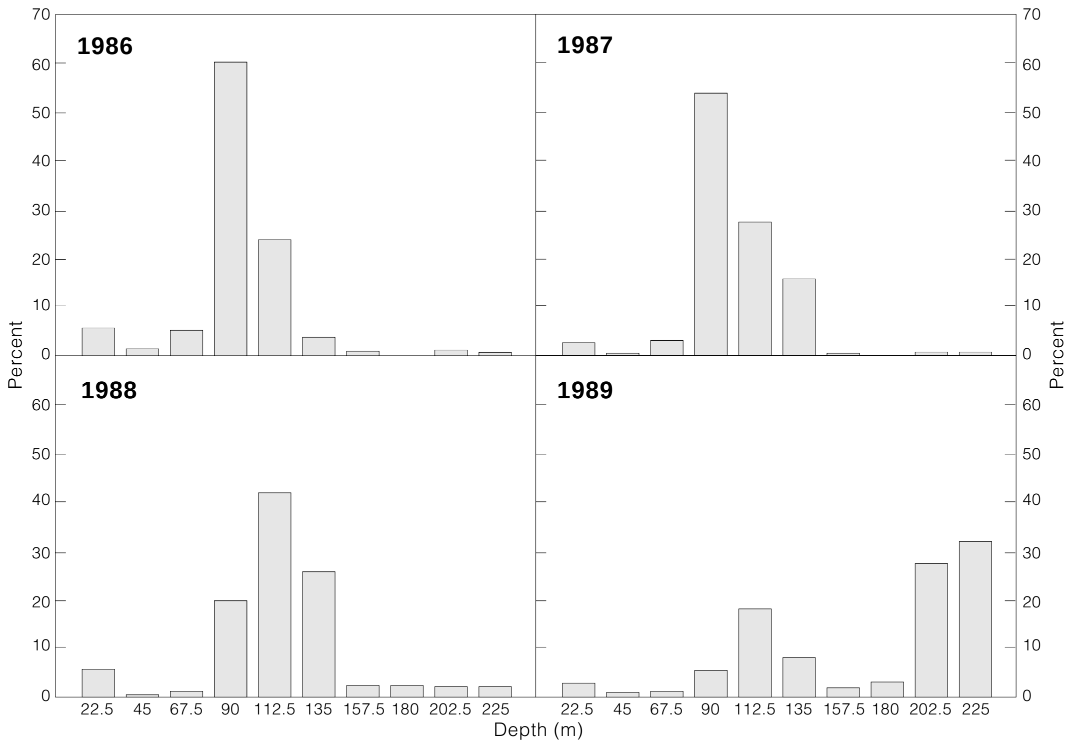

Fig. 7. Histogram of depth zones where otter trawl activity occurred in the period January to April 1986-89.

moved its fishery to deeper waters (Fig. 6 and 7). At one point the warps of these vessels were lengthened to allow this fleet to catch cod that was found at depths never fished before.

According to the partial recruitment values reported by Fréchet and Chouinard (MS 1987), an average fish caught by otter trawl was 9.7 years old while the longline fish averaged 10.6 years. This 1-year advantage for the otter trawl fleet, however, was not considered an important factor since there was little contrast between low and high incoming recruitment and pulses of recruitment were not common in this stock, as illustrated in Fig. 8. The exploitable biomass was very similar for both fleets in the last 4 years from the Sequential Population Analysis (SPA). The rapid decline of the fixed gear catches occurred during 1988 to 1991, while the SPA shows a stable exploitable biomass for both gear sectors.

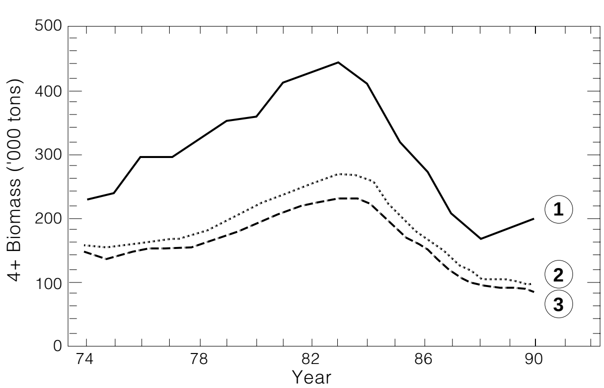

Fig. 8. Total age 4+ biomass of cod (**1**), exploitable age 4+ biomass of cod for otter trawlers (**2**) and exploitable age 4+ biomass of cod for longlines (**3**), according to the most recent assessment (Fréchet, 1991).

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