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Distribution and Abundance of Three Fish Species on the Grand Bank in Relation to Depth and Temperature of the Water

by

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Introduction

The uneven and changing distribution of fish is reflected in the fishing patterns of the commercial fleets. Best concentrations are found not at random but at locations which change in a regular pattern depending upon the season. Factors influencing the size and location of such concentrations in the Northwest Atlantic were examined in ICNAF at a symposium in 1965. The distribution and abundance of cod, American plaice, and yellowtail flounder on the Grand Bank in spring are examined here in relation to depth and bottom temperature.

Materials and Methods

Observations of near bottom temperatures, depth of water, and size of catch by species have been made during the random-stratified surveys conducted by Canada on the Grand Bank since 1971. A series of surveys has been conducted in the spring in Div. 3L, 3N, and 3O to depths of 200 fath and extending to within 12 miles of the coast (Fig. 1). In some years coverage has been far from complete because of restrictions in the vessel time available, mechanical problems in the ship or gear, or weather (including ice) difficulties. No survey at all was done in 1983.

The Grand Bank extends over 200 miles from the coast and includes water shallower than 50 m. Beyond the edge of the continental shelf, water extends to great depths. Surveys have generally been limited to a depth of about 400 m. The area involved is about 71,000 square nautical miles (Table 1).

Otter trawl tows have been of 30 minute duration with a codend lined with small mesh. Bottom temperatures are recorded usually at the end of the fishing set but sometimes at a position near the mid-point of the tow. The sounder depth is recorded as part of the oceanographic record.

Results and Discussion

A. Bottom temperatures

Bottom temperatures over the Bank in the spring are usually not greater than 1° or 2°C. From isotherms constructed by eye for each cruise (see Fig. 2 for legend), the average temperature regime consists of water of negative temperatures along the west slope (Avalon Channel) and north and east slopes of the Bank south to about 45°N (Fig. 2). In a cold year, temperatures <0°C may practically surround the Bank (Fig. 3) and a substantial area in the north is covered with water of temperatures of <-1°C. In a warm year, there may be no temperatures of less than -1°C and negative temperatures only along the Avalon Channel (Fig. 4).

With respect to bottom temperatures, the cold intermediate layer of water arriving from the north may thus run almost entirely in the Avalon Channel in warm years, or be split at about the 100 m depth level in intermediate years. In cold years the cold (negative temperature) water may be present up to as shoal as about the 70 m level on the top of the Bank.

Based on the southern extent of the cold (negative temperature) water and the extent of the warm (greater than 1°C) water, an arbitrary scale was set up as follows to describe the bottom temperature regime as a whole:

1. Quite warm. Temperatures less than 0°C are confined mainly to the Avalon Channel. There are no temperatures less than -1°C.

2. Warm. Temperatures less than 0°C are found in the Avalon Channel and along the northeast slope to approximately the 100 m contour south to about 45°N. Few or no temperatures are present less than -1°C.

3. Average. Temperatures less than 0°C extend south of the 100 m contour and south of 45°N. Few or no temperatures are present less than -1°C.

4. Cool. Temperatures less than -1°C are prevalent in the Avalon Channel. Temperatures less than 0°C extend south of 45°N.

5. Cold. Temperatures less than -1°C are prevalent in the Avalon Channel and along the northeast slope. The area occupied by temperatures greater than 1°C is quite restricted.

In this rough scheme, the years 1971-88 may be classified on the basis of bottom temperatures in the spring as:

1. Quite warm	1978
2. Warm	1976, 1979, 1981
3. Average	1971, 1975, 1977, 1980, 1982, 1987
4. Cool	1984, 1988
5. Cold	1972, 1973, 1974, 1985, 1986

B. Distribution of fish in the spring, 1971-88

The distribution of fish is indicated by symbols representing the weight of the catch per 30 minute tow (Table 2).

Yellowtail flounder are rarely taken north of 47°N, although a few good catches were taken in 1971 just north of that latitude. Further, most catches are taken in depths less than 100 m (Fig. 5). Within this depth zone there is usually no very cold water (<-1°C) and when there is, yellowtail are not abundant. Within the range 0° to -1°C, catches are generally small but in some years (e.g. 1986) there may be some good catches (Fig. 6). Catches are generally good within temperatures greater than 1°C. In summary, yellowtail were usually found within positive temperatures and the best catches were taken south of about 45°N.

American plaice catches were small in water of temperature greater than 1°C (Fig. 7) although some good catches were taken in 1978 and 1981 in such water (Fig. 8). Catches were generally small at bottom temperatures in the 0 to 1°C range and most good catches in this temperature range were taken in the northern part of the area. The best concentrations of American plaice were taken in the ranges 0 to -1°C and even lower than -1°C. In summary, American plaice were most abundant in water of temperature less than 0°C. The best concentrations were usually found north of about 46°N although in some years the distribution of good catches was more evenly spread over the whole bank (Fig. 9).

Cod catches were generally small in water of temperature less than -1°C but occasional good catches were taken (Fig. 10). Catches were often good in the temperature range 0° to -1°C range and usually good in temperatures over 0°C. Concentrations may usually be found off Cape Bonavista and along the north east slope of the Grand Bank. Good catches were sometimes taken off the Avalon Peninsula (Fig. 44) and at about 46°N in the region of the Virgin Rocks. In some years good catches are quite widespread over the Bank (Fig. 11).

From these spring surveys it might be concluded that yellowtail flounder are found in shallow and warm (<0°C) water usually in the southern portion of the Bank. American plaice are spread over a much wider area but are more concentrated in the northern part of the Bank, including the slopes, and in cool or cold water (0° to -1°C and even lower). Cod are taken within a wider depth and temperature range than American plaice but are less tolerant of water less than -1°C.

C. Seasonal variation in temperatures and fish distribution in Division 3L

Additional surveys were conducted in Div. 3L in 1985-86 to provide an indication of the seasonal variation in environmental conditions and fish distribution. Because cod are known to undergo extensive seasonal migrations in the Newfoundland area, this species was chosen here to examine differences in seasonal distribution by depth and temperature in the 1985-86 surveys.

In the winter and spring cruises in 1985 (Fig. 12, 13), the bottom temperature regimes were similar. The 0° isotherms followed the slope at about the 200 m level. There was no >0°C water in the shoaler areas where most of the bottom temperatures were less than -1°C. An exception was the presence of some temperatures greater than 0 in the south of the area at about 46°N in spring 1985.

In summer and fall 1985 (Fig. 14, 15) the bottom temperature regimes were similar. In contrast to the previous winter and spring, the area of water with bottom temperatures greater than 0°C was much larger and the area of water with temperatures less than -1°C on the northeast slope was decreasing.

The temperature pattern in winter 1986 was not much different from that in the previous winter. In spring 1986 there were still no temperatures >0°C but the extent of the cold (<-1°C) water was lessened.

The distribution of cod in 1985-86 shows the best concentrations in winter to be along the slopes usually at temperatures greater than 0°C. In 1986, there were also good catches at about the 100 m level around the Virgin Rocks area in temperatures less than 0°C and also at temperatures less than -1°C. In spring 1985 there were good catches along the northeast slope and also in the Virgin Rocks area where the temperatures were close to -1°C. By summer 1985, the best catches were in the Virgin Rocks area at temperatures closer to 0°C. In the fall of 1985, concentrations still existed in the Virgin Rocks area but a concentration had formed at the northern slope off Cape Bonavista in water of about 1°C. This concentration off Cape Bonavista expanded along the northeast slope in winter 1986 at about 1°C. In spring 1986 this concentration had been reduced to occupy a much smaller area. No concentrations were found in spring 1986 in the Virgin Rocks area.

In summary, concentrations of cod in winter in Div. 3L occupy mainly the warm (+) water on the northeast slope. There was a concentration of cod in the Virgin Rocks area in cold (-) water in spring 1985 but not in spring 1986. Concentrations of cod in spring in both years were still to be found on the northeast slope. In summer 1986 there was a concentration in the Virgin Rocks area but not on the slope while in fall 1985, in addition to the Virgin Rocks concentration, cod had begun to concentrate on the slope as well.

D. Average catch per tow in relation to depth and temperature groupings

Catch per tow of yellowtail flounder in Div. 3LNO were averaged in intervals of one-half degree temperature and 5 m depth for the years 1971-87. Except for the years 1971-73, practically all yellowtail flounder catches were at depths less than 86 m and temperatures greater than 0°C (Fig. 16).

Catch per tow of American plaice in Div. 3L, 3N, and 30 were averaged in intervals of one-half degree temperature and 25 m depth. Because of incomplete coverage in the early years, only the period 1977-87 is considered here. In Div. 30, catches were taken usually in depths less than 150 m. Catches were usually small and the best catches were taken in temperatures less than 2°C (Fig. 17). Catches in deep and warm water were invariably zero. In Div. 3N catches were generally small but good catches were taken in depths from 50 to 150 m (occasionally to 200 m) and temperatures less than 2°C (Fig. 18). The wide variation in temperature at the 76-100 m interval is due to the different temperature regimes at the northern (low temperatures) and southern (high temperatures) portions of the Bank. Superimposed on this pattern is a pattern showing the change from shallow cool or cold water to warm and deep water.

In Div. 3L best catches of A. plaice were taken in the range 0.5 to -1.5°C in depths from 50 to 200 m (Fig. 19).

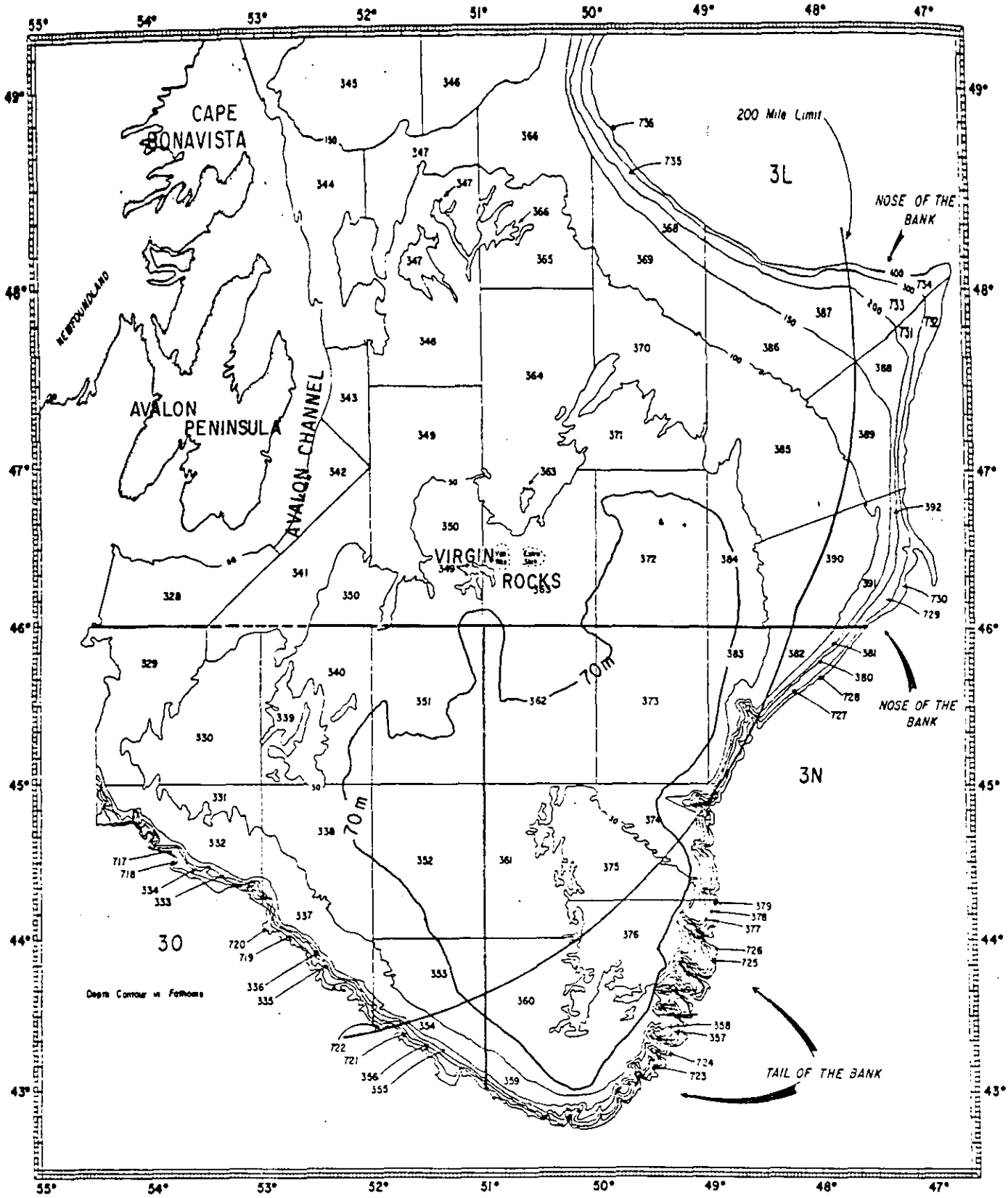
Catches per tow of cod were averaged in a manner similar to that for American plaice. Only the years 1977-87 are considered here since previous years had incomplete coverage by Division. In Div. 30 cod were taken usually in depths of 100 m or less but occasionally good catches were taken as deep as 125 m. Most good catches were taken in the temperature range 0-3°C (Fig. 20). In Div. 3N catches were generally small but best catches were generally at 100 m or less and temperatures from 0 to 3°C. There were, however, a number of good catches at depths from 200 to 350 m (Fig. 21). In Div. 3L best catches were taken at depths from 100 to 350 m and temperatures from -0.5 to 3.0°C (Fig. 22).

Table 1. Area (sq. n. mi.) of the Grand Bank from the contour 12 miles from the coast to the 200 fath. contour.

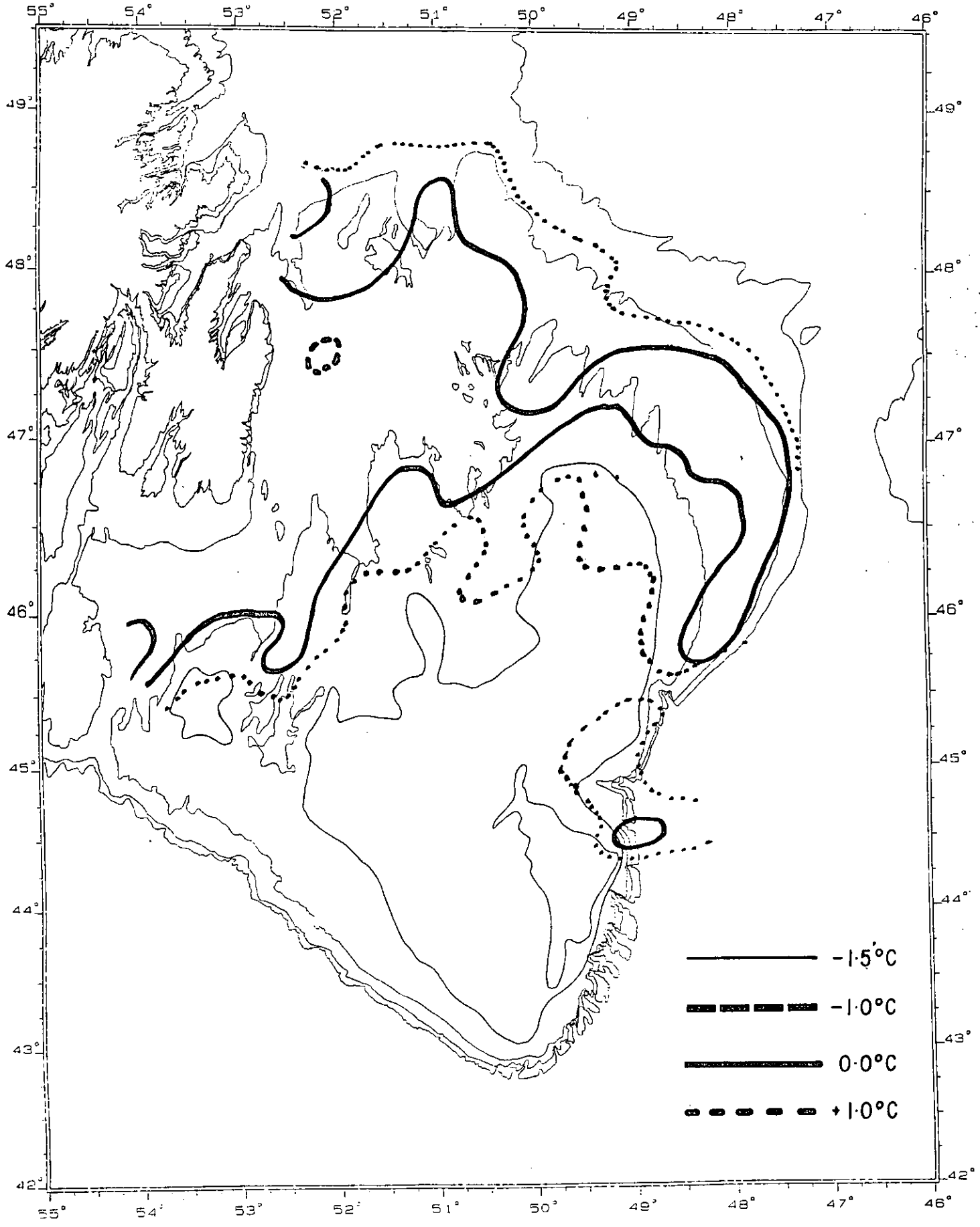
NAFO Div.	Depth range (fm) <30	31-50	51-100	101-150	151-200	Total
3L	-	8552	17452	6918	3855	36777
3N	3092	11490	1168	546	386	16682
3O	-	12541	4775	375	211	17902
Total	3092	32583	23395	7839	4452	71361

Table 2. Size categories of catch per tow represented in the abundance figures by symbols whose areas correspond to the respective size categories.

Symbol size		Catch (kg) per tow
	1	0
	2	.01-63.00
	3	63.01-125.00
	4	125.01-250.00
	5	250.01-500.00
	6	500.01-1000.00
	7	>1000.00



Map of the Grand Bank (Div 3LNO) showing depth stratification (fm)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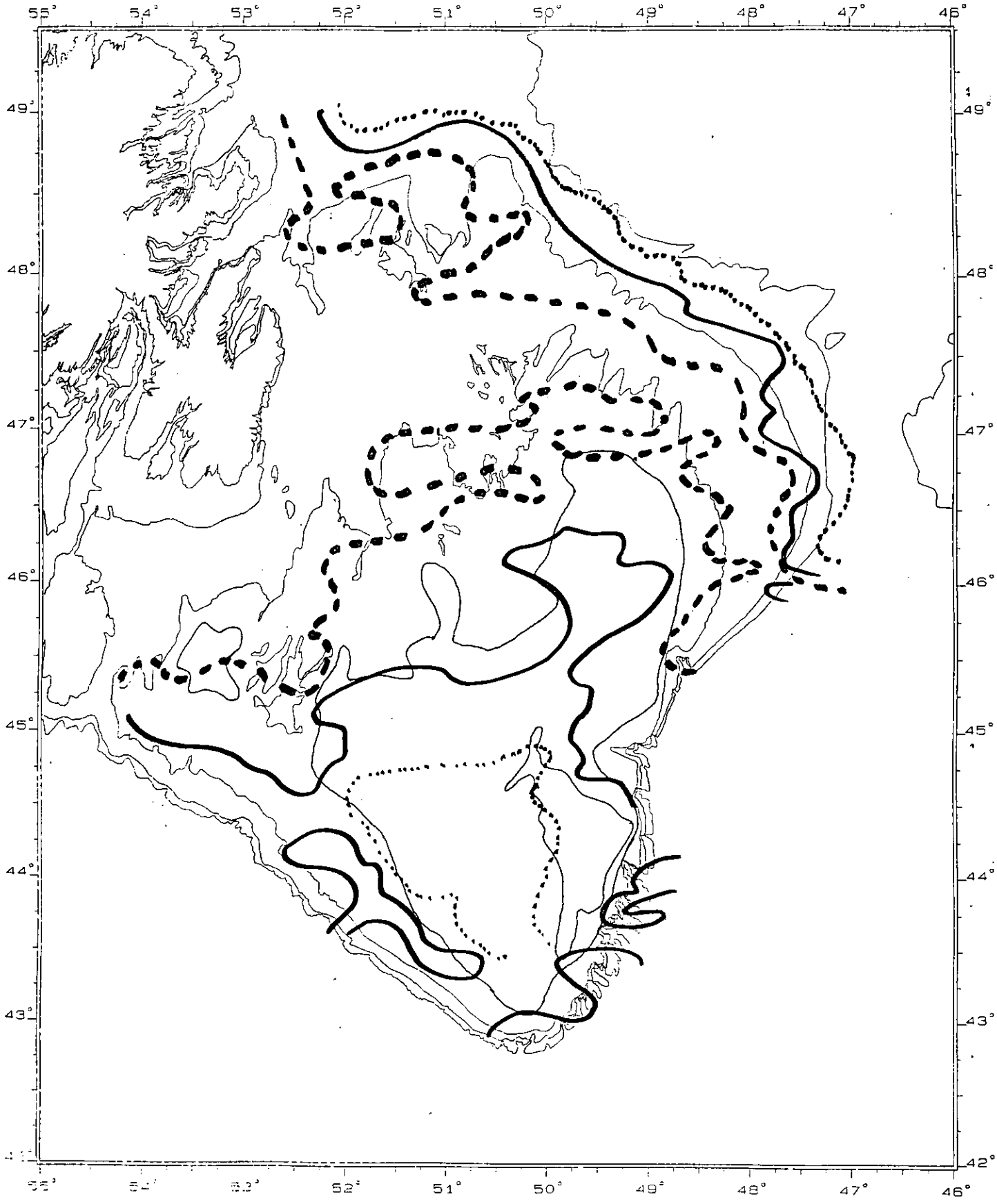


FIG. 3. Temperature regime on the Grand Bank in the spring of a typical year of lower than average bottom temperatures over most of the area

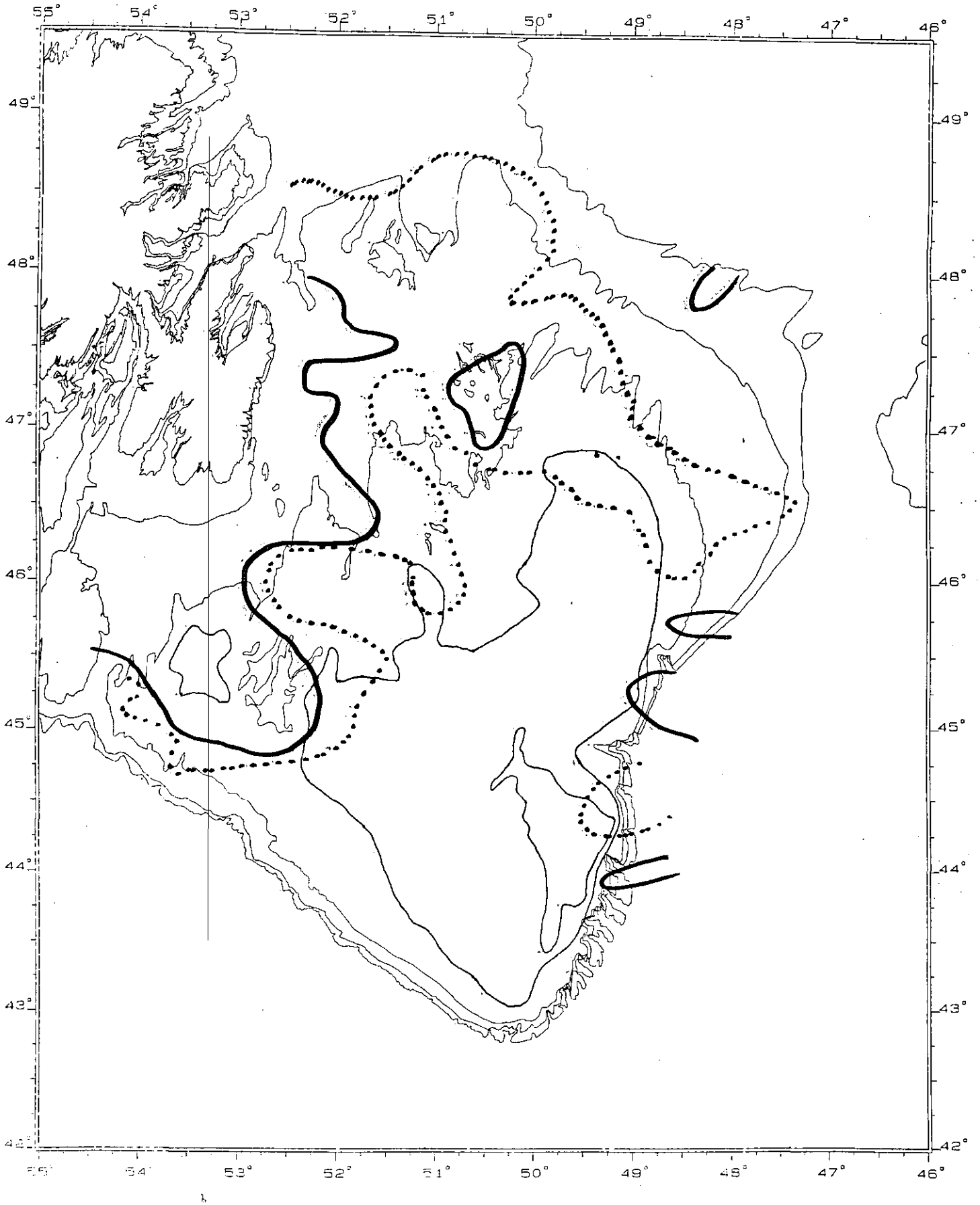


FIG. 4. Temperature regime on the Grand Bank in the spring of a typical year of higher than average bottom temperatures over most of the area.

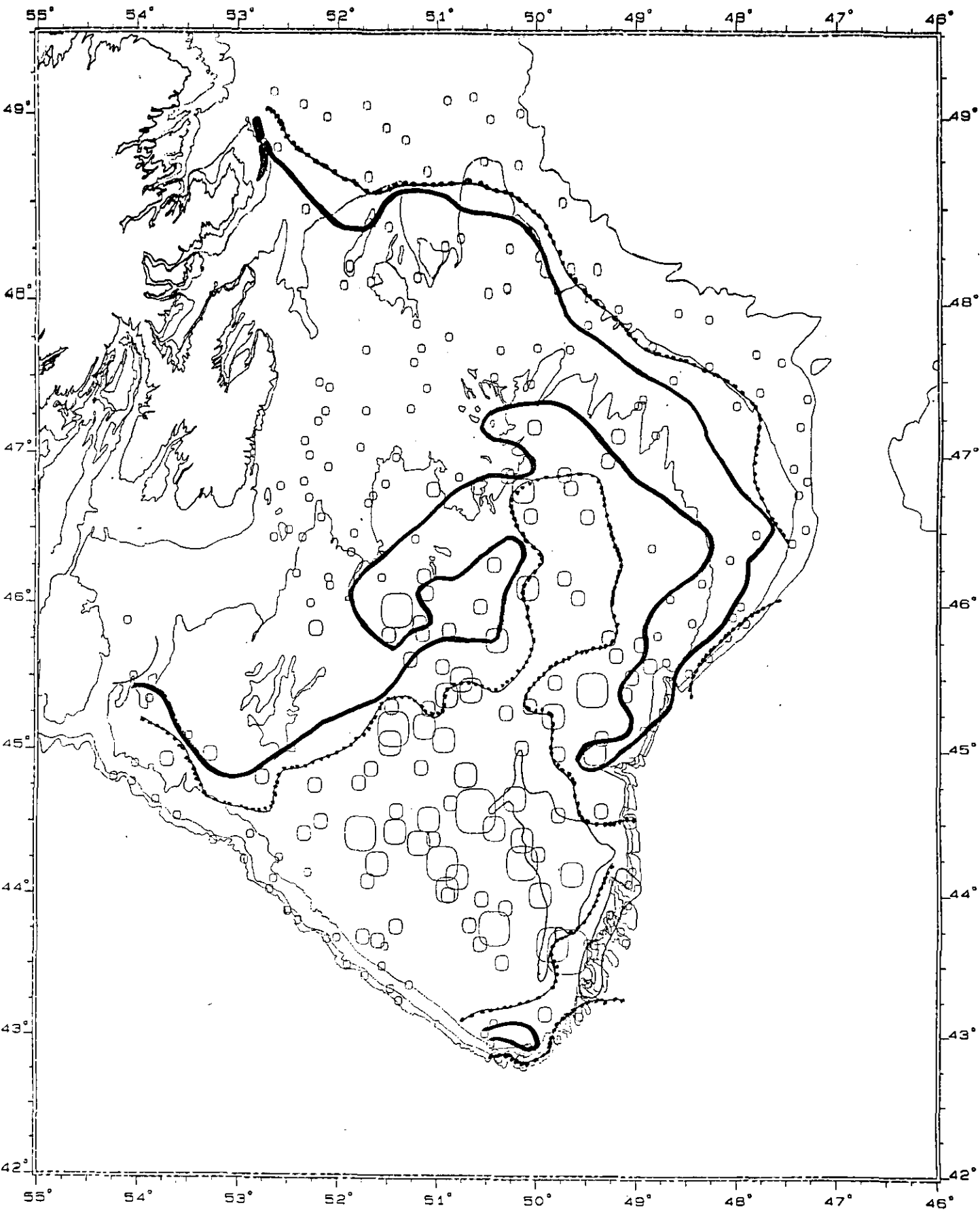


FIG. 5. Distribution of yellowtail flounder

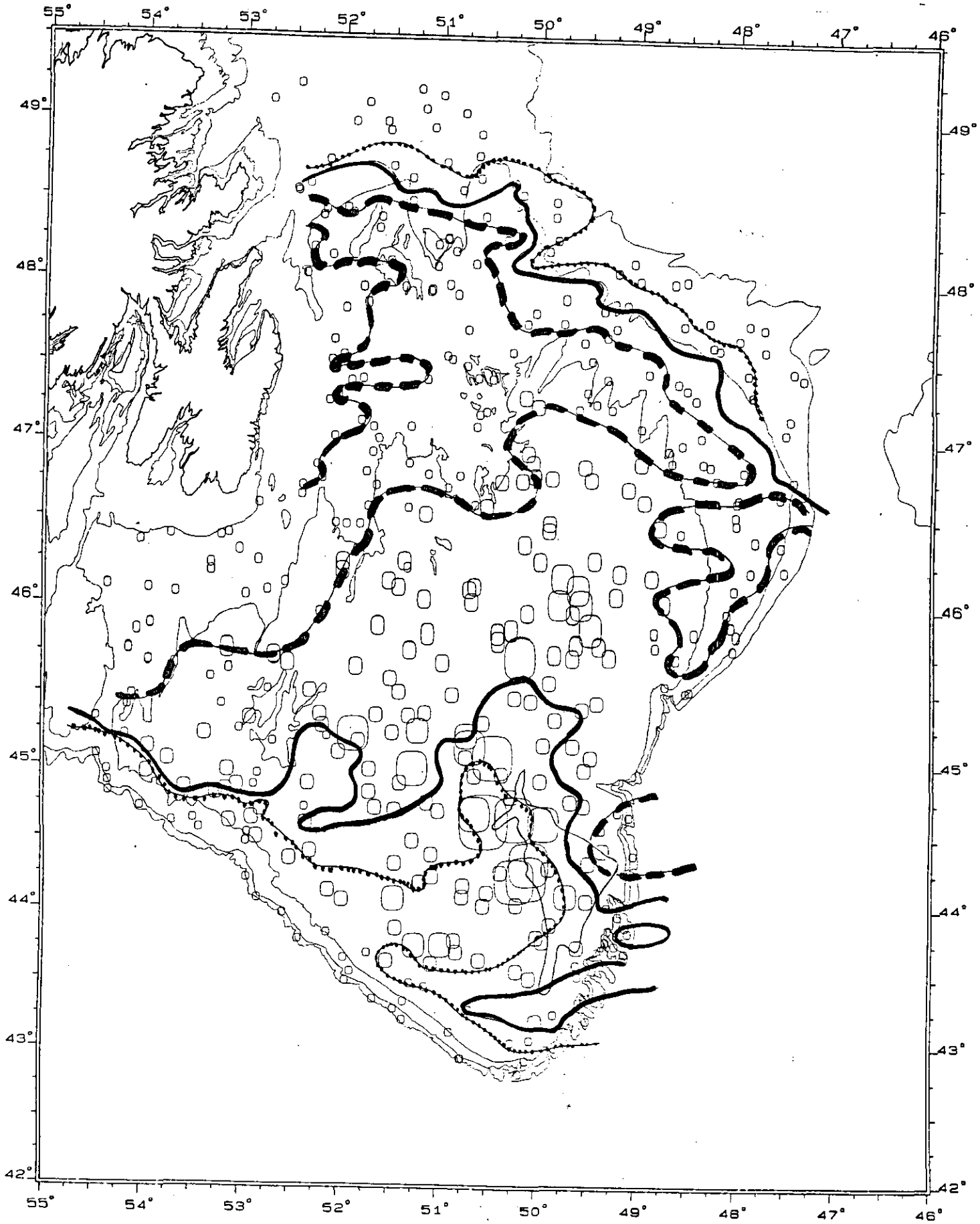


FIG. 6. Distribution of yellowtail flounder on the Grand Bank from the spring survey in 1986.

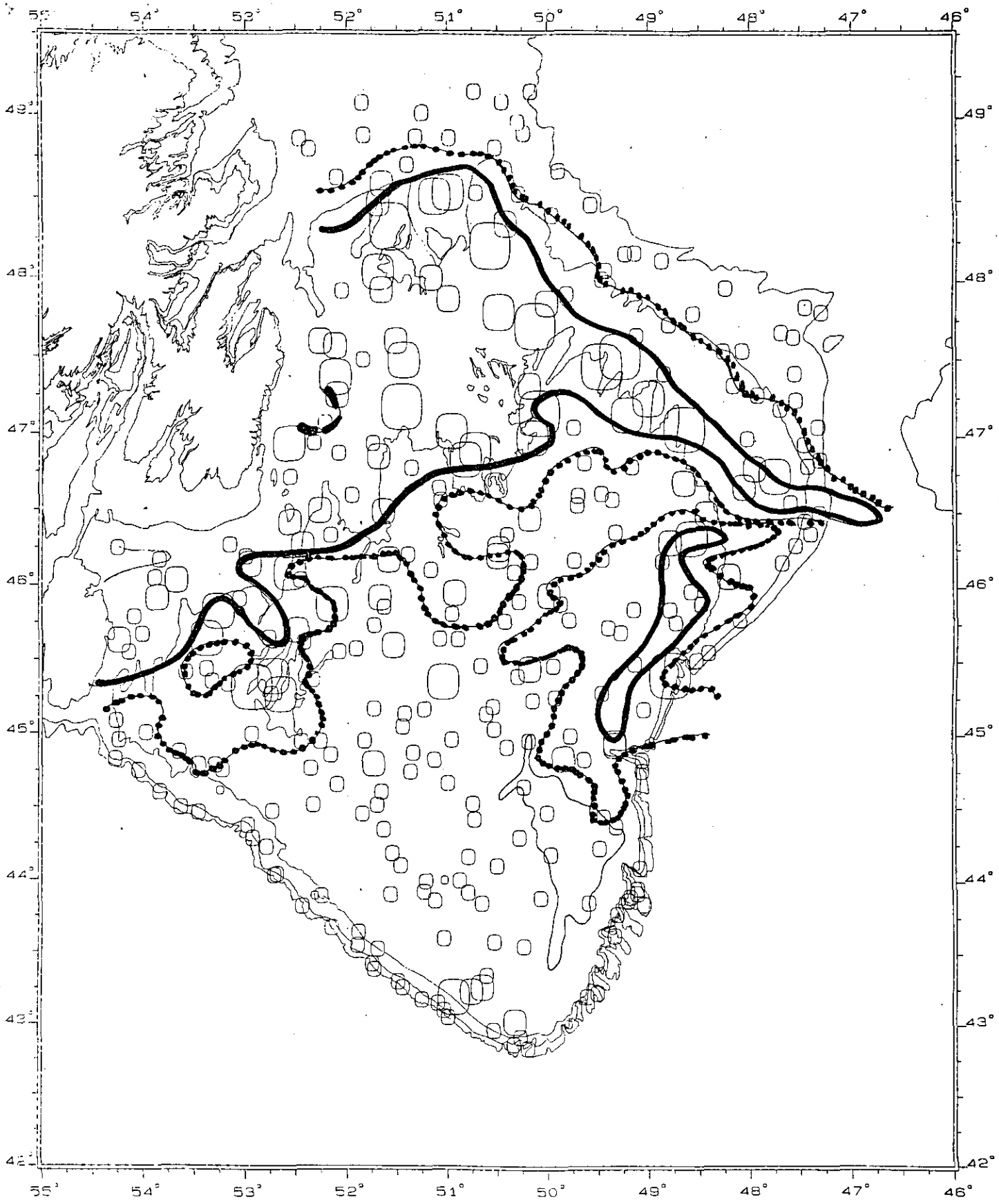


FIG. 7. Distribution of American plaice on the Grand Bank from the spring survey in 1979.

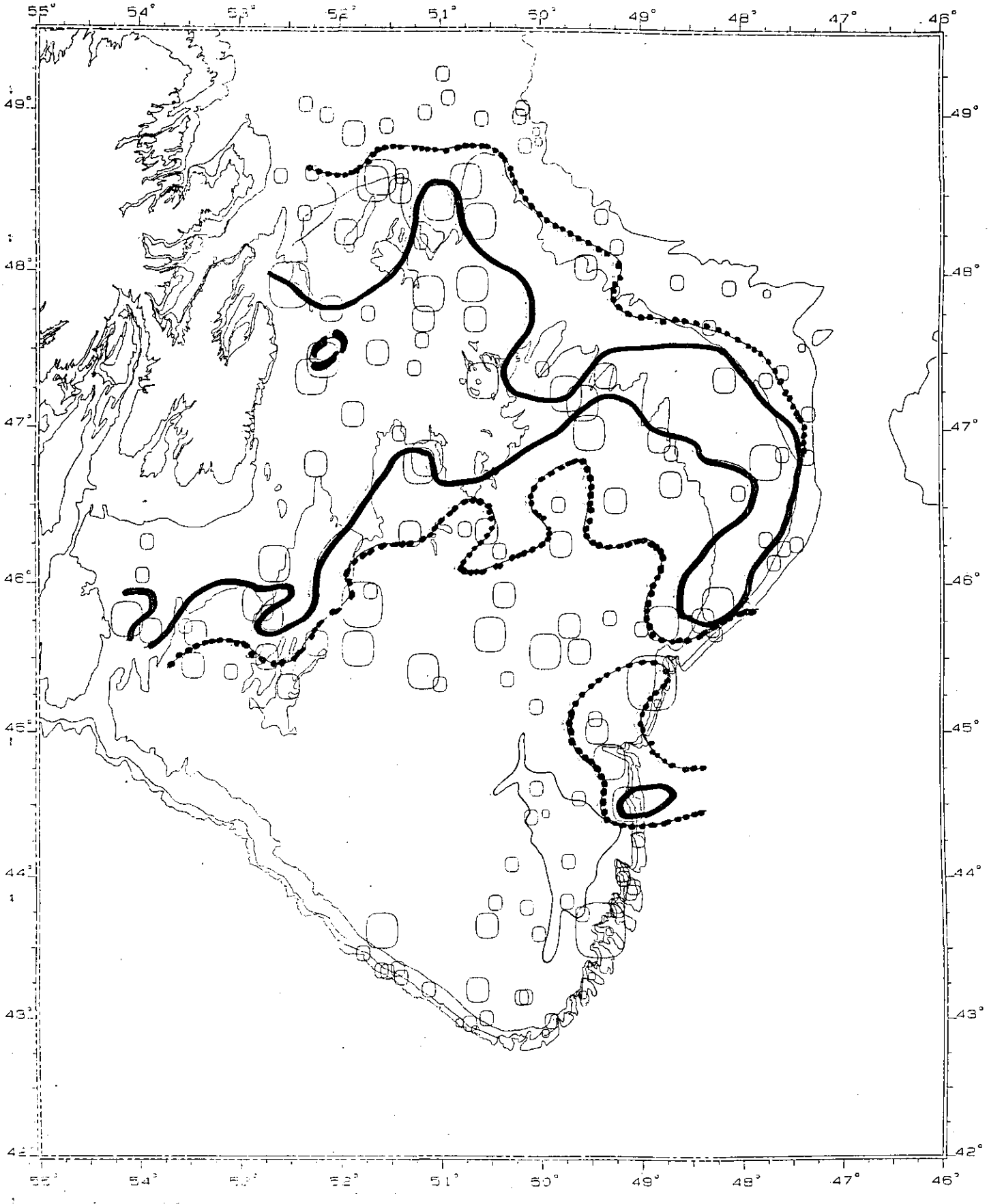
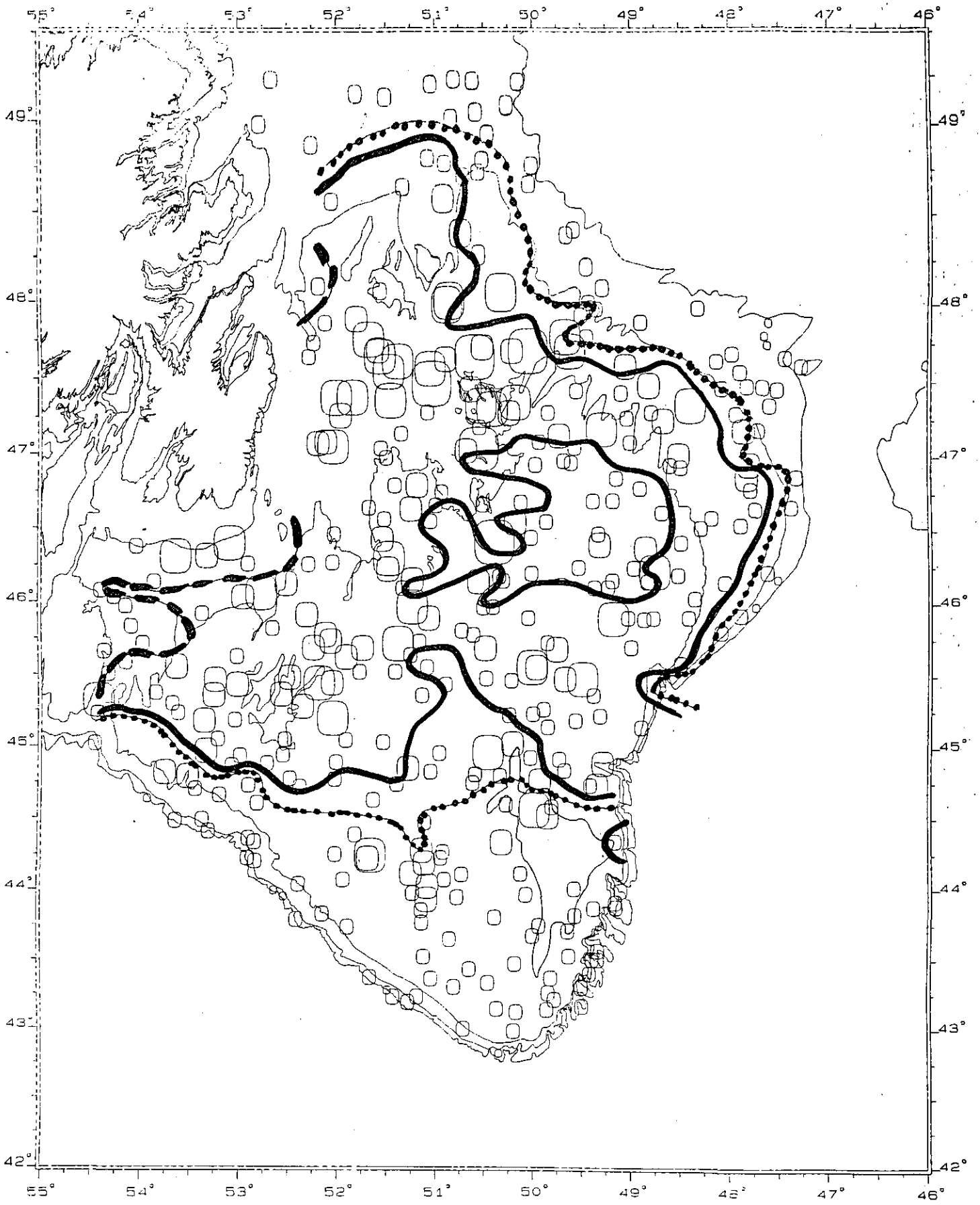


FIG. 8. Distribution of American plaice on the Grand Bank from the spring survey in 1981.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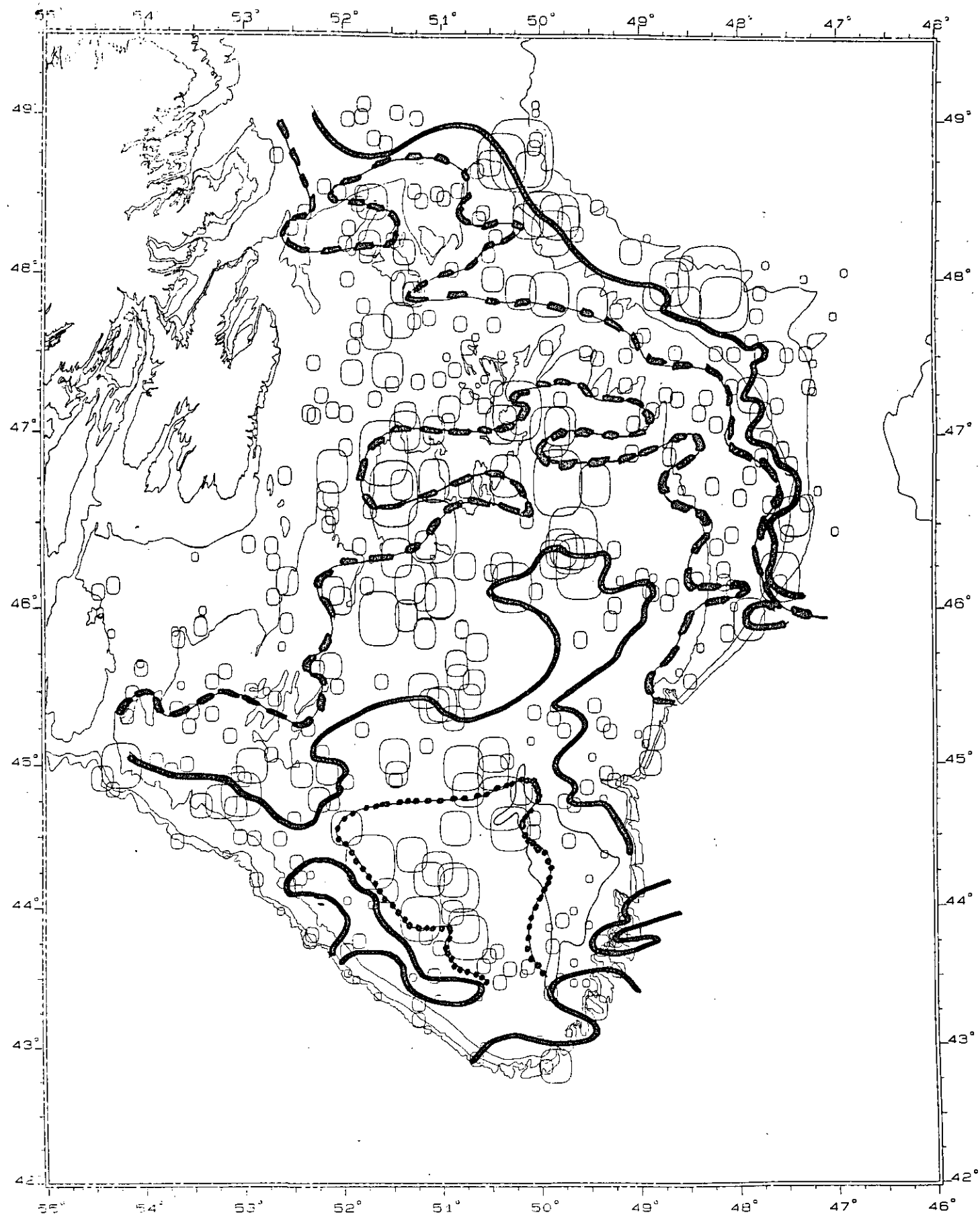
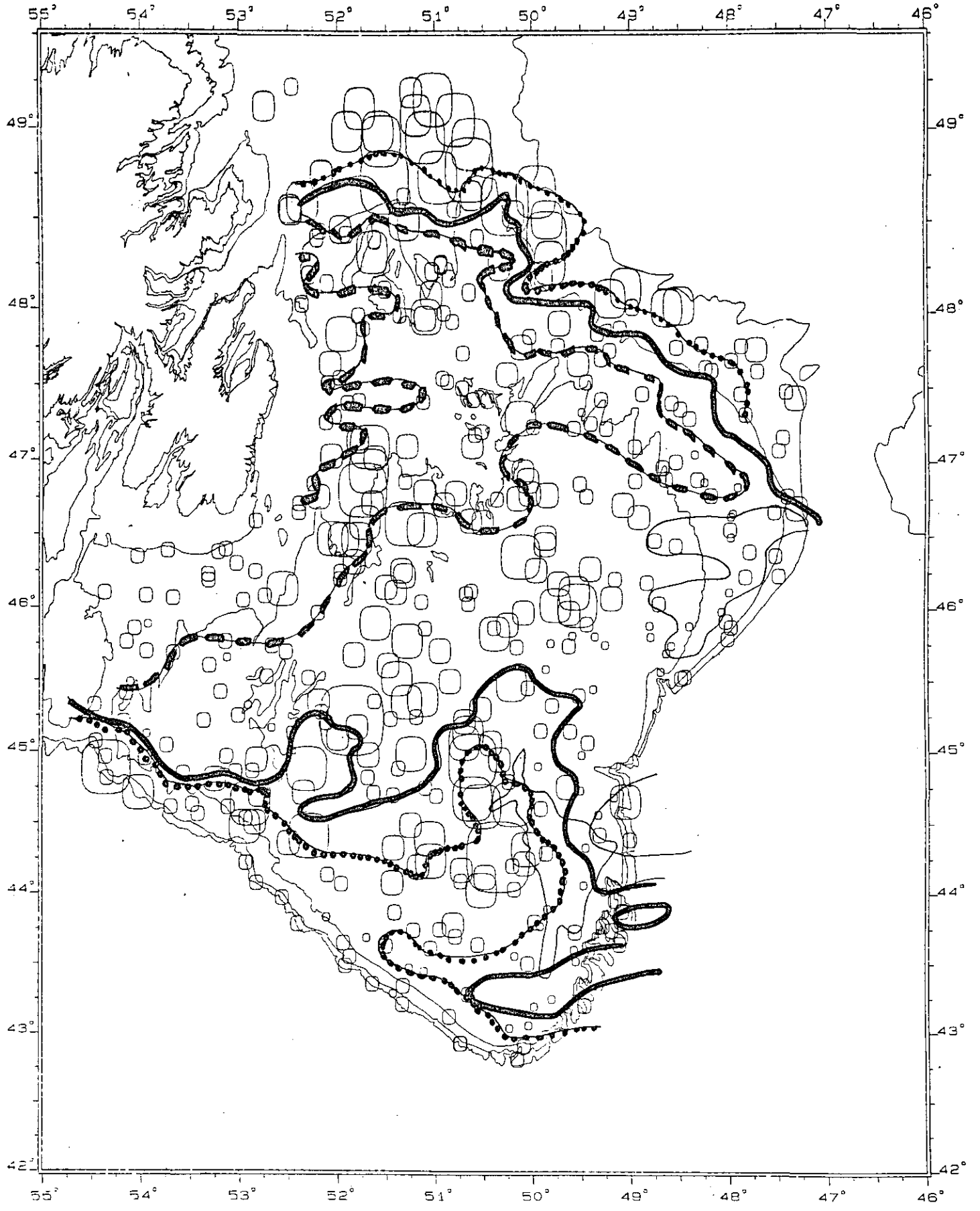


FIG. 10. Distribution of cod on the Grand Bank from the spring survey in 1985.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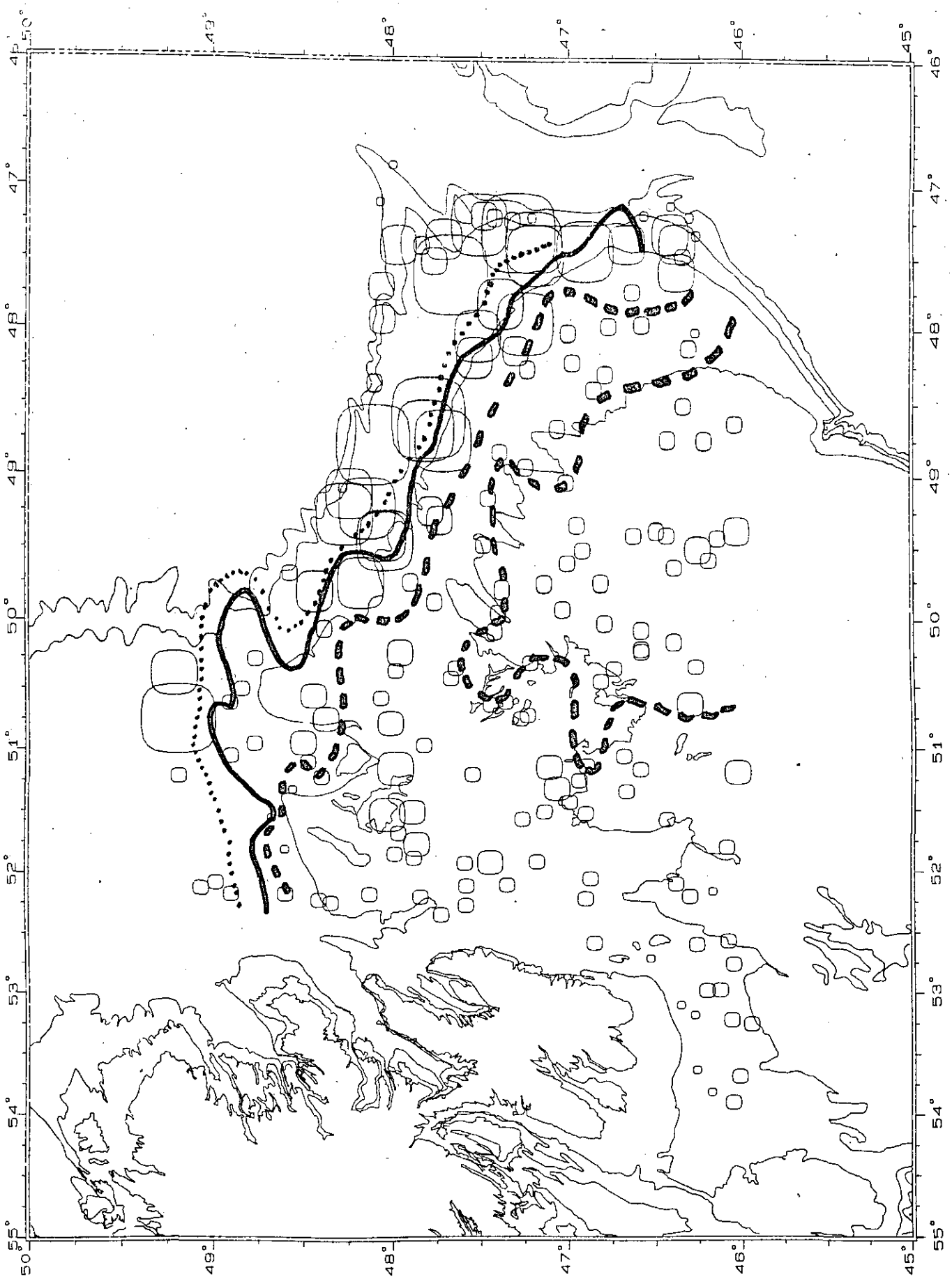

FIG. 12. Distribution of cod in Div. 3L from the winter survey in 1985.

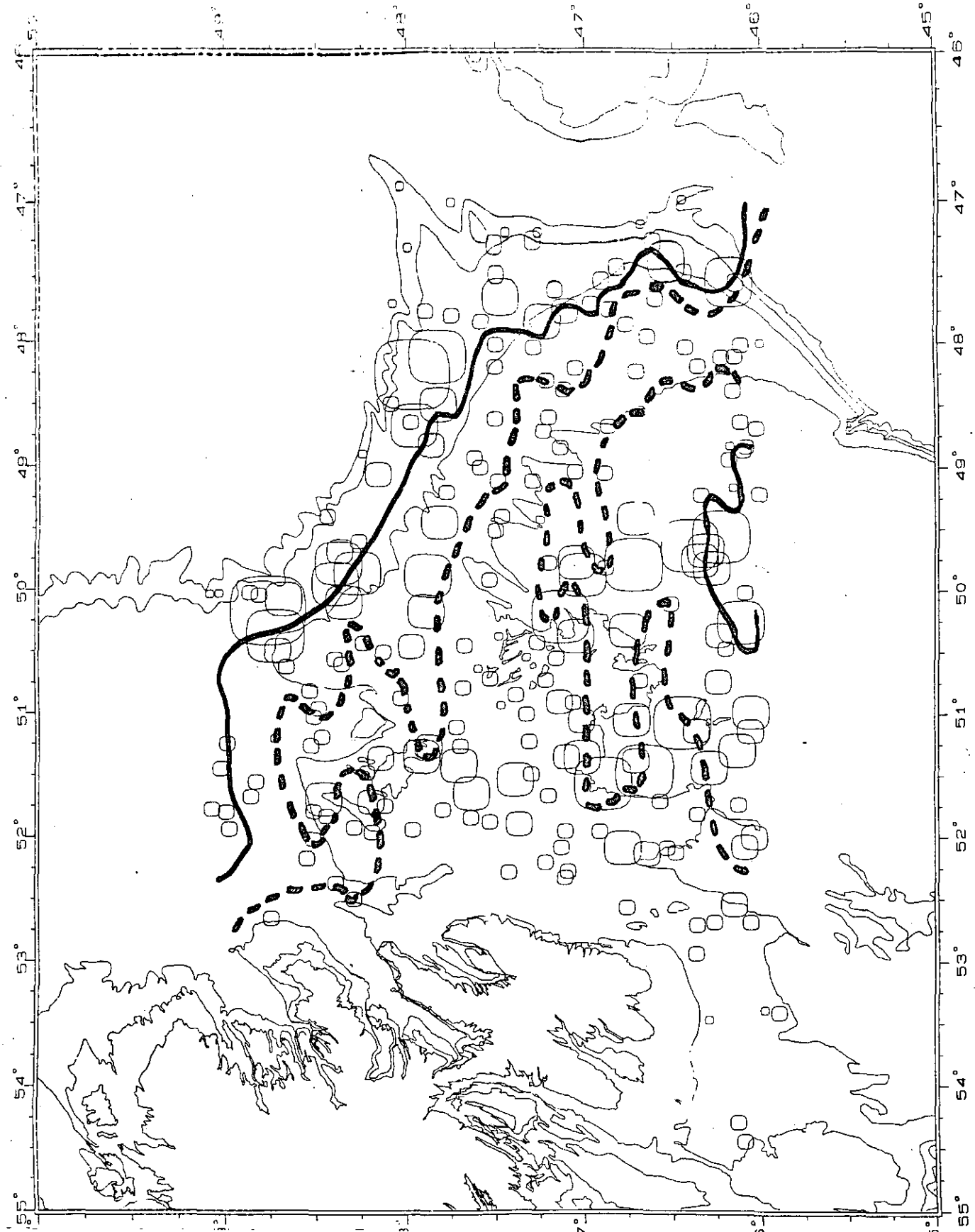

FIG. 13. Distribution of cod in Div. 3L from the spring survey in 1985.

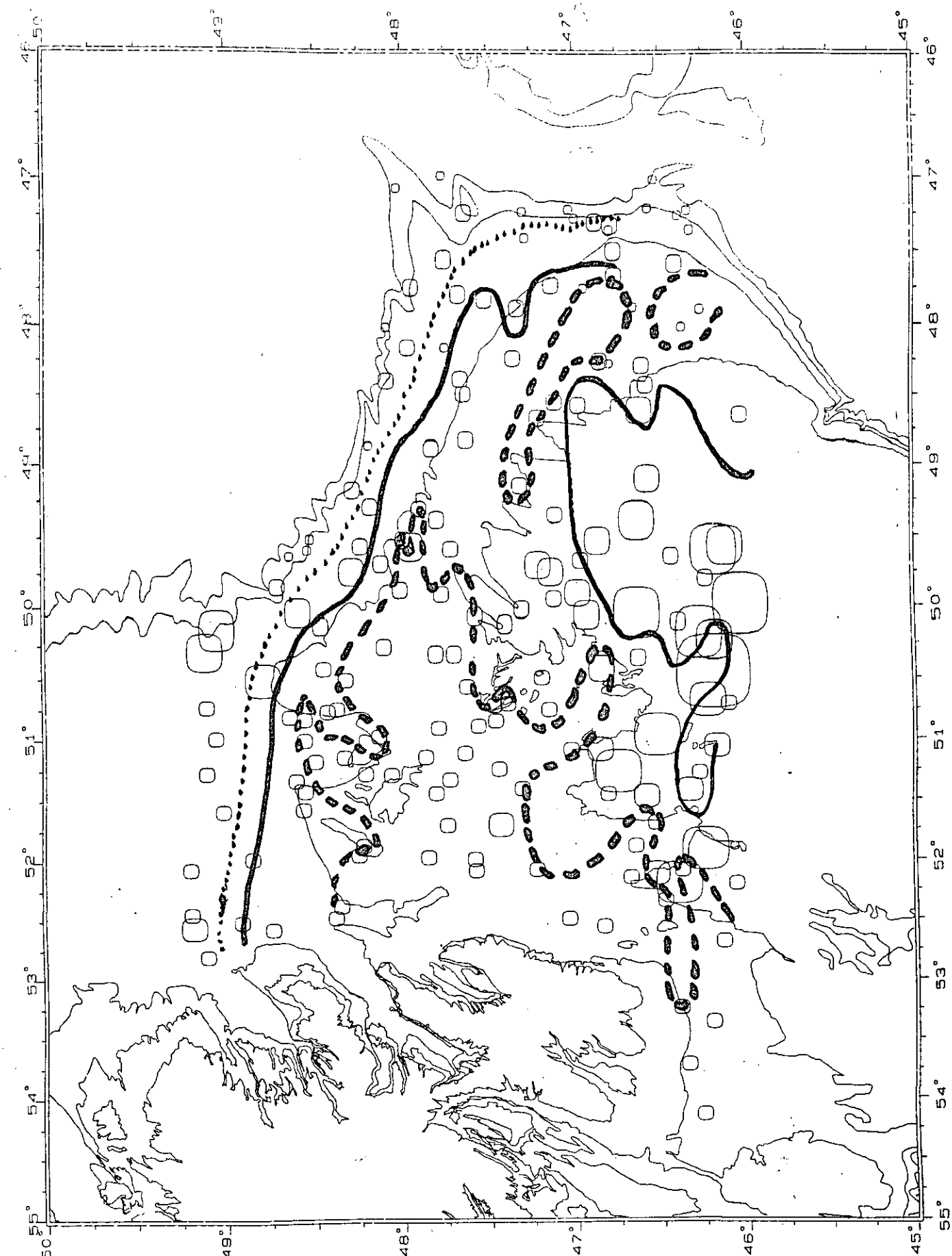

FIG. 14. Distribution of cod in Div. 3L from the summer survey in 1985.

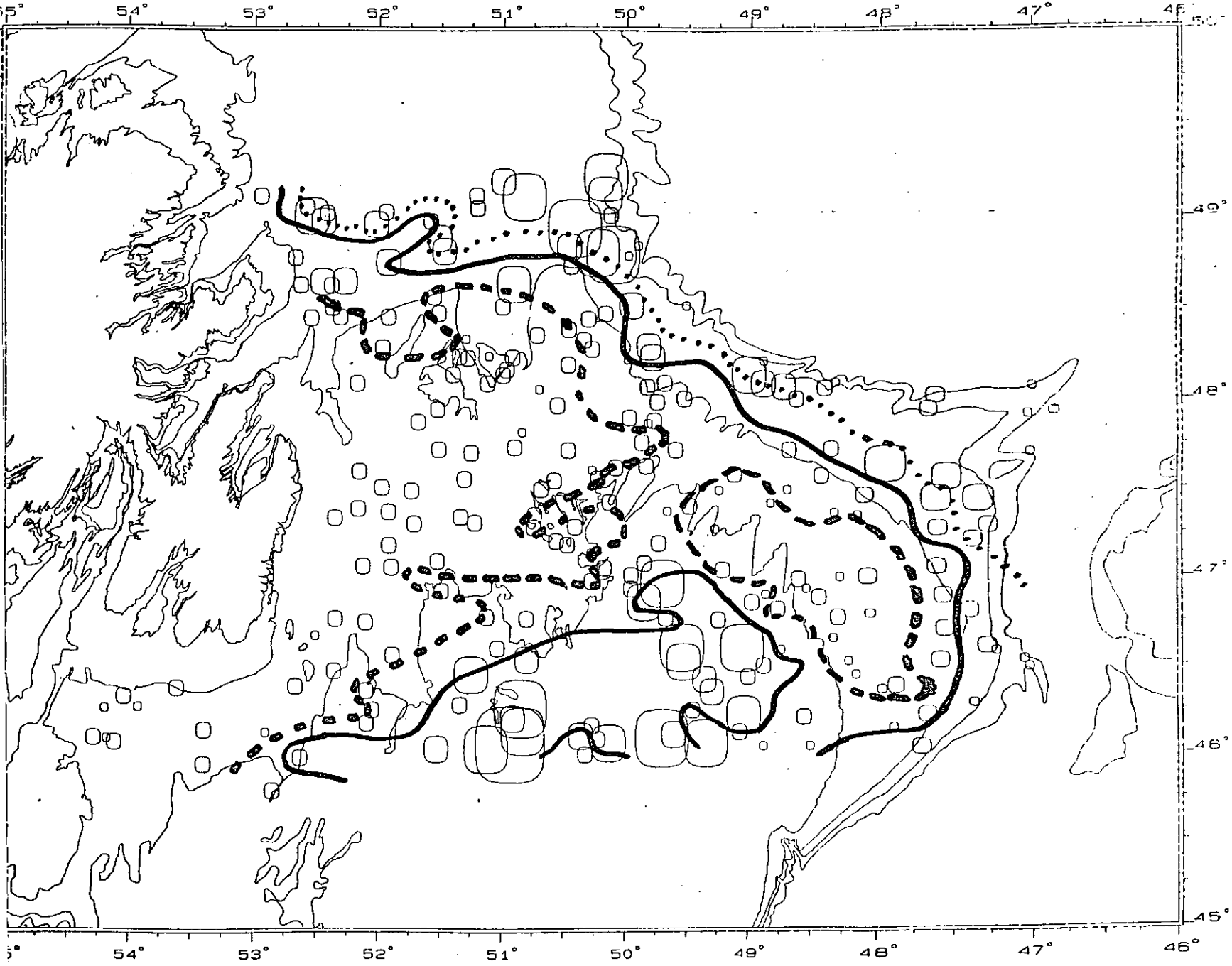

FIG. 15. Distribution of cod in Div. 3L from the fall survey in 1985.

Avg. catches(kg/tow) of yellowtail by depth and temperature.

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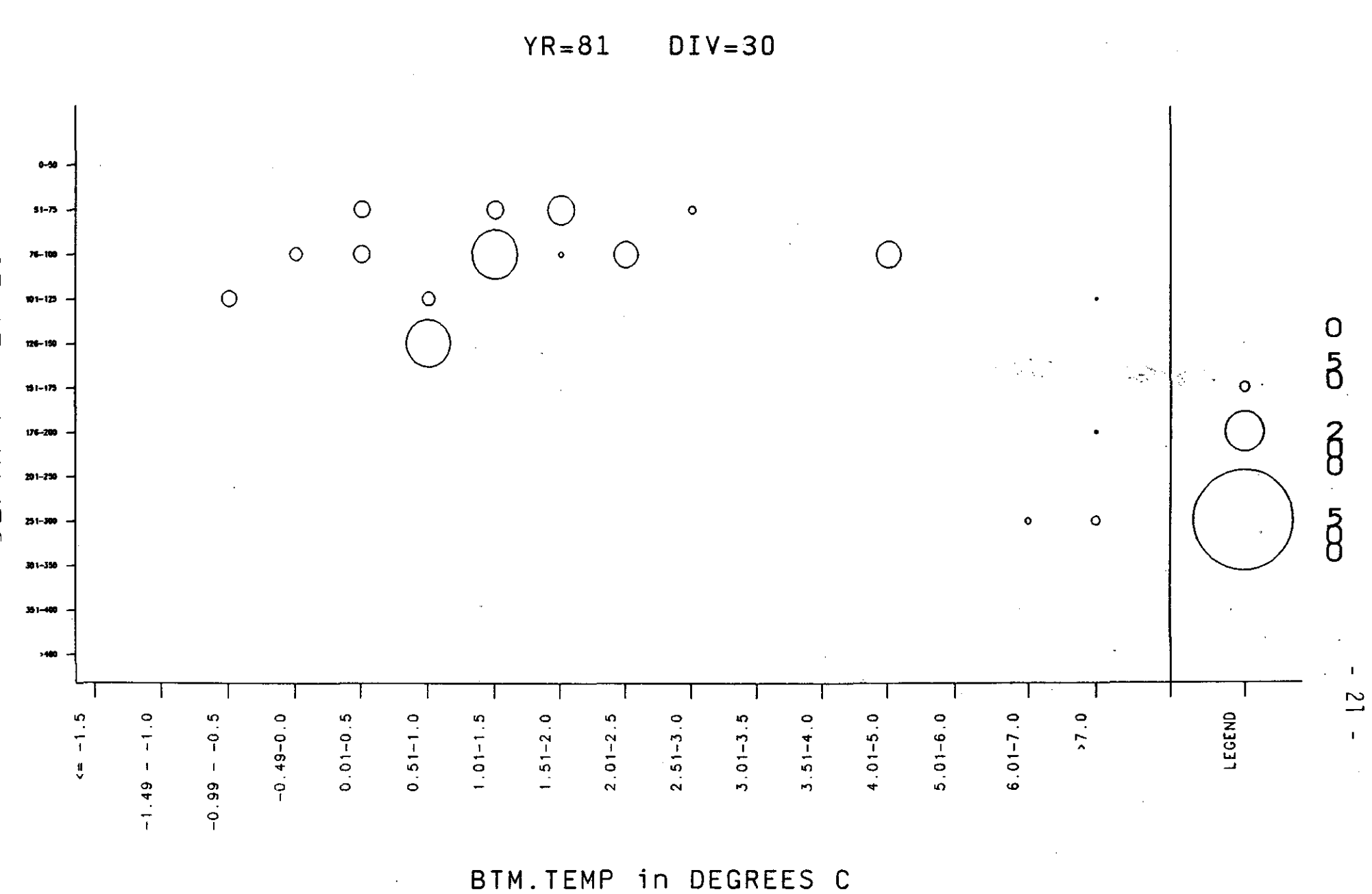
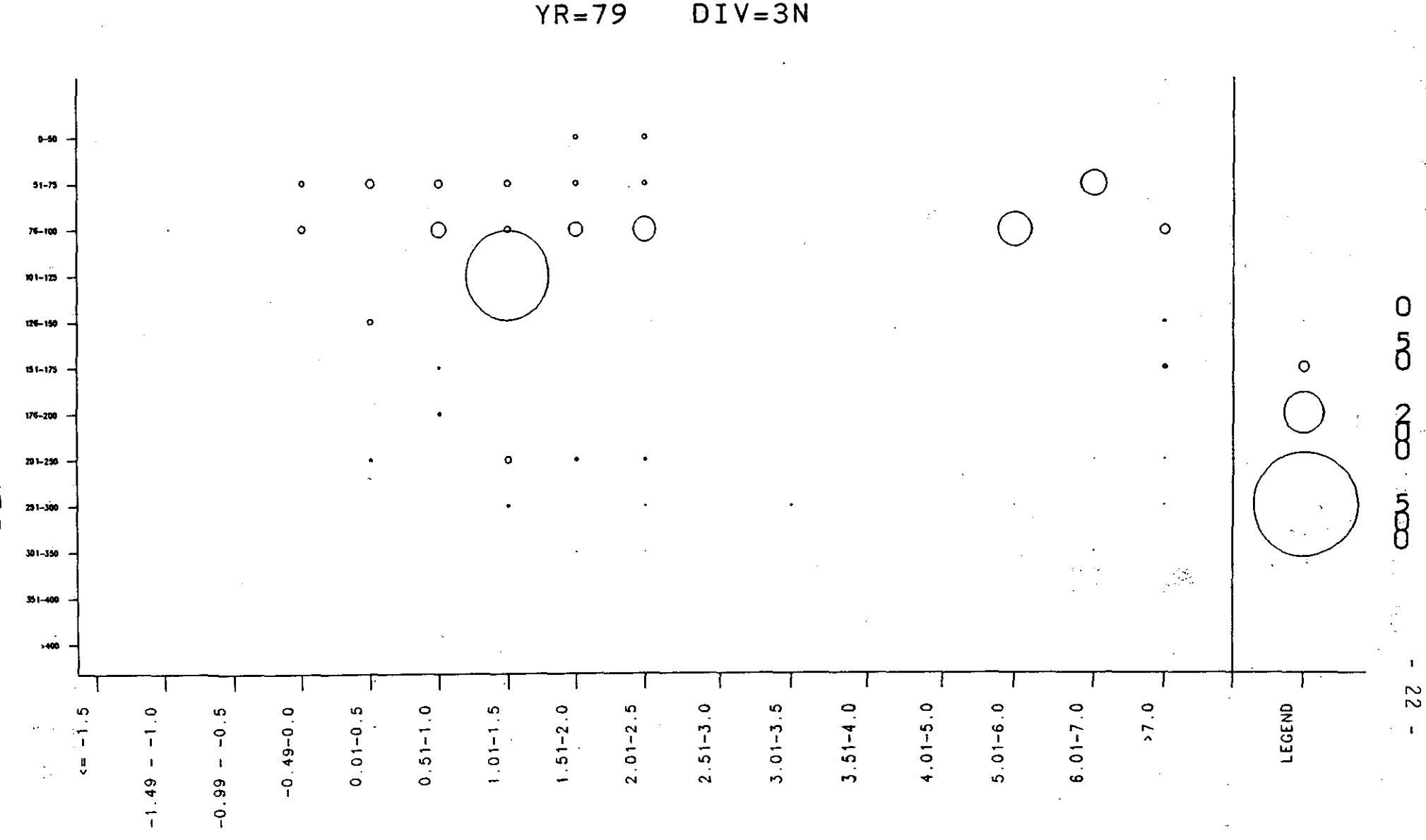
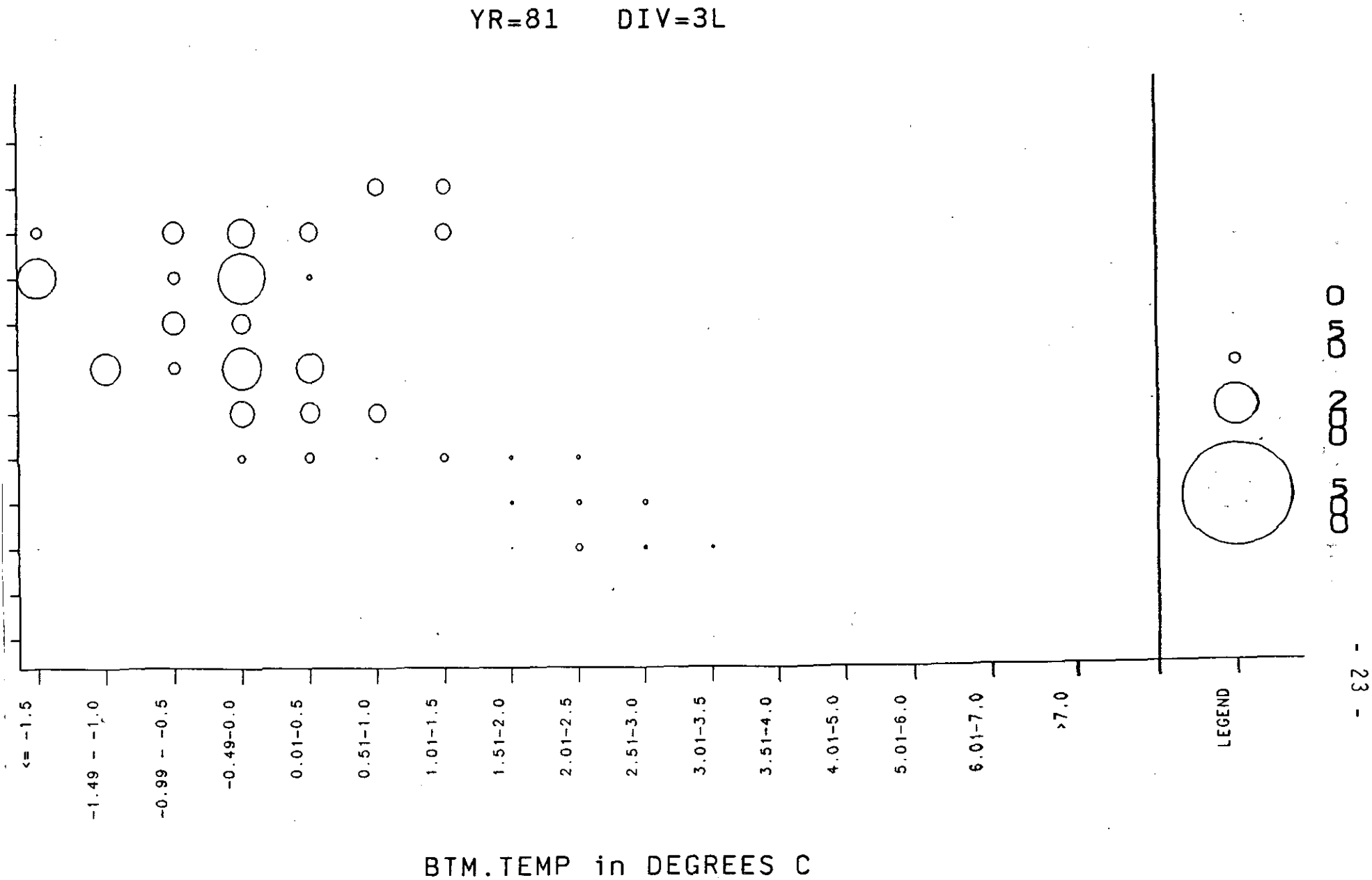


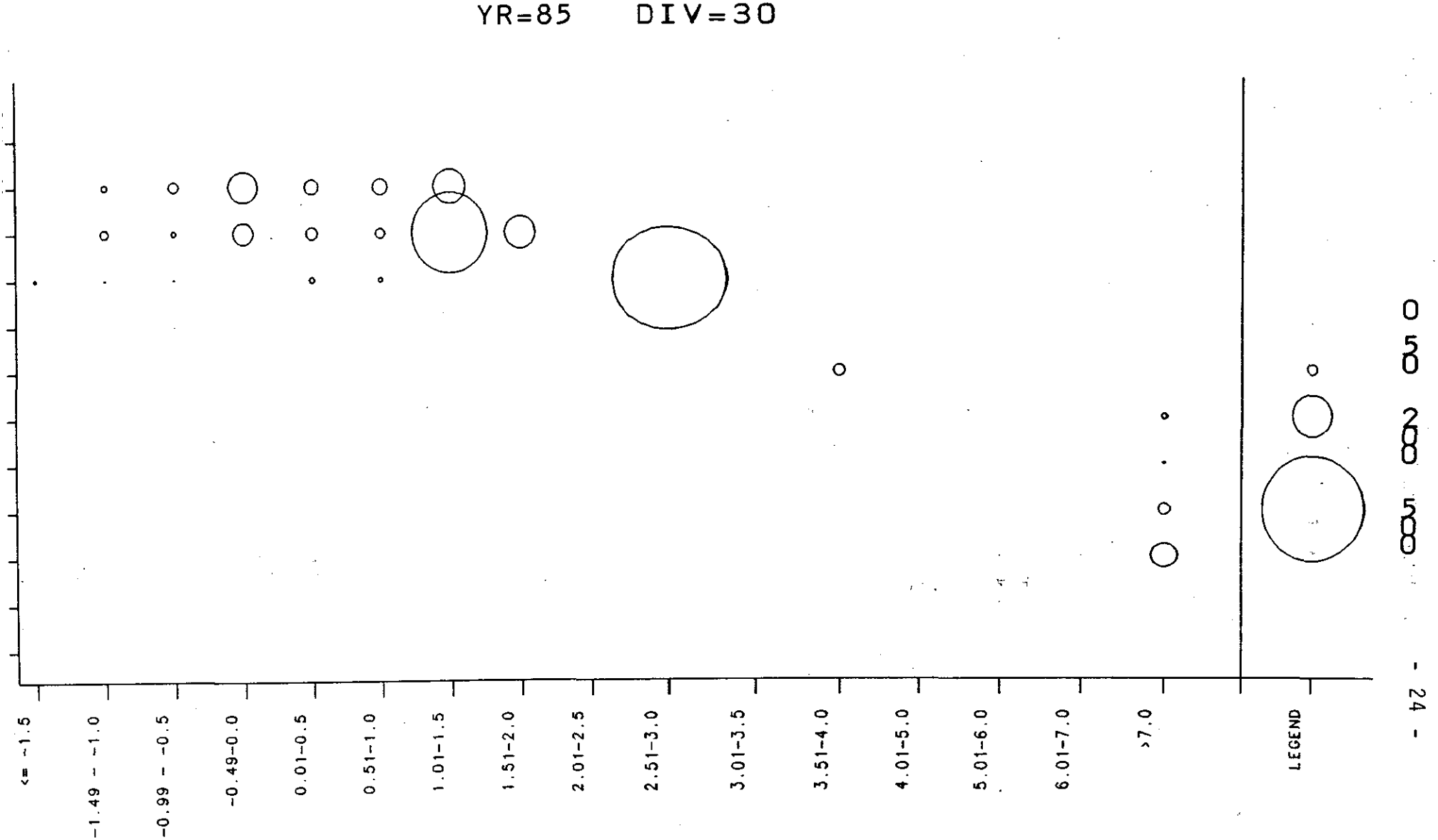
Fig. 17 Avg. catches(kg/tow) of A.plaice by depth and temperature.



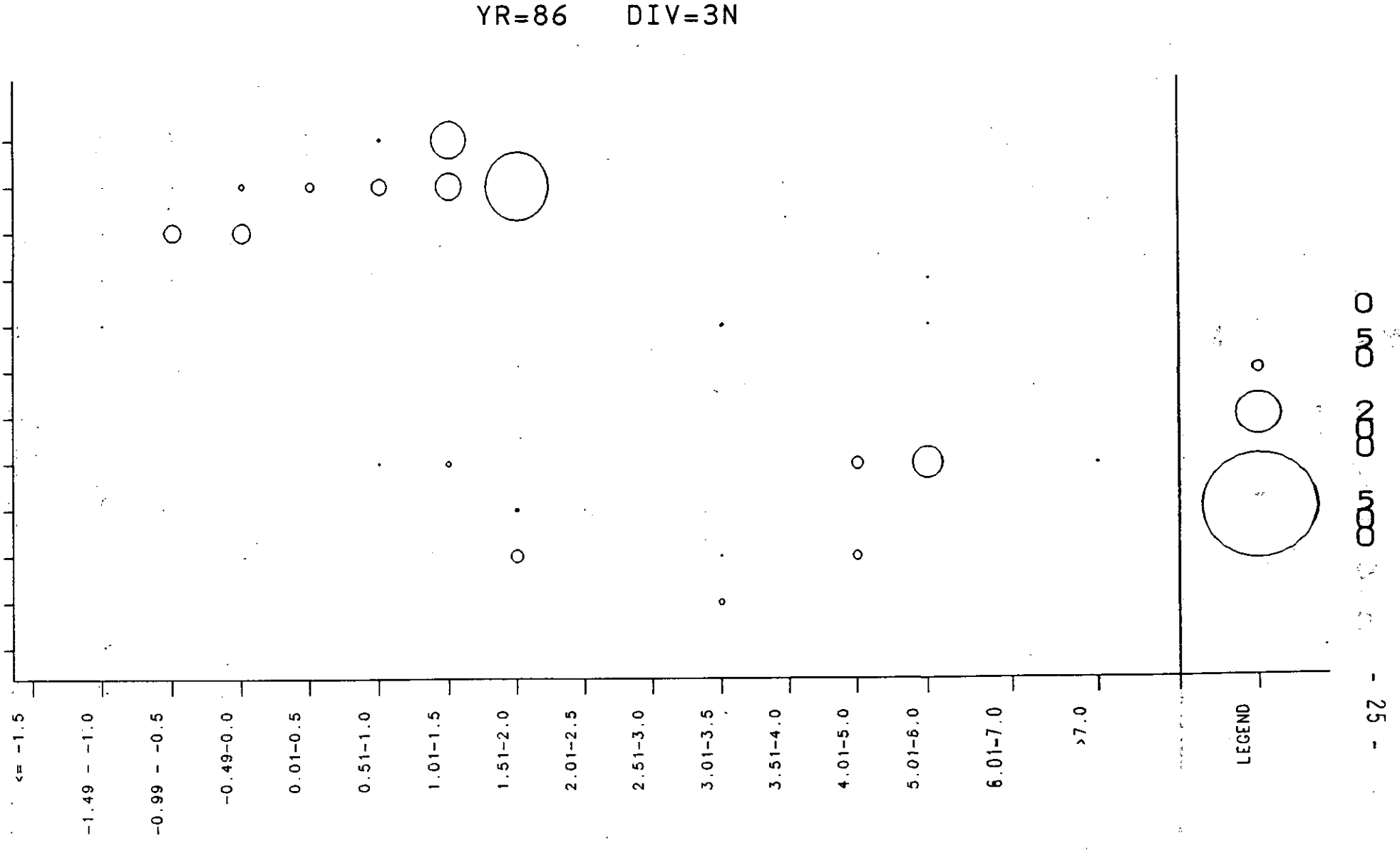
ig.18 Avg. catches(kg/tow) of A.plaice by depth and temperature.



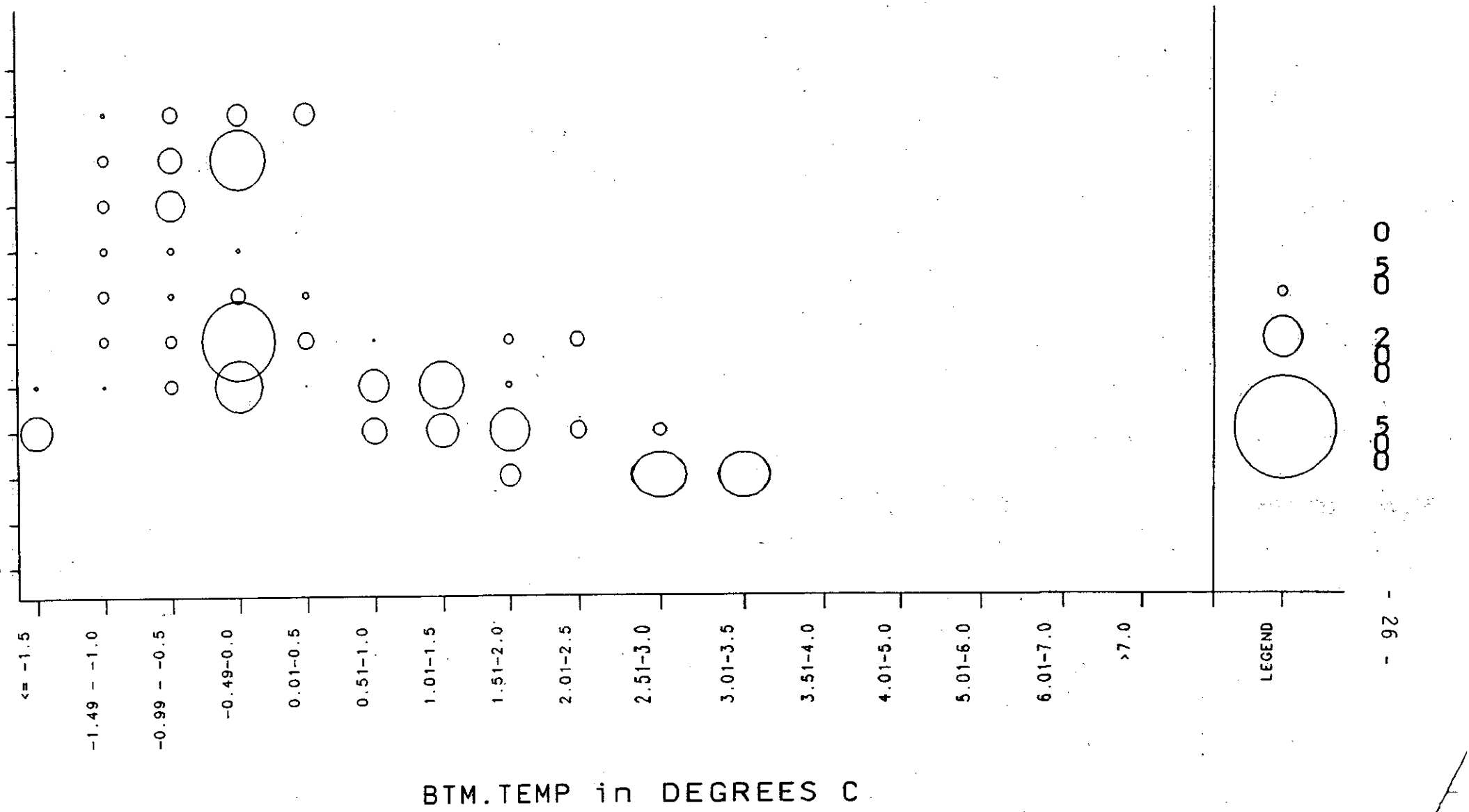
19 Avg. catches(kg/tow) of A.plaice by depth and temperature.



20 Avg. catches(kg/tow) of cod by depth and temperature.



21 Avg. catches(kg/tow) of cod by depth and temperature.



22 Avg. catches(kg/tow) of cod by depth and temperature.