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# Distribution and Abundance of 0-Group Silver Hake and Thermal Conditions of Scotian Shelf Waters in October-November 1987

by

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## ABSTRACT

Charts of distribution of 0-group silver hake, water temperature fields at 0, 50, 75 m and near the bottom and fields of water temperature anomalies based on the data of the traditional inventory survey of the Scotian Shelf silver hake carried out according to the USSR-Canada program from 18 October to 13 November 1987 are given. Presence of negative water temperature anomaly in the intermediate cold layer and faint positive anomaly in the near bottom layer on the Scotian Shelf is noted. The data on distribution and abundance of 0-group silver hake of the 1987 year class have been analyzed.

## INTRODUCTION

Regular observations of the Scotian Shelf silver hake stock have been made since 1962. The stock size has been found to be subjected to sharp fluctuations depending on the recruitment size. The strength of the year class can be judzed be the abundance of the young (0-group) fish at the post-metamorphosis stage. The surveys of assessment and distribution of the young silver hake have been carried out annually since 1978 according to the joint USSR and Canada program. Simultaneously, observations are made of feeding conditions for the young fish. The results of these studies have been used for stock assessment and forecasts of the Scotian Shelf silver hake fishery 2 years in advance. The results of one of such surveys made by the Soviet vessel SRTM-8102 "Maltsevo" in 1987 are given in the present report.

## MATERIALS AND METHODS

109 trawling surveys were made during the inventory survey of the young fish (18.10-13.11.87) (Fig. 1). At each station, water temperature measurements were taken by the Soviet mechanical thermobathygraph TM-9 in the 0-200 m layer and XBTs in the 0-50 m layer. As before (Sigaev, 1988), the square processing method for BT station data was used for plotting temperature fields and anomalies. Temperature anomalies are calculated for each square in accordance with new standards based on standards averaged for the 1962-1972 period and standards for the 1977-1986. The results of calculations are represented as water temperature fields and temperature anomalies for 0, 50, 75 m and near -bottom layer. Positive anomalies are shaded.

Trawling inventory survey of the Scotian Shelf silver hake was based on the principle of selective stratified analysis (Grosslein, 1969), i.e. was carried out in subareas (layers) (Doubleday, 1981), each of which was covered by a definite number of trawlings at random points. The fishing for the young hake and catch processing were made according to methodical recommendations (Konstantinov, 1973). As in the recent years, 1981-1986, the international midwater trawl (IYGPT) made of capron netting with 50 to 20 mm mesh, 6.5 mm in the codend, was used as a fishing gear. Trawlings of 30 minutes duration at the towing speed of 3.5 knots were made in the night time in three steps: near bottom (2-4 m off the bottom), intermediate (usually in the middle of the layer) and subsurface (3-5 m below the surface). For checkout of the preset trawling depth the echo cable depth meter (IGEC), attached to the upper headline, was used. All data on weight and size composition of the catches were entered on inventory trawling survey blanks.

For studying factors causing changes of indices for fry abundance during the inventory surveys some stations (27) made in the main area of massive young hake aggregations were reiterated according to the standard methods. The data obtained from repeated trawlings for the young fish size composition were used to calculate the absolute growth increment per unit time by the formula (Mina, Klevezal, 1976).

$$\Delta y = \frac{y_n - y_0}{t_n - t_0} ,$$

where $\Delta y$ is mean absolute growth increment per unit time;

$y_n$ is mean length by the end of time interval;

$y_0$ is mean length in the beginning of time interval;

$t_n$ is end of time interval;

$t_0$ is beginning of time interval.

Processing of materials for yielding the quantitative value of the young silver hake 1987 abundance followed the standard methods (Grosslein, 1969; Gasjukov, 1983).

RESULTS

Distribution of water temperatures

The temperature field is generally relatively homogeneous at the sea surface and is characterized by gradual increase from the north-east (7.8°C) to the south-west (12.8°C), without clearly pronounced temperature gradients (fig. 2A). The only location with the obvious heterogeneity is between 62°30' and 64°00'W, with the inflow of warm waters onto the shelf. The temperature distribution there is typical of that for the meander peak or a warm-core ring. The temperature difference between the periphery of this location and the center is of about 3°C.

The temperature distribution at the 50 m depth (fig. 2A) markedly differs from that at the surface due to the influence of the front passing between the waters of the cold intermediate layer and warm slope waters. Strong temperature gradients could be observed all along the boundary between these water massives. In separate locations, the difference in the water temperatures of the two neighbouring squares exceeded 10°C. The largest observed gradients were between 62°30' and 64°00'W. The second location, also influenced by the probable inflow of the worm-core ring or meander, is on the slope southwestward of Sable Island.

The temperature distribution at the 75 m depth is fairly similar to that at the 50 m depth except that the gradiens are weaker and the temperature field more homogeneous (fig. 3A). Apart from the two above-mentioned locations, predominance of the waters of the cold intermediate layer is ovserved everywhere, with the minimum values of 2.1-2.7°C in the north-east and the maximum values of 1.8 and 13.7°C on the shelf slope.

Thus, as is evident from the distribution of the water temperature at 50 and 75 m depths, in autumn of 1987, the waters of the cold intermediate layer occupied the largest part of the shelf area.

The near-bottom temperature field (fig.3B) is characterized by occurrence of relatively warm and cold water patches. Higher temperature values were recorded on the slopes, in above-mentioned locations. As usual, the band of warm near-bottom waters of the 8.6-8.9°C temperature spread along the Scotian Shelf Trough axis. Patches of cold water with the temperatures of 3.7°C in the west and 4.9°C in the east were located to the west and east of the axis. In the north-eastern part of the area, the near-bottom temperature dropped to 1.5°C.

Distribution of water temperature anomalies.

Two locations could be distinguished in the field of temperature anomalies at the surface (fig. 4A). The entire western part of the survey area was noted for positive temperature anomalies as low as 2.5-2.6°C. The eastern part was influenced by negative animalies of as low as - 2.1°C.

The distributions of anomalies and the temperature field at the 50 m depth were identical. The position of zero anomaly was approximately consistent with the front position between the cold shelf and warm slope waters. The maximum negative anomaly value was - 3.6°C on the shelf, and the maximum positive value was +10.1°C on the slope. Exceptionally large values for positive anomalies on the slope have resulted from simple calculations and do not seem to be realistic. They just confirm the fact that the inflow of warm waters onto the slope between 62°30' and 64°00'W and at 60-61°W has taken place. The largest part of the survey area was characterized by negative anomalies.

The distribution of anomalies at 75 m depth (fig. 5A) is similar to that at the 50 m depth. The boundary between the positive and negative anomalies corresponds to the front position between two different water massives. Centers of the largest positive anomalies were recorded in the same locations as at the 50 m depth.

The patterns of the near-bottom field of the water temperature anomalies (fig.5B) and near-bottom temperature field are similar. The position of locations with negative and positive anomalies coincides with the areas of increased and lowered temperatures. The square of positive anomalies somewhat exceeded the square of negative anomalies near the bottom.

From the above-mentioned description it can be inferred that positive anomalies predominated at the surface and negative anomalies in an intermediate cold layer.

Distribution and abundance of O-group silver hake.

As in 1986, the young silver hake catches did not exceed 50 sp/haul over the largest part of the area (fig.6), but unlike 1986, the young fish were actually absent from the catches in the area of Browns Bank and south-eastward of it. To make up for it, the aggregations of the young silver hake were of considerable values (to 500 sp/haul) north-eastward of Browns Bank and in the area of La-Have Bank and Hollow. As in 1985 and 1986, most dense aggregations of the young fish (over 500 sp/haul) were observed to the south-west of the Sable Island shoals along the 62 meridian, at the base of the quasistationary tongue of warm slope waters, where the areas with the temperatures ranging from 6.5 to 12.5°C were observed (fig. 3A). The results of the analysis of distribution of the young silver hake catch in 1987 by depth are presented in table 1. As in 1986, the largest quantities of silver hake (52% of the total catch) were taken above 200 m depths (68% of the total catch); the mean catch per haul was also large enough (114 sp.) with the least number of unsuccessful hauls (12%). The total catches taken above the depths of 100 m (25%) and over 200 m (7%) were considerably smaller.

Thus, during the 1987 survey period, major O-group silver hake aggregations occurred in a more deepwater part of the shelf (above 101-200 m) in immediate vicinity of the overwintering area

(La-Have and Emerald Hollows and Scotian Shelf slopes southward of Emerald and Western Banks).

Size composition of the 0-group young silver hake in the catches yielded by the fry trawl in 1987 is depicted in Fig. 7 against the same period in 1985 and 1986. Unlike the previous years, the catches apart from the young fish 23 to 70 mm in length, were represented by a large number of larvae (26%) 15 to 22 mm in length with yolk sacs. In this connection, the mean size of the youngs in 1987 amounted to just 3.3 cm, which is 2-3 times as low as in 1985 and 1986. This can be evidently explained by delayed massive spawning of the silver hake in the shallow water area of the Sable Island, where it usually takes place early in August (Noskov et al., 1982) as well as by the change for the worse of feeding conditions for the larvae and fry.

The length of embryonal stage is 48 hours for silver hake (Nichols et Nreder, 1927), however, the water temperature for egg incubation is not stated. The other investigators (Coombs, Mitchell, 1982) made experiments on artificial fecundation of the hake (Merluccius merluccius) eggs in various temperature regimes (5.3-23.2°C). The authors found a correlation between the embryo hatching and the water temperature, i.e. the developmental period from fertilization to hatching, which reduced from 220.5 hrs. at 8.1°C to 69.2 hrs, at 18.4°C. The larval silver hake sizes ranged from 2.64 to 3.52 mm, 3.02 mm on average (Colton, Marak, 1968).

Quantitative indices showing daily rates of growth of the young silver hake during the 1987 feeding period are presented in table 2. The absolute daily linear increment constituted 0.56 m /day. An attempt was made to determine a conventional date of the peak of the silver hake massive spawning in 1987 based on the above-stated information. The mean size was 33 mm in the middle of the first half of November - on 7 November (Fig. 7). Thus, approximately 54 days passed between hatching and the above date with the absolute daily linear increment of 0.56 mm/day so the 14th of September has been taken to be the conventional hatching date and the spawning peak to occur at the end of the first ten-day period of September. Thus calculated conventional date for the spawning peak at such a late time is quite realistic and is confirmed by the ichthyoplankton survey data collected on SRTM-8024 "Foton" from 21 September to 14 October 1977 in the Scotian Shelf area (Noskov et al., 1978, 1982). According to the survey results, the total abundance of the larval silver hake was large - $64.10^{11}$sp. with mean lengths in the area of massive aggregations on the Sable Island shoals amounting to only 6.43 mm.

Thus, in 1987, the peak of massive spawning of the Scotian silver hake obviously took place a month later than usual.

The materials on the distribution of silver hake spawning aggregations and dispersal of eggs and larvae in the Scotian Shelf area (Sauskan and Serebryakov, 1968; Noskov et al., 1978; 1982) suggest that this species is noted for long spawning times lasting from July to October. The initial trawling inventory surveys of 0-group silver hake carried out in October during the 1978 to 1980 period resulted in reduced numbers of small size specimens 10-22 mm in length at the pre-metamorphosis stage. In this connection, the starting time of the survey was set two weeks later. However , judging by the data on size composition of 0-group catches during the 1987 survey this measure was of no effect, and the reliability of the young fish abundance index has been affected. As is evident from calculations of the total abundance of the 1987 young silver hake, it was twice as low as the mean longterm value (table 3), however, variation factors of that index were very high (34%) and indicated that the obtained data were unreliable. Thus, it has become obvious that more reliable abundance indices of the Scotian 0-group silver hake, especially in years of late massive spawning, can be ensured if the survey begins two more weeks later (in November) or is reiterated.

It should be noted that partial reiteration of the survey undertaken in 1984, 1985 and 1987 did not help to solve the abovestated problem as the obtained data could not be used for calculation of the secondary abundance index due to small amount of materials, all the more, for calculation of the primary index due to long time interval (3-4 weeks). Nevertheless, reiterated surveys may deepen the knowledge on feeding conditions for the 0-group fish at later stages of the pelagic phase.

## DISCUSSION

indices of abundance of the 0-group silver hake can be used to deduce the preliminary estimate of the strength of silver hake year classes two years in advance (table 3). So, some investigators (Fanning et al., 1987) made a comparative analysis of 0-group abundance indices and the abundance of one year old fish calculated from the results of annual July surveys, and found an agreement between these two indices. The quantitative correlation of 0-group abundance indices and one year old fish abundance (r=0.74) estimated by the V.P.A. has been established by Rikhter (1988). At the same time, it is pointed out that sometimes the estimates of the 0-group abundance do not reflect the actual state of abundance of these year classes. So, the 1981 year class, the largest in terms of abundance (table 3), did not yield large catches per unit effort in the commercial fishery after three years. On the contrary, a relatively weak 1982 year class estimated as a result of 0-group abundance studies appeared to be numerous in the 1985 catches. In this context, a question arises whether indices of 0-group abundance are indicative of the recruitment size in the future. To answer this question, evidently it is necessary to study the changes occurring between the first and second years of life. So, for example, Ponomarenko (1974, 1978) found a dependence of survival of the young "bottom" cod of the Barents Sea on temperature conditions during the period of the temperature minimum in the course of the first and second wintering periods. Besides, considerable differences in abundance indices for fingerlings and one year old fish of the 1982 year class can be attributed to the fact that silver hake fingerlings appeared to be inaccessible to trawl during the surveys for some reasons (for example, disturbed vertical migrations, etc.).

Thus, the above-stated discussion proves the expediency of conduction of 0-group silver hake inventory surveys as the way to obtain prognostic values for the strength of the next year class. Another reason is the necessity of studying vertical distribution of fingerlings and conditions of their overwintering.

## CONCLUSION

Oceanographic conditions in October-November 1987 on the Scotian Shelf were characterized by negative anomalies of the water temperature of the intermediate cold layer and a weak positive anomaly of the water temperature in the bottom layer.

Decreased water temperatures might have caused delayed massive spawning of the Scotian silver hake (early September) and worsened feeding conditions for the larvae and fry, which is confirmed by mean sizes of the young fish in the catches (3.3 cm), i.e. 2-3 cm below the level recorded in the previous years of observations.

Massive aggregations of the young hake (500 sp/haul) in October-November 1987 were observed south-westward of the Sable Island shoals and in the La-Have Bank and Deep areas, i.e. in the areas with clearly defined gradient zones.

According to the inventory survey data, the total abundance of the young silver hake of the 1987 year class was 21,107 sp.,i.e. two times as low as the longterm mean. This abundance index, however, should be used with great care because of its unteliability (variation factor -34% and undercatch of the larvae 10-22 mm in length).

The available data from the 0-group silver hake surveys carried out during the 1981-1987 period in the Scotian Shelf area suggest that more reliable abundance indices, especially for years with delayed massive spawning, could be ensured if the survey times are fixed two weeks later (November) or the inventory survey is reiterated. Besides, the data on 0-group silver hake abundance required for assessment of the year class strength must be supplemented annually by the data from studies of vertical distribution of fingerlings and conditions of their overwintering.

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Table 1 Distribution of young silver hake catches by depth

in 1987

| Depth m | No. of trawlings | Unsuccessful trawlings,% * | Total catch,sp. | % of total catch | Mean catch per trawling, sp. |
|---|---|---|---|---|---|
| 0-100 | 32 | 37 | 2330 | 25 | 73 |
| 0-200 | 57 | 12 | 6500 | 68 | 114 |
| 0-300 | 20 | 50 | 689 | 7 | 34 |
| Total | 109 | 27 | 9519 | 100 | 87 |

* Hauls, in which the young hake was absent

Table 2 Indices of the young silver hake rate of growth in 1987

| Observation period | Mid-observation period | Interval between mid-surveys, days | No. of measured, sp. | Mean length, mm | Absolute daily linear growth, $\Delta y$, mm/day |
|---|---|---|---|---|---|
| 1-5.11 | 3.11 | | 2220 | 30 | |
| 19-23.11 | 21.11 | 18 | 1802 | 40 | 0.56 |

Table 3 Indices of Scotian Shelf O-group silver hake abundance

in 1981-1987

| Year | Survey area, strata No. | No. of trawlings | survey area, sq. mi | Mean weighted no. of young fish per haul $\bar{X}$ | Total young fish abund., $10^7$ sp. | Standard deviation S.E. | Variation factor $\frac{S.E.}{\bar{X}}$ (%) |
|---|---|---|---|---|---|---|---|
| 1981 | 53-81 | 105 | 22699 | 501 | 114 | 71 | 14 |
| 1982 | 60-78 | 61 | 14516 | 9 | 1 | 1 | 16 |
| 1983 | 60-78 | 64 | 15520 | 233 | 36 | 5 | 10 |
| 1984 | 43-81 | 132 | 37343 | 29 | 11 | 4 | 15 |
| 1985 | 48-81 | 113 | 28679 | 248 | 68 | 46 | 19 |
| 1986 | 53-81 | 99 | 22699 | 146 | 33 | 30 | 21 |
| 1-97 | 53-81 | 109 | 26502 | 79 | 21 | 27 | 34 |
| Mean for 1981-1987 | - | - | - | 178 | 40 | - | - |

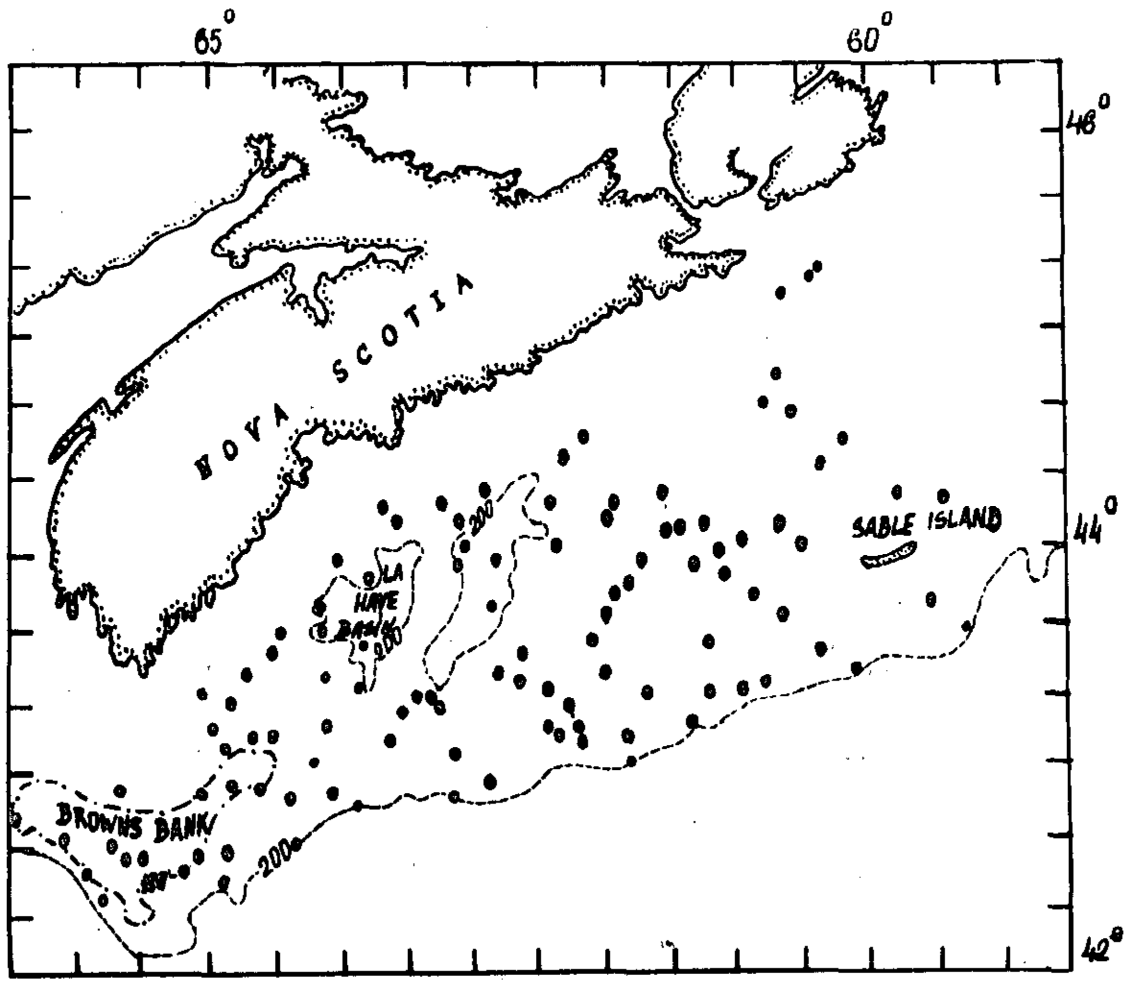


Fig. 1. Scheme of stations for fry trawling stations (18.10-13.11.87)

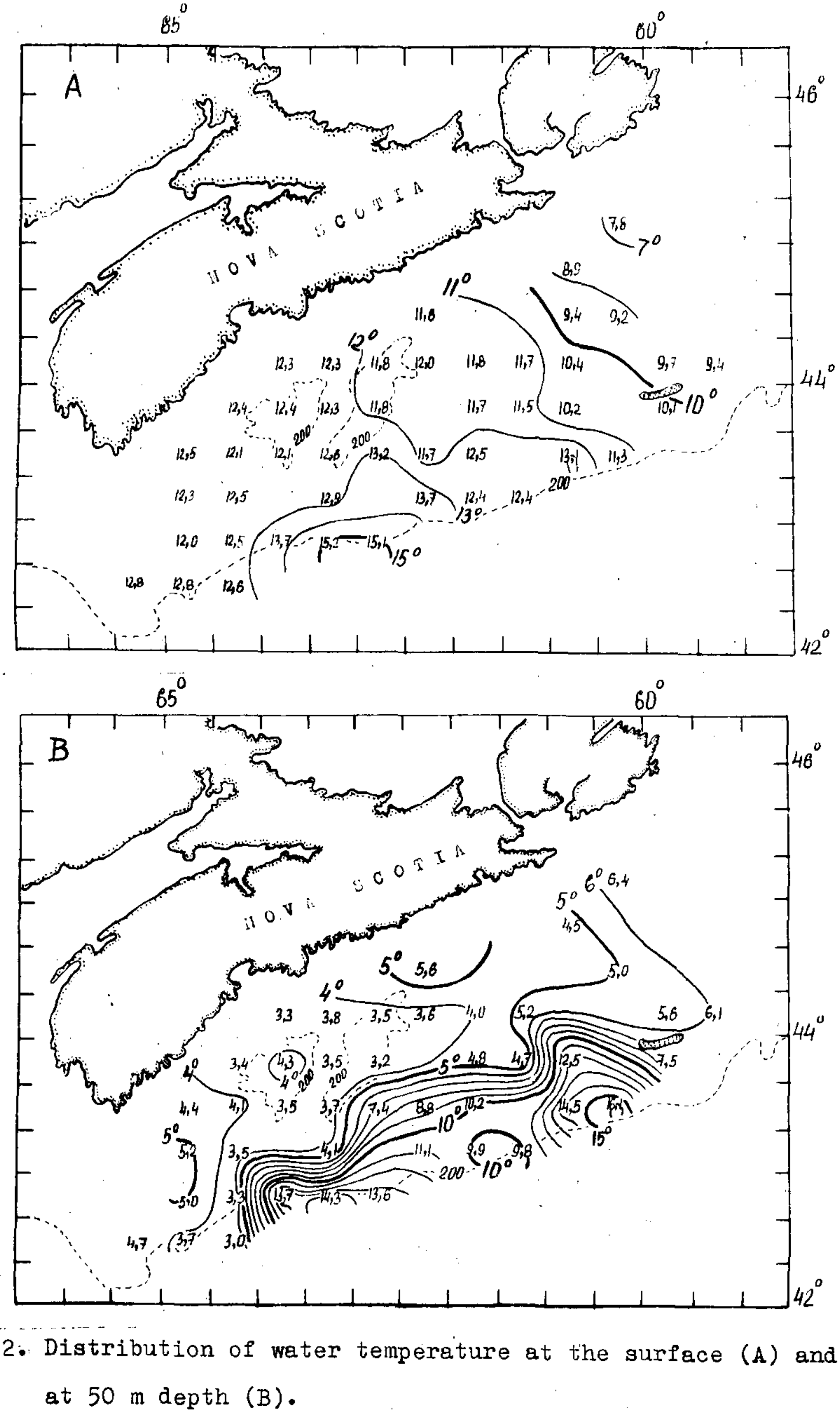


**Fig. 2.** Distribution of water temperature at the surface (A) and at 50 m depth (B).

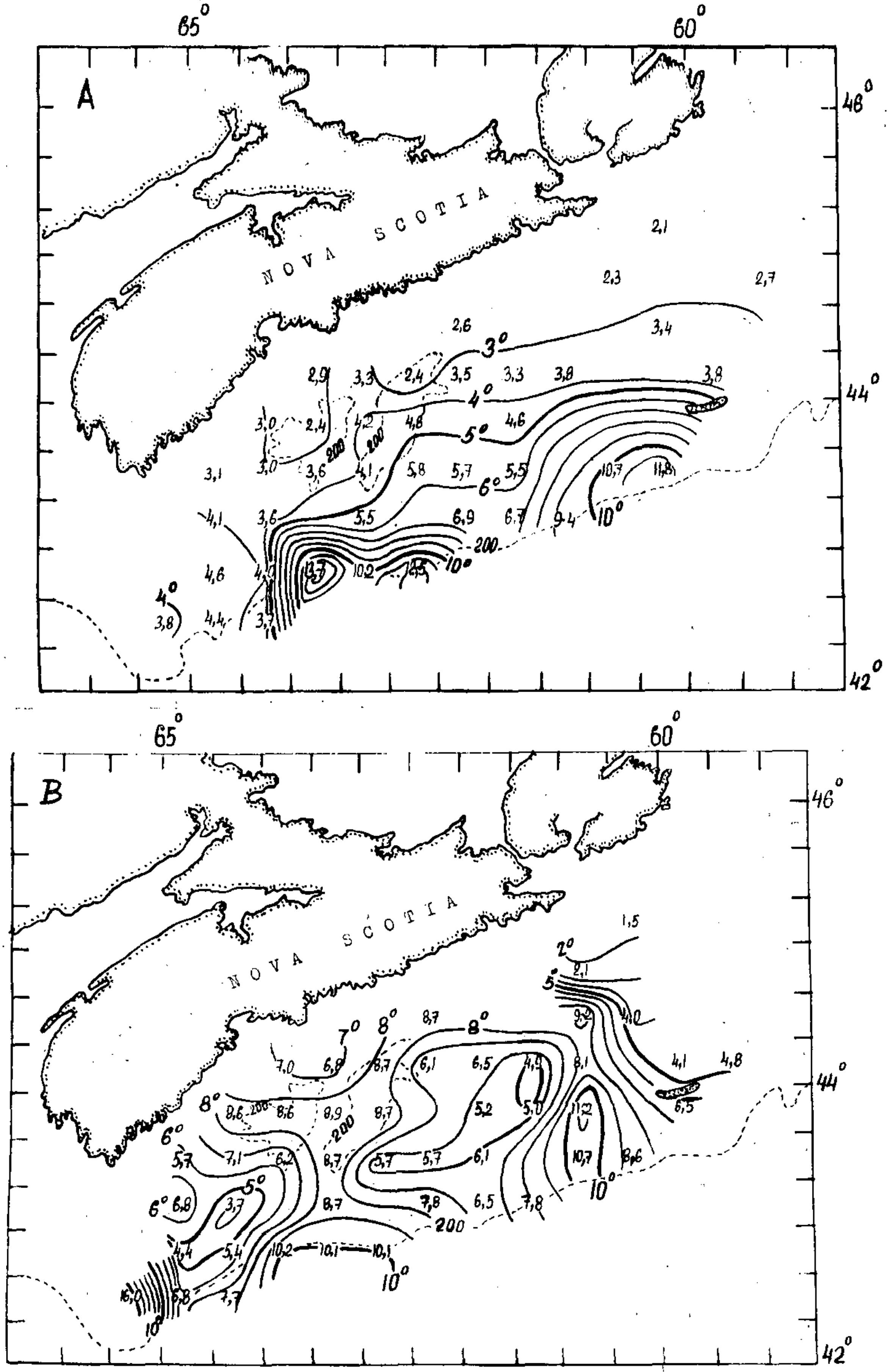


Fig. 3. Distribution of water temperatures at 75 m (A) and near the bottom (B).

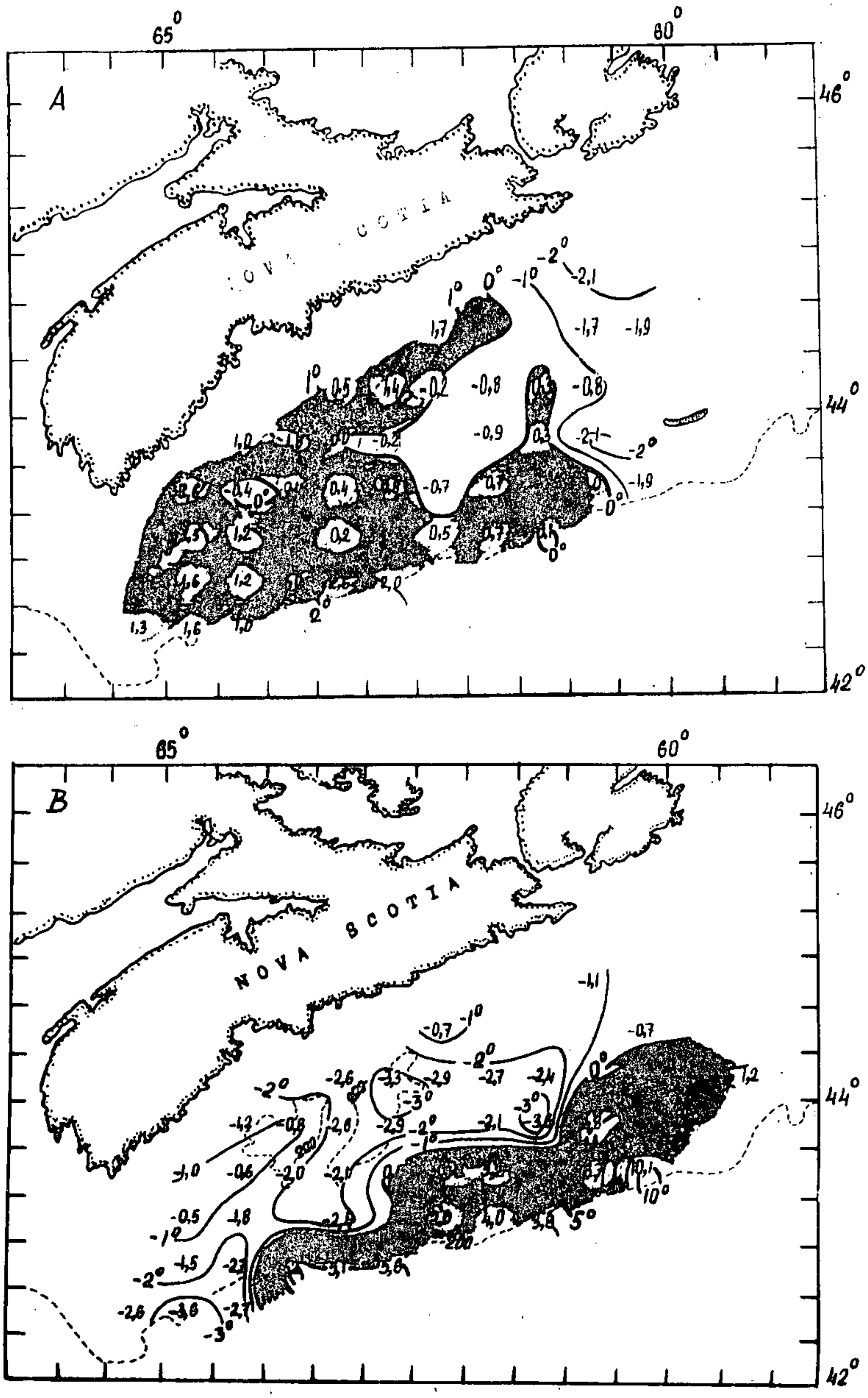


Fig. 4. Distribution of water temperature anomalies at the surface (A) and at 50 m depth (B).

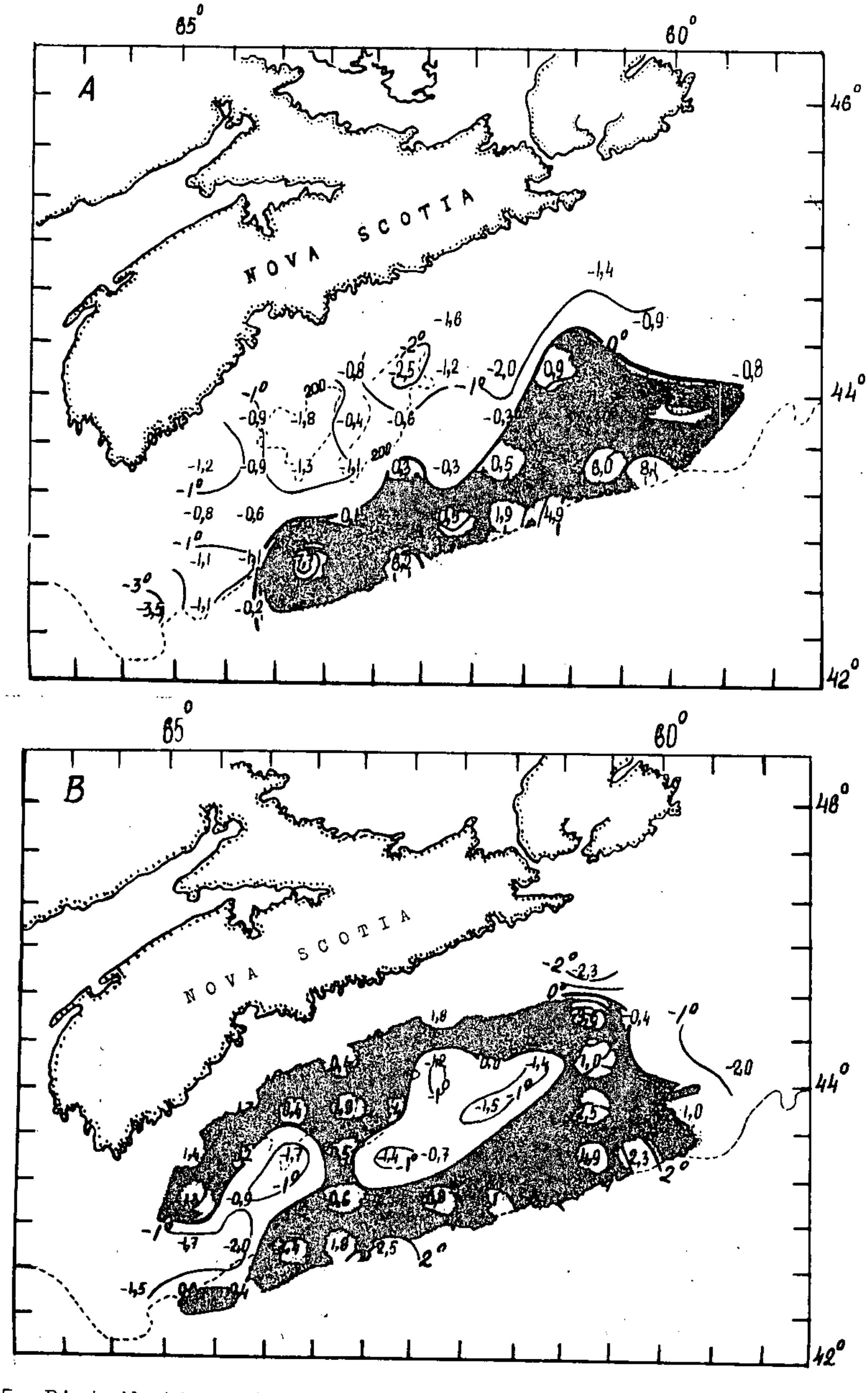


Fig. 5. Distribution of water temperature anomalies at 75 m depth and near the bottom (B).

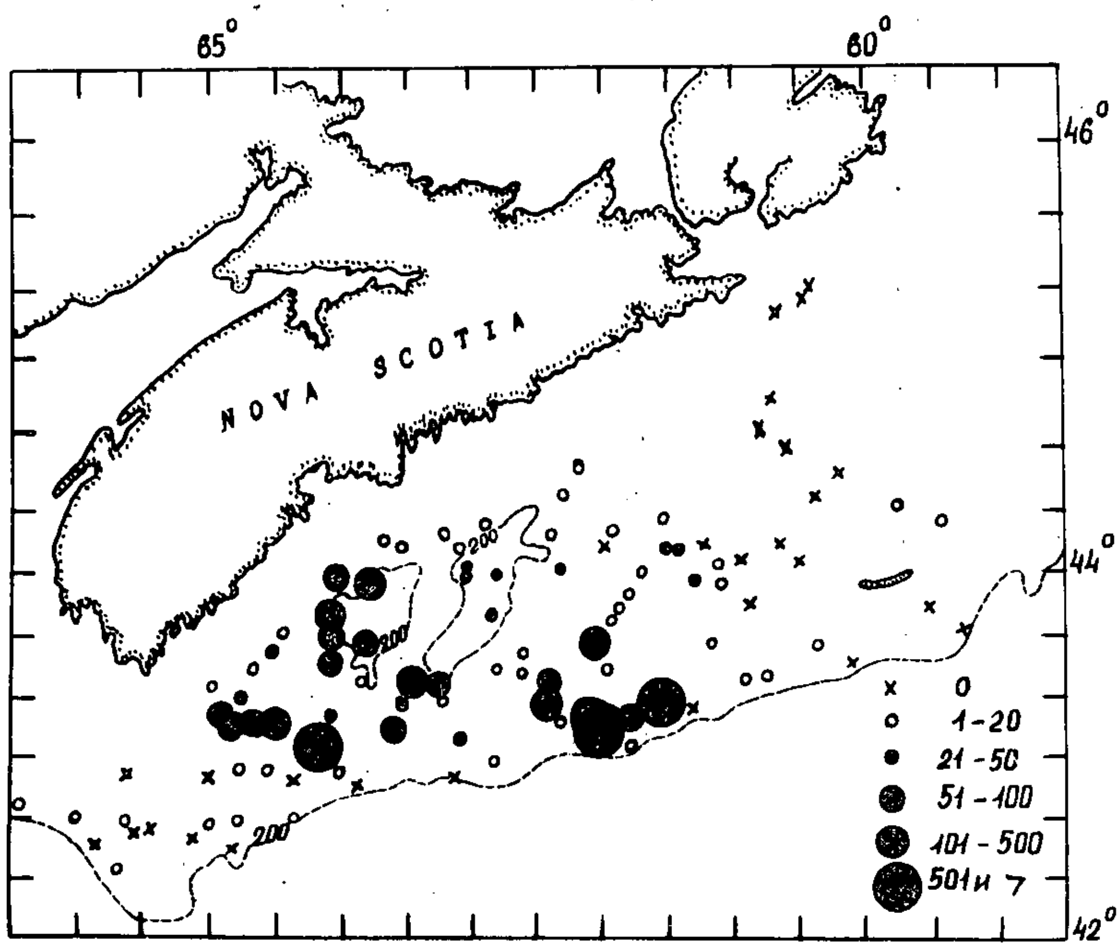


Fig. 6. Distribution of Scotian Shelf O-group silver hake, sp/haul (18.10.-13.11.87).

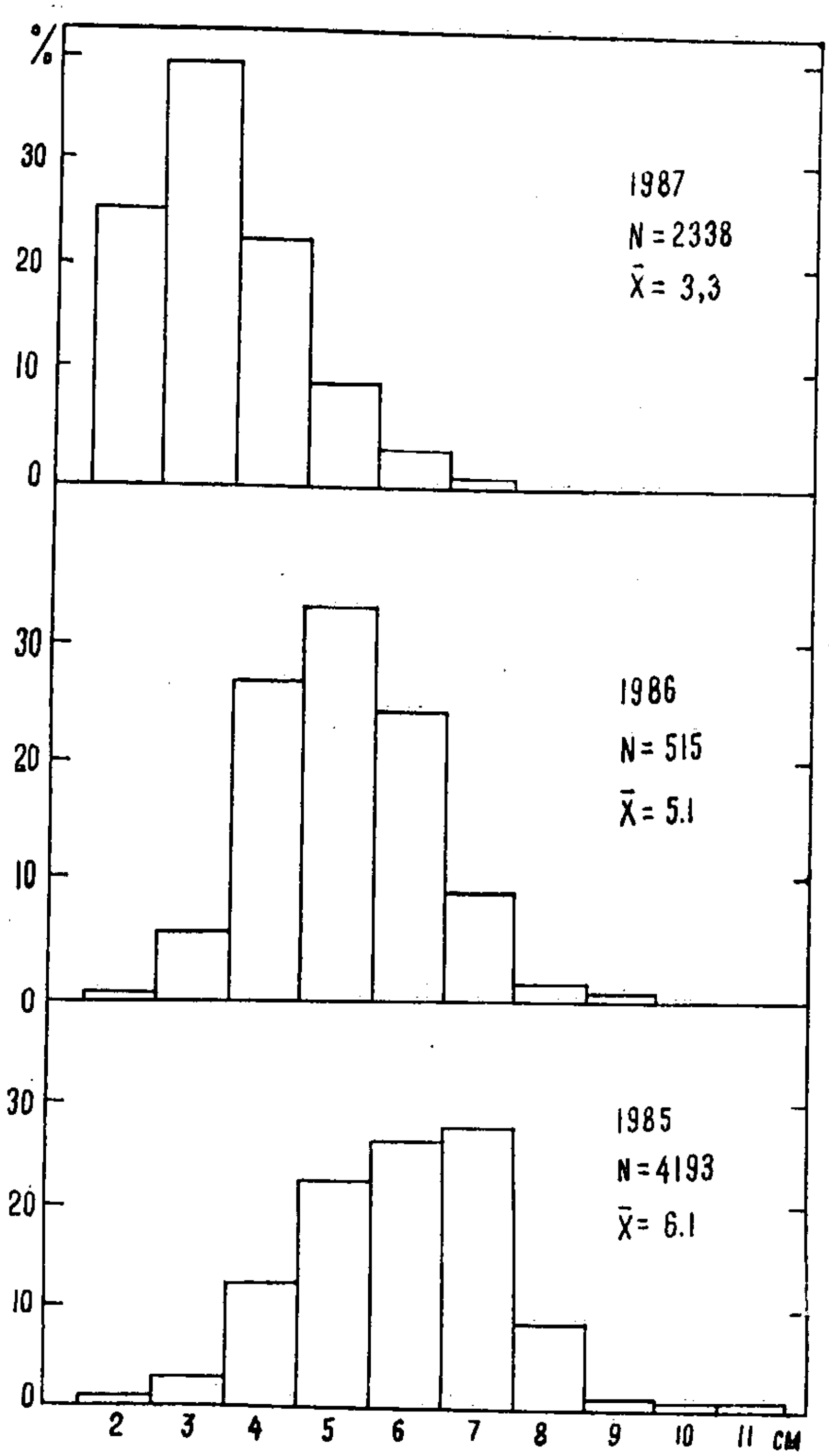


Fig. 7. Size composition of O-group silver hake (first half of November) in 1985-1987.