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Distribution and Abundance of Young Silver Hake of 1989 Year-class on the Scotian Shelf in 1989-1990 Fall-winter Season

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ABSTRACT

There have been described results of the Soviet-Canadian Studies on geographic distribution and inventory survey of 1989 young silver hake year class both for their feeding period (fall, 1989), and wintering season (winter, 1989-1990).

INTRODUCTION

One may have an idea of the Scotian silver hake year classes strength, which is very important for the international fisheries, with the anticipation of two or three years before their entry into the fishing by using data on 0-group juveniles inventory surveys carried out according to the Joint USSR-Canadian Program for 1978-1988. Quantitative relationship between 0-group abundance indices and those of yearlings (R=0.74) calculated by the VPA method has been recently obtained (Rikhter, 1988). In some years (for instance, in 1981 and 1982) abundance estimates for 0-group did not represent the actual state of those year classes' abundance. A necessity of studying variations which take place between the first and the second years of life, i.e. in winter season, became obvious to get more accurate estimates for young hake abundance. For the first time geographic distribution of hake and inventory survey of young fish were carried out for this purpose parallel with standard fall observations in 1989-1990 fall-winter season.

MATERIAL AND METHODS

Trawl surveys for the Scotian young silver hake inventory were based as in 1981-1988 on the principle of random stratified analysis (Grosslein, 1969; Doubleday, 1981) and carried out with the IYGPT international midwater trawl for young gadoids. All the data on weight and length frequencies of catches were put down into the trawl logs. In fall trawlings were realized at night at three levels, i.e. pre-bottom (2-4 m over the ground), intermediate (in the middle of layer depth) and subsurface one (3-5 m below the surface). In winter there were selected according to the data on young hake bathymetric distribution the following three horizontal trawling levels: pre-bottom one, 100 and 50 m as inventory survey depths. Each trawling duration was of 30 minutes, being vessel speed 3.5 knots. Material processment to obtain a quantitative estimate of 1989 young hake year-class was done by standard methods (Grosslein, 1969; Gasiukov, 1983).

Hake egg and larvae sampling was realized simultaneously with a plankton net which had mesh of 505 μк and was attached to the trawl codend.

Having carried out inventory trawl surveys of young hake, at each station measurements of water temperature were made with MBT (at the depths of 0-200 m and 0-140 m) and XBT (at the level of 0-200 m). The same measurements were made when realizing Halifax section. Plots of water temperature horizontal distribution at the depths of 0, 50, 75 and 100 m were made according to the data observed. The data on water temperature distribution on the Scotian Shelf in fall of 1989 were compared with the same period of 1988 to analyse them in more detail. A principle of "block" processment of results observed in 30' x 30' blocks was applied.

Calculation of water temperature variation was made for each 1989 block as compared with the data for 1988. Results of calculation were represented as fields of water temperature variations at the depth of 100 m and Halifax section. Negative values were indicated in the charts as a continuous shading. In addition, facsimile information which is transmitted by Halifax Meteorological Center (Canada) was used to analyse hydrometeorological conditions in the area of Nova Scotia.

RESULTS AND DISCUSSION

Water temperature

Vertical structure of the Scotian Shelf waters is characterized by a three-layered condition (Smith et al., 1978). Dynamics of superficial layer of the Scotian Shelf waters was examined basing on the analysis of 11°C isothermal surface topography isolines of which were mostly timited by the depths of 25 through 40 m (fig. 1). In fall 1989 topography relief represented two systems of cyclonic circulation (upwelling). The first one was a large-scaled system covering the south western Shelf (Brown Bank and adjacent waters) and well agreed with the observed centrifugal upwelling (Garret and Loucks, 1976). The second system was a small-scaled one and consisted of numerous small cyclonic water gyrals which were mostly observed over the Shelf shallow areas (Emerald Bank, La Have Bank and Sable Shoals). These water gyrals appearance in the superficial layer is evidently the results of an orographical effect, i.e. an interaction between the Nova Scotia Current (Sutcliffe et al., 1976) and the Shelf shallow waters. Water dynamics in the superficial layer was significantly affected by warm eddies of Gulf Stream. Thus, during the whole fall survey a slow movement of a warm ring towards Brown Bank was observed (fig. 2), coming another ring into the area of Sable Shoals in November 1989. As a result, a warmening of surface waters was observed in the above mentioned areas (fig. 3). An intermediate layer was represented by waters of Labrador Current (0°-5°C) which came into the Shelf from the north-east. Topography of the layer thermal minimum (fig. 4) confirms a general scheme of Labrador Current on the Scotian Shelf. Thus, its maximum depth is observed in the north-east of the area (100-120 m), along the coast of Nova Scotia (80-90 m) and over the slope to the south of Sable Island (80-100 m). The flow of Labrador intermediate waters created, when moving, several small-scaled gyrals which were probably directed along the bottom relief, as in the surface layer. The pre-bottom layer forms warm slope North-Atlantic waters which penetrate into the Shelf depressions through the water deeps to the west of Sable Island. Mechanism of the process is clearly indicated in fig. 5. Attention should be paid to the interannual variations in this inflow core position at the depth. In 1987 the core was observed at the depths of 100-120 m, varying between 120 and 180 m in 1989. It was registered at 24 from 109 stations occupied during the fall survey, fluctuating water temperature inside the core between 8.1°C and 9.0°C. The warmest water (more than 10°C) was observed at the northern slopes of Sable Shoals. As a result of cold Labrador water coming powerful horizontal temperature gradients of 7°C/10 miles were formed there (fig. 6). A comparison of the hydrological observation data on the Scotian Shelf in autumn 1989 with those for the same period of 1988 showed that the temperature variation field in the superficial layer (fig. 7) had positive values (between 1°C and 5°C). This was evidently attributed to milder climatic conditions in 1989 and an intensification in slope water advection as a result of Gulf Stream warm rings coming to the shelf edge in the area of Browns Bank and to the south of Sable Island (fig. 2). The effect of those eddies was observed in the pre-bottom layer as well (100 m) which was confirmed by considerable fields of positive temperature variations (1°-2°C) extending onto the shelf from the areas cited (fig. 8). The whole central Scotian Shelf was affected by an intermediate layer of cold water, fluctuating negative values of temperature variations between 0°C and -3°C. One may come to a conclusion basing on the above analysis that in the surface layer of the Scotian Shelf waters positive variations were observed in 1989, existing in the intermediate cold layer negative variations which extended into the upper pre-bottom layer, especially over the central shelf water area.

Hydrological survey was repeatedly carried out over the Scotian Shelf water area, principally at larger depths, in the period from 23 December, 1989 to 8 January, 1990 to define wintering conditions for 1989 young hake year-class. Survey results showed that a considerable water cooling (by 10°C) had taken place in the surface layer, as compared with 1989 fall season. Surface temperature field was generally rather uniform, being between 0°C and 2°C. As a result of cooling and convective mixing surface waters reached the depths of 60-70 m in the areas of anticyclonic water gyrals which were observed over Emerald and La Have Hollows (fig. 9). The most significant interaction of cold and warm inflows was observed at the depth of 75 m (fig. 10), where horizontal gradients were 3-4°C/10 miles in the area of Emerald Hollow and 7°C/10 miles over the southern slopes of Sable Shoals. A comparison of data on distribution of an intermediate layer cold waters in 1989-1990 winter season with

1989 autumn season showed that in winter their effect had been less marked. A plot of 7°C isothermal surface topography clearly shows water circulation in the pre-bottom layer (fig. 11). One may see that the relief was limited by the depths of 50-160 m and was located 20-30 m higher to the surface, as compared with 1989 fall season survey (fig. 5). In the pre-bottom layer the penetration onto the shelf of a band of warm slope waters with the temperature of 8°C-10°C was well observed between 62°W and 63°W. In peripheral zones of the inflow, especially in the area of La Hav Bank and Sable Shoals, where the interaction with cold Labrador waters was observed horizontal gradient zones of 3°-4°C/10 miles temperature values appeared. On the whole, in 1989-1990 winter season an intensification of warm slope water advection onto the shlef took place, as compared with 1989 fall season. Therefore, in 1989-1990 winter season when carrying out a repeated trawl survey of 1989 young hake year-class the following features of hydrological regime of the Scotian Shelf were noted. Waters of the surface layer acquired an uniform character owing to winter cooling and convective mixing with the intermediate layer waters. The intensity and depth of penetration of a warm quasi-stationary inflow of slope waters were significantly larger than in 1989 autumn season.

Distribution and Abundance of 1989 Young Silver Hake Year-Class in 1989-1990 Fall-Winter Season

110 stations were occupied during annual standard trawl surveys fro inventory of 0-class of the Scotian silver hake from 19 October to 13 November, 1989 (fig. 12). Young hake catches, as in the previous three years, did not exceed 50 ind./trawling in major water area (63 stations) (fig. 13). Major concentrations of hake 0-class (between 51 and 822 ind./trawling) were located between 62°W and 65°W, in the area of the inflow of warm slope water (fig. 5). The highest catches (more than 500 ind./trawling) were observed at the periphery of the inflow in the clearly defined gradient zones with temperatures of 2°-4°C/10 miles. The greatest amount of young fish (84% of total catch) was found in the deepwater shelf zone (over the depths of 101-200 m), where average catch per trawling was 140 individuals (table 1). A comparison of data on 1989 young hake length composition (fig. 14) with the similar data for a discrete

period of the previous years (1983 and 1985) allows to suggest that silver hake massive spawning took place in 1989 as usual late in July or early in August. It is known that the Scotian silver hake have a prolonged spawning season, from July to October, during which two portions of egg as a minimum are spawned (Sauskan and Serebryakov, 1968; Noskov et al., 1978). Hake egg and larvae samplings realized on 6 of November, 1989 with a plankton net in shallow waters of Sable Shoals where water temperature was of 9°-10°C over the bottom (fig. 6) evidenced the fact that hake spawning could be continued later in the season. Abundance index of 1989 year-class silver hake 0-class was twice less than an average multiannual value for 1981-1989 according to the data of 1989 autumn survey (table 3).

A repeated winter trawl survey for inventory and geographical distribution of 1989 year-class young hake was carried out from 23 December, 1989 to 8 January, 1990 at 71 stations of the Scotian Shelf (fig. 15). Survey area covered mainly deep-water shelf zone, as preliminary data on hydrological regime of the Scotian showed that in winter the whole superficial layer up to the depth of 75 m was occupied by cold waters (0°-2°C) of Labrador and coastal origin, observing inflows of warm (more than 6°C) slope water below 100 m (Vialov and Karasiov, 1967). At the same time, inflows of warm (6°-9°C) slope waters were observed in the area of Emerald Bank and Western Bakn when carrying out the winter hydrological survey of 1989-1990. Therefore, the volume of trawlings was increased taking into account the above shallow waters, although young hake were almost absent, as it turned out (fig. 16). As in fall of 1989, winter catches of young hake did not mainly exceed (at 3/4 of all stations) 50 ind./sampling. Their denser concentrations (51-163ind./ sampling) were only observed in the shelf deep waters over Emerald Hollow and La Have Hollow, i.e. in the areas of an active interaction between the warm inflow of slope waters and cold Labrador waters. Therefore, young hake were found in the wintering locations. The relationship between catches and location depths is also the evidence of the fact (table 2). Thus, a share of catches over the areas of more than 200 m in depth increased from 10% (table 1) to 37% as compared with a fall survey. Mechanism of young hake movement towards wintering areas is represented in fig. 17. Small individuals (of 75 mm in length) were encountered near Emerald Bank and La Have Bank, and the largest specimens (of 90-95 mm in length) already migrated to La Have Hollow. Length composition of young hake winter catches by IYGPT trawl varied between 2 and 12 cm, and in contrast to the fall data, bimodality was observed (fig. 18). This bimodality is evidently attributed to differences in growth rate of 0-class individuals or explained by the appearance of a smaller group of young individuals which were reproduced by the females spawning for the second time (in September). Dependence of degree between the values of absolute daily linear increment for 0-class and average length obtained by the data of ichtyoplankton and fry surveys on the Scotian Shelf (Sherstyukov, 1990) is the following:

$$y = 0.15 \times X^{0.31},$$

where y is absolute daily linear increment for 0-class (mm/day);

X is average length of 0-class (mm).

Quantitative indices which characterize daily growth of young hake in the season between fall and winter surveys of 1989 were 0.52 mm/day what corresponds to the values calculated by the above-mention equation. Hypothesis of origin of fry lesser mode from hake later spawners is more probable.

Index of young fish weighted average number per trawling obtained by the data of 1989-1990 winter survey was twice less than that of fall one, i.e. 35 ind./trawling. Failure in coincidence of indices is obviously attributed to a number of reasons related with young hake inaccessibility to fishing gears owing to: good swimming ability of larger individuals (of 87 mm in average length), limited areas of investigation (mainly deepwater locations) etc. In spite of differencies in abundance indices, it should be futher obtained a series of annual abundance estimates (for 5 or 6 years, as a minimum) which will possibly be more correlated to abundance indices for yearlings (Fanning et al., 1987).

CONCLUSION

Hydrological conditions in October-November of 1989 on the Scotian Shelf were characterized by an intensification of cold Labrador water effect, as compared to the same period of 1988, not only in the intermediate layer, but in upper pre-bottom layer, especially over the central shelf water area. Intensity and depth of penetration of quasi-stationary warm drainage water inflow were less than in 1988. When carrying out a repeated hydrological survey in December-January, 1989-1990, waters of superficial and intermediate layers were of uniform character owing to cooling and convective mixing, and extension of warm slope waters over the Shelf significantly increased as compared to fall of 1989.

In autumn, 1989 hake 0-class ctaches did not mainly exceed 50 ind./trawling, being observed the most dense concentrations (more than 500 ind./trawling) in distinct gradient zones, as in previous years. Abundance index for the 1989 year-class hake 0-group (79 ind./trawling) turned to be twice less than average multiannual value for 1981-1989. Young hake length composition (of 2-10 cm in length, 5.8 cm average length) in the catches by IYGPT trawl is similar to those for 1983 and 1985 and evidences the massive spawning late in June or early in August, as usual. Following the accompanying research work (hake egg and larvae sampling with a plankton net), it was stated that hake spawning could be continued during the season later than in October, i.e. in November.

In winter of 1989-1990 major young hake concentrations of 1989 year-class (55-157 ind./trawling) were encountered close to Emerald Hollow and La Have Hollow, where an intensive inflow of warm slope waters was observed. Their abundance index was twice less than the autumnal one or 35 ind./trawling. The failure to coincide the indices is evidently attributed to a number of reasons related with the young hake inaccessibility to fishing gears. Bimodality which appeared obviously as a result of two egg portions spawned in August and September was observed in fry length composition.

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Table 1

Distribution of young hake abundance in catches by IYGPT Trawl relatively to depth in autumn, 1989

Depth, m	Total catch, ind.		Average catch per trawling, ind.	Number of empty trawlings		Number of trawlings	
	n	%		n	%	n	%
0-100	541	6	15	11	10	37	34
101-200	7858	84	140	6	5	56	51
201-300	908	10	53	2	2	17	15
Total	9307	100	85	19	17	110	100

Table 2

Distribution of young hake abundance in catches by IYGPT Trawl relatively to depth in winter, 1990

Depth, m	Total catch, ind.		Average catch per trawling, ind.	Number of empty trawlings		Number of trawlings	
	n	%		n	%	n	%
0-100	6	1	1	4	6	5	7
101-200	1433	62	29	4	6	50	70
201-300	866	37	54	4	6	16	23
Total	2305	100	32	12	18	71	100

Table 3

Abundance indices for the Scotian silver hake 0-class in 1981 through 1989

Years	Survey area, strata ≠	Number of trawl-ings	Survey area, square miles	Young fish average number per trawlings $\bar{X}$	Total abundance of yonug fish, 10^7 ind.	Standard deviation S.E.	Coefficient of variation, % $\frac{S.E.}{\bar{X}}$
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
1987	53-81	109	26502	79	21	27	34
1988	53-81	111	26502	125	33	23	19
1989	53-81	110	26502	79	21	12	15
average	-	-	-	179	42	-	-

* Abundance indices are not authentic because of late terms of silver hake massive spawning

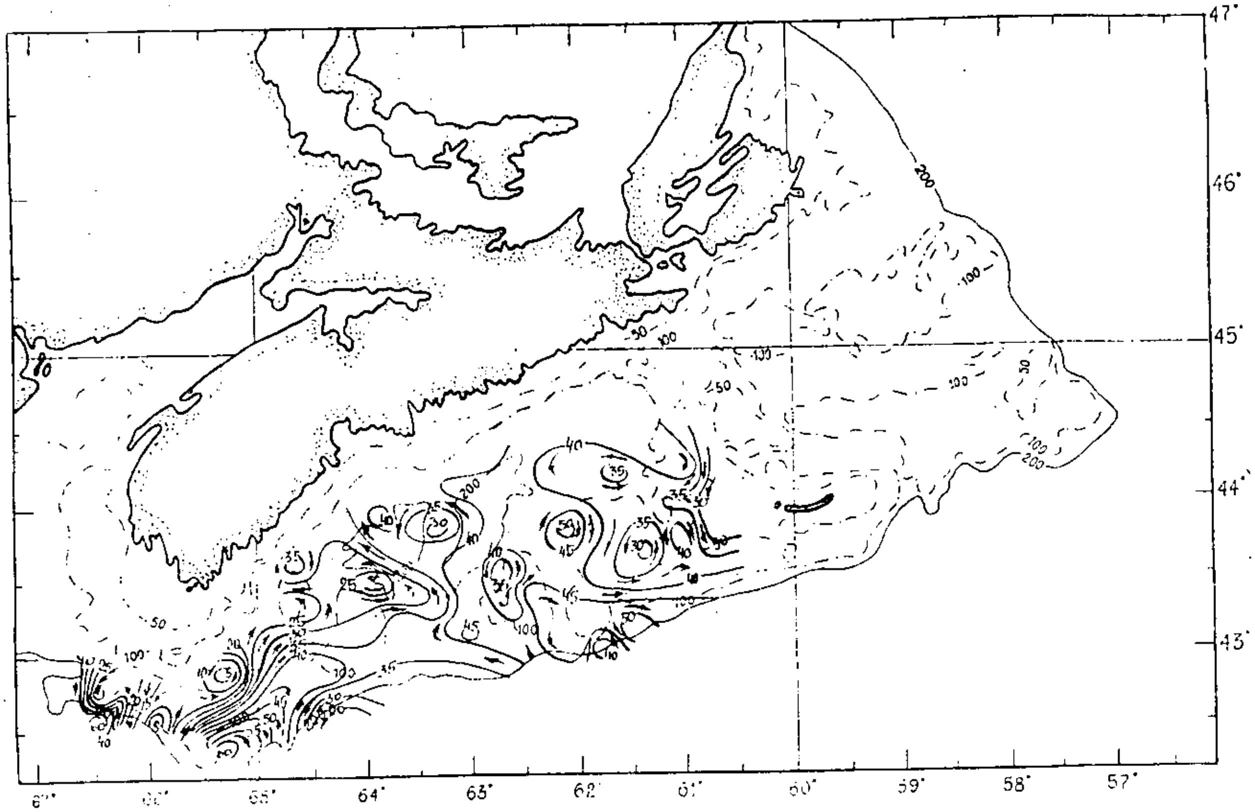

Fig. 1. Topography of 11°C isothermal surface (19.10-13.11.89).

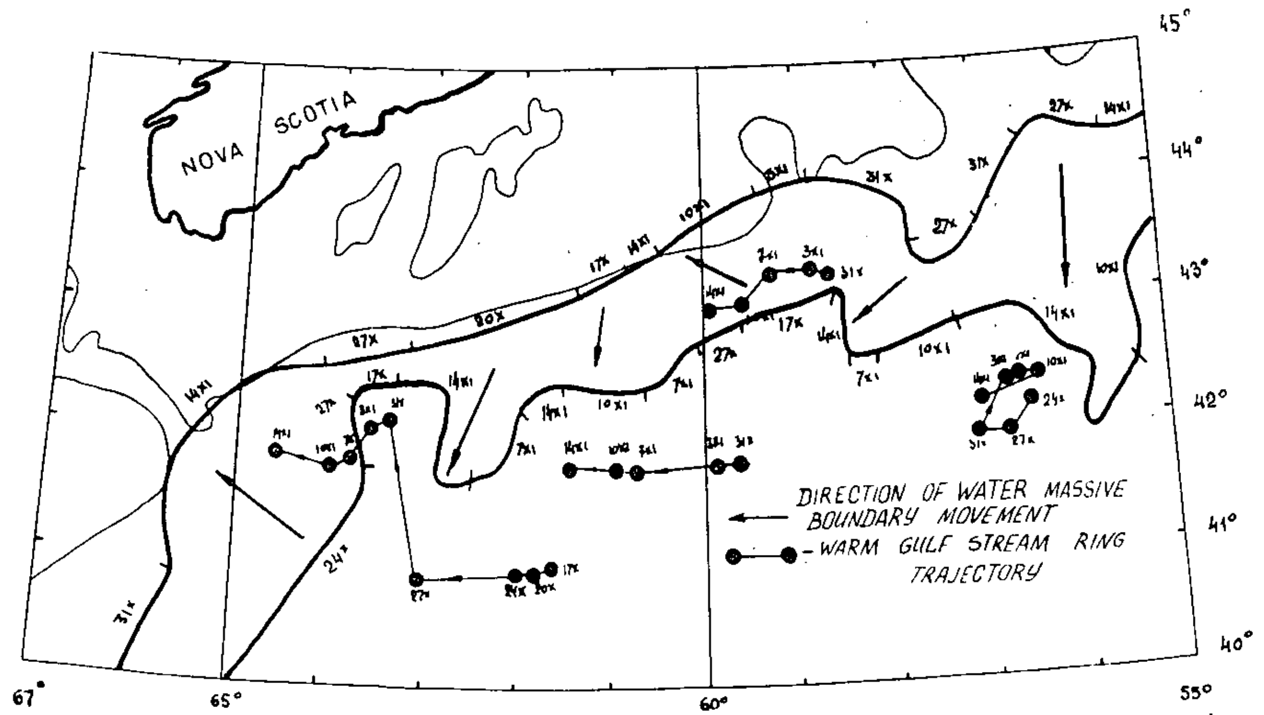

Fig. 2. Dynamics of slope water northern boundary (17.10-14.11.89).

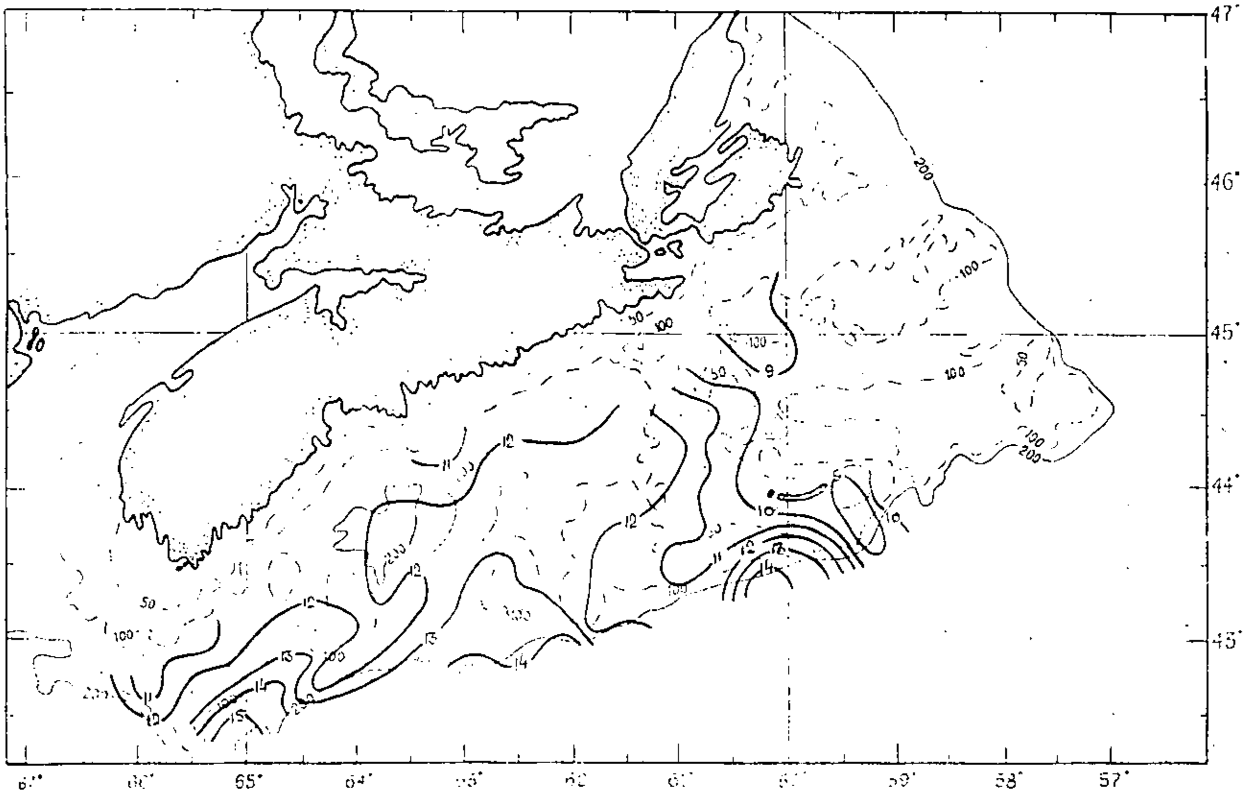

Fig. 3. Water temperature distribution at the depth of 0 m (19.10-13.11.89).

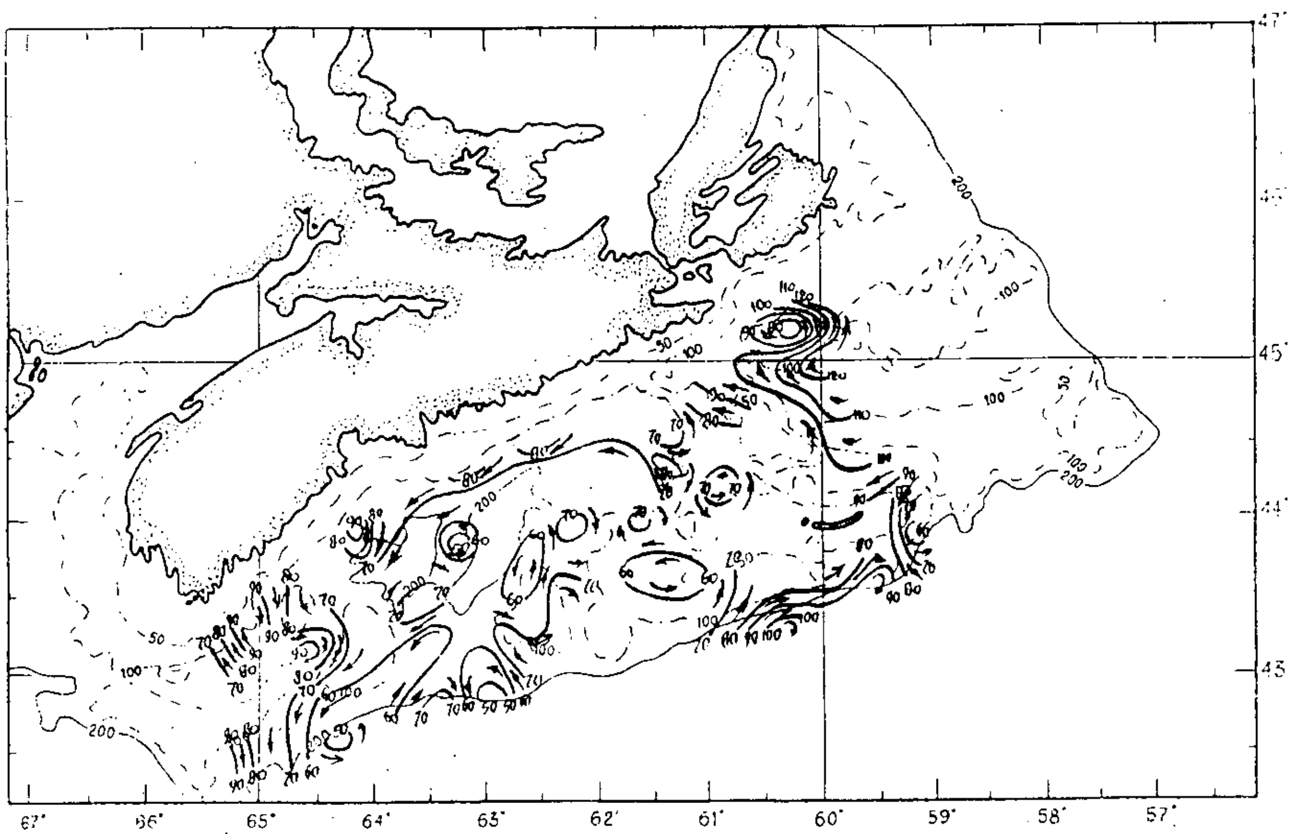

Fig. 4. Topography of water temperature minimum in intermediate layer (19.10-13.11.89).

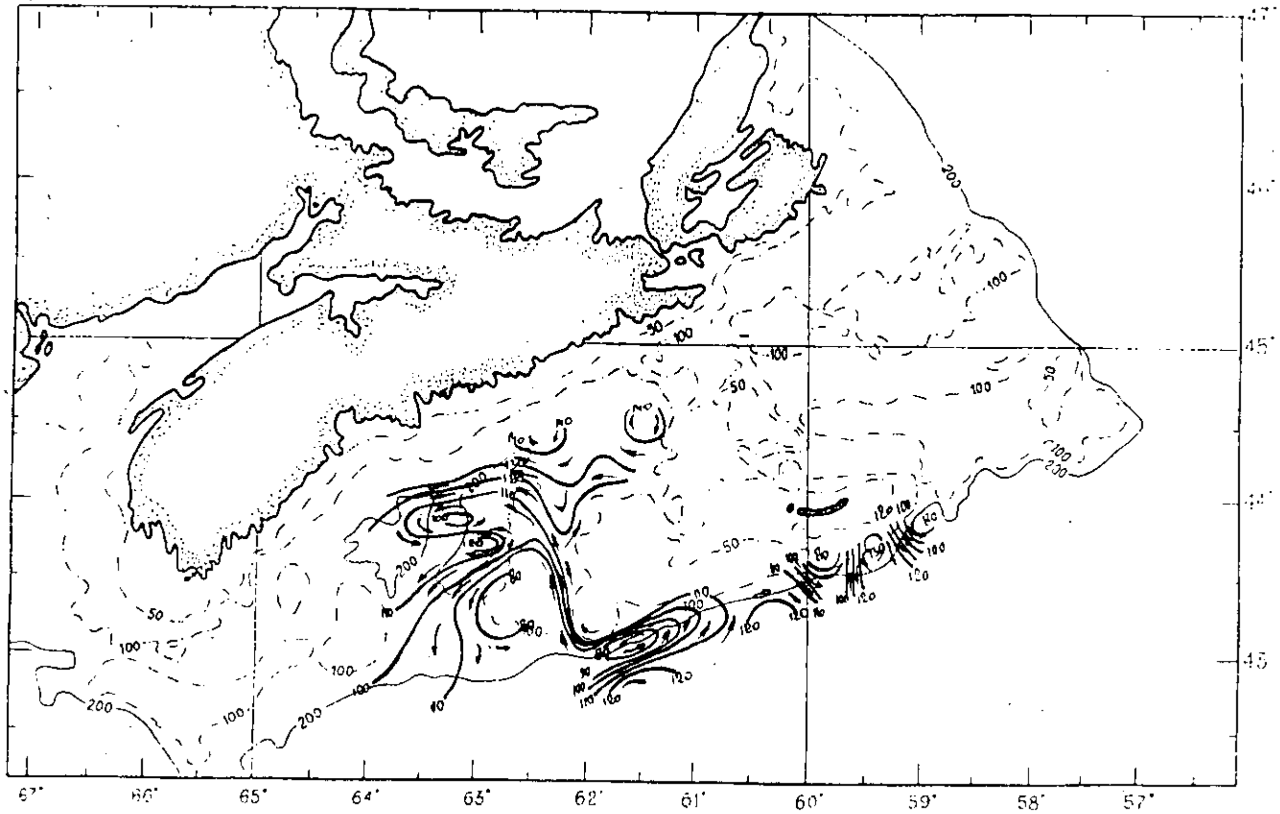

Fig. 5. Topography of 7°C isothermal surface over the bottom (19.10-13.11.89).

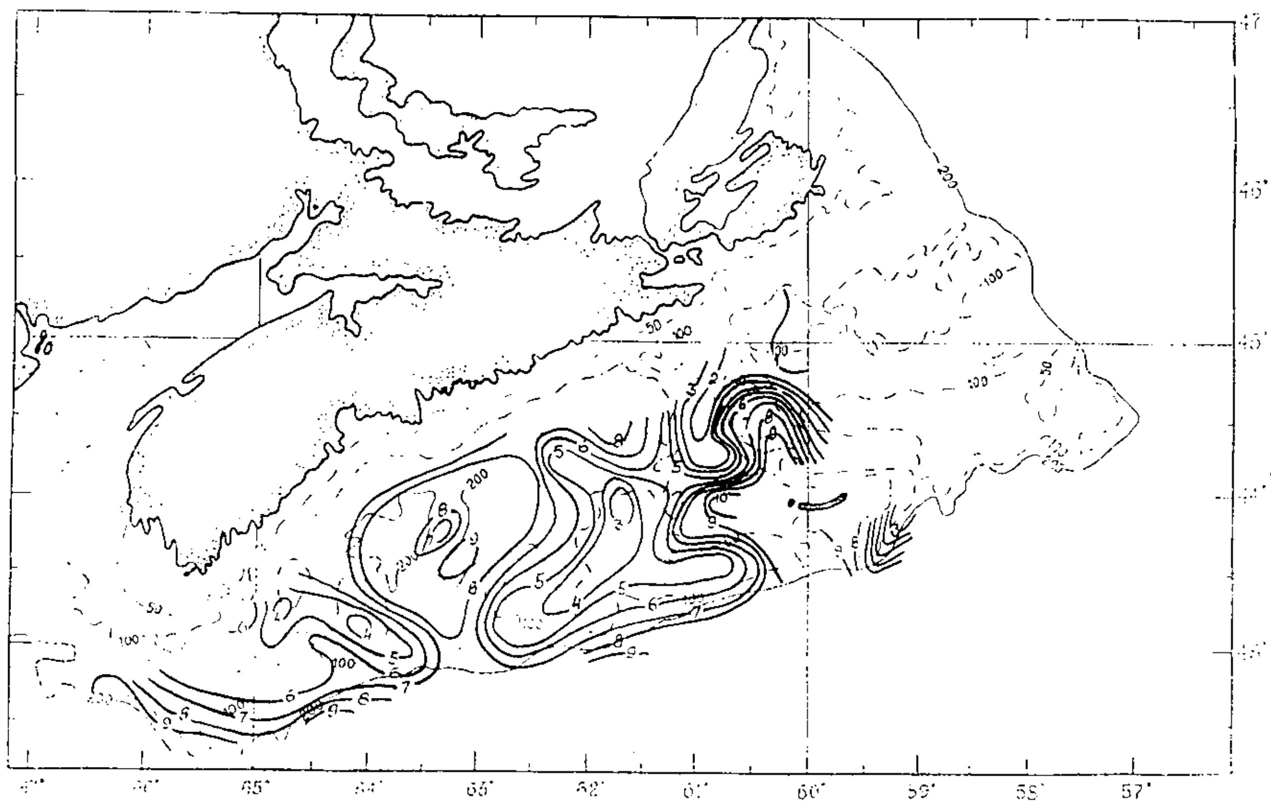

Fig. 6. Water temperature distribution over the bottom (19.10-13.11.89)

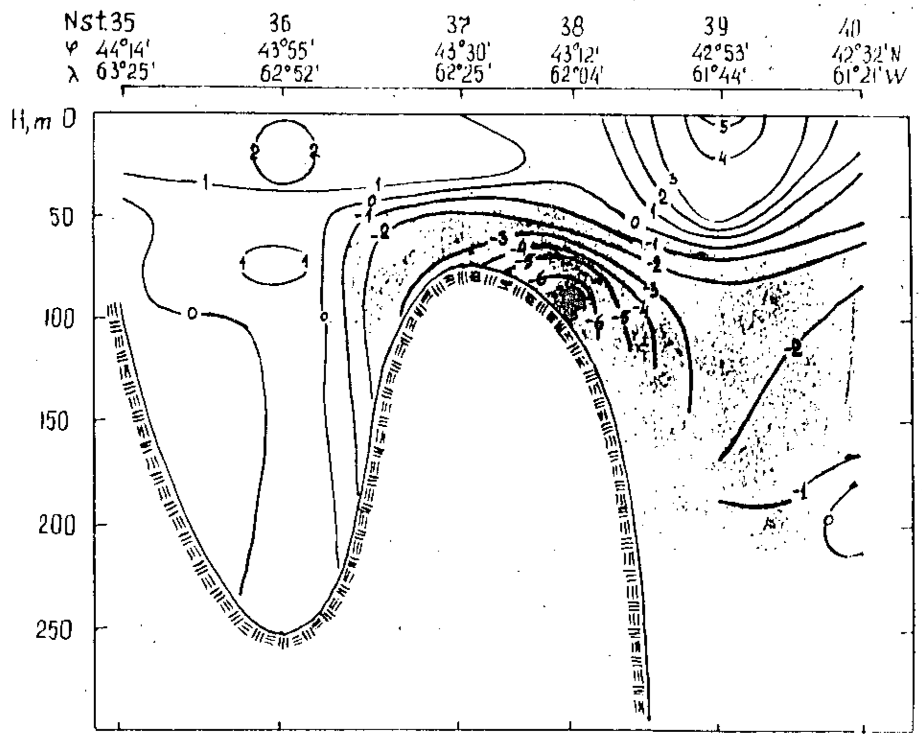

Fig. 7. Water temperature variations in Halifax section in November 1989 as compared to November 1988.

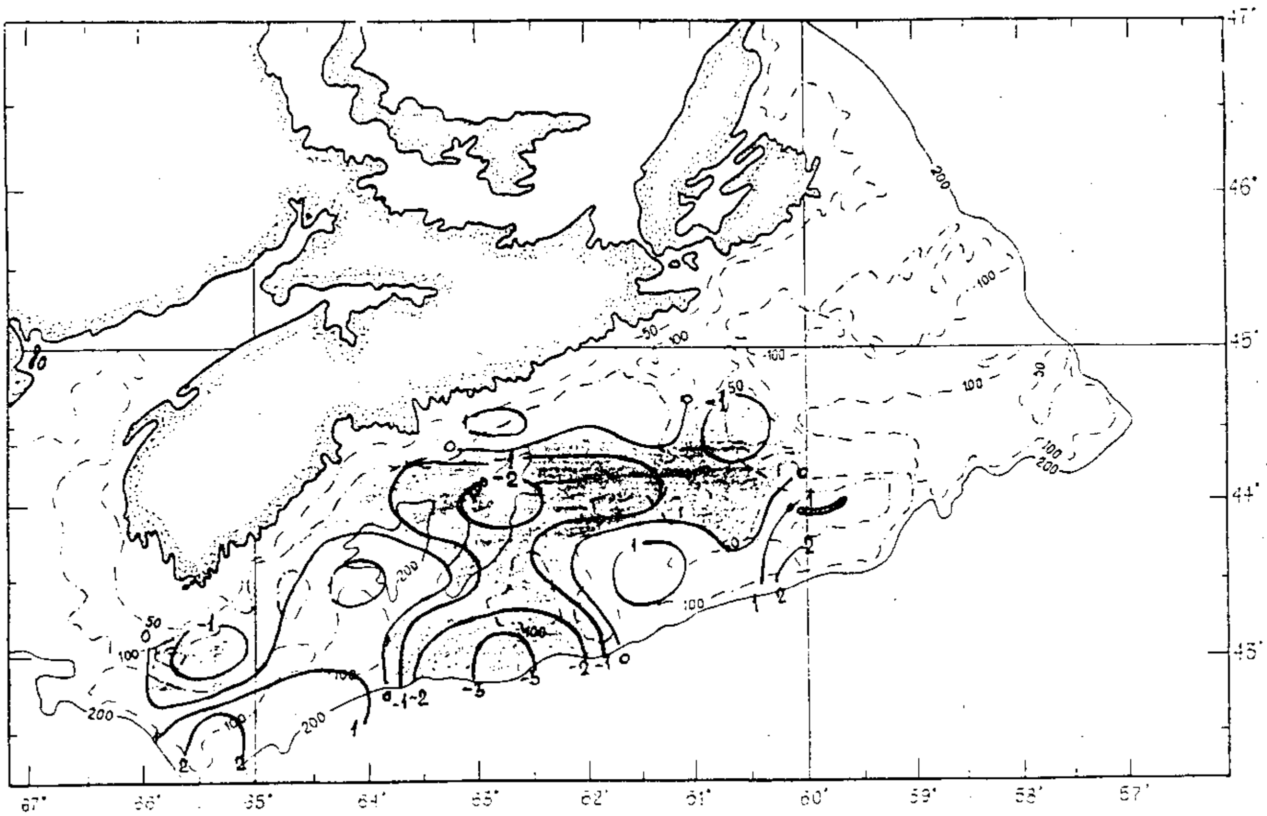

Fig. 8. Fields of positive temperature variations.

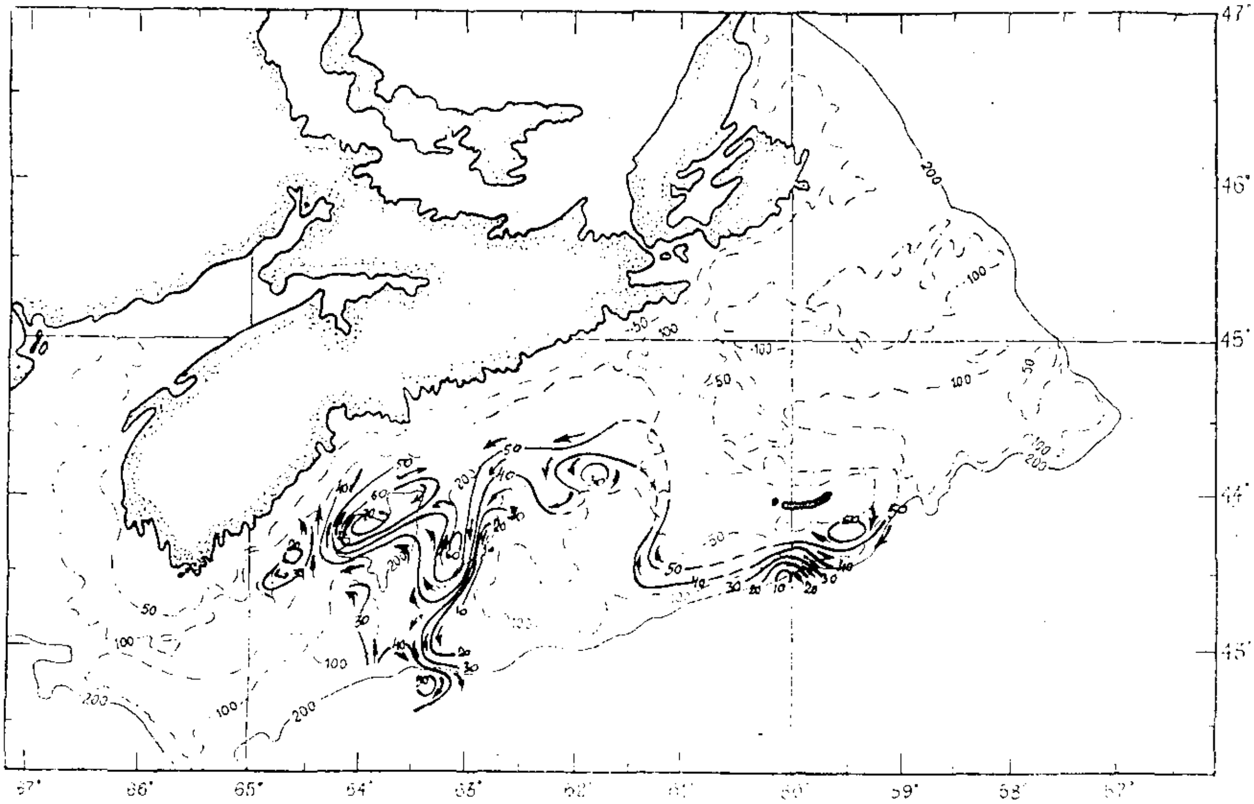

Fig. 9. Topograpfy of 2°C isothermal surface (23.12.89-08.01.90).

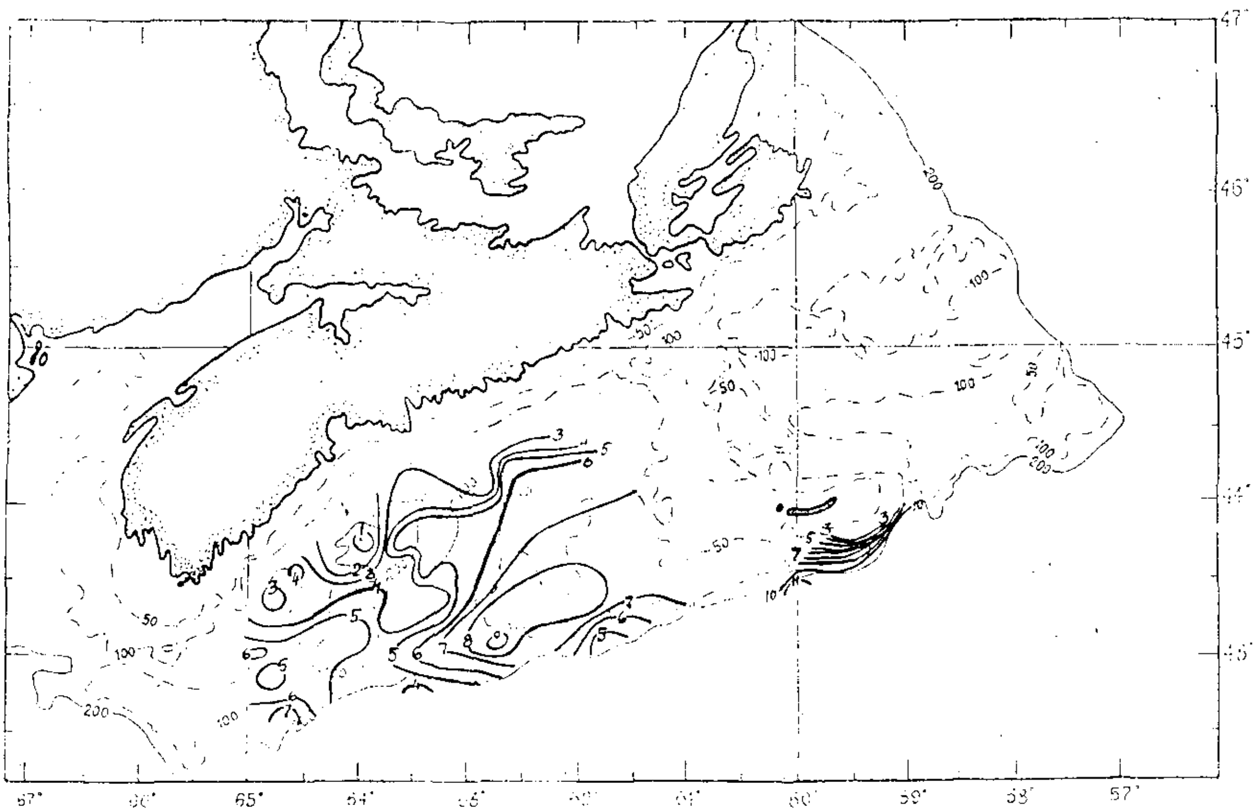

Fig. 10. Water temperature distribution at the depth of 75 m (23.12.89-08.01.90).

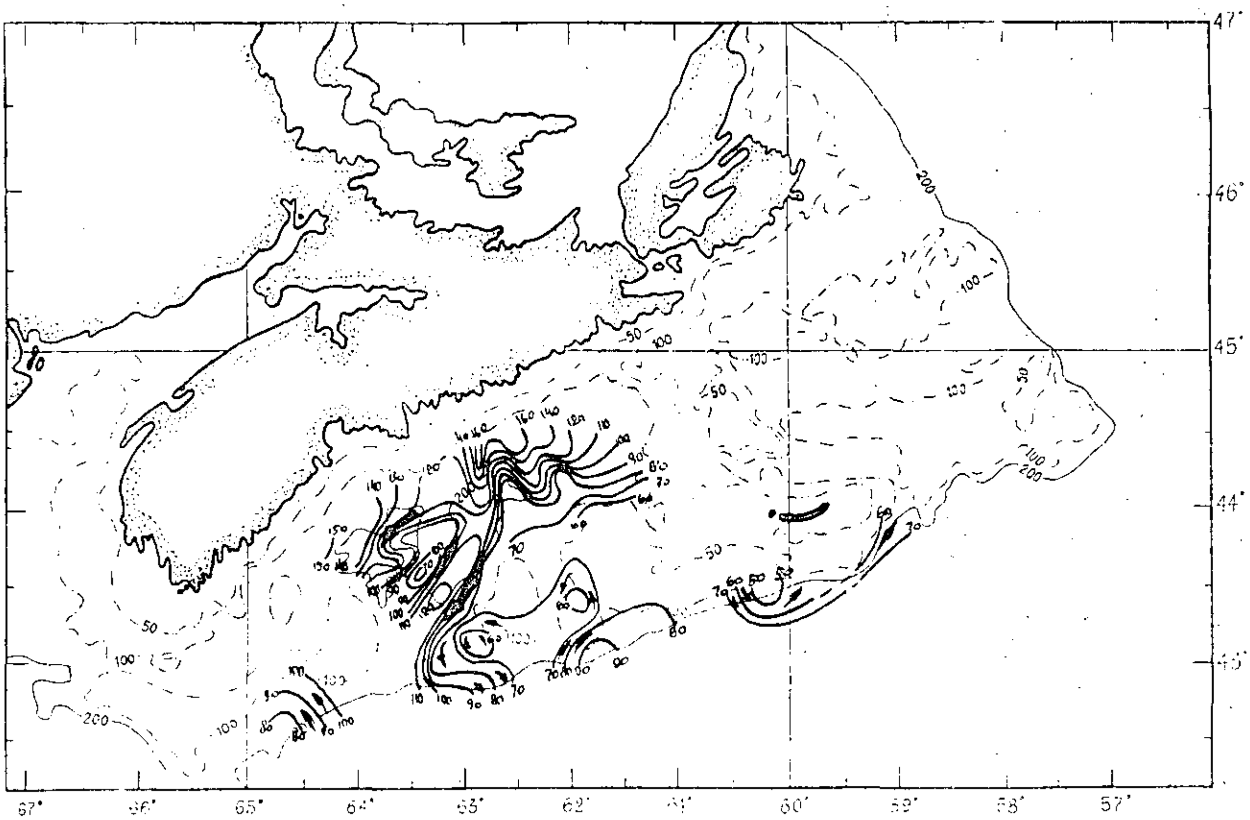

Fig. 11. Topography of 7°C isothermal surface (23.12.89-08.01.90).

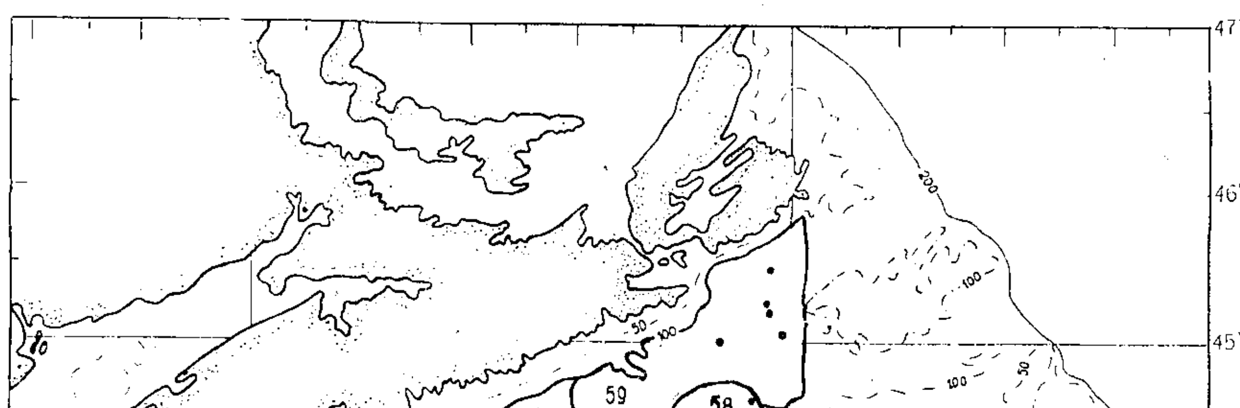

Fig. 12. Station locations for fry trawl survey (19.10-13.11.89).

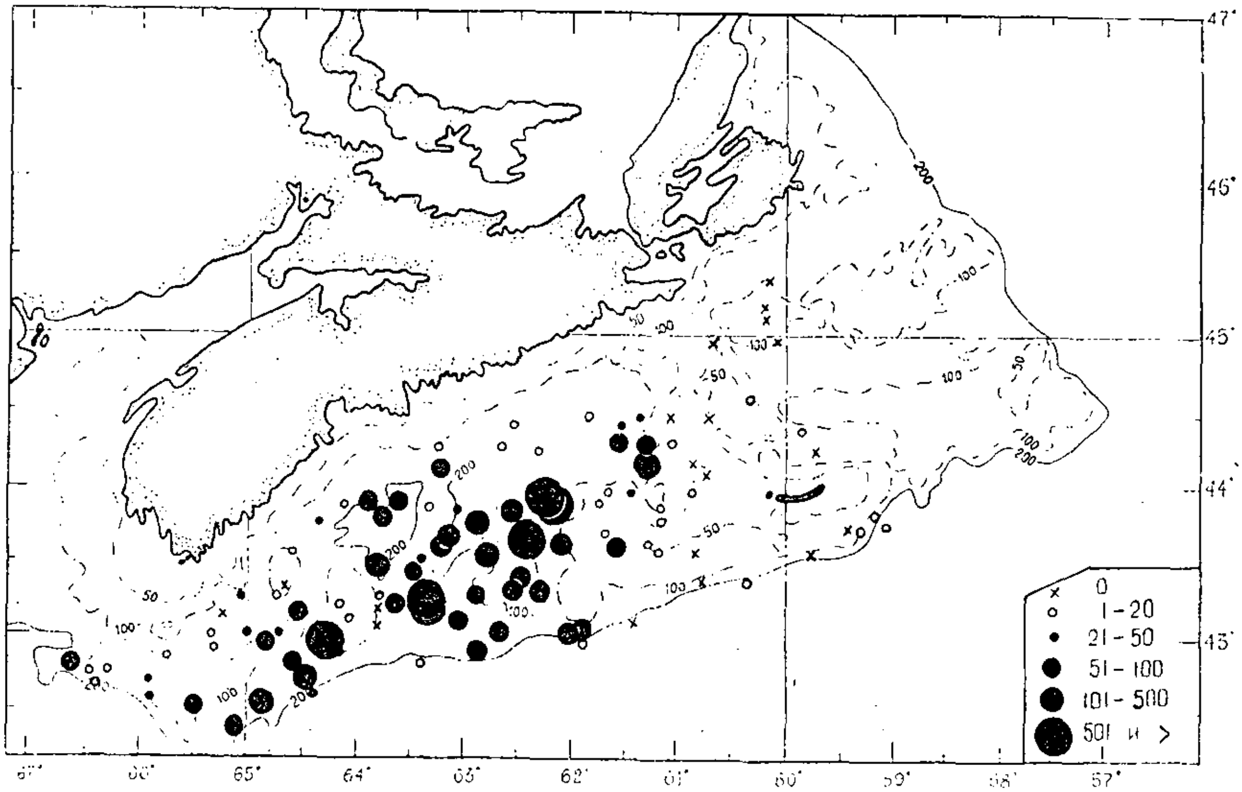

Fig. 13. Young silver hake distribution, ind./trawling (19.10-13.11.89)

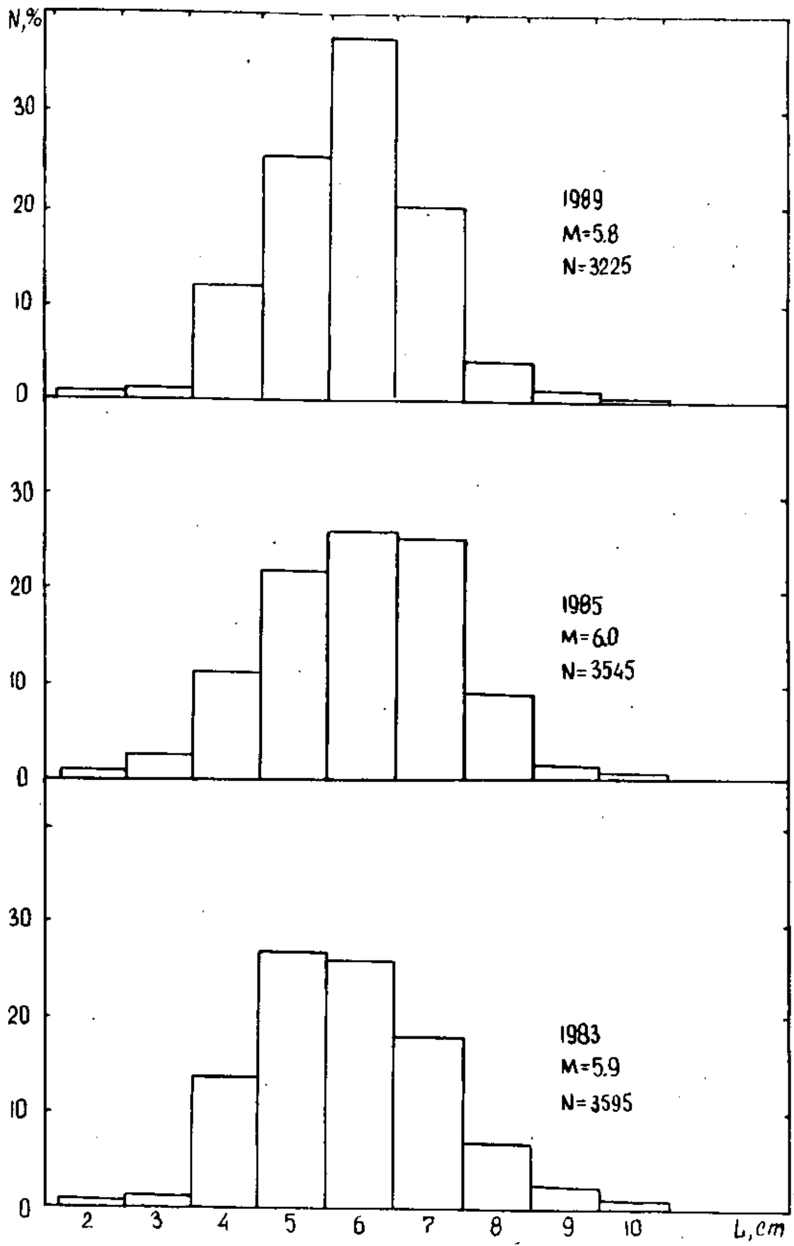

Fig. 14. Young silver hake length composition (I half of November).

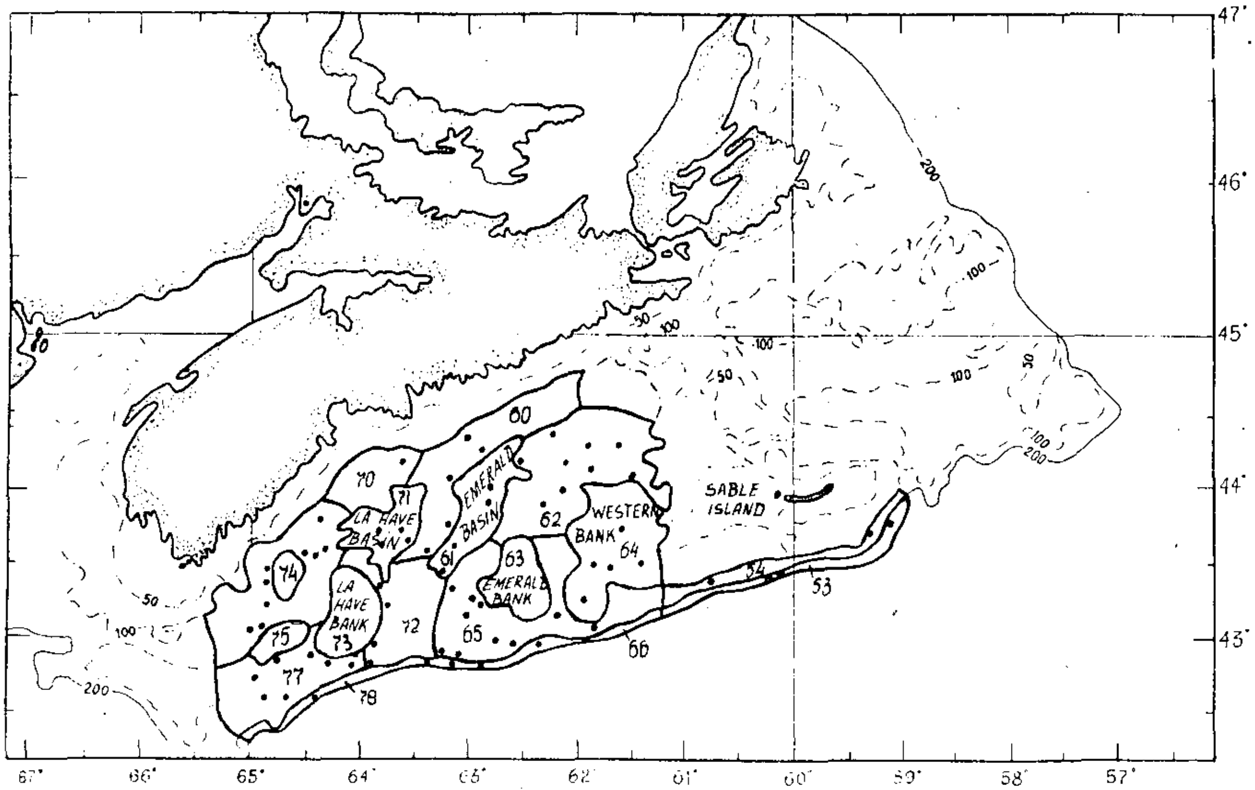

Fig. 15. Station locations for fry trawl survey (23.12.89-08.01.90).

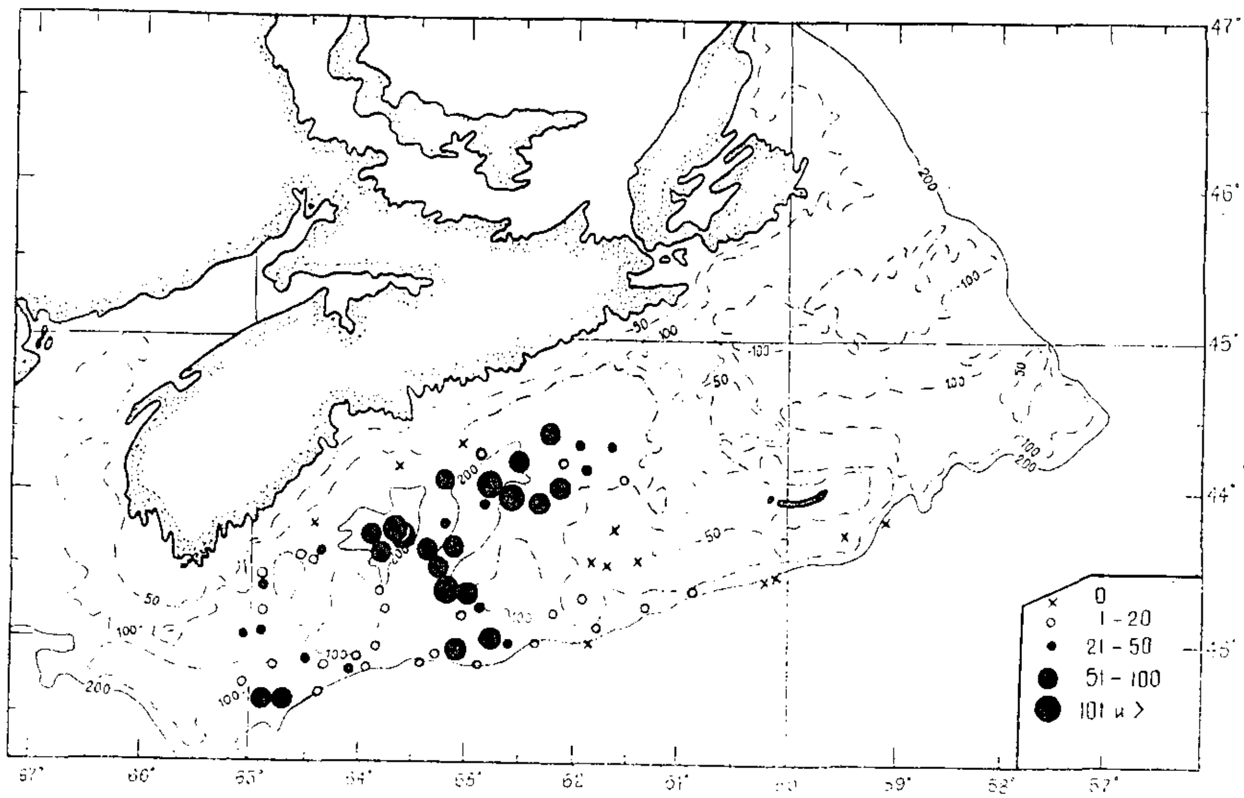

Fig. 16. Young silver hake distribution, ind./trawling (23.12.89-08.01.90).

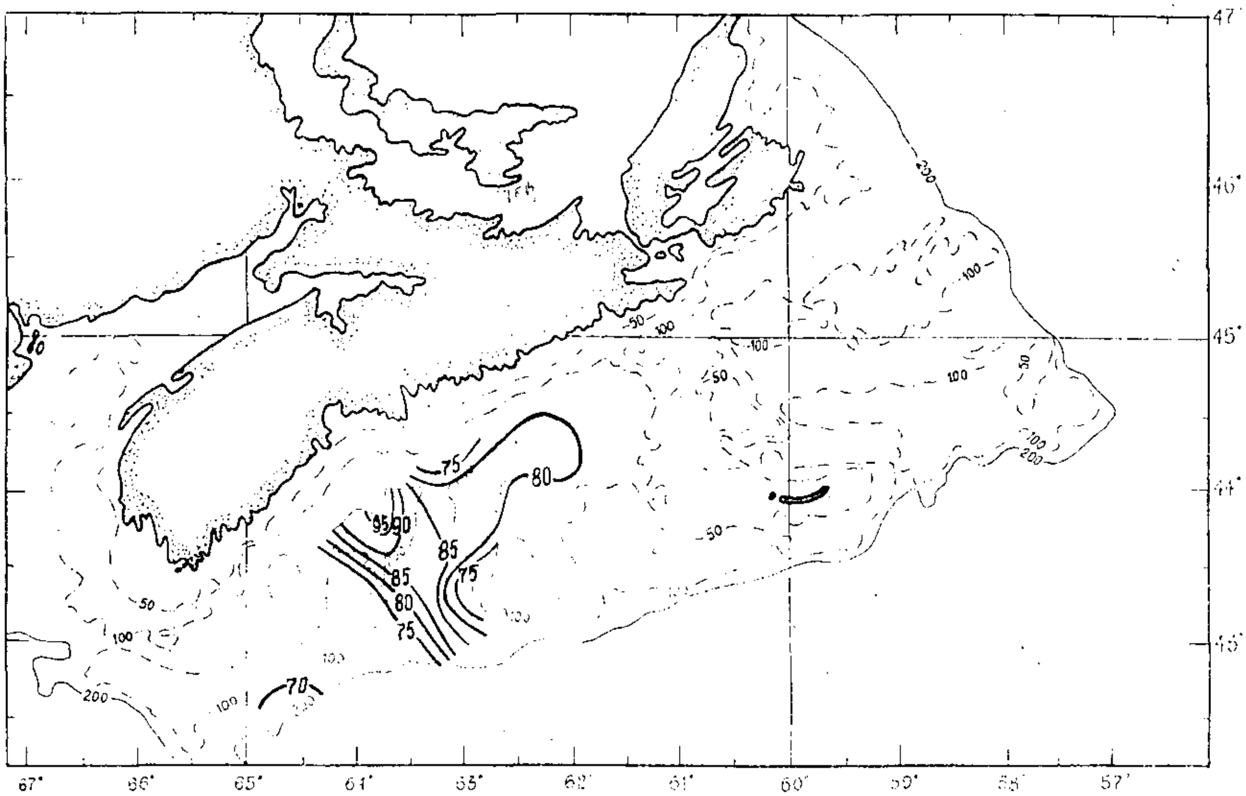

Fig. 17. Young silver hake distribution, average length in mm (23.12.89-08.01.90).

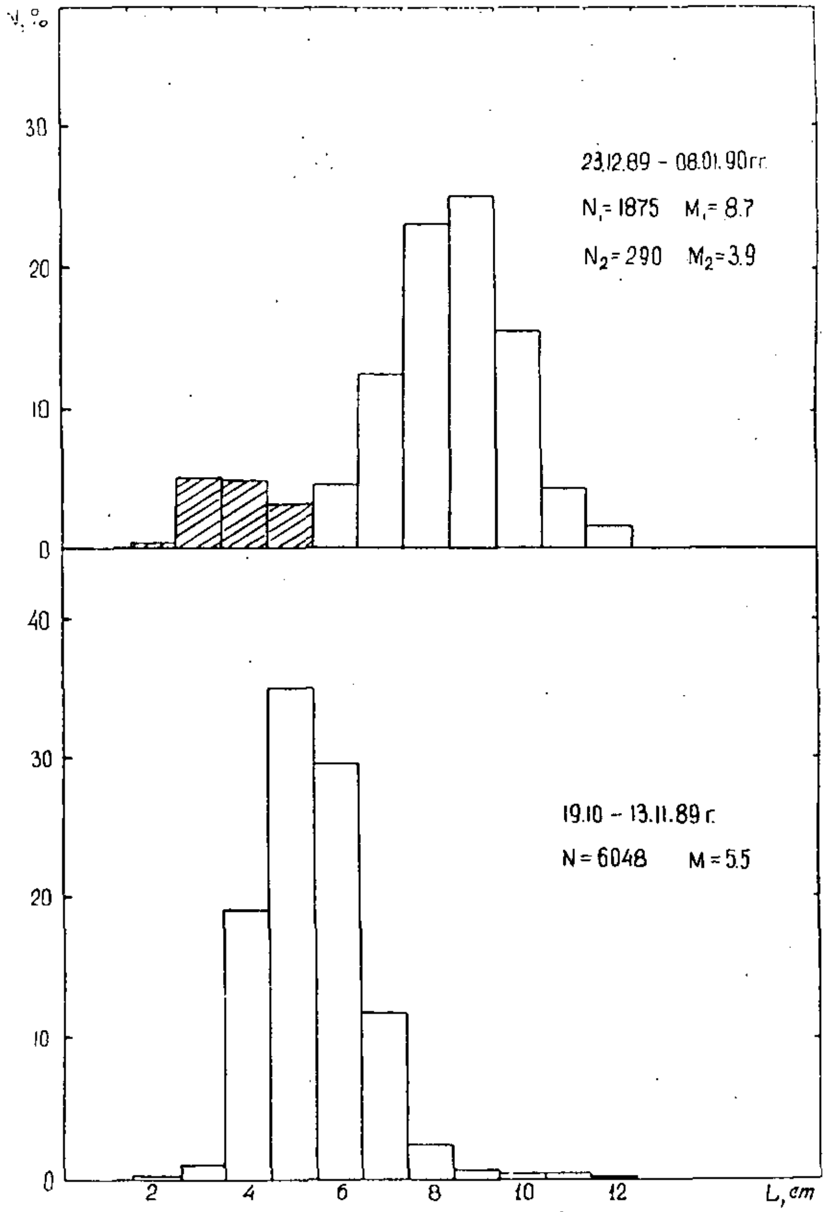

Fig. 18. Dynamics of length composition of 1989 year-class young silver hake.