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Vertical Migrations and Feeding of the Scotian O-group Silver Hake in November 1985

by

A. I. Sherstyukov and G. I. Nazarova

Atlantic Research Institute of Marine Fisheries & Oceanography (AtlantNIRO)
5 Dmitry Donskoy Street, Kaliningrad, 236000, USSR

ABSTRACT

Results of joint studies of the USSR and Canadian scientists carried out in November 1985 on the Scotian Shelf and aimed at the studying of the vertical migrations of the young silver hake relative to the temperature structure and feeding intensity are presented.

INTRODUCTION

The knowledge of regularities of diurnal distribution of the fish is an indispensable condition for improving the strategy for the O-group fish surveys aimed at the determination of the year class abundance. The studies of vertical distribution of the young silver hake carried out in October 1980 on the Scotian Shelf have shown that the fish perform diurnal migrations (Koeller, 1981). However no clarity has been introduced in elucidating the reasons causing diurnal ascents of the fish to the surface. That is why, the studies of diurnal vertical migrations of the young hake in relation to temperature structure, light and feeding intensity were conducted by the scientists of the AtlantNIRO (USSR, Kaliningrad) and of the Marine Fish Department of the Bedford Oceanographical Institute (Canada, Darthmouth) in November 1985.

MATERIALS AND METHODS

Experimental studies were carried out on the SRTM-8095 "Tava" in the area of the massive young fish aggregations westward and eastward of Browns Bank (Fig. 1), where different types of water masses were observed (thermal-homogeneous and stratified). The fishing gear used was the IYGPT trawl fitted with the karpon netting with the mesh size of 50 to 10 mm, and 6.5 mm in the codend. The hauling at each of the two stations made in different water massives (homogeneous and stratified) continued over two days. The hauls were made daily for 16 hours (from 0 to 16.00 hrs in the first day, and from 8.00 to 24.00 hrs. in the second day). The working time was divided into four periods. During each period three successive hauls were made at the following horizons: near bottom (2-4 m off the bottom, intermediate (usually in a stratified layer) and subsurface (3-5 m from the surface). The haul duration was 30 minutes at the velocity of the vessel of 3.5 knots. The water temperatures were measured after each second haul using the XBTs. The light intensity in the daytime was measured by means of the deck cell transducer submerged on the lighted side of the vessel. All primary materials of these observations are being processed by the Canadian scientists, therefore, the light factor is missing in the analysis of the young hake distribution. For the feeding intensity studies, a sample of the young hake was taken from each catch. All collected and processed materials are presented in Table 1.

Each catch was sorted out by species, and measurements of the maximum absolute length (from the tip of the snout to the end of the caudal fin) of the young fish of all the species (approximately 350 specimens) were taken to within 1 mm. If the number of specimens in a sample exceeded 350, they were counted, and a subsample of 350 specimens was taken for measurements. After measurements each length class was converted to the whole sample using the linear conversion factor obtained from the subsample to sample ratio.

In processing the materials on the young silver hake feeding the "Methodical manual on feeding studies and food relations of the fish in the nature" (1974) was used. The fry were weighted to within mg, and then preparated under the binocular microscope. Organisms contained in the intestine were sorted out, identified and measured. The food organisms were arranged by species and group and counted. Their initial weight was determined by means of the tables of weight characteristics of the zooplankters of the North Atlantic Seas (Bogorov, 1939; Kanaeva, 1962). All the results have been combined by the following size groups: 20.0-29.9 mm, 30.0-39.9 mm, etc. The feeding intensity has been estimated from the proportion of the food containing fry and consumption indices (in $^{o}/_{ooo}$). The consumption index is the ratio of the weight of food organisms to the weight of food containing fry of the given size group.

RESULTS

Peculiarities of vertical distribution of the young hake

The preliminary studies on the vertical distribution of the young hake carried out in October, 1980 showed that the fish is uniformly enough distributed in the water column in the daytime, and is almost missing in the catches taken in the pelagial (Koeller, 1981).

Similar studies conducted in November, 1985 showed that the young silver hake still performs diurnal vertical migrations during that time (Fig. 2). The thermocline layer does not affect these migrations significantly. The young hake crosses the zone of temperatures of 5-9°C twice a day. The largest recorded catches were from the upper layer (0-65 m) in the night hours, between the twilight and the dawn. The young hake evidently form shoals at night, which change their position in the water column. When the hauling depth coincides with the shoal position, large catches are taken (Figs. 2A, 2B). In the daytime, the youngs are absent from the pelagial, with insignificant aggregations (0.1-5%) retaining in the near bottom layer. Main aggregations, avoiding the day light, probably keep close to the ground (Bowman R. et Bowman E., 1980).

Sometimes this distribution pattern undergoes changes. For example, considerable numbers of the young fish (10%) were observed in the daytime in the pelagial, at the 65 m depth (Fig. 2A). It also happens that the fish do not rise to the upper layers at night. So, during the experimental studies in October, 1983, large aggregations of the silver hake were fished near the bottom at night, from 27 to 28 October, before the storm (Noskov et Sherstyukov, 1984). These behavioural peculiarities of the young silver hake emphasize the importance of reasons determining the diurnal migrations.

The studies of the vertical distribution of the young hake in November 1985 revealed that the fish had been still associated with the pelagial. This statement is supported by the variation of the average length of the fish during the day (Fig. 3). At night, the larger individuals (70-80 mm in length) occur in numbers both near the bottom and at the surface. With the dawn, the mean length of the youngs in the catches decreases, which is especially well observed at the station with stratified waters.

Food composition and feeding intensity

The results of the quantitative - weight analysis of the young silver hake stomach contents indicate that the euphausiids are the main food organism (mostly the North Atlantic species Meganyctiphanes norvegica) constituting 65-100% of the total weight (Tables 2,3). As is evident from Table 3, the smaller specimens (20.0-29.9 mm in length) consume different Copepoda 2.8 to 3.2 mm in length, the proportion of which averaged to 59.3%. The larger fish (100.0-109.0 mm) are noted for the cannibalism (Tables 2,3). On the whole, no significant differences were found in the diet of the young hake caught at the stations with diverse types of water masses.

In Fig.4 the indices of the young silver hake stomach fullness in different hours of the day at the stations with the homothermal (Fig. 4A) and stratified (Fig. 4B) waters. In both cases, the highest index of stomach fullness was recorded at night, remaining relatively low during the day. The mean number of the euphausiids found in the hake stomachs changed similarly (Fig. 5). The only exception was the case, when a large number of the young fish (10%) with a high index of fullness (790°/₀₀₀) (Fig. 4A) was caught in the daytime (9 hrs. 35 min.) at the 65 m depth (Fig. 2A). This rise in the feeding intensity of the young fish in the morning can be attributed to better conditions for catching the prey due to increased illumination. According to Girsa (1962), the sight in the gadoids plays an important role in catching the prey. During the feeding period, the young hake are characterized by a large proportion of the feeding specimens. Even in the youngs 50-80 mm in length, which comprised the majority of the fish caught, the average indices of stomach fullness were the highest (482-2 204 $^{o}/_{ooo}$) (Tables 2,3).

DISCUSSION

Diurnal vertical migrations is a complex phenomenon directly related to illumination conditions. Some workers relate the rise of the fish to the upper water layers to the fact that the digestion proceeds more intensively in the warmer surface waters (Manteifel, 1955). At the same time, there exists an opinion that the temperature gradient is an insuperable barrier for the fish, and, consequently, they have to form aggregations in the thermocline layer (Schnakenbeck, 1952). However the majority of the investigators believe that the nocturnal rise of the plankton-eaters is of the trophic character (Lebour, 1924; Zusser, 1956, 1966), and the morning discent of the fish to lower water layers can be regarded as a protective measure against the predators (Manteifel, 1961).

The study of the diurnal vertical migrations of the young silver hake on the Scotian Shelf, and the analysis of the literary data on vertical movements of the planktonophagous fish allowed us to assume that the nocturnal rise of the youngs to the upper layers can be related to their feeding on the euphausiids (Meganyctiphanes norvegica) that perform diurnal vertical migrations in November (Mauchline, Fisher, 1969). In the daytime these crustaceans keep close to the bottom (at 100-150 m depth) and begin to rise to the surface at about 16.00 hrs. Some specimens reach the surface at about 20.00 hrs. and stay there till the dawn, and the rest distribute between the surface and the bottom. By 08.00 hrs. the crustacean populations descends nearly to the bottom. On the other hand, according to Zelikman (1961), the shoaling euphausiids can be observed at the surface in the daytime as well. These phenomena await for elucidation.

The shoaling way of living during the feeding period typical of many fish species is a very important adaptive feature providing for an increased food supply for the population. During the feeding period a shoal usually performs a double function: it facilitates finding and yielding the food, on one hand, and provides protection, on the other hand (Manteifel and Radakov, 1960). The protective role of the shoal is lost by many fish species at some stages of the onthogenesis. It is more peculiar to earlier stages. After the example of the relations of the cod (predator) and the young saithe (prey) it can be deduced that multiplicity of the prey and protective manoeuvres exhibited by the shoal confuse the predator and make the prey difficult of access (Radakov, 1972). The studies of the vertical distribution of the silver hake fingerlings carried out in November on the Scotian Shelf showed that they also form shoals during the feeding period, which evidently perform protective functions. It should be noted that the migration of these shoals in the water column during the inventory surveys may considerably influence the assessment of the fingerling abundance.

CONCLUSIONS

1. In November 1985, on the Scotian Shelf, the young 0-group silver hake was observed in numbers in the layer of thermocline and above it at night, and moved to the bottom in the morning.

2. The nocturnal rise of the young fish to the upper layers is related to their feeding on the euphausiids (Meganyctiphanes norvegica), which perform diurnal vertical migrations in November, and represent the main food item for the hake (65-100% in weight).

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Table 1 Amount of the materials used

Date	Hauling depths	Station type	No.of hauls	No. of young fish samples	No. of analysed specimens
18-19.11.85	160-65-3	Homothermal	24	18	222
21-22.11.85	110-50-3	Stratified	24	18	244
T o t a l			48	36	466

Table 2

Food composition (% in weight) of the young silver hake at the station with homothermal waters

Food organisms	40.0-49.9		50.0-59.9		60.0-69.9		70.0-79.9		80.0-89.9		90.0-99.9		100.0-109.9	
	mm	%	mm	%	mm	%	mm	%	mm	%	mm	%	mm	%
Copepoda	1.4-1.8	0.5	1.2-2.8	0.2	2.0-3.2	traces								
Amphipoda	7.8-8.0	2.0			18.0	0.1	12.0-17.0	0.8						
Euphausiacea	8.0-18.0	97.5	8.0-27.0	66.5	10.0-32.0	87.2	12.0-32.0	84.0	16.0-32.0	94.7	30.0	100.0	27.0-30.0	95.4
Decapoda			8.0-25.0	33.3	14.0-22.0	12.7	14.0-25.0	15.2	15.0-20.0	5.3				
Gastropoda			1.4	traces										
Merluccius bilinearis													16.0	4.6
No. of analysed fish	9		41		79		61		28		3		1	
No. of empty stomachs, %	11		12		9		7		-		-		-	
Average index of stomach fullness, °/ooo	286		2 204		869		782		535		453		691	

Table 3 Food composition (% in weight) of the young silver hake at the station with stratified waters

Food organisms	20.0–29.9		30.0–39.9		40.0–49.9		50.0–59.9		60.0–69.9		70.0–79.9		80.0–89.9		90.0–99.9		100.0–109.9	
	mm	%	mm	%	mm	%	mm	%	mm	%	mm	%	mm	%	mm	%	mm	%
Copepoda	2.8–3.2	59.3	2.8–3.2	35.4	2.8–3.2	1.2	3.0–3.3	0.1										
Amphipoda					4.0	0.6	1.2–12.0	0.2			11.0	0.2						
Euphausiacea	8.0	40.7	9.0–14.0	64.6	9.0–19.0	98.2	12.0–36.0	99.6	11.0–29.0	100.0	13.0–40.0	99.7	15.0–32.0	100.0	13.0–32.0	100.0		
Gastropoda							0.8	0.1			0.7–1.5	0.1						
Merluccius bilinearis																	37.0	100.0
No.of analysed fish, sp.	5		15		27		43		55		55		34		9		1	
No. of empty stomachs, %	-		-		4		16		9		9		15		-		-	
Average index of stomach fullness °/₀₀₀	165		228		518		804		661		482		454		391		450	

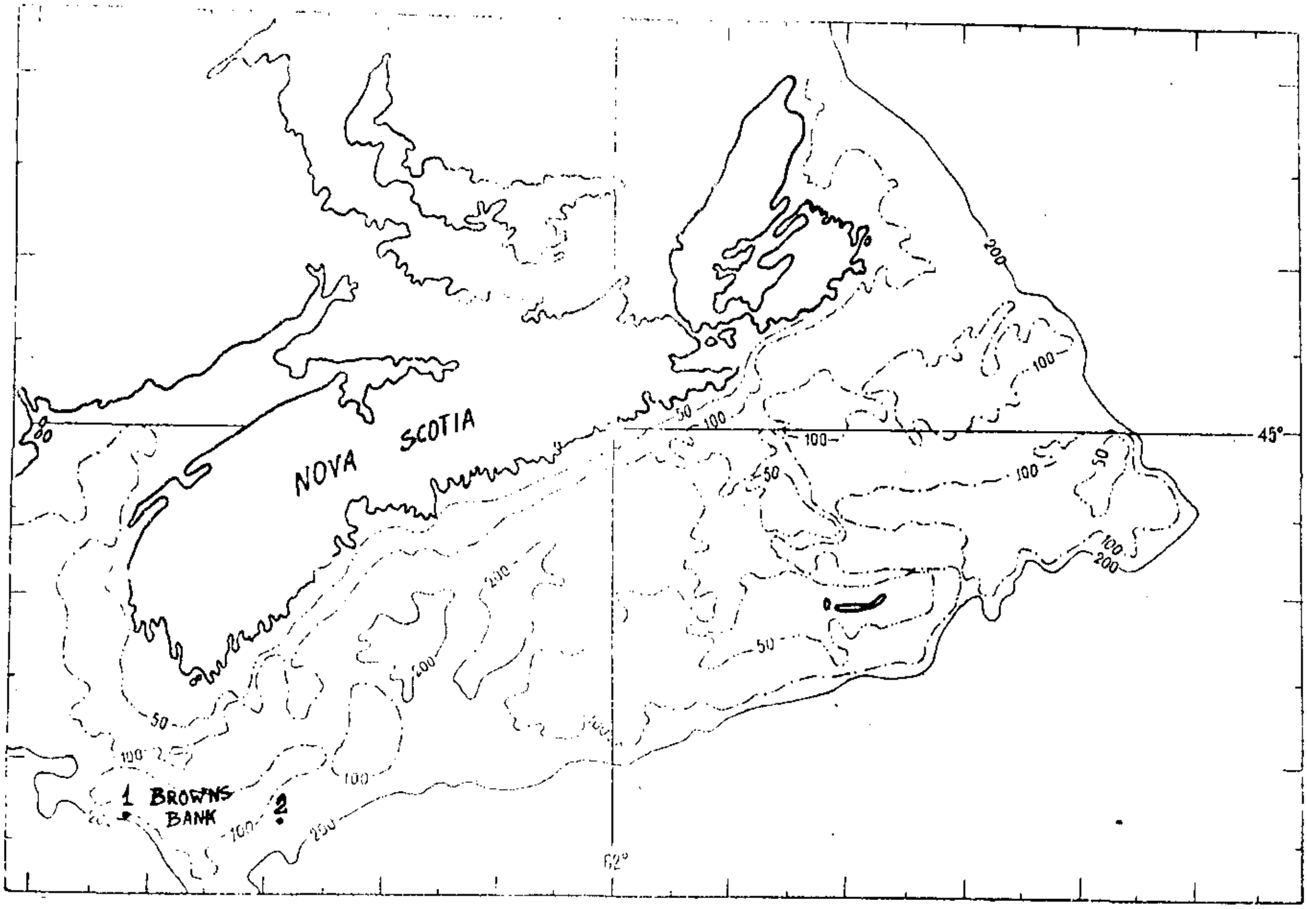

Fig. 1. Areas of experimental studies on vertical distribution of the O-group Scotian silver hake: 1 - with thermal-homogeneous waters; 2 - with stratified waters.

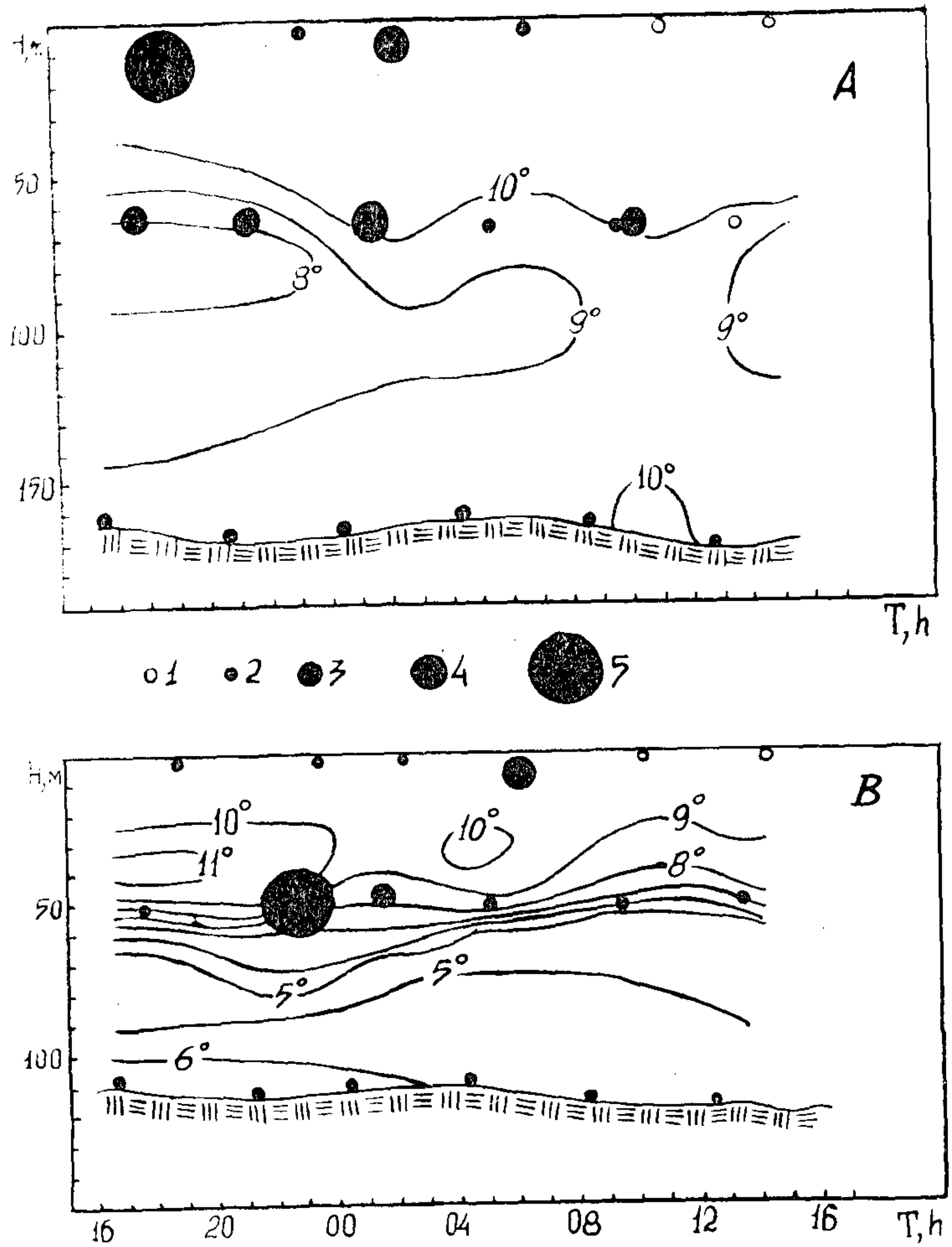

Fig. 2. Distribution of the young silver hake catches during the day at stations with homothermal waters (A) and stratified waters (B):

1-0; 2-0.1-5.0; 3-5.1-10.0; 4-10.1-20.0; 5-20.1-56.3% of the total catch.

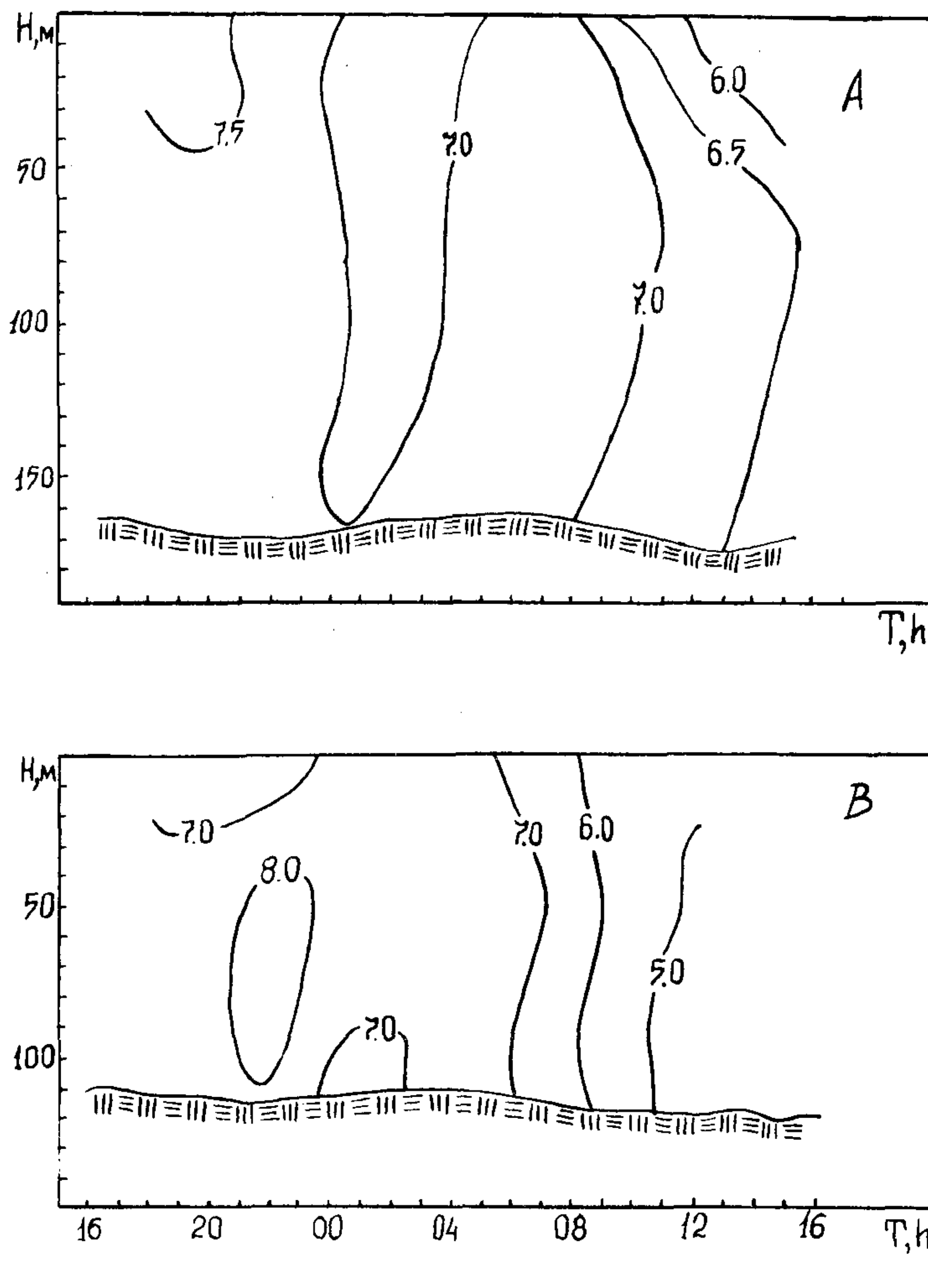

Fig. 3. Distribution of mean lengths (cm) of the 0-group silver hake during the day at stations with homothermal waters (A) and stratified waters (B).

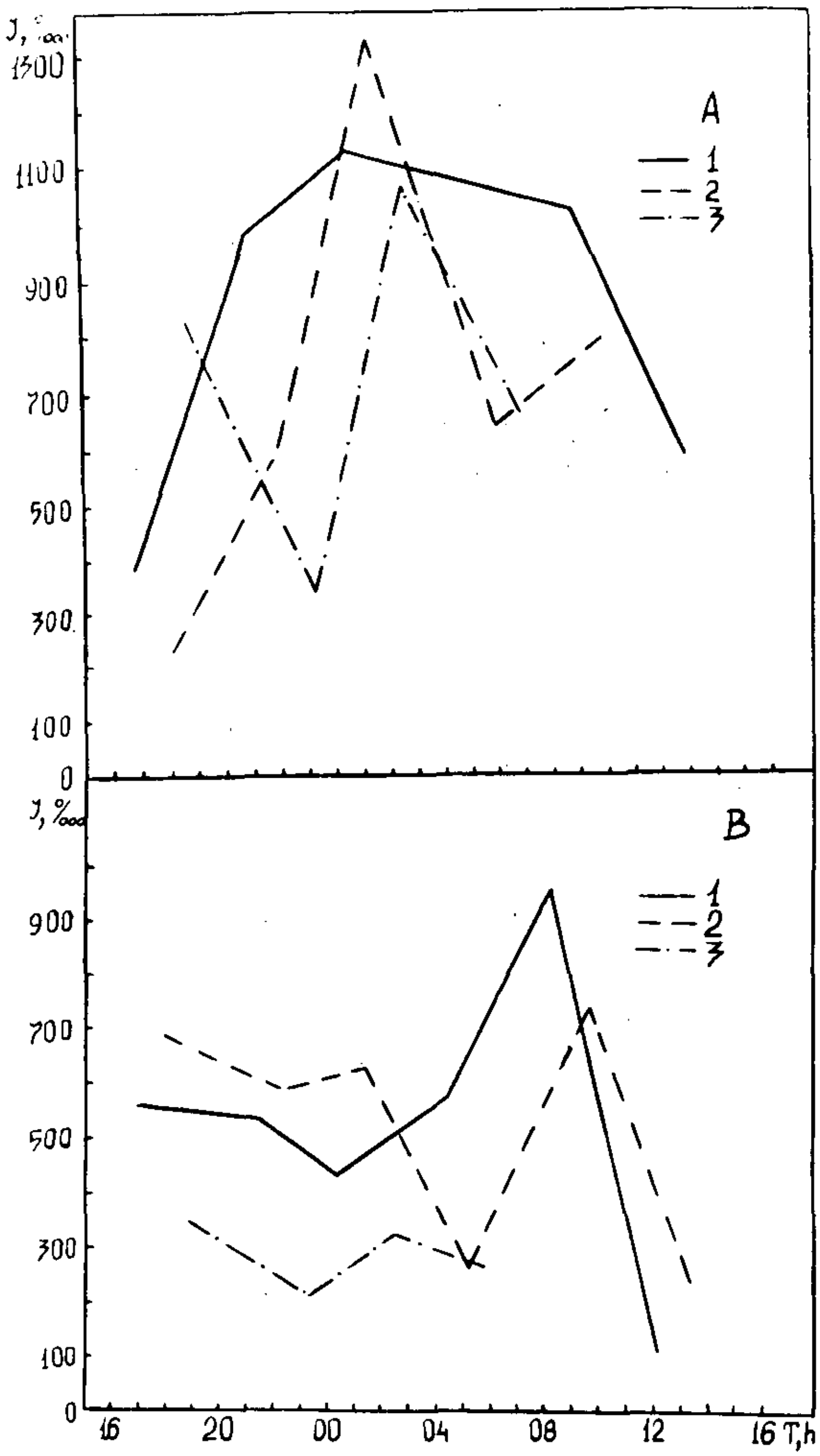

Fig.4. Average indices of stomach fullness for the O-group silver hake in different hours of the day at stations with homothermal waters (A) and stratified waters (B): 1 - near bottom; 2 - at intermediate horizon and 3 - near surface.

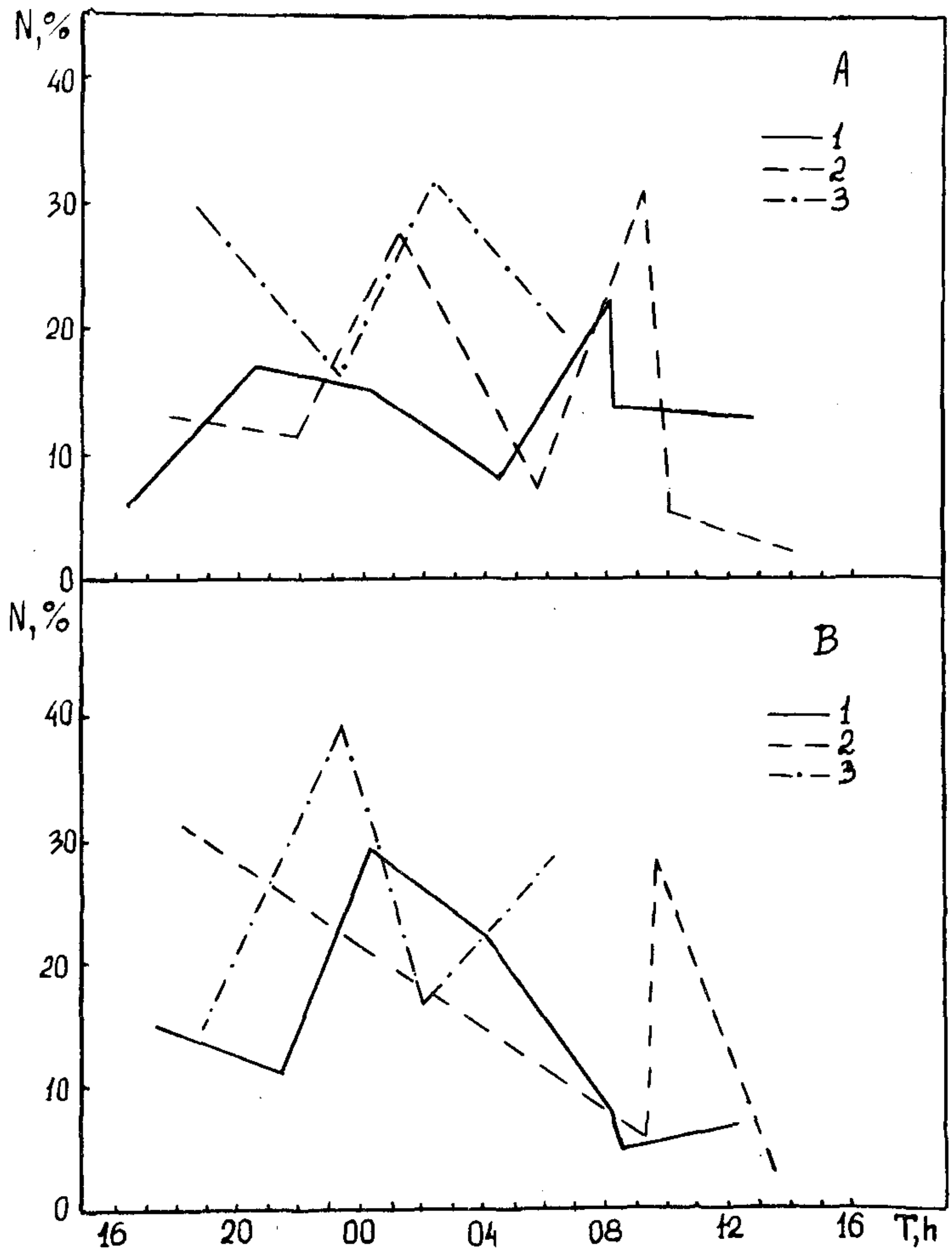

Fig.5. Mean number of euphausiids found in the o-group silver hake stomachs during the day stations with homothermal waters (A) and stratified waters (B):

1 - near bottom; 2 - at intermediate horizon and 3 - near surface.