NAFO Sci. Coun. Studies, 15: 53–58

Vertical Migrations and Feeding of 0-Group Silver Hake (*Merluccius bilinearis*) on the Scotian Shelf, November 1985

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Abstract

Results of joint studies carried out by USSR and Canadian scientists in November 1985 on the Scotian Shelf to investigate diurnal vertical migrations of young silver hake in relation to temperature sturucture and feeding intensity are presented. Approximately 500 specimens of the silver hake fry were processed to determine the food composition and feeding intensity. The rise of the young silver hake to the upper layers at night time was found to be related to feeding on the euphausiid *Meganyctiphanes norvegica*, which perform diurnal vertical migrations in November and form the basic food item for the young silver hake.

Introduction

A knowledge of regularities of diurnal distribution of silver hake (*Merluccius bilinearis*) is an essential condition for improving the strategy for the 0-group fish surveys aimed at the determination of the year-class abundance (Koeller *et al*., 1986). The studies of vertical distribution of the young silver hake carried out in October 1980 on the Scotian Shelf have shown that they perform diurnal migrations (Koeller, MS 1981). Studies on vertical migrations and feeding patterns are described in published literature (Koeller *et al*., 1986; 1989). However, the reasons causing diurnal ascents of these fish to the surface have not been adequately elucidated. It is hypothesised that the diurnal vertical migrations of the young silver hake are related to conditions such as temperature structure, light and feeding intensity. These conditions were studied in a survey conducted by the scientists of the AtlantNIRO (Kaliningrad, USSR) and of the Department of Fisheries and Oceans, Marine Fish Division, Bedford Institute of Oceanography (Dartmouth, Canada) in November 1985 and the results are presented in this report.

Materials and Methods

The survey was carried out on the *SRTM*-8095 *Tava* in an area of large aggregations of young silver hake, westward and eastward of Browns Bank (Fig. 1), where different types of water masses were observed (thermally homogeneous and stratified). The fishing gear used was the IYGPT trawl fitted with kapron netting with the mesh size tapering from 50 to 10 mm in the belly, and 6.5 mm in the codend. Hauling was conducted at each of two stations identified to have different water masses (*viz* homogeneous and stratified) over a period of 2 days. The hauls were made daily for 16 hr, from 0000 to 1600 hr on the first day, and from 0800 to 2400 hr on the second day. The hauling 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 within a stratified layer) and subsurface (3–5 m from the surface). The haul duration was 30 min at a vessel velocity of 3.5 knots. Water temperatures were measured after each second haul using XBTs. Light intensity in the daytime was measured by means of a deck cell transducer submerged on the lighted side of the vessel, however, the light factor is not included in this analysis. For the feeding intensity studies, a sample of the young hake was taken from each catch and all collected and processed materials are presented in Table 1.

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

The young silver hake feeding materials were analyzed using the methods described in the manual on feeding studies and food relations of the fish (Anon, 1974). The fries were weighed to within 1 mg, and organisms contained in the intestine were sorted, identified and measured under a binocular microscope. The

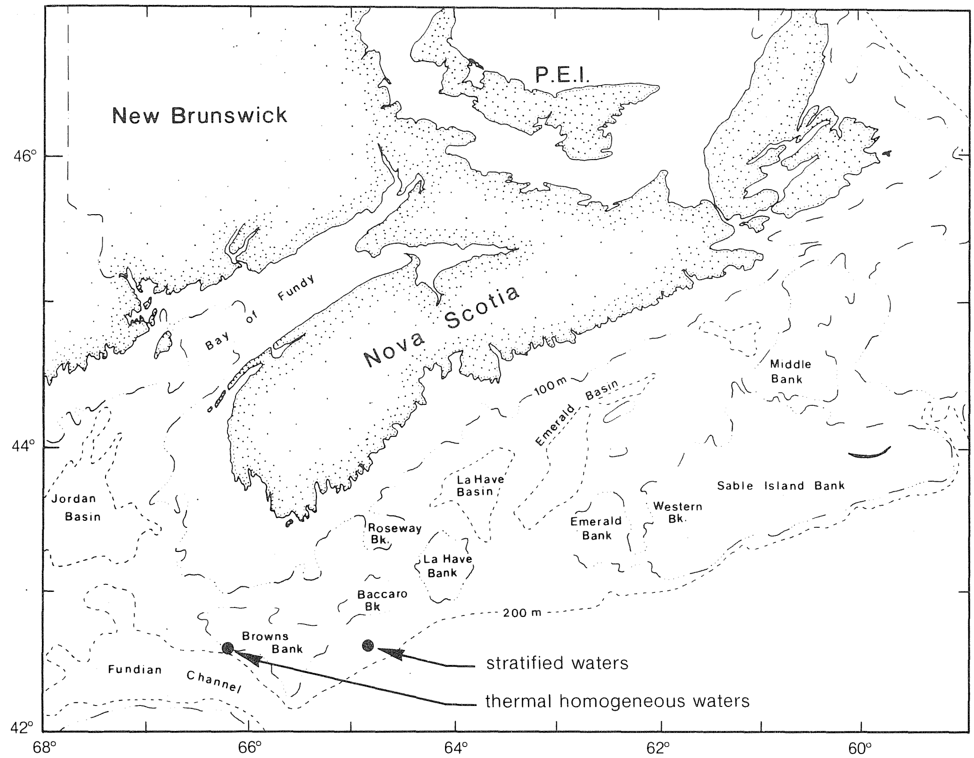

Fig. 1. Map showing the two areas of experimental studies on vertical distribution of 0-group silver hake in November 1985 on the Scotian Shelf.

TABLE 1. Dates, depths, stations, hauls and number of young silver hake analysed during a survey on the Scotian Shelf, November, 1985.

Date	Hauling depths (m)	Station type	No. of hauls	No. of young fish sampled	No. of specimens analysed
18-19 Nov	160-65-3	Thermally homogeneous	24	18	222
21-22 Nov	110-50-3	Stratified	24	18	244
Total			48	36	466

food organisms were sorted by species or species group and counted. Their initial weight was determined by means of the tables and weight characteristics of the zooplankers of the North Atlantic Seas (Bogorov, 1939; Kanaeva, 1962). All the weights were then combined in 10 mm size groups (20.0–29.9 mm, 30.0–39.9 mm, etc.). The feeding intensity was estimated from the proportion of fry containing food and the consumption index (in $^{\circ}/_{\circ\circ\circ}$). The consumption index was defined as the ratio of the weight of food organisms to the weight of food containing fry, of the given size group.

Results and Discussion

Vertical distribution of young silver hake

The preliminary studies on the vertical distribution carried out in October 1980 (Koeller, MS 1981) showed that the fish were distributed uniformly enough in the water column during the night, but were often missing in the catches taken in the pelagial during the day. The similar survey conducted in this study in November 1985 also showed that the young silver hake perform diurnal vertical migrations during that time (Fig. 2). The thermocline layer apparently did not affect the migrations significantly since the young crossed the 5° to 9° C temperature zone twice a day. The largest recorded catches were from the upper layer (0–65 m) in the night hours, between twilight and dawn. The young silver hake evidently formed shoals at night and these shoals changed their position in the water column. When the hauling depth coincided with the position of the shoals, large catches resulted (Fig. 2A, 2B). In the daytime, the young were absent from the pelagial, with insignificant aggregations (0.1–5%) occurring in the

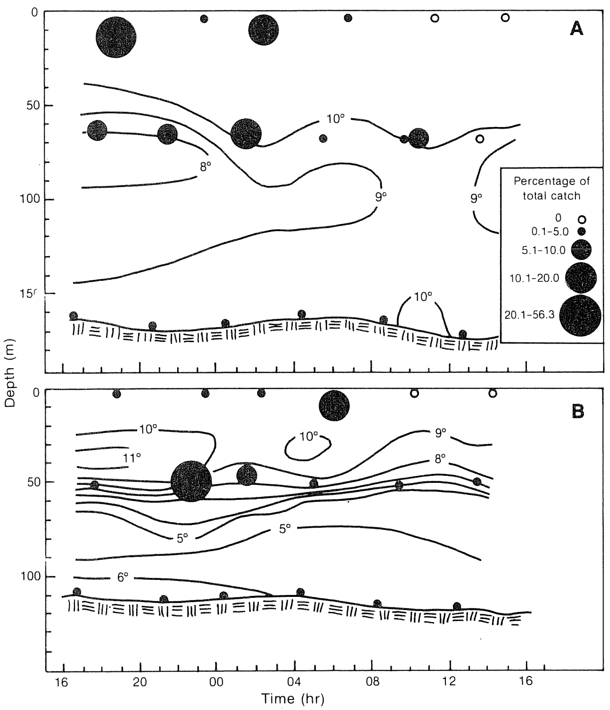

Fig. 2. Distribution of the young silver hake catches during the day at stations with (**A**) thermally homogeneous waters and (**B**) stratified waters.

near bottom layer. Main aggregations, avoiding the day light, probably kept close to the ground (Bowman and Bowman, 1980).

Sometimes the distribution patterns were noted to undergo changes. For example, Fig. 2A shows an instance when considerable numbers of the young fish (10%) were observed in the daytime in the pelagial, at the 65 m depth, and this was accompanied by the fish not rising to the upper layers at night. During some other experimental studies in October 1983 (Noskov and Sherstyukov, MS 1984), large aggregations of silver hake were fished near the bottom at night, from 27 to 28 October, and the event occurred just before a storm. This demonstrates that these behaviourial peculiarities of the young silver hake emphasize the importance of understanding the reasons behind the diurnal migrations.

This study in November 1985 also revealed that the young silver hake were still associated with the pelagial, as demonstrated 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) occurred in numbers both near the bottom and at the surface. With the approach of dawn, the mean length of the young in the catches decreased. This was especially well defined at the station with stratified waters.

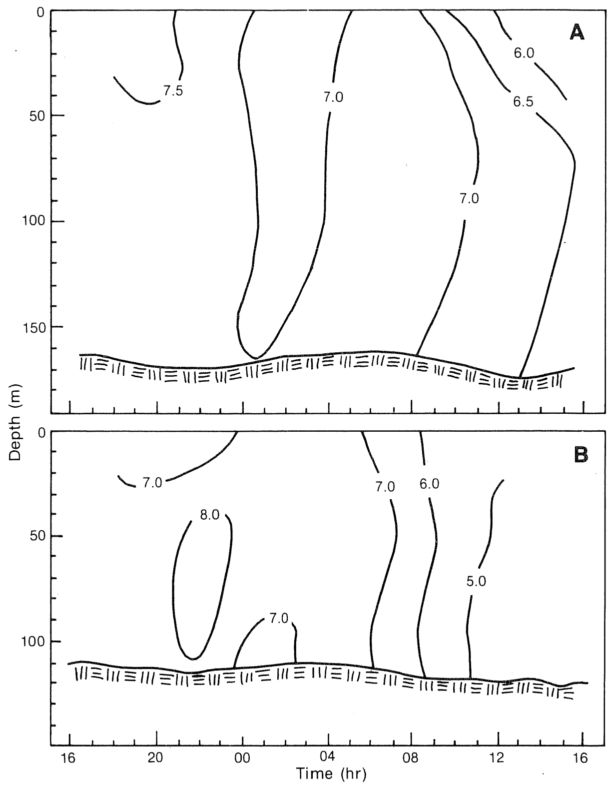

Fig. 3. Distribution of mean lengths (cm) of 0-group silver hake at different hours of the day at stations with (**A**) homogeneous waters and (**B**) stratified waters.

Food composition and feeding intensity

The weight analysis of the stomach contents indicated that the euphausiids (mainly the North Atlantic species *Meganyctiphaenes norvegica*) were the main food organism of the young silver hake. Euphausiids constituted 65–100% of the total weight (Tables 2, 3). Table 3 also shows that the smaller silver hake (20.0–29.9 mm in length) consume a different crustacean, Copepoda, ranging from 2.8 to 3.2 mm in length. The proportion of copepods averaged 59.3%. The larger silver hake (100.0–109.0 mm) on the other hand are noted to show cannibalism (Tables 2, 3). In general, no significant differences were found in the diet of the young silver hake caught at the stations with different types of water masses.

The indices of the young silver hake stomach fullness during different hours of the day at the stations with the thermally homogenous conditions and stratified conditions are shown in Fig. 4A and 4B respectively. In both cases, the highest index of stomach fullness was recorded at night, while they remained relatively low during the day. The mean number of the euphausiids found in the stomachs also changed in a

TABLE 2. List of prey, their length (mm) and percentage in terms of weight taken by young silver hake (40.0 to 109.9 mm) collected at the thermally homogeneous station.

	Length (mm) of young silver hake													
	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	
Food organisms	(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 fish analysed	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. List of prey, their length (mm) and percentage in terms of weight taken by young silver hake (20.0 to 109.9 mm) collected at the stratified station.

	Length (mm) of young silver hake																	
	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	
Food organisms	(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 fish analysed, sp	5		15		27		43		55		55		34		9		1	
No. of empty stomachs (%)	—		—		4		16		9		9		15		—		—	
Average index of stomach fullness (°/ₒₒₒ)	165		228		518		804		661		482		454		391		450	

similar pattern (Fig. 5). The only exception was a case when a large number of the young fish (10%) with a high index of fullness (790°/ₒₒₒ) (Fig. 4B) was caught in the daytime (9 hr 35 min) at the 65 m depth. We suggest that 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.

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 digestion proceeds more intensively in the warmer surface waters (Manteifel, 1955). At the same time, there are opinions 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, a majority of the investigators believe that nocturnal rise of plankton-eaters is of a trophic character (Zusser, 1965, 1966), and the morning descent of the fish to lower water layers can be regarded as a protective measure against predators (Manteifel, 1961).

The study of the diurnal vertical migrations of the young silver hake on the Scotian Shelf, and published data on vertical movements of the planktonophagous fish allow us to assume that the nocturnal rise of the young to the upper layers can be related to their feeding, and they are coincident with patterns in November of the euphausiid *Meganyctiphanes norvegica* that perform diurnal vertical migrations (Mauchline and Fischer, 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 1600 hr. Some specimens reach the surface at about 2000 hr and stay there till dawn, while the remainder are distributed between the surface and the bottom. By 0800 hr the crustacean populations descend to the near bottom area. 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 further elucidation.

The shoaling behaviour during the feeding period is typical of many fish species and is an important adaptive feature providing for an increased food supply for the population. During the feeding period, a shoal usually performs a dual function; it facilitates finding the food on one hand, and provides a protective role on the other hand (Manteifel and Radakov, 1960). The protective role of the shoal is lost by many fish species at some stages of onthogenesis. It is more peculiar to

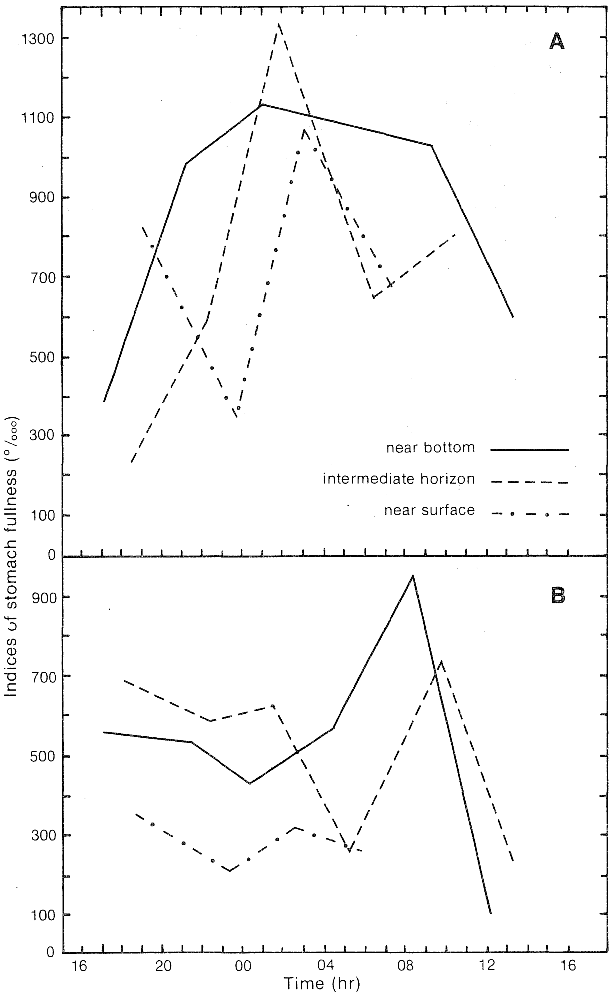

Fig. 4. Average indices of stomach fullness for 0-group silver hake at different hours of the day at stations with (**A**) homogeneous waters and (**B**) stratified waters.

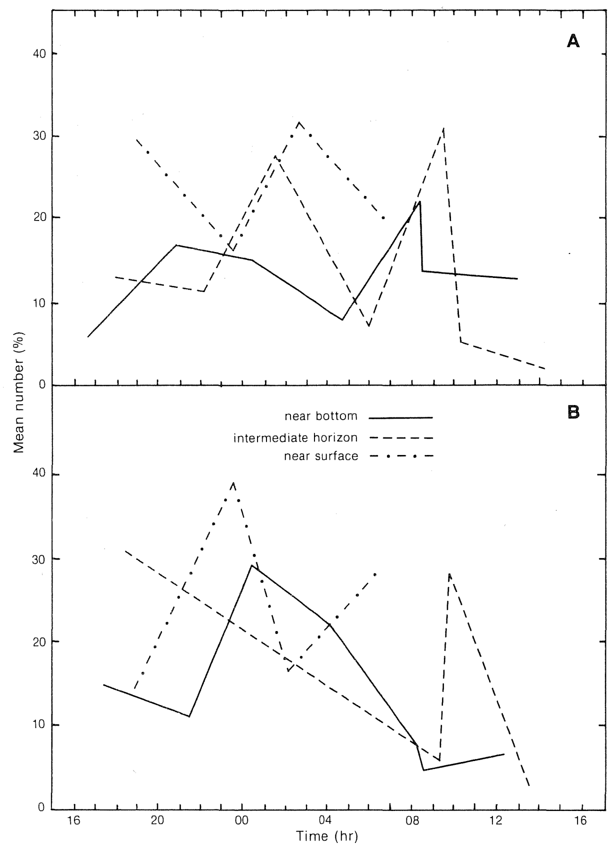

Fig. 5. Mean number of euphausiids found in the stomachs of 0-group silver hake at different hours of the day at stations with (**A**) homogeneous waters and (**B**) stratified waters.

earlier stages. Similar to the example of the relationship of 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 to 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 inventory surveys may considerably influence the assessment results of fingerling abundance (Koeller *et al.*, 1986).

Conclusions

1. In November 1985, the 0-group silver hake on the Scotian Shelf 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 euphausiid *Meganyctiphanes norvegica*, which perform diurnal vertical migrations in November, and represent the main food item for the silver hake (65–100% in weight).

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