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Studies on Vertical Distribution of Scotian Young Silver Hake in Fall-winter Season 1989-1990

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Abstract

Results of joint Soviet-Canadian studies on vertical movements of Scotian young silver hake at night in fall-winter season relatively to vertical distribution of zooplankters and feeding intensity have been described.

Introduction

As a result of preliminary studies on vertical distribution of Scotian young silver hake in October 1980 it was stated that they were undertaking diurnal migrations (Koeller, 1981). In fall young hake ascend with dusk to the upper layer (0-65 m) following *Meganyctiphanes norvegica* and crossing over the thermocline. They sink towards the bottom before dawn and are kept there during the entire daylight (Sherstyukov and Nazarova, 1987). Studies on vertical movements of young hake were continued in fall-winter season of 1989-1990. Relationship between these migrations at dark and vertical distribution of food stuff within water column was learned, being simultaneously studied the nature and intensity of hake fry feedinf both in feeding season (fall of 1989) and during wintering (winter of 1989-1990).

Material and methods

Studies on vertical movements of young silver hake were carried out by Soviet and Canadian scientists on board Soviet vessel SRTMK-8102 MALTSEVO in different locations of Nova Scotian Shelf (Fig. 1) on 18-21 of November and 19-20 of December 1989 and on 8-11 of January 1990. International pelagic trawl for young gadoids (IYGPT) made of kapron netting with 50 to 10 mm mesh bar (6.5 mm in codend) was utilized as a gear. In fall trawlings were made at night (from 18.00 to 06.00) in the following levels: superficial layer (3-5 m under the surface), over the thermocline (35 m), under the thermocline (60 and 100 m) and near the bottom (2-4 m over the ground). In winter trawlings were realized under the thermocline (50, 60-70 and 100 m) and near the bottom. Trawling duration at each level was 30 minutes, being vessel speed 3.5 knots. To control trawl deepening to the preset level a measuring instrument IGEK attached to the float line was applied.

Water temperature measurements were taken after each trawling with XBT (being the range of measurements between 0 and 200m). Zooplanrton sampling was carried out parellel to fry fishing with a plankton net (of 36 cm in opening diameter and 505 μK in mesh size) attached to the trawl codend. The sample was preserved in 4% formaldehyde solution.

50 individuals of young hake were selected from each haul and preserved in 10% formole solution to study food composition and feeding intensity. Material collected and treated is represented in Table I.

Zooplankton samples treatment was carried out with the MBS-I binocular microscope. For this purpose a fraction of some 500 zooplankters which were identified with the keys (Gayevskaya, 1948; Brodsky, 1950) was selected from the total sample using Folsom's divider (Mc Ewen et al., 1954). Large organisms and single species were counted in the whole fraction selected, i.e. in 100 blocks of random chamber (Mednikov, Starobogatov, 1961), and the rest of organisms was only counted in 10 blocks selected by Zimmermann Table of two-digit random numbers (1959). Then, recalculation of all organisms found relatively to the whole sample was done.

Material on young silver hake feeding was treated following "Methodical recommendations on feeding and food relationship of fish in natural environment" (1974). Fries were measured from the tip of snout to the end of caudal fin to within 1 mm and weighed by balance to within 1 mg. Fry abdomen was cut and organisms which were contained in the intestines were examined under binocular microscope. Their specific pertinency was identified. Organisms which were too digested were identified to order. Then, numbers were counted, length to within 0.1 mm was measured and extent of food organisms' digestion was determined. Their regenerated (raw) mass was determined by a relationship between length and weight described in different literature sources (Bogorov, 1939; Kanaeva, 1962).

It is known that the length of formed silver hake fry avergas 22.5 mm (Sauskan and Serebryakov, 1968). Therefore, starting from this size all the results on fry feeding were combined by the following length groups: 22.5-25.5 mm; 25.6-35.5 mm; 35.6-45.5 mm and so on.

Results

Bathymetric distribution of young silver hake

In fall 1989 the most dense concentrations of 0-group hake (398-1917 ind./trawling) were observed at night at the level of 35 m (Fig. 2, I), i.e. directly over the thermocline. At other levels (superficial, under the thermocline and over the bottom) their catches did not in most cases exceed 100 ind/trawling.

Young hake continued still migrating to the upper water layers from 19 to 20 of December 1989 (Fig. 2, 2). Thus, their concentrations (up to 80 ind./trawling) were observed at the level of 60 m, where water temperature was only 4°C.

In January 1990 (Fig. 2, 3) major concentrations of young hake (55-157 ind./trawling) were already in a demersal phase, ascending from time to time to the level of 100 m. Some hake individuals reached the level of 50 m.

Vertical distribution of zooplankters

Zooplankton in the area examined consisted mainly of boreal forms: Metridia lucens, Calanus finmarchicus, Limacina retroversa, M. norvegica, Thysanolssa inermis and others. In fall copepodes dominated (59 through 70% of total zooplankton), decreasing their proportion to 16-25% in winter (Table 2). A contrary trend was observed in euphausiids. Thus, M. norvegica proportion was insignificant (not more than 6%), increasing to 30-54% of total amount in winter. During the entire fall-winter period of 1989-1990 larvae of L. retroversa were found in number (12-33%) and in the whole water column over the Scotian Shelf (Table 2). M. lucens, the most numerous species as the majority of other copepodes was uniformly distributed within the whole water column (Table 2). In fall the species made up 22-33% of total zooplankters' abundance, increasing that amount to 45-54% in the transitional period. In winter the proportion decreased, being 8-25%. A similar tendency was observed in Centropages typicus, but in contrast to M. lucens, an abundance decrease took place already in the transional period (from 21-28% to 2-4%). A characteristic distributional feature of one more copepodes representative, namely C. finmarchicus, was the fact that the species was concentrated under the thermocline, at the depths of 60 and 100 m during all the periods of observations (Table 2). Distribution of M. norvegica in fall-winter 1989-90 season was earlier described. I. inermis, one more euphausiid species, made up a small proportion of plankton (1 through 7%), however, a significant increase in the amount of the species (up to 23%) was observed at the level of 100 m in fall (Table 3). Other zooplankters played insignificant part in most cases did not exceed 3% of total plankton amount.

Food composition of young hake relatively to consumer length, dwelling depth and season

In individuals of 30 mm in length major food components were copepodes, mainly C. finmarchicus (Table 3). In other fry (40-50 mm in length) food consisted of euphausiids and smaller amphipodes. Large individuals (60-100 mm in length) consumed mainly euphausiids of 25-30 mm in length. Thus, average lengths of prey increased with the increase of fry lengths. Cannibalism was absent in young hake which could evidently be attributed to lower abundance of 1989 year class.

In fall 1989 consumption index in fish of moderate length (40-50 mm) due to their feeding on calanoides and amphipodes near the surface was rather small (not exceeding 300 $^{\circ}/_{\circ\circ\circ}$), but it increased much (up to 926 $^{\circ}/_{\circ\circ\circ}$) when feeding on euphausiids at the level of 35 m (over the thermocline) attaining the largest values (1400-2000 $^{\circ}/_{\circ\circ\circ}$) under the thermocline at the levels of

60 and 100 m. In winter 1990 fry of the same lengths possess lower feeding intensity (151 $^{o}/_{ooo}$) when feeding on C. finmarchicus. Larger individuals (60-100 mm) had mainly higher consumption indices both in fall, and in winter at every trawling depth. The transitional period (December), when copepodes (2-4 mm) dominated in the diet if fish of 90-100 mm, and consumption indices decreased to zero, was an exception.

Variation in food composition of hake fry at different levels of stratified water of Scotian Shelf in 1989-90 winter season was the effect of daily movements of zooplankters. The main food item, as in fall 1985, was North-Atlantic boreal M. norvegica, being 52 through 95% of total mass of stomach contents (Sherstyukov and Nazarova, 1987). However, with the increasing concentrations of I. inermis, especilly in the pre-bottom layers (Table 2) young hake start intensively feeding on this species (Table 4).

Discussion

In 1989-90 fall-winter season young hake undertook clear daily vertical migrations in previous years (Koeller, 1981; Sherstyukov and Nazarova, 1987), concentrating at night mainly over the thermocline (at the level of 35 m), but those migrations were gradually limited by the level of 100 m with the cooling of surface waters by January 1990. For the period under examination young hake consumed both smaller organisms dwelling in the superficial layer, and larger crustaceans migrating at night from the bottom towards the upper water layers. Average length of prey increased with fry length. However, as in young haddock (Koeller et al., 1986) exceptions were observed. Thus, copepodes dominated in the diet of hake individuals of 90-100 mm in length in December 1989.

Major plankton species (59-70% of total amount) were M. lucens and C. finmarchicus for the 1989 fall-winter season. However, M. lucens, the most nimerous species, which was also found in number previously over the Scotian Shelf in fall (Sameoto, 1984) was not found in the hake fry stomachs. Hake fry were most intensively feeding on euphausiids (M. norvegica: Table 3) the proportion of which was only 1-6% of total plankton abundance in fall 1989 (Table 2). This euphausiid amount was quite enough for the young fish normal feeding which high consumption indices evidenced for (926-2000 $^{o}/_{ooo}$).

In winter 1990 copepodes proportion in plankton markedly decreased (to 16-25%: Table 2) which affected feeding of smaller hake individuals. Their consumption index decresed, as compared to the fall season, from 300 to 151 $^{o}/_{ooo}$. Fry of moderate and larger size had in winter high indices of euphausiid consumption the proportion of which sharply increased in plankton from 6 to 30-54%, as compared to fall (Table 2).

Therefore, young silver hake in 1989-90 fall-winter season, as in fall 1985 (Sherstyukov and Nazarova, 1987), ascended towards the upper water layers following M. norvegica. Sometimes divergences from such distributional character were observed. Thus, in spite of the fact that in winter 1990 M. norvegica was found in number at the level of 60 m, young hake did not migrated there, their major concentrations ascending only to the depth of 100 m for that period.

Different locations of young hake within the water column at night in the period of active movements following euphausiids naturally affect accuracy of abundance indices obtained when carrying out annual inventory surveys and fishing fry at three given levels, i.e. near the bottom, within intermediate layers and near the surface (Sigaev et al.,1988). A comparative analysis of abundance indices for 0-class and yearlings which were obtained as the result of annual July surveys by Fanning et al. (Fanning et al., 1987) is the evidence of the above-mentioned indices' coincidence. At the same time, it is noted that estimates of 0-class abundance did not represent actual abundance of those year-classes in some years. Considerable disagreements in abundance indices for 0-class and yearlings are possibly attributed to a number of reasons, for instance, formation of fry dense consentrations in the intermediate layers between trawling depths, cannibalism, etc. The first reason could not be excluded, since the choice of one or another level for carrying out inventory surveys of hake 0-class which would show every variation in nocturnal vertical distribution is hardly probable.

Another important reason which affected young hake abundance dynamics is cannibalism. It is characteristic of adult silver hake, especially of elderly age classes (Clay et al., 1984). Other authors (Koeller et al., 1989) observed this phenomenon even in young hake both in the years of their high abundance, and in those of lower one. Thus, in 1981 the abundance of 0-class was the most high for the period under examination, from 1978 to 1983 (Noskov and Sherstyukov, 1984). Hake fry was an important food element for the individuals of 76-90 mm in length, and in 1980 (poor year-class) hake fry was also a considerable proportion of stomach contents (25% of total mass). In 1985 (Sherstyukov and Nazarova, 1987) cannibalism was observed in the individuals of 100-109 mm in length, as well. In 1989-90 fall-winter season cannibalism in young hake was absent. Therefore, cannibalism increases in years of unfavourable feeding conditions. Such conditions may appear in cases of hake strong year-classes' birth, as it was in 1981. Feeding conditions for young hake were apparently favourable (absence of cannibalism) in 1989-90 fall-winter season, and young fish decrease for their wintering will probably be minimum which in the end will decrease disagreements between abundance indices for 0-class and yearlings.

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Table 1

Volume of collected and processed material

D a t e	Trawling levels, m	Number of zooplankton samples collected	Number of hake fry samples collected	Number of hake fry treated	Number of empty stomachs	Number of stomachs overted
18-21.11.89	5	2	107	34	6	1
	35	2	174	40	4	1
	60	1	166	45	8	-
	100	1	60	10	1	2
19-20.12.89	50	1	82	11	1	2
	70	1	119	20	5	4
	100	1	151	21	6	5
	120-140	1	107	18	3	4
8-11.01.90	60	2	50	34	3	4
	100	2	101	40	9	3
	130-143	2	145	34	4	15
Total		14	1262	307	50	40

Table 2

Composition and abundance of food stuff (%) at different levels of the Scotian stratified waters in 1989-1990 fall-winter season

Zooplankters	Length, mm	Date	18-21.11.89				19-20.12.89				8-11.01.90		
		trawling depth, m	5	35	60	100	50	70	100	120-140	60	100	130-143
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Copepoda													
Candacia armata	2.6- 2.8		-	-	2	-	-	-	-	-	-	-	-
C. bipinnata	2.2- 2.5		2	3	-	-	-	-	-	-	-	-	-
Calanus finmarchicus	2.0- 6.5		4	5	13	8	4	7	16	3	8	25	10
Metridia lucens	3.0- 4.0		22	31	29	33	48	45	37	54	8	25	14
Centropages typicus	1.0- 1.8		28	21	25	28	2	4	2	4	+	+	1
Undinula vulgaris	2.1- 3.1		3	3	1	1	-	-	-	-	-	-	-
Paracalanus parvus	-		-	-	-	-	-	-	-	-	-	-	-
Amphipoda													
Parathemisto gaudichaudii	5.0-11.0		1	+	1	+	-	-	-	-	1	1	+
Euphausiacea													
Meganuctiphanes norvegica	14.0-36.0		+	6	+	+	18	16	17	10	54	30	46
Thysanoëssa inermis, furcilia	1.5-20.0		+	+	3	23	-	-	-	-	4	5	7
Decapoda													
Pandalus borealis	39.0-56.0		-	-	-	+	-	-	-	-	-	-	+
Gastropoda													
Limacina retroversa	2.0- 4.5		33	19	14	1	27	28	28	29	22	12	21
Chaetognatha													
Sagitta spp.	14.0-24.0		+	-	+	-	-	-	-	+	-	+	-
Ctenophora	12.0-15.0		6	11	11	5	1	-	-	-	-	-	-
Others	-		+	-	-	-	+	-	-	-	3	1	-
	Total:		100	100	100	100	100	100	100	100	100	100	100

± less than 1%

Table 3

Food items (weight %) and feeding intensity ($^{\circ}/_{\circ\circ\circ}$) in different length groups of Scotian young silver hake in 1989-1990 fall-winter season

Zooplankters	Date: 18 - 21.11.89							8 - 11.01.90								
Length: cm	4	5	6	7	8	9	10	3	4	5	6	7	8	9	10	11
Copepoda	1	1	+	+	-	-	-	-	2	+	-	2	-	+	-	-
Calanoida	2	1	+	+	+	-	-	46	5	1	-	-	+	+	+	-
C. finmarchicus	10	1	-	+	+	-	-	54	11	1	-	+	+	+	1	+
Pseudocalanus sp.	-	+	+	-	-	-	-	-	-	+	+	-	-	-	-	-
Microcalanus sp.	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Isopoda	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amphipoda	46	12	10	11	6	-	-	-	-	-	3	3	-	1	3	-
Euphausiacea	-	-	26	21	-	-	-	-	-	22	-	-	-	-	65	8
M. norvegica	40	19	54	59	91	100	100	-	81	75	96	25	99	59	10	91
T. inermis, furcilia	-	65	8	8	2	-	-	-	-	-	-	69	-	39	20	-
Gastropoda L. retroversa	+	+	+	+	+	-	-	-	1	+	+	+	+	+	+	-
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Consumption Index	971	940	1070	1612	1377	1406	392	49	423	885	2595	1179	821	1033	206	1358

$\pm$ less than 1%

Table 4

Food items (weight %) and feeding intensity ($^\circ/_{\circ\circ\circ}$) of Scotian young silver hake in different levels of stratified waters in 1989 - 1990 fall-winter season

Zooplankters	Date: 18-21.11.89				19-20.12.89				8-11.01.90		
Trawling depth, m	5	35	60	100	50	70	100	120-140	60	100	130-143
Copepoda	+	+	+	-	-	+	+	+	+	-	1
Calanoida	-	-	+	1	-	-	+	+	+	+	+
C. finmarchicus	+	+	+	+	+	+	+	1	+	+	1
Pseudocalanus sp.	-	-	+	+	+	+	+	-	-	+	+
Microcalanus sp.	+	-	-	-	-	-	-	+	-	-	-
Isopoda	-	+	-	-	-	-	-	-	-	-	-
Amphipoda	12	3	16	1	4	-	4	2	2	1	-
Euphausiacea	-	28	-	50	-	36	-	-	-	3	14
M. norvegica	79	61	71	-	95	63	95	96	52	93	63
T. inermis, furcilia	8	7	12	47	-	+	-	-	45	2	20
Gastropoda											
L. retroversa	+	+	+	+	+	+	+	+	+	+	+
Total:	100	100	100	100	100	100	100	100	100	100	100
Consumption index	873	1313	1364	1392	798	891	303	830	1302	783	824

+ less than 1%

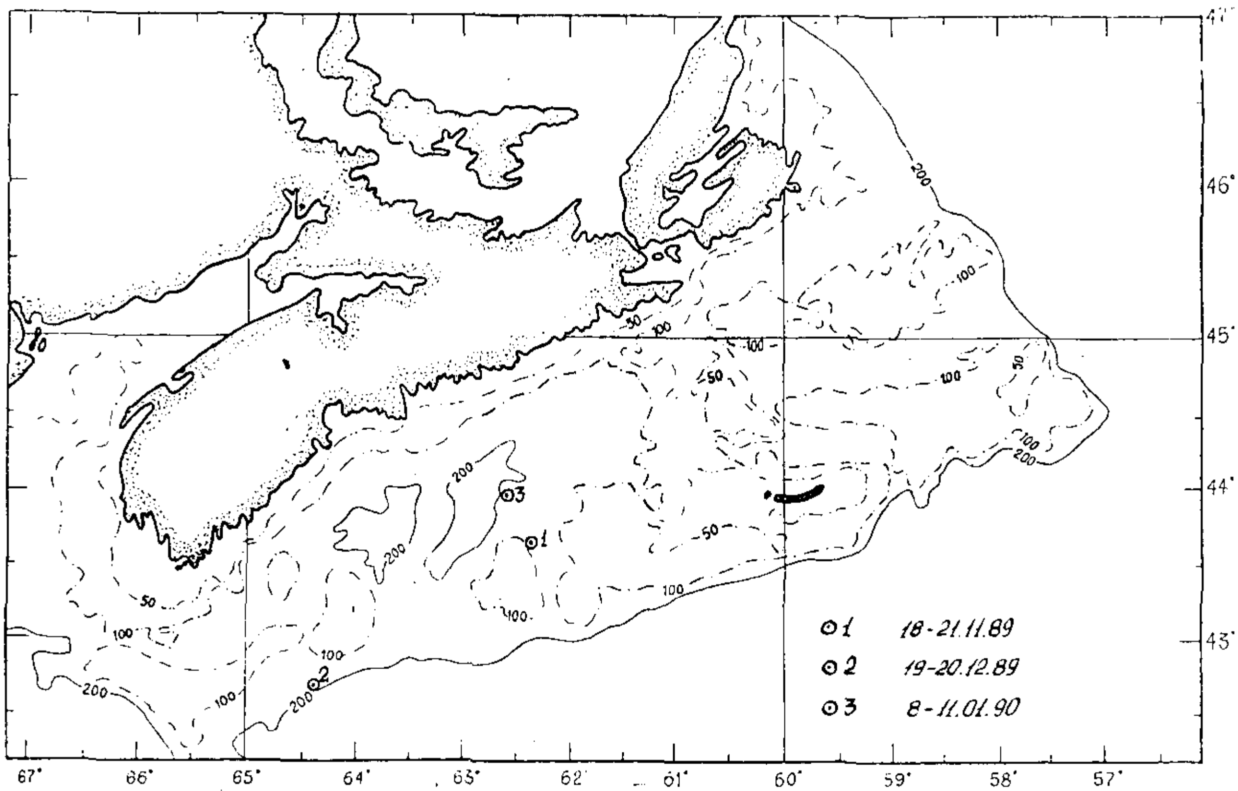

Fig. 1. Network of experimental stations for studies of vertical distribution of Scotian young silver hake in 1989-1990 fall-winter season.

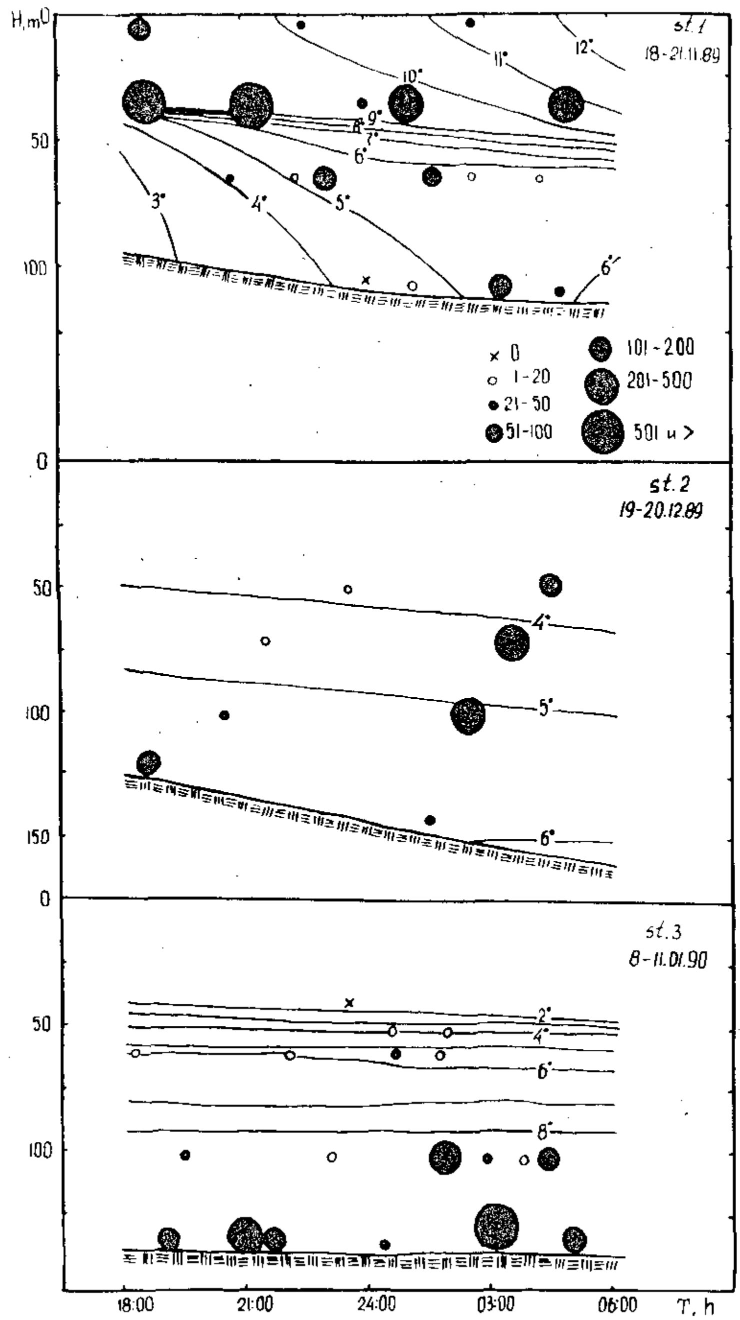

Fig. 2. Vertical distribution of Scotian young silver hake (ind./trawling) in 1989-1990 fall-winter season.