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Vertical Migrations and Feeding of 0-Group Cod in the Barents Sea in September-October

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by

A.S. Baranenkova, S.S. Drobysheva and
I.Ya. Ponomarenko

Practically no information is so far available on the time, conditions and causes of pelagic fry's turn to the demersal "way of living". It has not been established, either, to what extent young fish of various age groups are associated with near-bottom water layers. Studies of young fish catches from bottom trawls conducted for a number of years have revealed year-to-year variations in the time of "sinking" of young fish. It is also known that the sizes of "demersal" individuals of 0-group exceed those of pelagic specimens captured at the same time.

In September and early October 1962 special investigations were carried out by the research vessel "Persei-2" in the southern part of the Barents Sea (Kildinskaya and Murmanskaya Banks, Murmansk shallow waters, and West Coast area) to ascertain the horizons inhabited by young cod during that season. The gears used were 25-metre bottom and 16-metre pelagic herring trawls with small mesh covers (5 mm knot-to-knot lumen)[x]. During that season 0-group cod appeared in the catches taken by both trawls. The number of young 0-group specimens varied from 1 to 108 specimens in bottom trawl catches, and from 2 to 279 specimens in pelagic trawl catches depending upon the time of the day and the horizon fished. At night and early in the morning the richest catches of fry were taken from the near-surface layer; later in the morning and during daytime - from deeper water layers and near the bottom. That indicated diurnal vertical migrations of fry during the season. The length of 0-group individuals caught ranged from 5 to 12 cm. Those in bottom trawl catches were somewhat larger and had a higher fat content (3.72% against 3.44%)[xx] than in the pelagic trawl catches (Figure 1).

On September 30 - October 2 diurnal stations were taken in the Murmansk shallow waters, at a buyo, 69°35'7" N - 41°19'5" E, to ascertain the causes of the young cod's vertical migrations. The depth at that point was 155-200 metres. The gear used for young cod fishing was a bottom trawl during the period from 00:30 a.m. September 30 to 05:30 a.m. October 1, and a pelagic trawl during the following day. Trawlings were performed at four-hour intervals. The total number of trawlings was 6 for the bottom trawl and 13 for the pelagic trawl. The 13-25 meter, 50 meter, and 100 meter horizons were fished with the pelagic trawl. The depth of trawling was measured with TAG-100 meter.

Every four hours, in standard horizons, water temperatures were taken and plankton fished with a small Juday net. Besides, a No. 140 silk tow net with 50 cm inlet diameter, used to be fixed to the headline of the trawl when hauling. This net is good for fishing euphausiidae of any size.

The diurnal station was taken in the stream of the warm Kanin-Kolguev current and, therefore, no substantial fluctuation in temperature was observed in any horizon during the two days of operations The 0-100 metre horizon was stratified. In the thermocline layer considerable vertical temperature gradients were observed (around 0.1° per 1 metre). The temperatures in that layer varied from 3° to 6°. In the near-bottom layer the range of temperature changes was small, from 2.9° to 3.1° (Figure 2).

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[x] Each fishing operation was, as a rule, of 1 hour's duration, except for fishing with pelagic trawl in the surface layer (circulating). In those cases the duration was from 25 to 30 minutes.

[xx] Fat content is the ratio of the weight of the liver to the weight of the fish in %.

The young cod catches obtained during the two-day period of working diurnal stations are represented in Table 1. In the bottom trawl catches specimens of all age groups were found, individuals of II and III age-groups prevailing. In the pelagic trawl catches only 0-group cod appeared. The richest catches of 0-group cod were taken: by the bottom trawl - in the morning and during daytime, by the pelagic trawl - at night and in the morning. Apparently, the existance of a thermocline did not impede the vertical migrations of the 0-group cod. The same thing was mentioned by K.G. Konstantinov (1958) for adult cod.

A quantitative and weight analysis of the stomach contents of young cod revealed that 0-III age-groups fed mainly on euphausiidae, the share of euphausiidae in the diet of 0-group cod amounting to 91.5%, and in that of the elder age-groups of young cod to about 70.0% of the total weight of food. The frequency of occurrence of euphausiidae in the stomachs of young fish exceeded 90%.

Studies of plankton showed that during the period of our investigations the euphausiidae performed easily recognisable diurnal, vertical migrations. Composition by species and age composition of euphausiidae in tow-net catches are shown in Table 2. It can be seen from this table that Thysanoessa inermis were represented in the Murmansk shallow waters mainly by young specimens. Among Thysanoessa raschii adult individuals prevailed. And only single specimens of Meganyctiphanes norvegica were observed. On the whole, small-size immature individuals prevailed in the tow-net catches (70.5%). Captures of euphausiidae per hour of hauling contained up to 3603 specimens from the near-bottom layer, and up to 2000 specimens from pelagical. Such rich catches indicated the presence of their abundant accumulations in the area. According to S.S. Drobysheva (1960), abundant accumulations of euphausiidae were observed in the Murmansk shallow waters every year.

The investigations revealed a close relation between vertical migrations of 0-group cod and diurnal, vertical migrations of euphausiidae.

Figure 3 is a graphical representation of the stomach-content indices and of the amounts of euphausiidae present at a depth of 50 metres (Figure 3A), and in the near-bottom layer (Figure 3B), at different times of a day. In both cases the time of the highest degree of young cod's stomach filling coincided with the time of the greatest influx of euphausiidae in the horizon. During daytime, when euphausiidae were absent from the upper water layers, or were present there in only very small amounts, the degree of 0-group cod's stomach filling was comparatively low, the mean stomach content index being equal to 50 - 60 prodecimille (°/ooo)[x]. By midnight, when euphausiidae ascended to the upper water layers, the stomach content index of 0-group cod increased sharply, to 129 °/ooo at a depth of 50 metres and to 176 °/ooo at a depth of 13 metres from the surface. After "sinking" of euphausiidae to the lower water layers, the rate of feeding of 0-group cod decreased somewhat, - to 116 °/ooo at 3.30 a.m.; later on, by 8.00 a.m., the index value increased again to 139 °/ooo. By noon it dropped to 38 °/ooo.

The decline in the degree of the stomach filling of 0-group cod proceeded more slowly than the decrease in the amount of euphausiidae in the upper water layers. This is easy to explain, since digestion takes time. A certain increase in the rate of the feeding of the 0-group cod was observed in the morning, despite of a sharp decrease in the amount of euphausiidae at that time, and we believe this was caused by better hunting conditions, i.e., stronger illumination. According to data published by I.I. Geersa (1962), the sight plays an important role in the cod's hunting for food. It is apparently more important for pelagic young cod than for cod inhabiting the near-bottom water layers. However, the data we obtained indicate that when high concentrations of food are available, cod fry can feed intensively even in the dark.

The index of mean stomach content, the percentage of feeding individuals, and the average amount of euphausiidae in the stomach of a 0-group fry, were changing in a very similar way in the course of 24 hours (Figures 3 and 4). The highest euphausiidae content was observed in the morning (on an average 6 specimens per stomach). It reached its minimum during daytime (1-2 specimens per stomach).

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x) The common stomach content index is the ratio of the weight of food to the weight of fish multiplied by 10.000, - i.e., in prodecimille (°/ooo). The particular index for a certain kind of food, e.g., euphausiidae, is

It should be mentioned that the share of adult euphausiidae in the food of the O-group cod was greater at night than in the morning (Figure 4). The O-group cod from bottom-trawl catches taken during daytime showed comparatively low stomach content indices (from 64.5 °/ooo to 52.9 °/ooo), similar to those determined for fry from pelagic trawl catches. On the other hand, young cod of I-III age-groups inhabiting the near-bottom layers showed the highest stomach content indices during daytime (Figure 3B), which coincided with the time of the presence of the greatest amounts of euphausiidae in the near-bottom horizon. This supported the idea that O-group cod, at least the bulk of fry, were caught not at the bottom but in the thickness of water in the process of lifting the trawl. This assumption was further corroborated by the fact that not a single typical bottom form was ever observed in the food composition of the O-group cod from bottom-trawl catches, whereas in the food of the I-III age-groups such bottom forms as Polychaeta were found.

According to the data obtained by I.Ya. Ponomarenko, typical bottom organisms, such as Polychaeta, Isopoda, and others, were found in the stomachs of the O-group cod from bottom-trawl catches taken in the Murmansk shallow waters in November/December. The complete absence of O-group individuals with everted stomachs from the bottom-trawl catch taken on October 1-2, was another evidence of the non-abidance of the O-group cod in the near-bottom layers at that early date. On the other hand, from 7 to 1o% of O-group cod caught by bottom trawl at depths of 15o - 2oo metres in November/December usually had everted stomachs. Apparently that should be explained by the effect of the change in pressure.

A comparative study of the size and age composition of euphausiidae in plankton and in the stomachs of young cod indicated a selective feeding of O-group cod on small-sized, one-year-old euphausiidae, and of cod of I-III age-groups - on large-sized, two-year-old individuals (Table 3).

Conclusions

1. The investigations carried out in the southern part of the Barents Sea in September and early October 1962 showed that during that season the O-group cod stayed in the thickness of the water and performed diurnal, vertical migrations. At night and early in the morning the best catches were taken from the near-surface layers, later in the morning and during daytime from deeper and near-bottom layers. In their migrations the O-group cod got over the thermocline.

2. O-group cod from bottom trawl catches taken in various areas were somewhat larger and had a somewhat higher fat content (mean lengths from 89.7 to 97.1 mm, mean fat content 3.72 %, than those from the pelagic trawl catches taken at the same time (mean lengths from 8o.1 to 85.o mm, mean fat content 3.44 %).

3. A close relation was revealed between vertical migrations of the O-group cod and the diurnal vertical migrations of euphausiidae, which were the main food of young cod during that season. Pelagic cod of the O-group were feeding on euphausiidae mainly at nights when the latter ascended to the surface water layers. Young cod of the I-III age-groups abiding near the bottom were most intensively feeding on euphausiidae during daytime when euphausiidae descended to near-bottom layers. Selective feeding was observed.

References

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Table 1 Catches (numbers of specimens) of young cod taken from the Murmansk shallow waters at different times of a day, October 1-2, 1962.

Type of trawl	Trawl No.	Time of fishing (beginning)	Duration of hauling (minutes)	Depth of the sea	Depth of fishing (m)	Young cod catches	
						0-group	I-III age groups
Bottom	11	00.25	60	175-185	Near-	6	314
	13	08.00	"	155-185	bottom	175	406
	14	12.00	"	160-180	layer	108	264
	15	16.05	"	175-180	"	3	240
	16	19.45	"	180-185	"	-	77
	17	23.55	"	165-170	"	-	224
Pelagic	19	08.00	60	180-165	50	54	-
	20	10.45	30	155-155	25	5	-
	21	12.40	60	165-175	50	6	-
	23	16.25	60	160-172	50	24	-
	24	19.35	60	180-175	50	85	-
	25	23.00	30	175-175	13	62	-
	26	00.00	60	175-165	50	170	-
	28	03.30	60	170-165	50	49	-
	29	05.05	45	175-200	100	12	-
	30	06.40	30	190-192	25	274	-
	31	08.05	60	180-150	50	279	-
	32	11.30	30	165-165	25	100	-
	33	12.40	60	120-190	50	7	-

Table 2 Composition by species and age of euphausiidae in the Murmansk shallow waters determined from tow-net catches taken on October 1-2, 1962.

Species	Number of individuals		Length (mm)			
			from - to		prevailing	
	% of total no. caught	% of total no. of given species	Young	Adult	Young	Adult
Thysanoessa inermis	57	99.5	8-12	20-27	12	23
Thysanoessa raschii	43	31.0	"	"	"	"
Meganyctiphanes norvegica	0.1	-		25-40		33

Table 3 Ratios of various size- and age-groups of euphausiidae in plankton and in the stomachs of young cod (%).

Horizon fished	Frequency of occurrence of euphausiidae	Length and age of euphausiidae	
		8-13 mm 0+	20-38 mm 1+
Near bottom	in plankton x)	51	49
	in the stomachs of 0-group	83	17
	in the stomachs of I-III groups	26.2	73.8
Pelagical	in plankton x)	46	54
	in the stomachs of 0-group	88	12

x) From tow-net catches

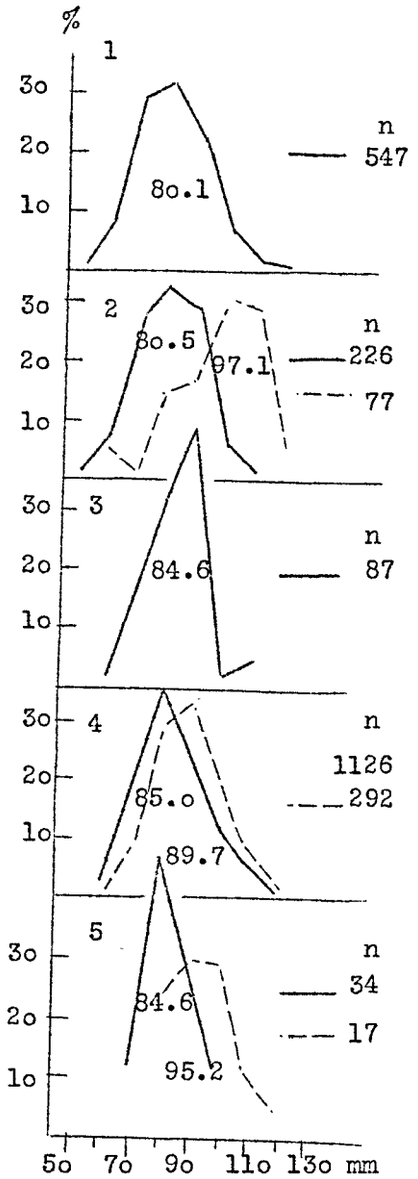

Figure 1. Sizes of 0-group cod from pelagic and bottom trawl catches.
1. Murmansk Bank - September 7-8, 1962
2. Kildinskaya Bank - September 9, 1962
3. Kildinskaya Bank - September 28, 1962
4. Murmansk shallow waters - September 31-October 2,1962(diurnal stations)
5. West Coast Area - October 6-7, 1962

Figures on the curves indicate mean lengths of fry.

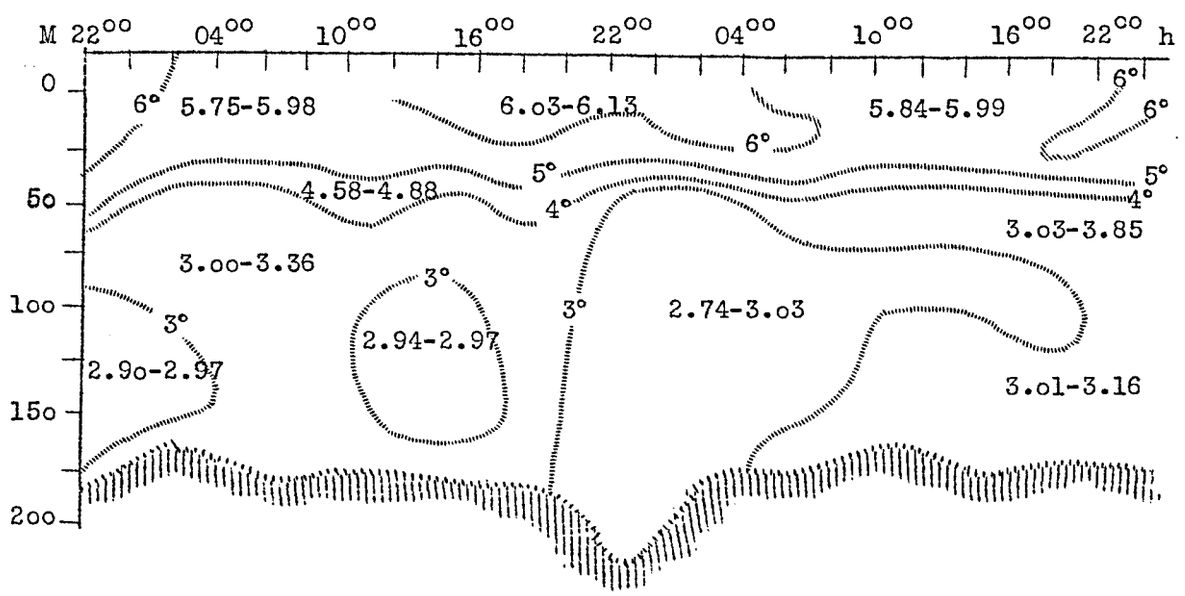

Figure 2. Vertical distribution of water temperatures at the place of taking diurnal stations, at a buyo, 69°35'7" N - 41°19'5"E, as observed during 24 hours (according to I. I. Svetlov).

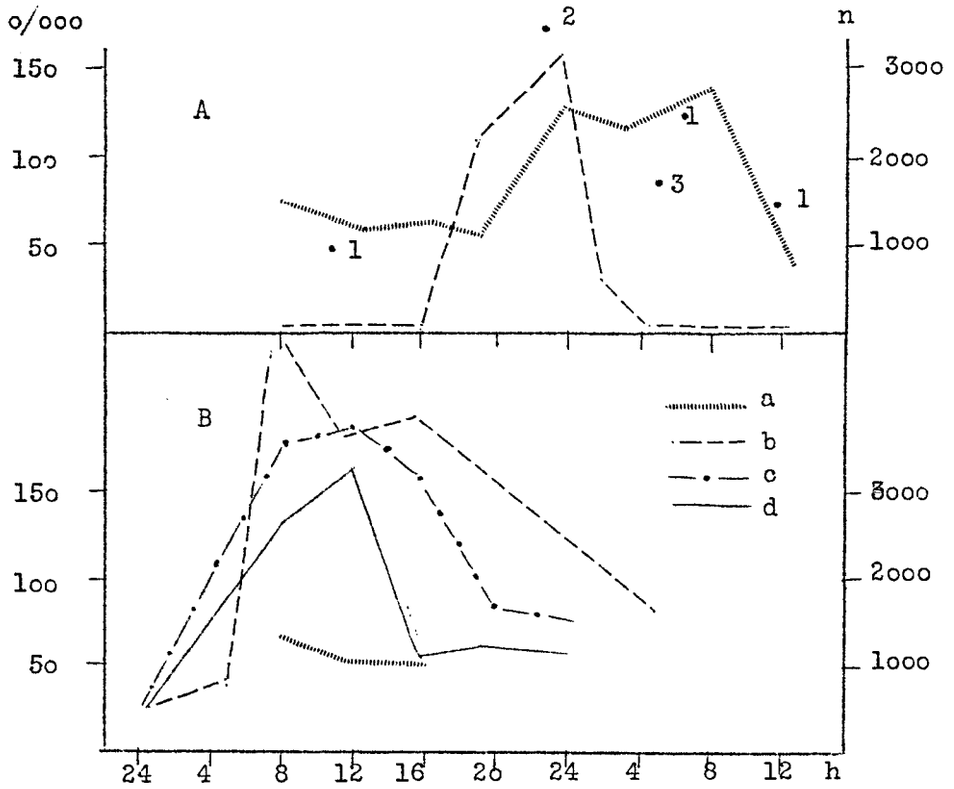

Figure 3. Changes in young cod's stomach contents indices and amounts of euphausiidae observed in the course of 24 hours: A - 50 m horizon, B - near bottom.

a. Common stomach contents index for 0-group
b. Numbers of euphausiidae in tow-net catches
c. Common stomach contents index for I-III age-groups
d. Particular euphausiidae index for I-III age-groups.

Points indicate stomach contents indices for 0-group cod:

1 - in 25 m horizon
2 - in 13 m horizon
3 - in 100 m horizon.

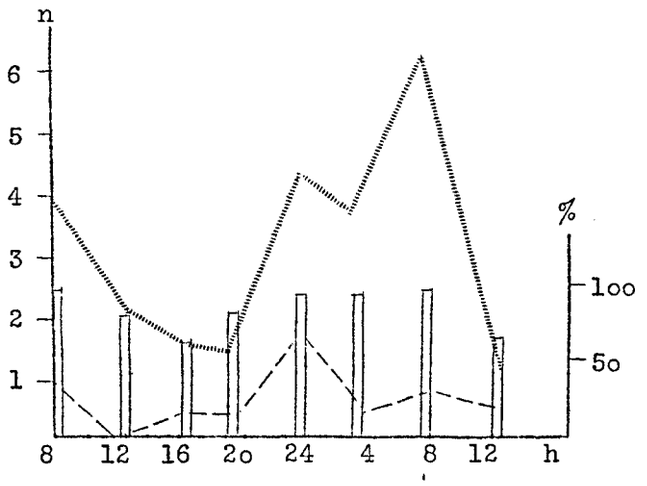

Figure 4. Diurnal rhythm of consumption of euphausiidae by 0-group cod from pelagic trawl catches.

..... Total number of euphausiidae (adult and young) in a stomach

– – – – – Number of adult euphausiidae in a stomach

Columns represent numbers of feeding individuals (percentage)