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On Hake Feeding Related to Distribution of Food Organisms in the Scotian Shelf Area in 1988, 1990

by

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ABSTRACT

Distribution, diurnal migration and conditions of predator and prey aggregating are presented based on the analysis of hake feeding, researches qualitative and quantitative estimates of food organisms composition and biomass. It was reveiled that in the area of food organisms domination, considerable hake aggregations appeared at high average daily catches. The fishery aggregations of hake and successful fishery are determined by abundant food organisms concentration revealed.

INTRODUCTION

Feeding intensity of hake in the Scotian Shelf area increased in the years when its food consisted mainly of abundant organisms (Vinogradov, 1988). Feeding intensity of males and females changed synchronously slightly prevailing in the latter and coinsiding with seasonal periods named by Karasyov (1975) as "wintering" (November-April) "breeding" (April - June) and "spawning" (July - October).

Temperature conditions on Scotian Shelf often result in near-bottom water layer warming up in spawning area off Emerald and Sable Island banks at 1-2 month delay, which is unfavourable for hake spawning. Temperature gradients occured in that period, as a rule provided favourable feeding conditions, contributing in hake breeding and creating dense fishery aggregations (Vinogradov, 1988). In the years of high uniform temperatures over the entire shelf area with worse feeding conditions, hake dispersed to search food and no dense concentrations occured. Thus, we attempt to reveal and assess long-term factors affecting hake distribution, density of concentrations, recruitment and fishery conditions in the Scotian Shelf area, based on joint Soviet-Canadian researches.

MATERIAL AND METHODS

The program of joint Soviet-Canadian ecological cruises in the Scotian Shelf area provided forage zooplankton sampling to estimate hake concentration steadiness in relation to species composition, abundance, distribution of food organisms and hake feeding dynamics. Samples were taken at each station with subsequent identification and indication of the main forage zooplankton groups: copepods, euphausiides, gyperiids, shrimps, sagitts. Species biomass and number of specimens were estimated in samples.

Forage zooplankton was sampled with small Bongo net - 20.3 (gauze 73 mm), large Bongo net - 60.1 (gauze 73 mm) at two horizons from the surface to the layer of temperature bound and from the bottom to the layer of temperature bound. A "sub-trawl" net IKS-80 (gauze 645 mm) was attached to the trawl to catch hake food organisms immediately during hauling. Temperature measurements preceded zooplankton sampling.

During cruises hake stomachs were sampled by the following length size groups*: 12-20 and 21-25 cm (1^+, 2^+ - juvenile), 26-35 cm (3^+, 4^+, 5^+, 6^+ - mature, spawning) 36-58 cm (7^+, -10^+ - the older age groups with significant natural mortality, mainly females). Stomachs were sampled separately for males and females (Manual of methods, 1974). Samples for individual feeding study were made in males and females of size groups 12-58 cm, 2 specimens (if available) of each 1-cm size interval. Samples were taken from fishes with uninverted stomachs, usually during complete biological or special analysis at feeding study. To reveal diurnal dynamics of hake feeding, catches of hake and food organisms, two diurnal stations were carried out with trawls DT/TB 30/36 and "Hake-4" on 25-26 July, 1988 and 2-3 Junne, 1990 in the Scotian Shelf area.

General indices of stomach fullness (in %oo), food composition by weight (in %), biomass of food organisms (in mg/m^3, g/m^3, g/haul), total hake catch (in kg/half an hour) were calculated during subsequent treatment of feeding data.

RESULTS AND DISCUSSION

Forage zooplankton composition and distribution in 1988.

Data of Scotian Shelf slope survey, obtained in the first half of June, showed abundant zooplankton development in the area

* Size groups are indicated based on maturity stage and possible age changes in feeding.

of Emerald bank south-western slope. Westwards of the area a copepod patch occurred with peak biomass of 3.11 g/m^3. The major food item of young hake, euphausiids, were rare and scarce. (0.03-0.11 g/m^3). Subsequent observations of copepods development during the second half of June revealed intensive development through the period over the entire area. Biomass growth amounted to 0.2-2 g/m^3. Survey in the first half of July showed the wide spread of copepods over the shelf and occurence of separate euphausiid "patches" at eastern and western slopes of Emerald bank. Biomass of the latter varied from 0.1 to 0.4 g/m^3 at different stations.

Subsequent surveys at the end of July and in the first ten days of August showed significant concentrations of copepods on the eastern slope of Emerald bank.

Euphausiids distribution at the end of July through the first half of August resemled "wedging" from deep ocean zones into the slopes of Emerald Bank, where biomass varied from 0.02 to 0.68 g/m^3 at different stations. In the second half of August forage zooplankton was characterized by uniform distribution of copepods over the entire shelf area with slight domination in the north-eastern part (Fig. 1). The same situation was observed in sagitts-predators of copepods, with insignificant biomass variations (0.1-0.28 g/m^3) and domination in the north-eastern part of the shelf (Fig.2). The pelagic shrimp and euphausiids distribution was characterized by occurence close to the shelf edge and shoreline. (Fig. 3). The same distribution of forage zooplankton was observed by Sameoto (1984 a) in August of 1976. Apparently cold water masses drove those organisms to the boundary of warm and cold waters. Thus the conditions of hake feeding varied significantly and feeding selectivity was observed when hake consumed the most large and high-calorie items while passing a copepods layer, came into the layer of euphausiids and filled stomach with the latter.

Food distribution, water temperature and fishery of of hake in 1990

The observation in 1990 showed that the most abuntant zooplankton food items such as M. norvegica and H. galba constituting the major food of young hake, performed diurnal vertical migrations (Sameoto, 1984a), followed by hake, which resulted in hake catch increase, particularly in July 1990 from 16.00 to 18.00, during mass ascending (16.00-20.00) and descending (4.00-8.00) of euphausiids (Fig. 4). However hake catches varied by months and in relation to a depth of catch and water warming up. Thus in May (Fig. 5) the relation to euphausiids concentration and distribution was weaker then in June and July. During entire period euphausiids concentrations occurred at two temperature ranges 4-5°C and 7.5-11°C (Fig. 6) and associated with warm part of front, whereas gyperiids often were abundant in a cold part of the latter.

In May hake catches were observed at temperature 5-11°C and within depth of 140-220 m (Fig. 7,8); in June and July within two depth ranges of 95-145 m (lower catches) and within 150-250 m (high catches) at temperature 8-10°C in the Scotian Shelf area. In July hake distribution and catches were the same as in June (Fig. 7,8).

Thus,as observations in 1990 showed, diurnal hake catches were related to the time period, when hake migrated to follow its mass food item M. norvegica and created concentrations. As a rule high catches of hake (over 500 kg per half-an-hour haul) were observed in deeper areas at higher temperatures (9-11°C) and abundant zooplankton (70-200 g per half-an-hour Bongo haul). It should be mentioned, however, that hake catches are steady at temperature over 6°C and dense euphausiid concentrations, but very scarce at temperature below 4°C and high gyperiid biomass (over 2000 g per sample).

Diurnal trends of hake feeding and forage zooplankton migrations

The results of observations at diurnal station on 25-26 July, 1988 showed similar feeding rythms and intensity in young males and females from 12 to 25 cm in length. Migrating copepods and euphausiids were the major food items. The increase of males feeding intensity was observed from 6.00 to 10.00, and that of females from 8.00 to 11.00, i.e. somewhat later. Both males and females of 12-20 cm in length consumed copepods from 18.00 to 23.00, i.e. during dark hours when the latter migrated to the surface (Fig. 9). Feeding intensity of adult fish (females in particular) considerably grew during the period from 15.00 to 18.00 simultaneously with hake catch growth. At the same period euphausiids and copepods migrated to the surface and their biomass considerable lowered in seston (Fig. 10). During dark period from 22.00 to 6.00 food consumption was uniform and increased somewhat at dawn. It could be noted that euphausiid consumption increase followed the beginning of their migration to the surface.

Adult males (26-32 cm) consumed only euphausiids of 30-35 mm in length with considerable intensity increase at 15.00 and particularly at 23.00. Feeding pattern of females (26-35 cm), consuming euphausiids of 30-35 mm in length was the same, however, fish consumed with euphausiids, constituted the major food item over 24-hour periods. The larger females (36-52 cm) consumed small hake and other species of appropriate size, as well as shortfin squid and euphausiids in less amount. The bulk of food mass in large females consisted of such fish species as hake, rarely mackerel and white hake. Periodicity of feeding (upon large food items in particular) was hardly observed in large females over 24-hour periods. Any large prey available over a day seemed to become a food item for hake.

Thus the trends of hake feeding intensity upon abundant pelagic items over 24-hour periods were similar to that of catch and correlated with food organisms (euphausiids) number increase. During periods of food organisms dispersion hake consentration disappeared also. Therefore hake aggregations distribution and value were related to conditions favourable for feeding and available in particular period and fishing area. In turn food organisms distribution depended on temperature and other abiotic factors (Sameoto, 1984 b) indirectly affecting both those food organisms and their food items. Earlier (1977-1988) it was shown (Vinogradov, 1988) that qualitative and quantitative predominance of euphausiids, gyperiids, shrimp and copepods in hake food, even at unfavourable temperature conditions on shelf (1984), contributed to young hake (as food item for larger hake) abundance increase and resulted in successful fishery over a corresponding period (1985).

On 2-3 June 1990 the results of diurnal hake feeding trends study revealed two peaks of feeding activity from 20.30 to 01.30 and from 6.00 to 10.30 (Fig. 11), which correlated with euphausiids diurnal migrations (16.00-24.00 and 01.00-08.00 respectively) (Fig. 12).

However the research of euphausiid uptake by hake revealed that different size groups of males and females consumed food, as if "in turn", at various intensity. Thus juvenile males and females (12-20 cm) consumed food at similar high intensity from 01.00 to 08.00, and in the period from 10.00 to 18.00 feeding intensity of males was higher than that of females, however, indices of stomach fullness in both sexes were significantly lower by absolute values as compared with that for a previous period (Fig. 13). All other size groups of males and females (21-25 cm, 26-35 cm) and females of 36-58 cm in length feeded upon euphausiids during the same periods and their indices of stomach fullness were considerably lower (below 30‰o in old specimens of 36-58 cm in length). (Fig. 13). We suppose two reasons to explain this: first - physiological differences in feeding intensity of males and females before maturation and during gonad ripening; second - specific adaptive response to utilize food resources more efficiently.

It should be noted that food consumption by adult males and females (26-35 cm) and old females (36-58 cm) was not restricted to euphausiids uptake. Males of 26-35 cm in length consumed up to 12% of fish (hake) by weight, females up to 30% of fish (mainly hake) and 30 % of short-fin squid. Old females (36-58 cm) food consisted of 50% (by weight) of fish (mackerel, hake) and almost 50% of squid as the most rich in calories food and they consumed preys over entire 24-hour periods.

CONCLUSION

Abundant zooplankton species constituted the major food for hake (young hake in particularly) migrated vertically during 24-hour periods and were followed by hake. The latter concentrated in dense aggregations while feeding, which was already reflected in catch increase, particularly from 16.00 to 18.00 during mass zooplankton ascending (16.00-24.00). High catches of hake were observed at higher temperatures and scarce forage zooplankton. It was noted that different size groups of males and females, feeding upon euphausiids, consumed food at various time and at varied intensity, which could be caused both by physiological peculiarities at that period and an adaptive response to feeding conditions. Occurrence of layers with considerable food organisms concentrations at optimal temperatures could serve as a base for short-term prediction of both concentration locations and steady catches of adult and young hake.

Acknowledgements

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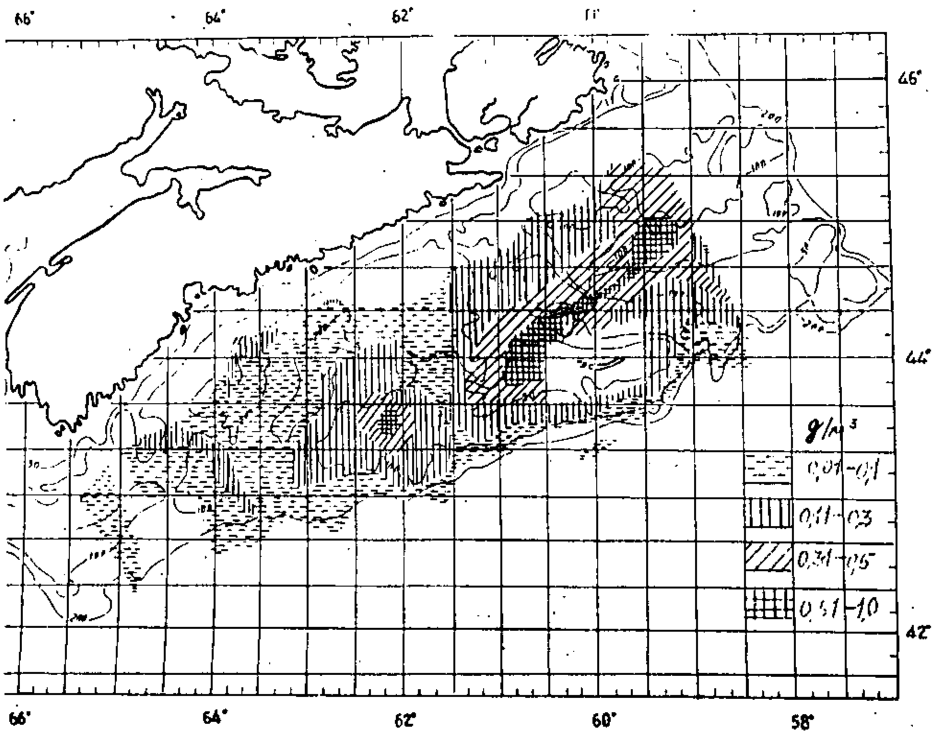

Fig. 1. Copepod biomass distribution in survey on Scotian Shelf on 12-29 August 1988.

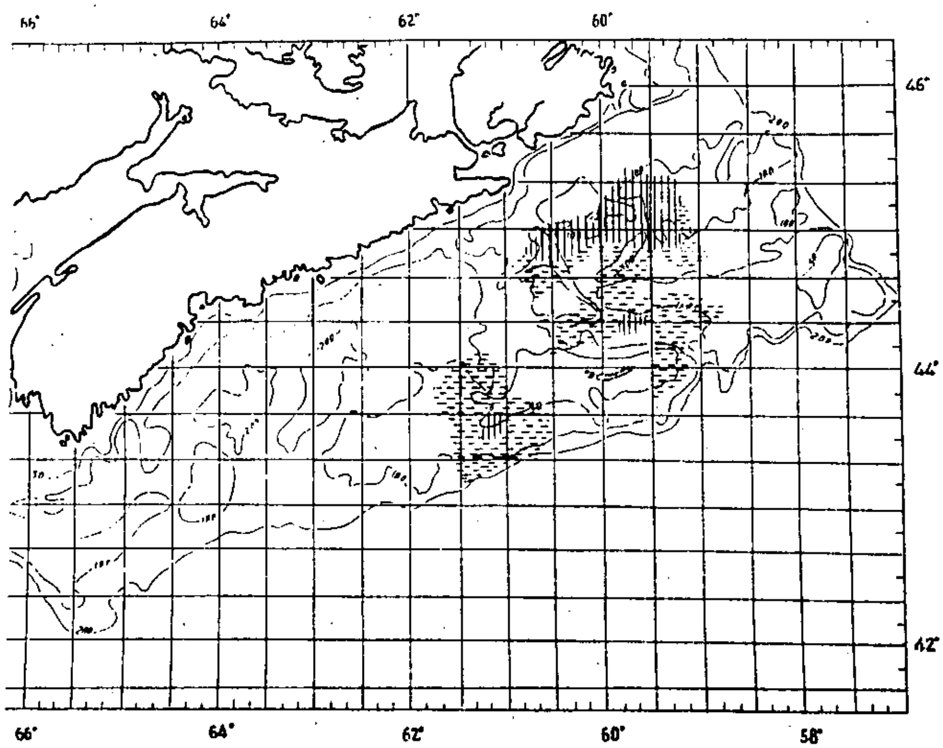

Fig. 2. Sagitt biomass distribution in survey on Scotian Shelf on 12-29 August 1988.

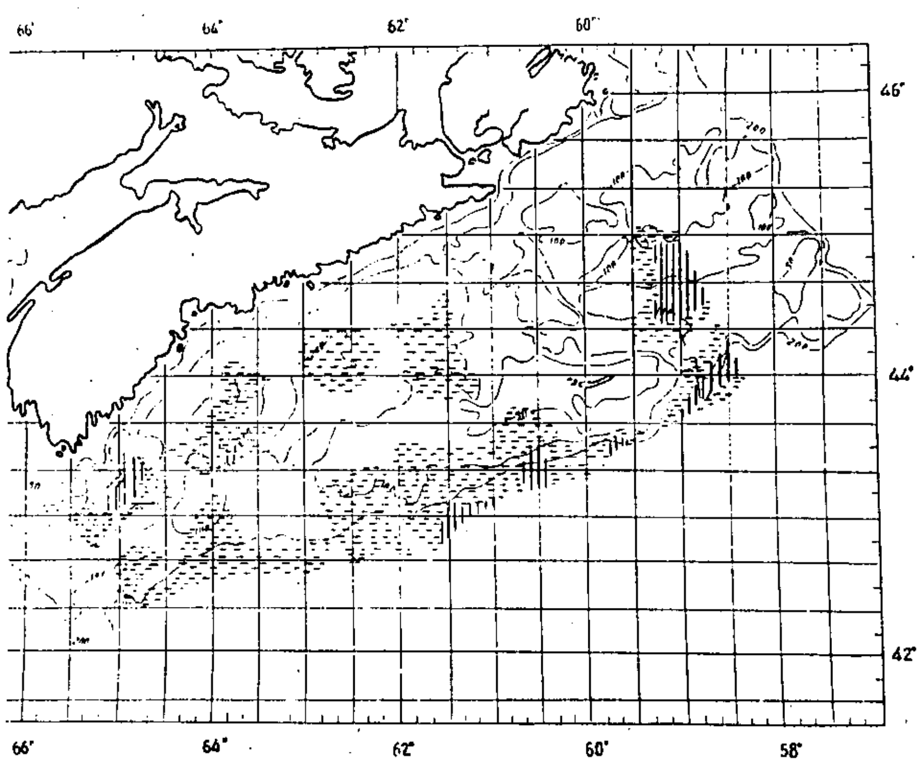

Fig. 3. Euphausiid biomass distribution in survey on Scotian Shelf on 12-29 August 1988.

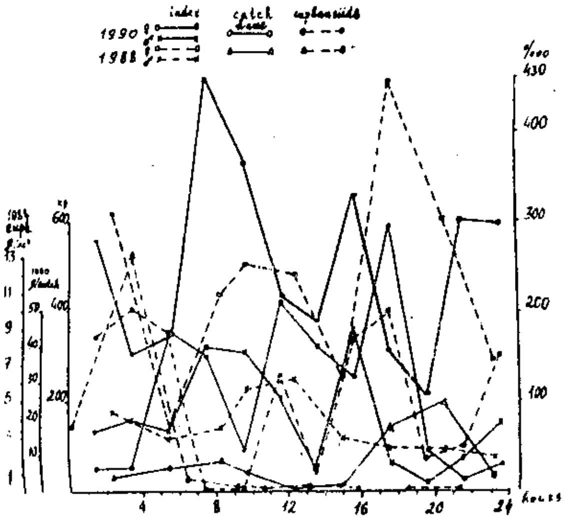

Fig. 4. Distribution of hake catches, indices of stomach fullness and euphausiids biomass over 24-hour periods in July 1988 and June 1990.

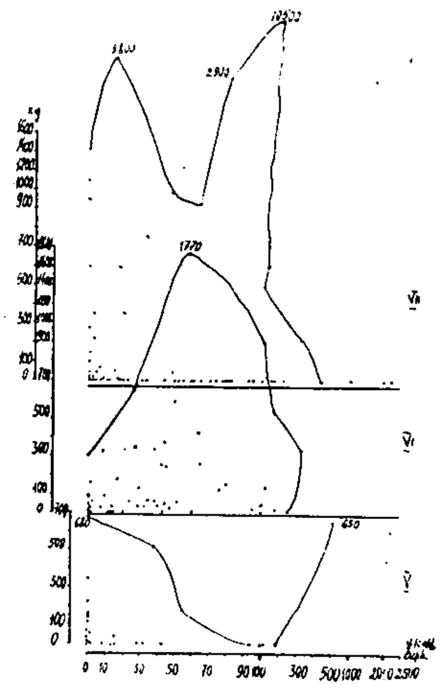

Fig. 5. Hake catch value in relation to euphausiids and gyperiids concentrations by months in 1990.

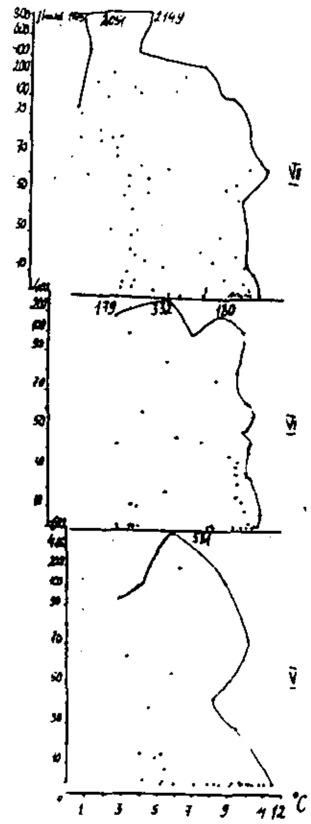

Fig. 6. Euphausiids and gyperiids concentrations in relation to water temperature by months in 1990.

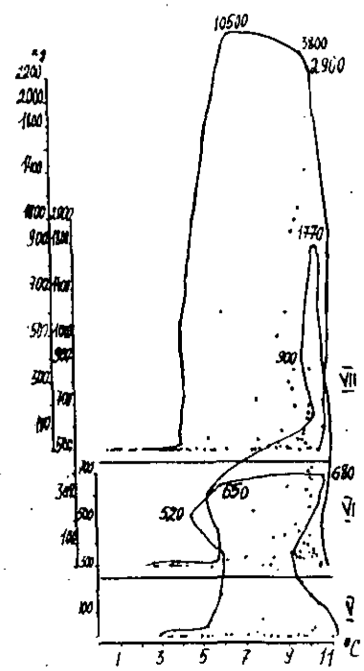

Fig. 7. Hake catch value in relation to water temperature at bottom by months in 1990.

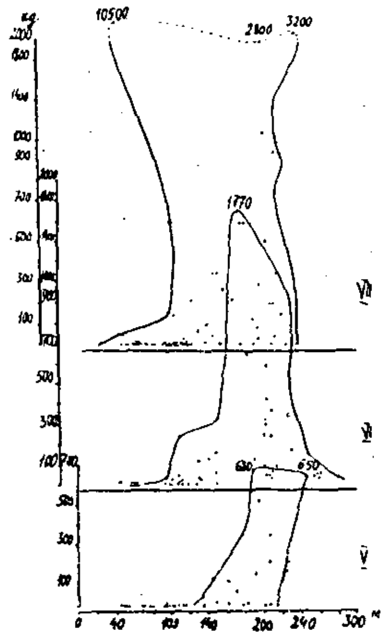

Fig. 8. Hake catch value by depth in various months in 1990.

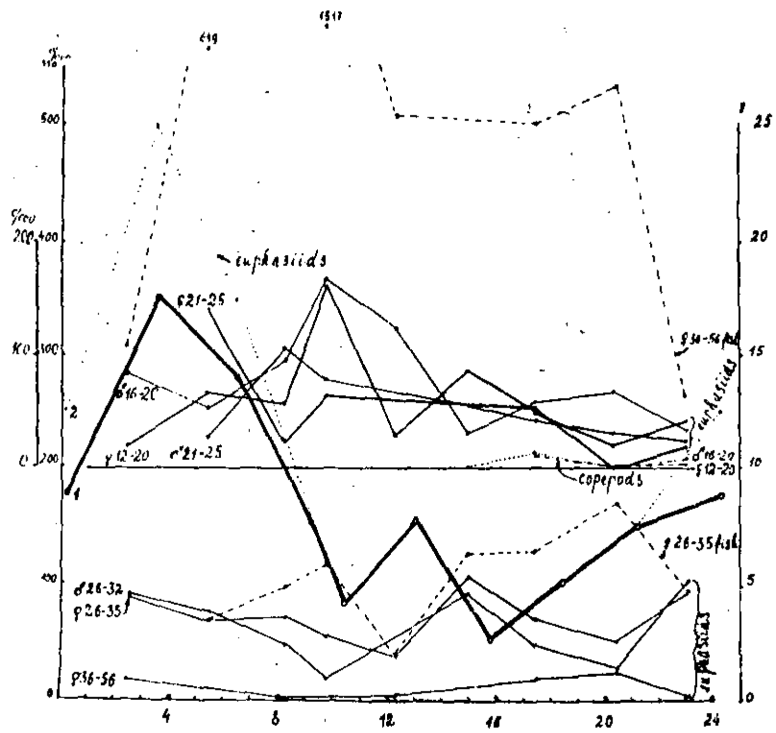

Fig. 9. Hake male and female feeding intensity by size groups at diurnal station in July 1988.

Legends: 1 - total biomass of forage zooplankton (mainly copepods);

2 - biomass of euphausiid.

Note: Size groups of hake (in cm) and indices of of stomach fullness (‰o) by food items are shown.

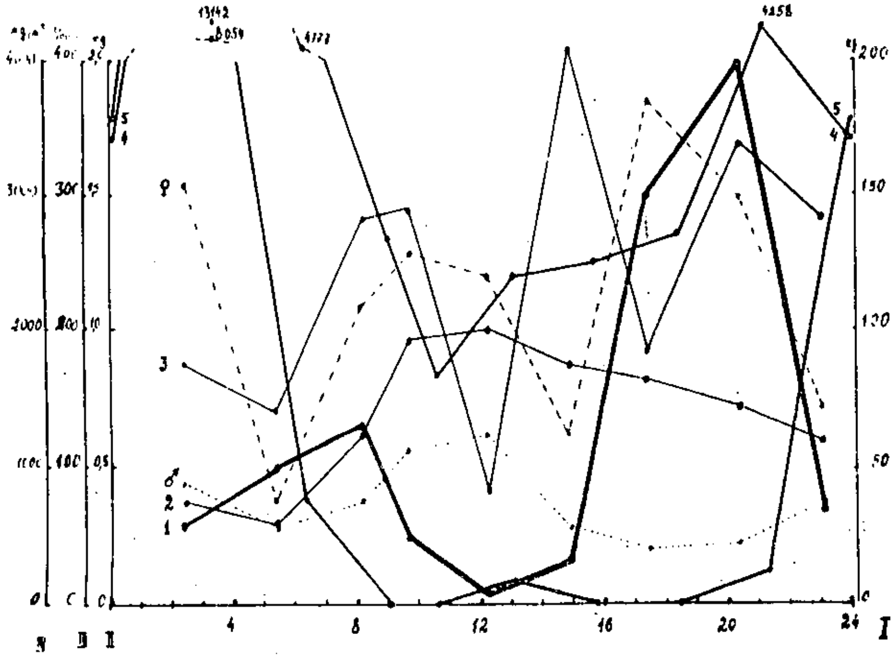

Fig.10. Hake catch value at diurnal station (scale I), copepods and euphausiids biomass in subtrawl net (scale II) and Bongo (scale IV), index of stomach fullness in hake males and females (scale III) in July 1988.

Legends: 1 - hake catch (kg);

2 - euphausiid weight in "subtrawl" net (kg/haul);

3 - copepod weight in "subtrawl" net (kg/haul);

4 - copepod weight in Bongo (mg/m^3);

5 - euphausiid weight in Bongo (mg/m^3);

- hake male index of stomach fullness (%oo);

- hake female index of stomach fullness (%oo).

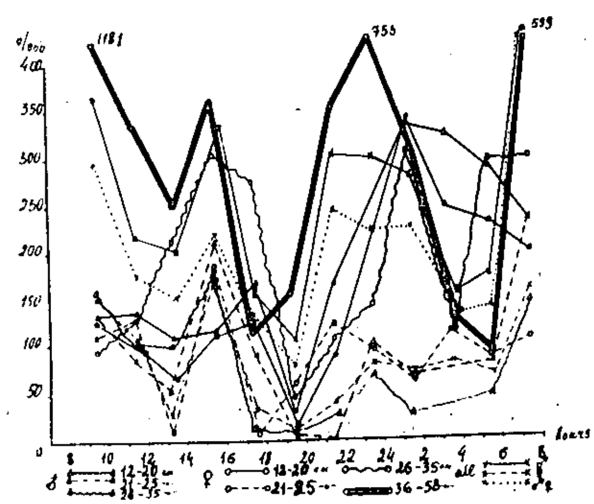

Fig.11. General indices of stomach fullness in hake males and females of different size groups at diurnal station in June 1990.

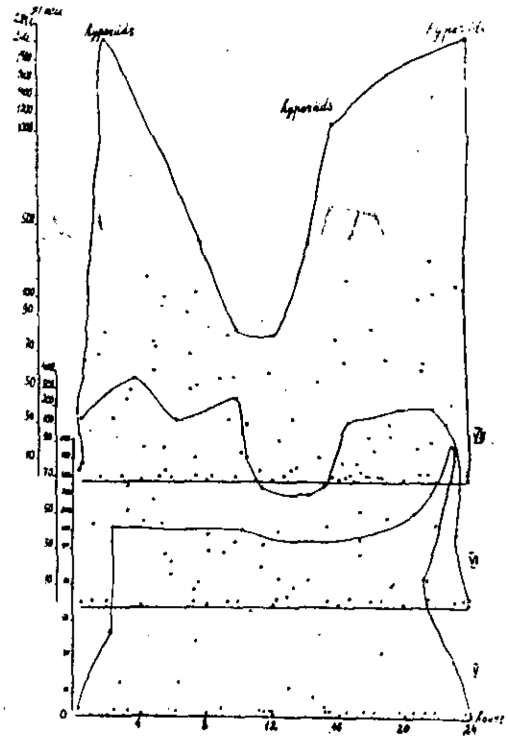

Fig.12. Catches of gyperiids, euphausiids (in g/30 min.) over 24-hour periods in May (large Bongo), June, July (IKS-80, "subtrawl" net) and June 1990.

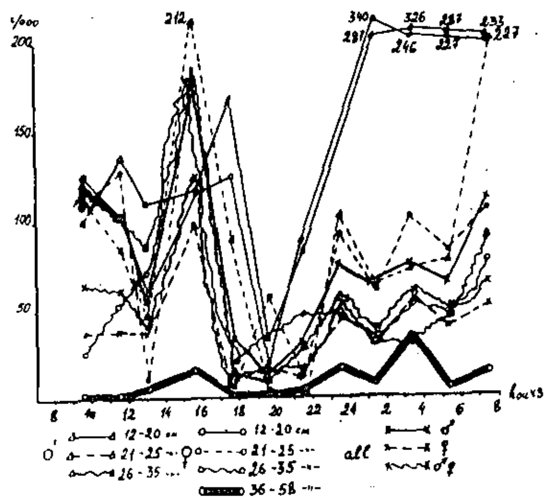

Fig.13. Individual indices of stomach fullness (euphausiids) in hake males and females of various size groups at diurnal station in June 1990.