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State of the Stocks of Deepwater Shrimps in the West Greenland Area

by

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INTRODUCTION

The shrimp fishery in fjords and coastal waters of Greenland has been of commercial importance since post-war years and since then a persistent tendency for an increase in catches was observed. Annual catch of shrimps by Greenland amounted to 8-10 thousand tons in the last years. Strengthening of press of the fishery on the fjord concentrations, which are more or less isolated populations, has never led to a decrease in the abundance of fishing populations. Some cases of decline of fishery were caused by unfavourable changes in hydrological conditions. Mass deaths of shrimps in the Holsteinsborg area after an extremely cold winter 1948-49 can provide an example of this event (Horsted S.A. and Smidt E., 1965).

In the 70's exploitation of shrimp concentrations started in the open area of the shelf. Norwegian vessels were most successful there. According to preliminary data shrimp catches taken by Norwegian vessels in the West Greenland area averaged 8 thousand tons in 1975 (newspaper "Fiskaren, N.85, 11 December 1975).

Soviet observations on the peculiarities of development and ecology of the deepwater shrimp (Pandalus borealis) on the slopes of West Greenland banks were conducted during cruises of

R/V "Zarnitsa","Medvezhi" and "Perseus III" in 1974-75. Dense concentrations of shrimps were found on the western slopes of Store-Hellefiske Bank,off Disko Island and in the Holsteinsborg Trench. These concentrations were fished by bottom selective trawls with a mesh of 18 mm in the cod-end (from knot to knot). Complex oceanological observations were made on the grounds of shrimp concentrations. Soviet fishery on the western slope of Store-Hellefiske Bank yielded about 6 thousand tons of shrimps in 1975.

DISTRIBUTION AND ECOLOGY OF DEEPWATER SHRIMPS

Pandalus borealis play a dominating role in the crustacean fishery in the North-West Atlantic waters. The shelf and fjords from Cape Farewell as far as 75-76°N are populated with Pandalus borealis along the West Greenland coast (Hjort J. and Ruwd J., 1938). Main concentrations of shrimps in this area are fjord concentrations or concentrations located in close proximity to to the coast (Smidt,1965). However,in the last years shrimp concentrations were found in the open localities of the area (Fig.1).

Our investigations showed that concentrations of the off-shore West Greenland shelf,as distinct from fjord ones,are under a great influence of relatively warm waters. Formation of fishing concentrations of shrimps in the area is associated with the zone of interaction of warm jets of the West Greenland Current and cold waters of the Baffin Land Current. Many years' observations on the hydrological regime are indicative of the presence of a relatively steady zone of the Polar front in the

Store-Hellefiske Bank area.

Formation of shrimp concentrations in the zones of interaction of water masses of different origin is characteristic both for the Barents Sea shrimps (Bryazgin V.F.,1970) and for shrimps of the northern Pacific Ocean (Ivanov B.G.,1967;Ivanov, 1969).

According to data of observations in October-November 1974 steady shrimp concentrations on the western slopes of Store-Hellefiske Bank were distributed along the frontal zone in waters with bottom temperature of 2-3°,and they were fished in depths 230-260 m (Fig.2,3).

Complicated ice conditions in the Canadian-Greenland Ridge area do not make it possible to conduct investigations of shrimps on the banks north of 65°N the year throughout. Drift ice,brought by the Baffin Land Current,freeze together with winter ice and closes the area of detected concentrations for a long period (6-8 months). Fishing for shrimps can be conducted approximately from July to November inclusive.

When studying the possibility of a rational exploitation of the shrimp stocks there arise some problems associated with natural fluctuations in the abundance,strength of individual year classes and influence of fishery on the state of stocks.

Deepwater shrimps,as known,are protandrous hermaphrodites; males are considerably smaller than females and are poorly fished by commercial trawls. It is evident from the analyses of the length and sex composition of samples from the Store-Hellefiske Bank area that the percentage of males in the total abundance of samples is insignificant (Fig.4). Females at the age of 4-5

years and intersexes at the age of 3-4 years make up the bulk of commercial catches. The maximal age of males is 3 years. Shrimps at the age of 6 and more years are extremely scarce in catches that is indicative of a great natural mortality at this age. This conclusion coincides with Smidt's point of view (Smidt, 1965) about a relatively short life cycle of shrimps off the West Greenland coast.

According to the 1975 data the shrimp spawning started in mid-August in the Store-Hellefiske Bank area, and in September number of specimens with eggs on pleopods reached 54.9% of the total number of females investigated. Hatching of larvae takes place apparently in April-May after an extended (up to 8 months) incubation period. Larvae are transported by currents over a considerable distance, recruiting to the stocks of concentrations on banks and in the open fjords. Numerous vortices of waters, originating in the areas of interaction of currents, promote the process of larvae sinking in the localities of shrimp concentrations.

Shrimps of the genus Pandalus are not active migrants and they make only local horizontal migrations. Vertical migrations, rather clearly pronounced in the summer-autumn period, affect the diurnal dynamics of catches. Catches are maximal during day, while at night there is observed a decrease in catches due to migration of shrimps to upper layers.

ASSESSMENT OF STOCKS AND ESTIMATION OF THE VALUE OF AN OPTIMAL YIELD OF SHRIMPS

An increase in the intensity of the shrimp fishery in the

West Greenland area generates a need for an assessment of stocks and evaluate the value of an optimal removal by the fishery in the open part of the shelf.

When assessing the stocks of shrimps a method of instrumental-trawl survey and underwater observations was used.

Shrimp concentrations, detected by Soviet vessels, distributed over an area of 320 miles. Average catch taken on these concentrations amounted to C'=550 kg/hour.

Density of concentrations was determined by means of underwater visual observations from hydrostate "Sever-1". It was found that large shrimps stay in the water layer $\bar{h}$ =50 m in height at a distance of 1.5-2.0 m from each other, that corresponds to density of 0.3-0.12 m^{-3}. The value of the average density $\rho_{st}=0.2 m^{-3}$ was used in calculations. At the sites of hydrostate diving the shrimp catch made up 406 kg per 1.08 trawling hour, or C'_{st}=376 kg/hour. Taking the value of density, that was determined visually, as standard one and catch per trawling hour as a relative index, we obtain the average density of concentrations:

$$\bar{\rho}=\bar{\rho}_{st}\frac{C'}{C'_{st}}=0.2\frac{550}{376}=0.3\ m^{-3}$$

Considering that 1 specimen weighs 9.2 g on the average, we obtain a tentative value of the total biomass of shrimp concentrations :

$$G=3.43\cdot10^{6}\cdot\bar{\rho}\cdot\bar{h}\cdot S\cdot q=3.43\cdot10^{6}\text{x)}\cdot 0.3\cdot50\cdot320\cdot9.2\cdot10^{-6}=151000\ t$$

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x) $3.43\cdot10^{6}$ - area of the first square mile in m^2.

To check the correctness of the assessment of the average density we determined the fishing efficiency of the trawl. The bottom trawl used during our investigations had the following parameters : horizontal opening h_r =20 m, vertical opening h_v=4m and cross-section of the trawl mouth $S_m = \frac{\pi}{4} \cdot 20 \cdot 4 = 63\ m^2$. Volume of water strained by the trawl per 1 hour with a speed of 3 knots is

$$V_{tr} = 63 \cdot 3 \cdot 1852 = 350\ 000\ m^3$$

Catch per 1 hour made up 376 kg, or at the average weight of one specimen of 9.2 g, C=41000 specimens/hour. At the average density $\bar{p}$ =0.2 m^{-3}, the fishing efficiency is

$$\eta_t = \frac{41000}{0.2 \cdot 350\ 000} = 0.59$$

The value obtained is higher than fishing efficiency under fishery (η_t =0.1-0.5) that can be explained by a more passive behaviour of shrimps in the zone of trawl operation. Therefore, the estimation of the average density and hence calculated value of the total biomass of concentrations could be considered to be close to reality.

When assessing the value of an optimal yield of shrimps in the West Greenland area we were guided by the following:

1. Reproductive ability of shrimp concentrations in the seas of North Atlantic is at a rather high level due to a relatively short life cycle.

2. Shrimp concentrations on Store-Hellefiske Bank should be considered to be populations of a semi-dependent type, as a

considerable recruitment to their stocks can take place at the cost of larvae transport from more southerly areas.

3. In connection with the peculiarities of individual development (protandrous hermaphroditism) fishery can have an effect only on females and large intersexes. In this case a rapid recruitment to the fishing stock is possible due to growing males and intersexes. This assumption is in good agreement with conclusions made by Rasmussen in his paper (Rasmussen,1958) dealing with necessity of protection of egg-carrying females.

According to data of our observations females aged 5+ make up 40-50% of fishing populations. As a rule,they do not survive till they are six. A great natural mortality at this age as well as the foregoing biological events enable one to recommend an annual yield of shrimps at 40-45% of the total stocks of detected concentrations.

Thus,an annual yield of shrimps in ICNAF Subarea IB (in the open part of the shelf) can amount to 60-70 thous. tons.

As measures of protection of stocks of shrimps and fish in the West Greenland area it is suggested to use only selective fishing gears for the shrimp fishery,to establish an optimal mesh size for all the vessels of all countries conducting shrimp fishery in the West Greenland area. Selective trawls with a mesh size of 18 mm in the cod-end were used by all Soviet vessels conducting shrimp fishery in 1975.

CONCLUSIONS

Main stocks of Pandalus borealis in the West Greenland

area are concentrated in fjords and coastal zone of the shelf. However,in the last years a number of concentrations was found in offshore areas on slopes of some banks.

Formation of these concentrations is connected with the zones of active interaction of warm waters of the West Greenland Current and Baffin Land Current waters. Local vortices in the Polar front zone promote sinking of shrimp larvae transported from more southerly areas of the shelf and fjords of West Greenland.

Females at the age of 4-5 years and intersexes at the age of 3-4 years make up the bulk of shrimp catches in the Store-Hellefiske Bank area. Shrimps at the age of 6 and more years are extremely scarce in the catches that is indicative of a great natural mortality at this age.

Total stocks of shrimps in the Store-Hellefiske Bank area was estimated at 151 thousand tons by the method of underwater observations and instrumental-trawl survey.

Taking into account a short life cycle of shrimps as well as possibility of recruitment to the fishing stocks due to transport of larvae from more southerly areas,we believe that the annual yield of shrimps in ICNAF Subarea IB (fjord and coastal concentrations excluding) should be 60-70 thousand tons.

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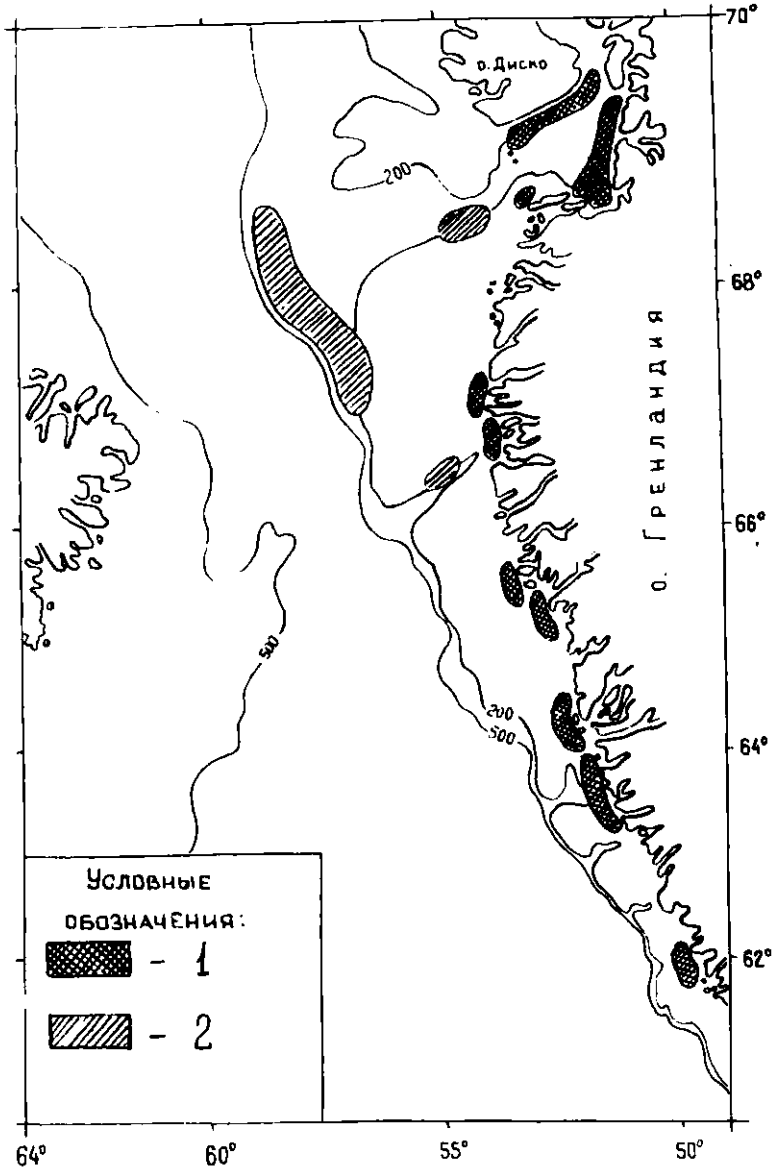

Fig. 1 Distribution of concentrations of shrimps (Pandalus borealis) on the shelf and in the coastal areas of West Greenland.

(1 - coastal concentrations)
(2 - concentrations of the open part of the shelf)

Рис.1. Распределение скоплений креветки P andalus borealis на шельфе и в прибрежных районах Западной Гренландии (1-прибрежные скопления; 2-скопления открытой части шельфа)

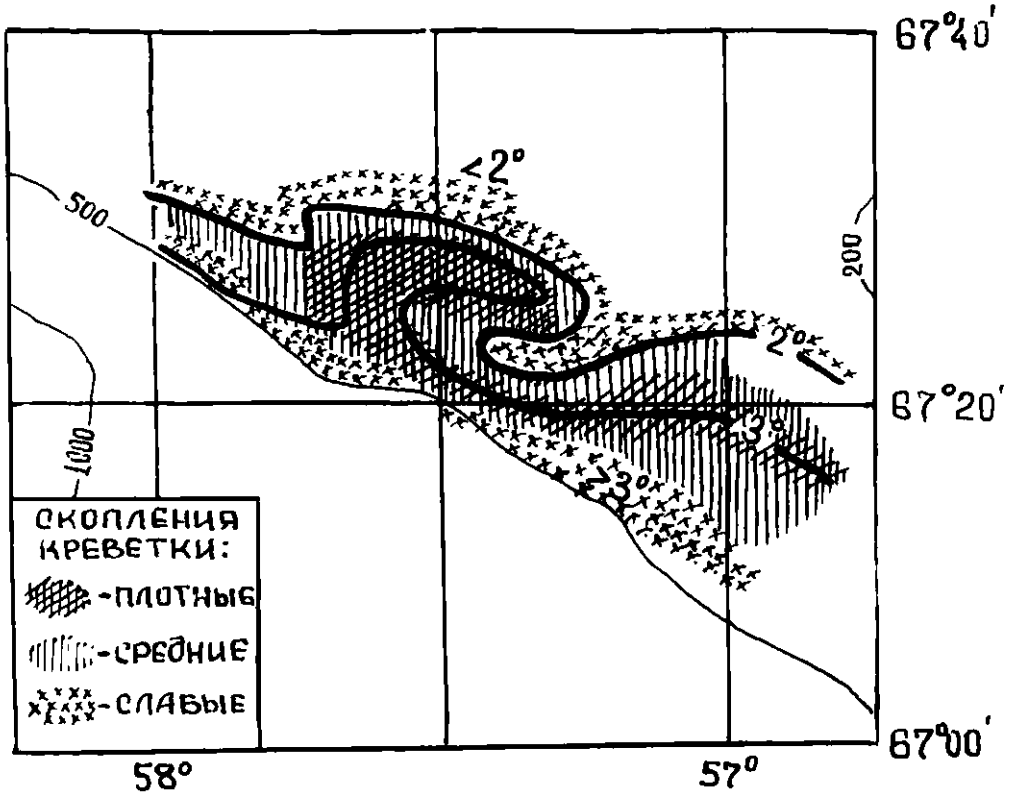

Fig. 2 Horizontal distribution of temperature and density of shrimps concentrations on the western slope of the Store-Hellefiske Bank in October 1974.

Рис.2. Горизонтальное распределение температуры и плотность скоплений креветки на западном склоне банки Сторе-Хеллефиске в октябре 1974 г.

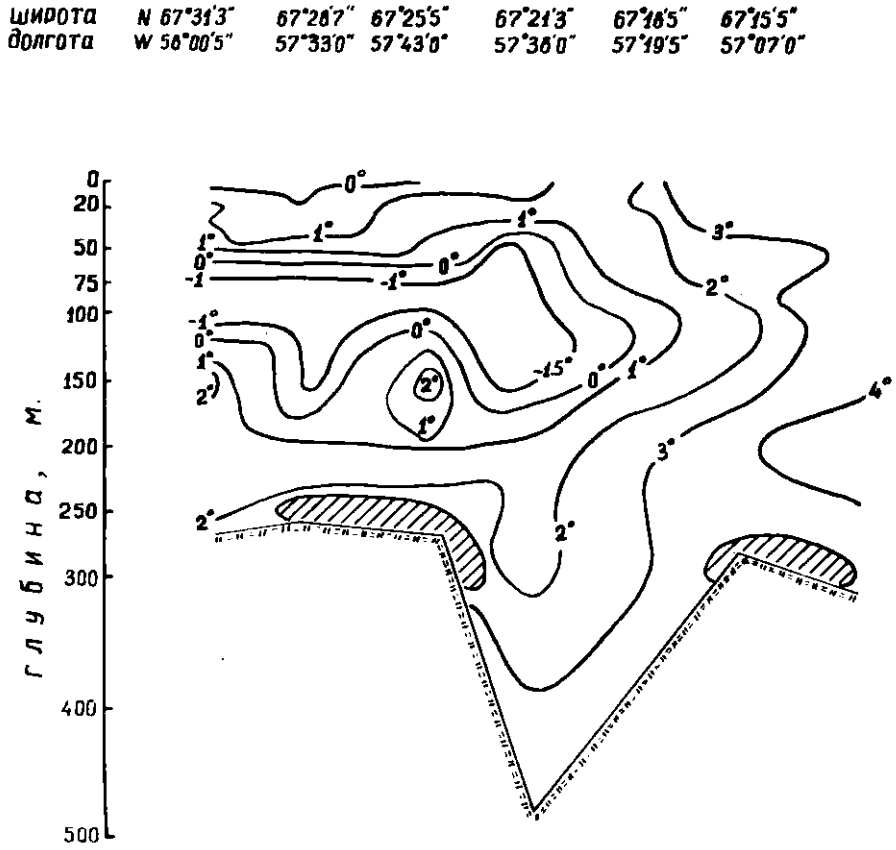

Fig. 3 Vertical distribution of temperature in the western slope area of the Store-Hellefiske Bank in October 1974 (grounds of shrimps concentrations are shown by the hatching).

Рис.3. Вертикальное распределение температуры в районе западного склона банки Сторе-Хеллефиске в октябре 1974 г. (штриховкой показаны места скоплений креветки)

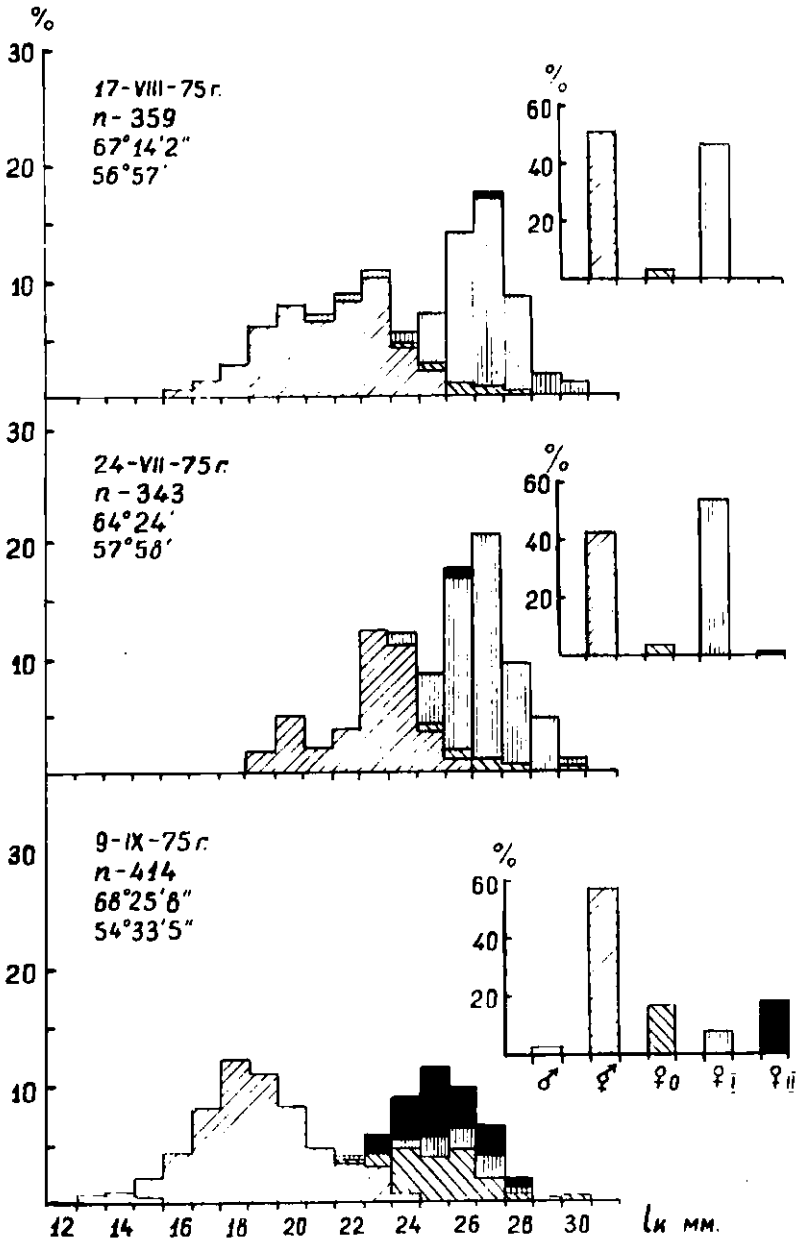

Fig. 4 Length composition and ratio of sex groups of shrimps in the Store-Hellefiske Bank area in July-August 1975.

♂ - males, ♂♀ - intersexes;
♀0 - females without eggs on pleopods;
♀I - females with developing ovocytes;
♀II - females with eggs on pleopods.

Рис. 4. Размерный состав и соотношение половых групп креветки в районе банки Сторе-Хеллефиске в июле-августе 1975 г.

♂ - самцы; ♂♀ - особи, меняющие пол;
♀0 - самки без икры на плеоподах;
♀I - самки с "головной" икрой;
♀II - самки с икрой на плеоподах

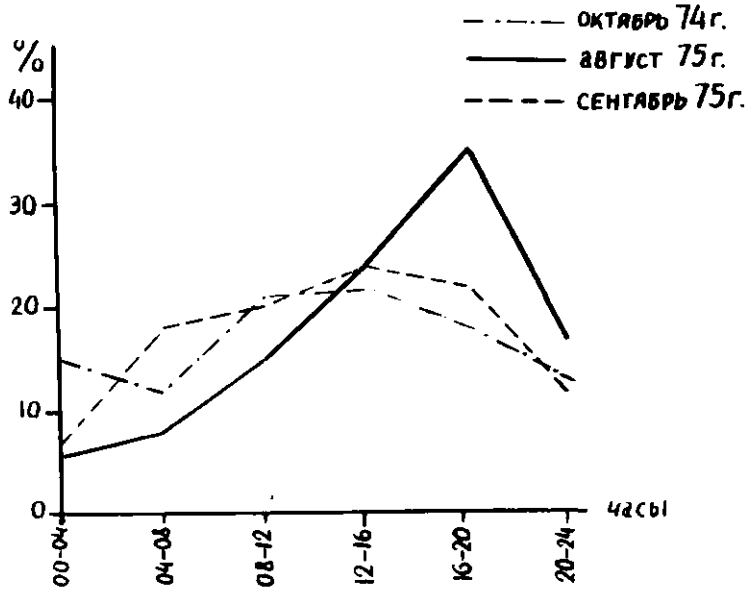

Fig. 5 Diurnal dynamics of shrimp catches in the Store-Hellefiske Bank area in October 1974 and August-September 1975.

Рис.5. Суточная динамика уловов креветки в районе банки Сторе-Хеллефиске в октябре 1974 г. и августе-сентябре 1975 г.