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RESULTS OF THE RUSSIAN TRAWL ACOUSTIC SURVEY FOR SEBASTES MENTELLA OF THE IRMINGER SEA IN 1993

by

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ABSTRACT

Results of the traditional Russian trawl-acoustic survey (TAS) for Sebastes mentella Travin of the Irminger Sea conducted in June-July 1993 by R/V "PINRO" are described. The TAS was carried out offshore both in the Irminger Sea and inside the 200-mile zone of the Eastern Greenland with the use of EK/ES-400 echo-sounder and SIORS echo-integrator following a standard method by contouring squares with similar density. The survey covered the area between 54°31′-63°00′ N and 28°45′-45°30′ W. Total biomass of redfish was calculated to be 2.5 mill.t with an abundance of 4.09 x 10^9 specimens. Concentrations of S.mentella consisted of fish 24-47 cm long with ages from 6 to 23 years were found predominantly at depths of 100-250 m together with the usual inhabitants at the acoustic scattering layer (jellyfish, Myctophidae and squid). Infestation of redfish by copepoda, S.lumpi remained at the mean long-term level. Geographical peculiarities of the redfish concentrations in the summer of 1993 are revealed.

1. INTRODUCTION

The most important commercial fish species in the pelagic waters of the central part of the North Atlantic is the deepwater redfish Sebastes mentella Travin. The first biological information collected on this species in this area was published by researchers of Russia and other countries more than 30 years ago (Taning, 1949; Zakharov, 1964; Magnusson, 1962). An active fishery for S.mentella in the Irminger Sea was commenced by USSR in 1982. Later on, the fishing fleets of Poland, Germany, Bulgaria, Iceland, Norway, Denmark and Faroe Isls became involved. During 1982-1993, the total international catch constituted more than 700.000 t (Anon., 199).

Immediately after discovering commercial concentrations of S.mentella in this area in 1981, Russian scientists began to conduct detailed studies on the biology of this species, on peculiarities of its distribution, and on stock structure (Pavlov, Mamylov and Noskov, 1989; Pavlov and Shibanov, 1991; Ermolchev et al. 1984; Bakay, 1988, 1989; Bogovski and Bakay, 1989; Pavlov, Galuzo, 1989). A long term plan to conduct annual observations on this important commercial stock has been developed and technological and analytical methods of stock assessment have been worked out and are regularly updated (Pavlov, Gorelov and Oganin, 1989; Pavlov, Mamylov, Noskov, Romanchenko and Ivanov, 1989). PINRO has conducted trawl acoustic and ichthyoplankton surveys of this stocks each year since 1982. Because of the increasing intensity of the international fishery for redfish, researchers from Iceland, Norway, Faroe Isls and Germany also now investigate this stock. In 1992, estimates biomass and distribution of concentrations of redfish were estimated during the joint Russian-Icelandic trawl-acoustic survey (Magnusson et al., 1992).

Results of research conducted in 1993 and reported here are the continuation of Russian monitoring of the S.mentella stock in the Irminger Sea which were began previously (Anon., 1991, 1992 and 1993).

2. MATERIAL AND METHODS

The traditional trawl acoustic survey (TAS) for commercial stock of S. mentella of the Irminger Sea was conducted using the RV "PINRO". The route of the survey is shown in Fig. 1.

TAS for the S. mentella stock was carried out from June, 07, till July, 08, 1993, offshore in the Irminger sea and inside the 200-mile zone off Eastern Greenland using the EK/ES-400 (38 kHz frequency) echo sounder and a SIORS echo-integrator. An interval of integral averaging (ESDU) was considered equal to one mile. An equation of redfish target strength (TS), shown below, obtained by Icelandic specialists in hydro-acoustics in 1992 with the help of new devices, was used in 1993 (Reynisson, 1992).

$$TS = 12.5 \text{ LOG } (L) - 59.5,$$

where L - fish length.

The use of the equation,protected against over-estimates of small redfish (by 83 % for fish to 27 cm long) and under-estimates large redfish (by 15 % approximately) allowing for comparison with the equation employed in PINRO.

A total of 2336 fish were processed to determine the level of invasion of redfish by the copepod Sphyrion lumpi (including observations including residual tracks of the parasite), and occurrence and character of pygments on the skin of the fish. Seventy specimens were investigated by full parasitological dissection. Collection, identification and fixation of evident parasites, as well as primary processing of materials were conducted following accepted methods (Bykhovskaya-Pavlovskaya, 1985; Bakay, 1988 and 1989; Bogovsky and Bakay, 1989).

PINRO investigations of fisheries oceanography in the Irminger Sea and adjacent areas has been directed at studying the influence of hydrometeorological conditions on redfish behaviour during their life cycle (Alexeeva, Balabanova and Svetlov, 1989; Alexeeva, Svetlov and Balabanova, 1990; Pedchenko, 1992; Shibanov, Bakay, Melnikov and Pedchenko, 1993). Peculiarities of formation conditions of redfish concentrations in summer 1993 were revealed by materials of works in

the Irminger Sea and adjacent areas. Oceanographic observations were made on tracks of TAS for redfish even 35-40 miles using a CTD "Smart" and a series of bathometers down to a depth of 1000 m. In June, observations were conducted at 13 stations in the 3-K section located north of 60° N (Fig. 1).

Analysis of oceanographic conditions was conducted in the conventional areas:

I - the northern area (north of 60°00′ N);
II - the central area (57°30′ - 60°00′ N);
III - the southern area (52°00′ - 57°30′ N including the eastern part of the Labrador Sea);
IV - fishing zone of Greenland.

3. RESULTS

3.1. Trawl-acoustic survey

Redfish abundance in the Irminger Sea amounted to 1693.8 mill. specimens with a biomass of 999.300 t. In the Greenland zone, redfish abundance was estimated at 2493.5 mill. specimens with a biomass of 1557.700 t (Table 1). Distribution of the redfish concentrations is presented in Fig. 2.

3.2. Peculiarities of S. mentella behaviour and distribution in the summer of 1993.

In the early June in areas north of 59° N, few concentrations of redfish were registered in the 70-450 m depth layer with small densities in 100-250 m depth range.

Redfish density did not exceed 5-8 t per sq. mile. The acoustic scattering layer was observed and consisted predominantly of jellyfish, Myctophidae and Entomostraca. Jellyfish constituted 25-75 % of the catches. South of 59°, redfish density was slightly higher than in the southern area. On the fishing grounds, the density of concentrations reached 100-1800 t per sq.mile within small areas. Schools of 3-5 miles extension and from 200 to 250 m depth were registered in the layer of 100 to 700 m. The distributional area of there concentrations did not exceed 600 sq. miles.

Within the 200-mile zone of the East Greenland, scarce concentrations of redfish were registered in the 70-300 m depth layer, increasing in number at 100-200 m depths. Species composition of acoustic scattering layer and correlation of its components were similar to those in the off-shore. By-catches of jellyfish constituted 30-75 %. Diel vertical migrations of redfish were not registered in any of the survey areas.

3.3. Biological characteristics of S. mentella

In summer mature males predominated (60.7 %) in redfish concentrations througout the area of the TAS. The length range of the mails was 33-38 cm long and females 34-39 cm long with mean sizes of 35.1 cm and 36.1 cm, respectively (Fig. 3A). The age of males (from scale readings) ranged from 6 to 21 and for females - from 6 to 23 (Fig. 3B). More than half of redfish females had gonads at the 3-d stage of maturity (Sorokin, 1961). It was evident that most of the mature females in summer were either migrants (specimens maturing for the first time) or females which did not spawn in 1993.

A trend of decreasing redfish mean length with increasing depth was noted. At depths less than 150 m, mean length of males was 35.9 cm and females - 37.6 cm; deeper than 200 m, mean length were 34.3 and 35.4 cm, respectively.

Intensity of redfish feeding increased notably in summer compared with spring period. Mean valueball of stomach fullness of males constituted 1.4 and of females - 1.3. The main prey in summer was Calanus and euphausids, Sagitta, young squid, octopus and Myctophidae.

In the parasitological investigations, 13 species of parasites were noted in redfish relating to 5 taxonomic groups: Cnidosporidia - 3, Cestoda - 4, Trematoda - 3, Nematoda- 2, Crustacea - 1. The fauna of parasites present indicates that redfish dwell feed in the pelagic waters of the area.

There were no significant differences in species composition of parasitofauna in redfish collected from the northern and the southern areas. This would suggest an existence of a single population of S. mentella in the pelagic waters of the Irminger Sea (Bakay, 1988).

The level of invasion of redfish by the copepoda S. lumpi was similar to the mean long-term level. Overall average extensity of infestation was 16.0 % of all fish sampled with 0.54 parasites per 1investigated fish. Including old cephalothoraxes, these indices increased to 34.2 % and 0.70 cases of infestation respectively. As in previous years, infestation increased with the age of fish, and it was 2-3 times higher in redfish females than in males. In connection with this, the level of invasion of redfish in the southern part of the area was lower than in the northern one because

males predominated in that area (Table 2). Infestation decreased by 5-15 % with depth, where small fish occurred as a rule in summer.

Larvae of Anisakis simplex, which are harmful to man when alive, were found in redfish muscles in 35-40% of the samples with an average intensity of 1.0 parasites per fish.

A incidence of redfish invasion by this parasite increased with the length (age) of fish, since these nematodes accumulate in the organism of thrughout its life.

Black and red pygments of non-parasitic origin (Bogovski and Bakay, 1989) were located on fish skin 3.7 times more on average in females than in males of redfish (Table 2). Occurrence with such pygments increased with length of investigated specimens and reached a maximum in males 37-38 cm long and in females 39 cm long. As in previous years, males and females differred in location of pygments on their bodies, which may be related to genetic conditionality.

3.4. Oceanographic conditions in 1993

Conditions of summer, 1993, in the area of the survey were characterized by a lack of warmth in the ocean surface. Deep cyclones, passed through the area in the direction of Iceland during winter cooling period. This favoured the intensive mixing of the upper layes of the ocean. Usually, our notion about conditions in the area of the Irminger Sea is formed in April yet by temperature and salinity of waters in the 3-K section (Alexeeva, Balabanova and Svetlov, 1989). Observations made in April, would suggest the oceanographic conditions in 1993 in the Irminger Sea were similar to those the "cold years" of 1983 and 1984 (Pedchenko, 1994). The temperature on the surface of the sea in spring 1990-1993 declined with decreased rates of seasonal warming in the active layer. If the difference in temperatures constituted 3.0°C in June and April at stations 1-6 of the 3-K section in the 0-50 m layer in 1990, than it did not exceed 1.0°C in 1992 and 1993 (Fig. 4a). In the lower layers (Fig. 4b, c and d), the change of temperatures from spring to summer was not so evident, but the tendency of minimal waming took place. Because of weak advection of the Atlantic waters by the Irminger Current, the warmness of waters of the intermediate structure (200-500 and 500-1000 m layers) in June 1993 was lower than that in April (Fig. 4c and d).

Oceanographic conditions in spring 1993 influenced the distribution of fattening concentrations of redfish. Because of weakened advection of Atlantic waters, the waters of Arctic origin predominated in Area 1. Dense schools of fish were absent there, and that, in our opinion, was caused by the decrease of thermohaline indices and a minimal change in their range in recent years (Fig. 5a). In Areas II and III, the oceanic conditions for fish concentrations were more favourable than in the northern area. The formation of fattening concentrations of redfish was noted there under lower thermohaline indices and with smaller amplitude of changeability than in previous years (Fig. 5b and 5c) (Shibanov, Bakay and Pedchenko, 1993). This led to changes in conditions of formation of redfish concentrations (Fig. 5) which coincided with interannual changes of rates of seasonal warming and advection of Atlantic waters (Fig. 4). Thus, when the mentioned processes were weakend, redfish concentrating was mainly located in the cold periphery of the frontal zone south of 59° N.

Redfish distribution in the area of the survey coincides well with areas of local upwelling of the intermediate structure (Fig. 6). Fish concentrations were noted in the peripheries of local upwellings, and the density of concentrations was determined by the intensity of water upwelling. An oceanographic microsurvey was conducted in one such area (at positon 57°18'N and 36°06'W). The largest densities of redfish concentrations were noted there during TAS with a biomass of 300 t/sq.mile in an area of about 600 sq.miles (Fig. 2). Investigations have shown that fish were concentrated in the periphery of local upwelling, supposedly conditioned by a cyclonic vortex. Temperature and salinity in the centre of the vortex were betwee 3.4-3.8°C and 34.80-34.85 promiles respectively (Fig.7). The horizontal gradient of temperature in the periphery of vortex changed 0.2-0.4°C per mile. Effective fishing work of the commercial fleet in this area lasted about 25 days, indicating the duration of upwelling in this area.

4. CONCLUSIONS

The traditional trawl-acoustic survey for Sebastes mentella in the Irminger Sea was conducted using R/V "PINRO". Results of the TAS in June-July 1993, showed that the abundance of S. mentella was 4187.3 mill. specimens (1693.8 mill. specimens offshore and 2493.5 mill. specimens in the Greenland zone) and a biomass of 2557000 t (999300 t offshore and 1557700 t in the Greenland zone).

Estimates of abundance and biomass of S. mentella should be considered as minimal, since redfish were under-estimated in the 400-600 m layer because of difficulty in distinguishing because fish of the acoustic scattering layer and because of a possible decrease in target strength of redfish in deeper waters. The under-estimate could constitute 20-30 %. The main source of errors during determination of the abundunce of redfish by the TAS method is the dual registration of redfish with jellyfish and interference of the acoustic scattering layer as well as changes in target strength of targets by area, depths and time.

Mature males constituted the greater proportion of redfish (60.7%) offshore in the Irminger Sea and in the Greenland fishing zone. Specimens 33-39 cm long with ages of 11-16 predominating in the catches. A large amount of redfish females, which did not spawn in 1993, were noted. A decrease in average size of redfish with the depth was noted. The predominant prey for redfish during fattening period were Calanus, euphausiids, squid, Sagitta and Myctophidae. The level of redfish invasion by copepoda Sphyrion lumpi, by larvae of Anisakis simplex, and occurrence of fish with pygments on the skin remained at the long-term mean level (for 1983-1993).

Warming and advection of Atlantic waters were poorly expressed in the summer by the Irminger Current. An interannual tendency of decreasing water warmness in the upper 500-m layer in the northern area was noted. Redfish concentrations in the summer were registered in areas with lower thermohaline indices than in previous years.

Concentrations of redfish were noted mainly in the cold periphery of the frontal zone in the area south of 59° N.

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Table 1. Results of the Russian trawl-acoustic survey of the Irminger Sea S. mentella in June-July 1993.

Areas of survey	Mean length	Mean weight, g	Abundance $x10^9$	Biomass, thou. t
Off shore	35.5	610.4	1693.8	999.3
200-mile zone of Greenland	35.9	624.7	2493.5	1557.7

Table 2.Infestation of redfish by copepoda S. lumpi (including old cephalothorax) and occurence of fish with pigmental spots in various areas of the Irminger Sea in 1993.

Area	Level of invasion S.lumpi			Occurence of fish with pygment spots, %		
	Males	Females	Total	Males	Females	Total
The north of the open part	21.4 0.4	48.2 1.1	38.9 0.9	9,2	33,1	24,8
South of the open part	21.1 0.3	47.6 1.2	29.7 0.6	10.1	42.1	20.5
The whole area	21.2 0.4	48.0 1.2	34.2 0.7	9.8	36.2	22.6

Note: over line - extencity of invasion (%), under line - intensity of invasion (spec. of infestation per fish)

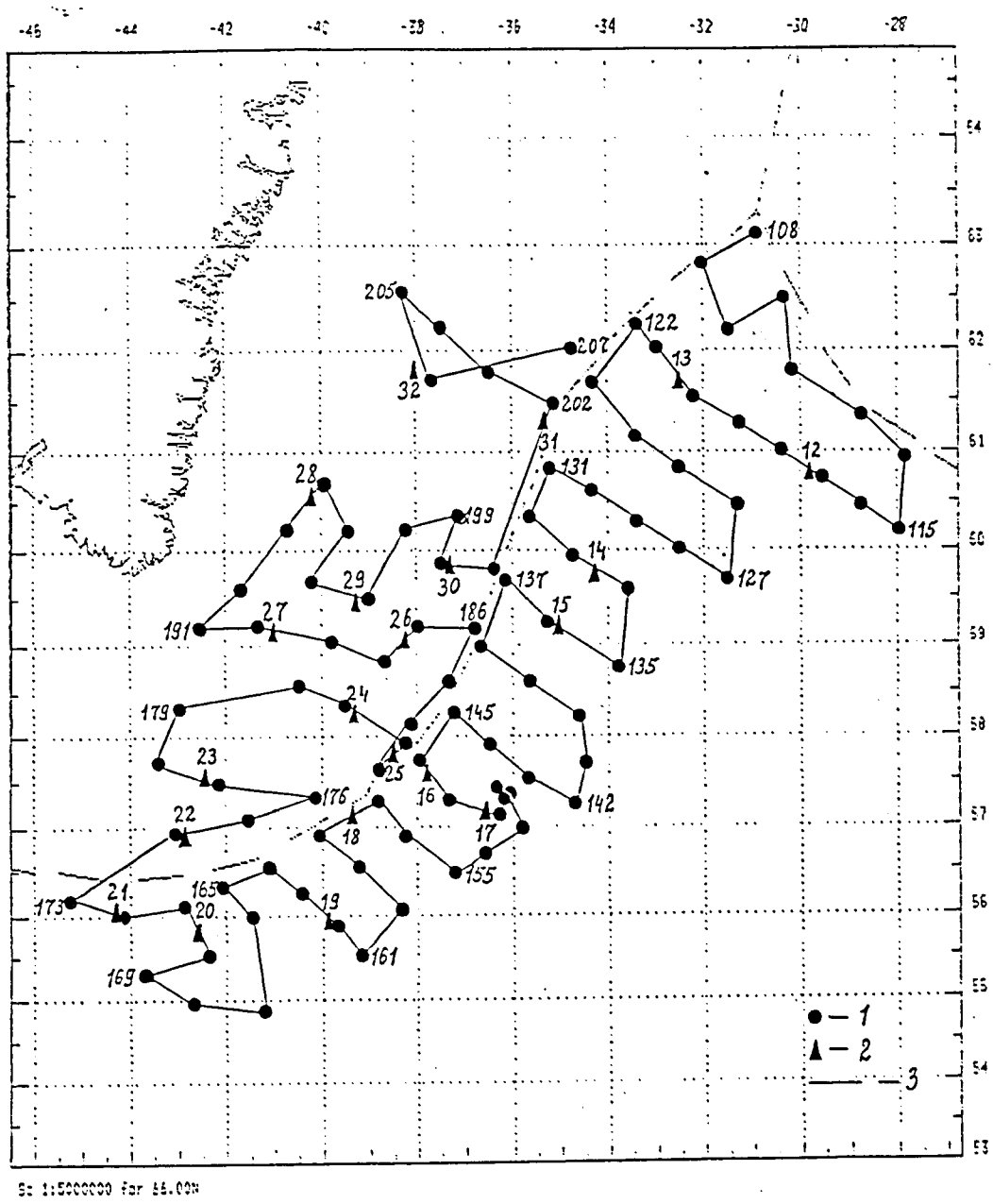

Fig. 1. The route of trawl-acoustic survey in 1993.
1 - Hydrographical stations,
2 - hauls, 3 - acoustic tracks.

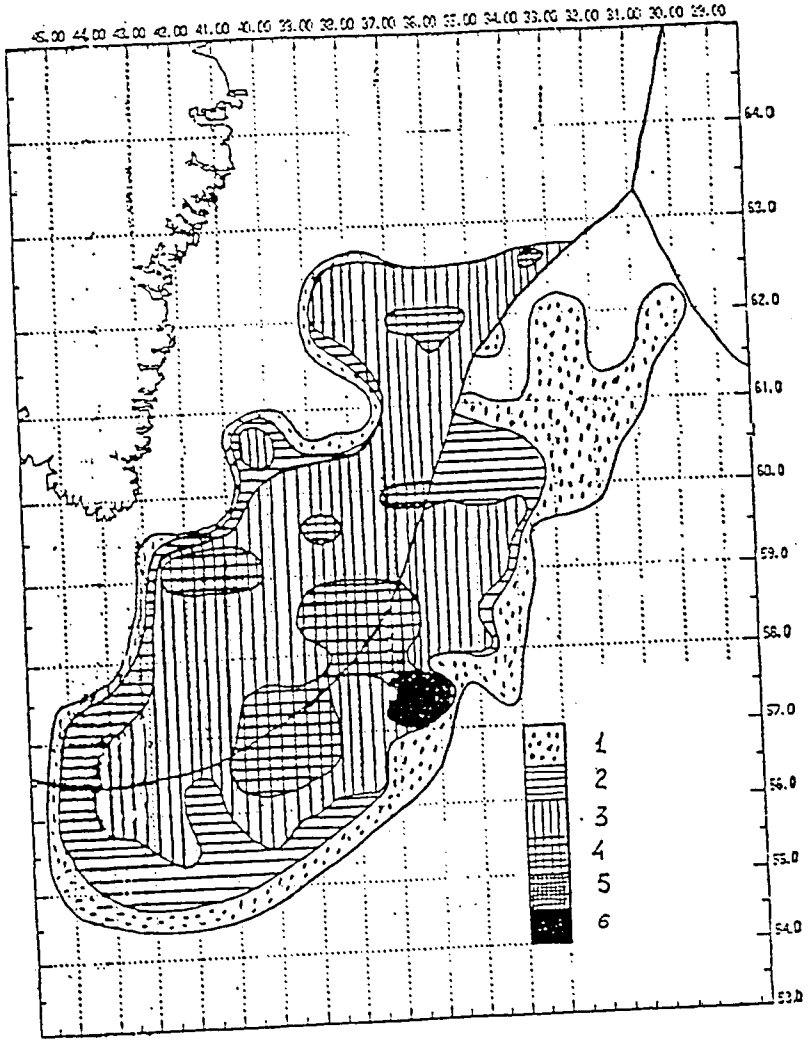

Fig. 2. Distribution and dencity of Redfish concentrations due to data of trawl-acoustic survey in 1993.
Dencity of concentrations, t/sq. mile:
1 - less than 5, 2 - 5-10, 3 - 10-30, 4 - 30-100,
5 - 100-300, 6 - over 300.

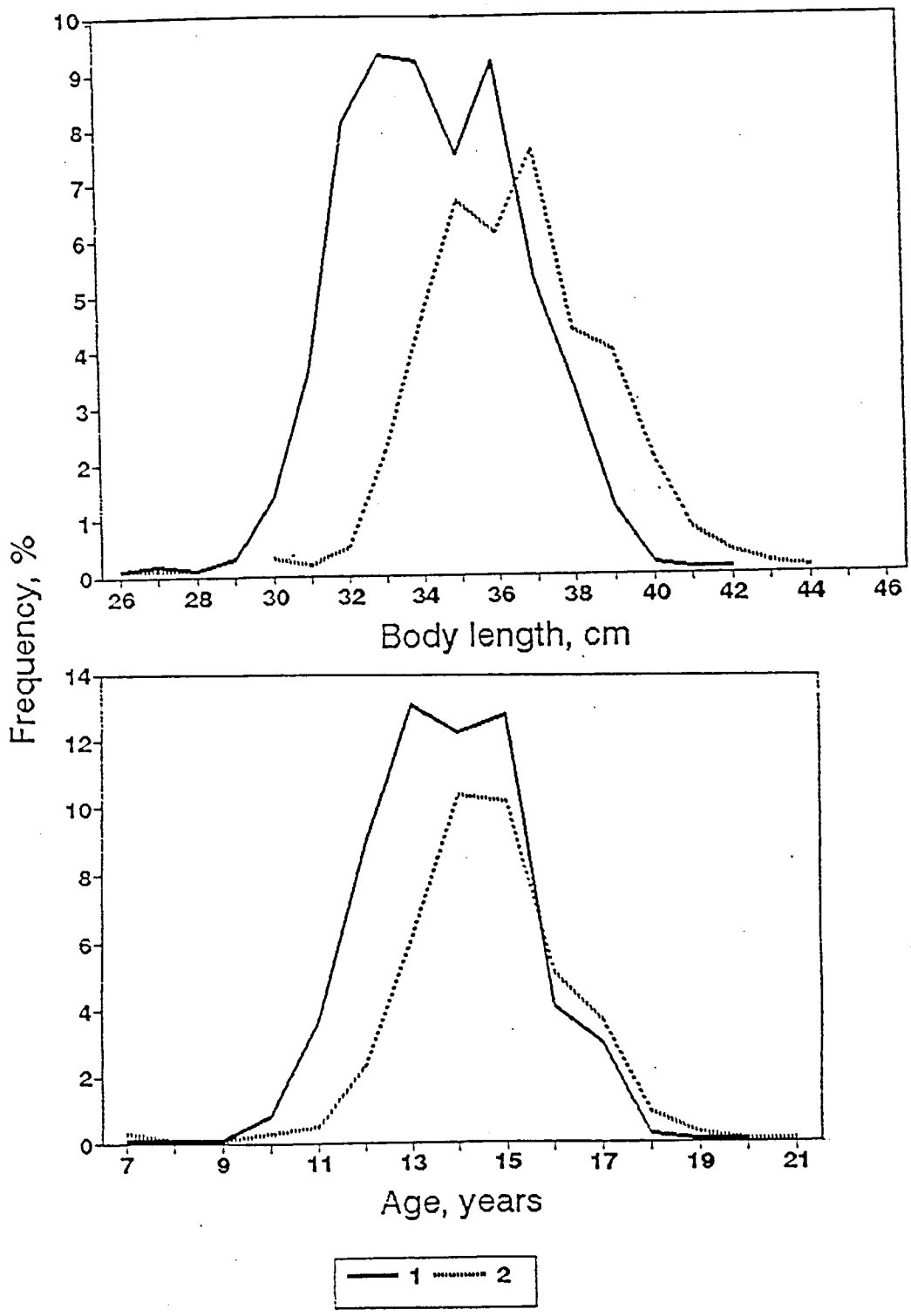

Fig. 3. Size (A) and age (B) composition of Irminger Sea S. mentella.
1 - males, 2 - females.

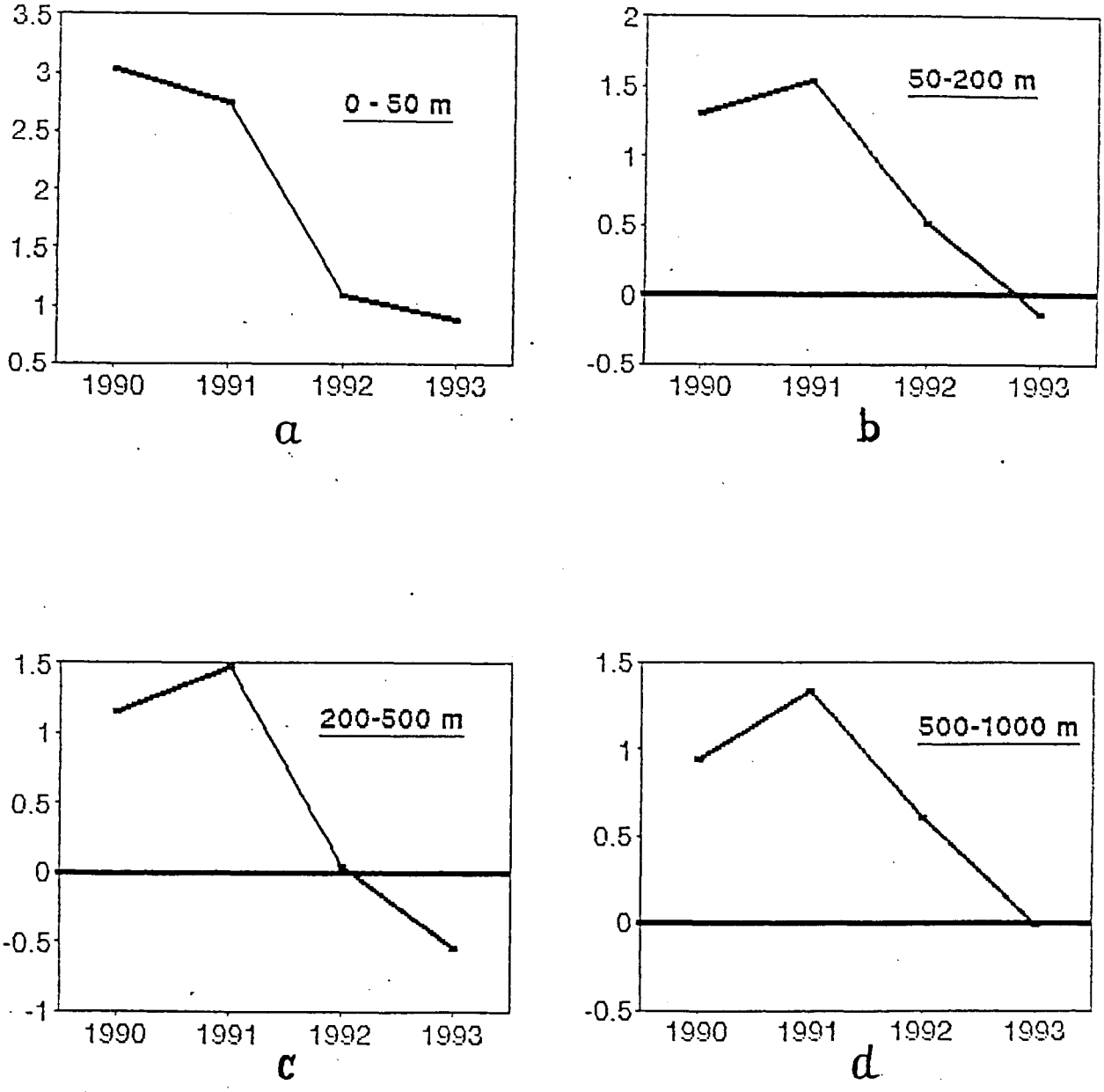

Fig. 4. Changes of water temperature at stations 1-6, section 3-K from April to June 1990-1993 in the 0-50 (a), 51-200 (b), 201-500 (c), 501-100 (g) m layers.

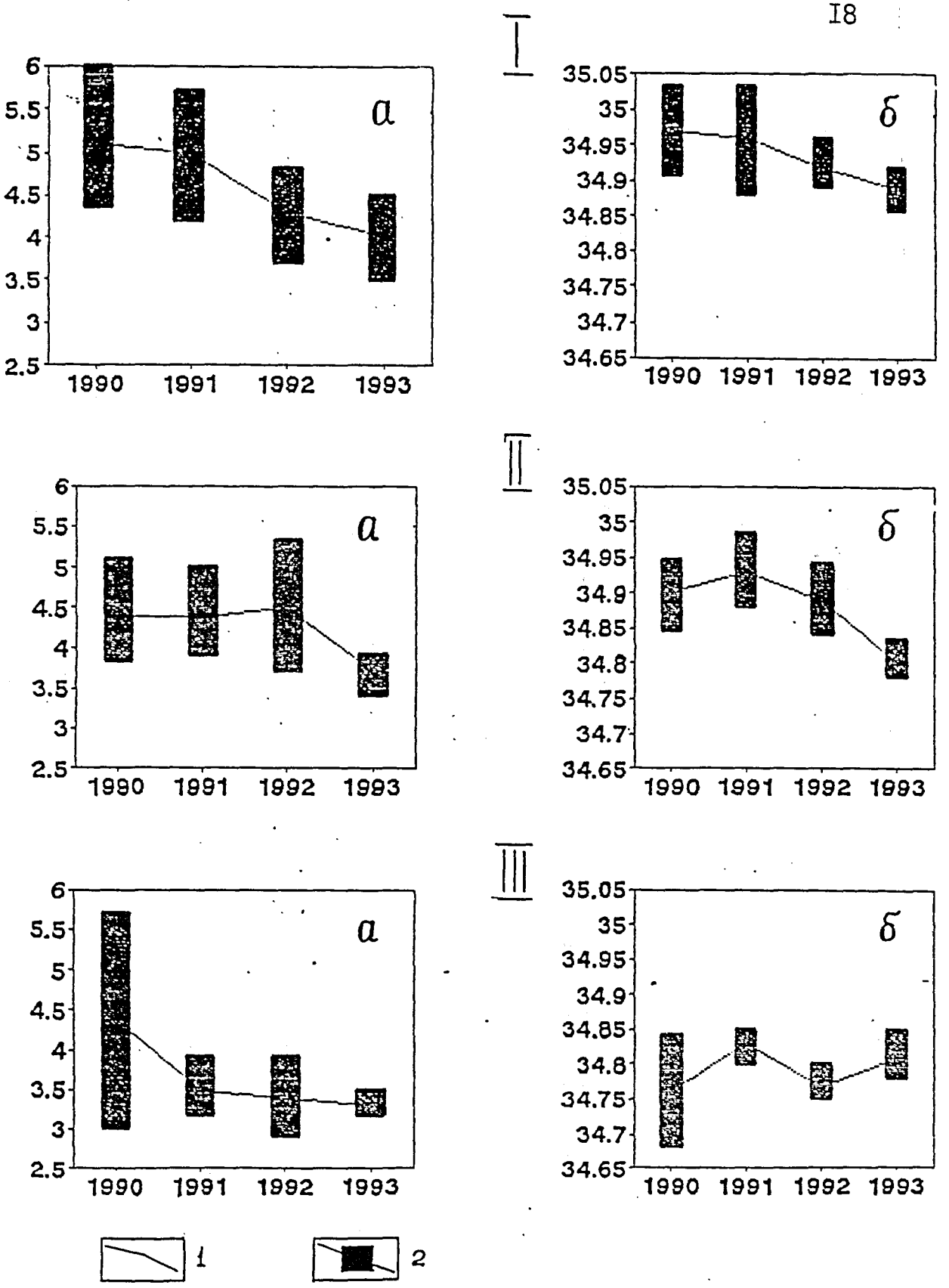

Fig. 5. Interannual changes of temperatures (a) and salinity (b) in the areas of Redfish concentrations in the northern (1), central (11) and southern (111) areas. 1 - interannual changes of average temperature and salinity, 2 - the range of changing.

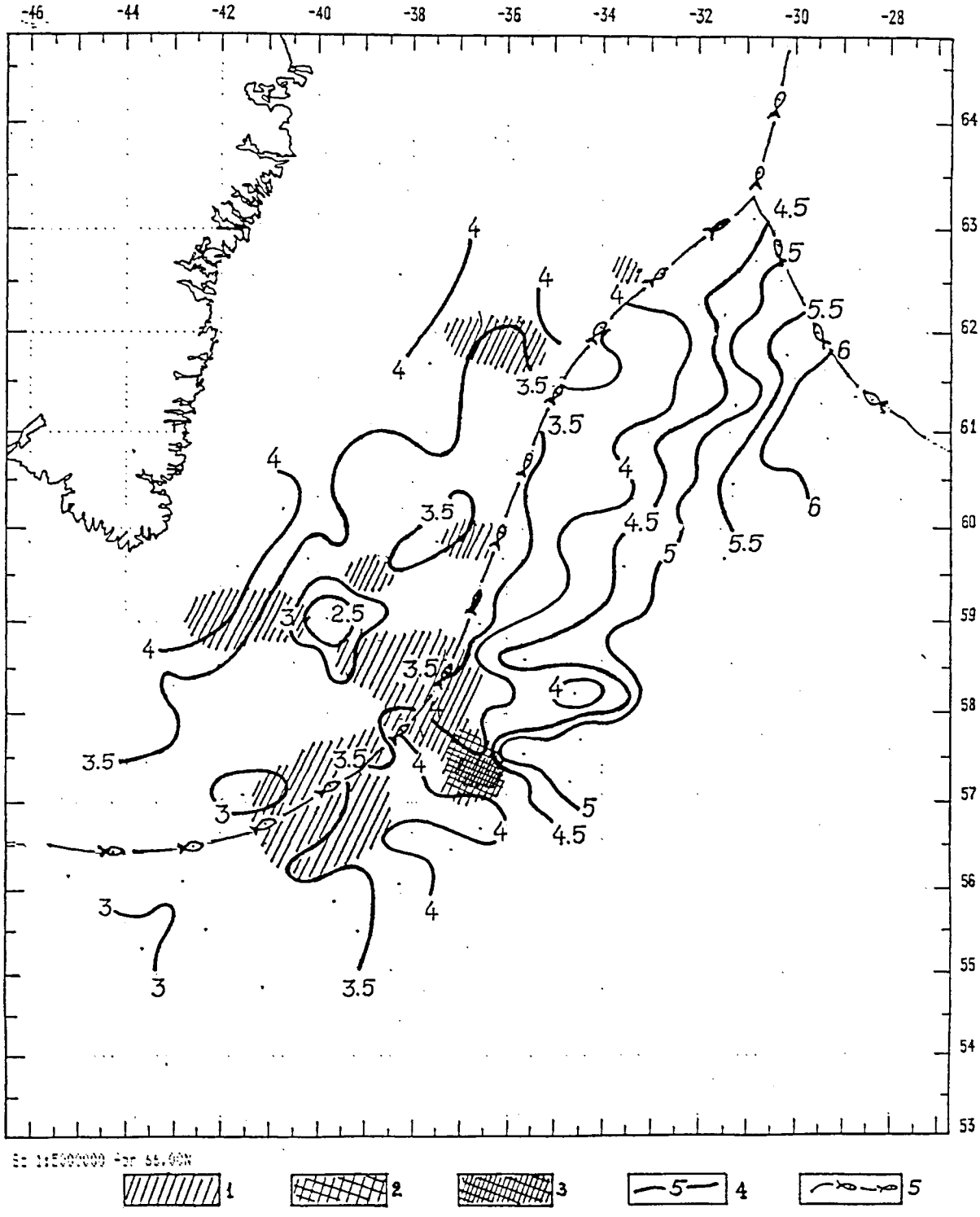

Fig. 6. Distribution of temperatures (C°) at the 200-m horizont and of densities of fattening concentrations of Irminger Sea S. mentella.

1 - 30-100, 2 - 100-300, 3 - over 300 t per sq. mile.

4 - isotherms, 5 - borders of Fishing Zones.

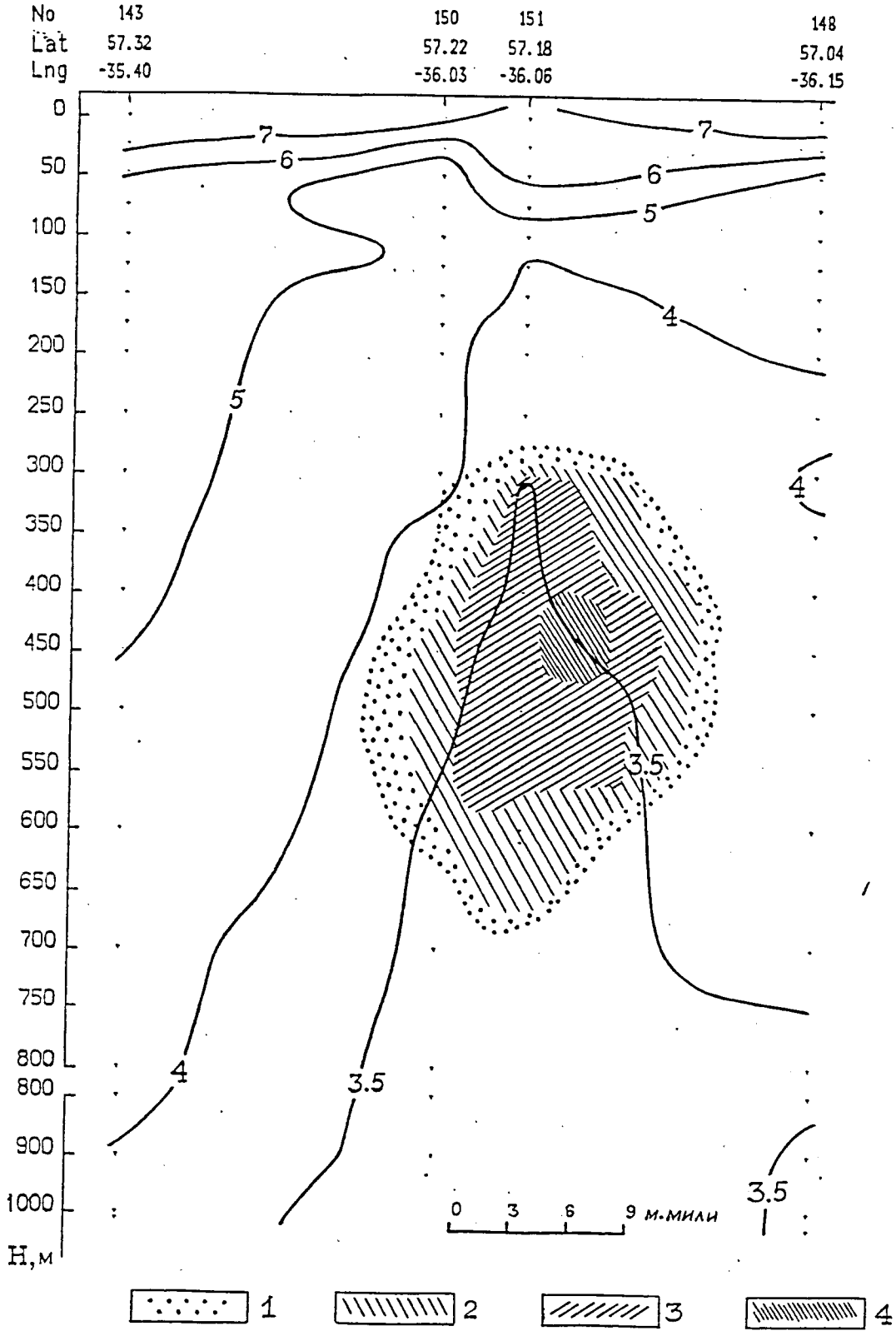

Fig. 7. Vertical distribution of temperatures (C°) and densities of redfish concentrations in the area of local upwelling:

1 - 50-100, 2 - 100-200, 3 - 200-500, 4 - over 1000 t per sq. mile. 5 - isoterm.