

Mesopelagic Micronekton and Macroplankton and the Conditions of Its Habitat in the Northeastern Pacific Ocean

A. S. Kurnosova^{a, *}, A. A. Somov^a, A. N. Kanzeperova^a, M. A. Zuev^a, S. Yu. Orlova^{b, c},
D. S. Kurnosov^a, and A. M. Orlov^{b, c, d, e, f, g}

^a Russian Federal Research Institute of Fisheries and Oceanography, Pacific Branch (TINRO), Vladivostok, Russia

^b Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow, Russia

^c Russian Federal Research Institute of Fisheries and Oceanography, Moscow, Russia

^d Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences, Moscow, Russia

^e National Research Tomsk State University, Tomsk, Russia

^f Dagestan State University, Makhachkala, Russia

^g Caspian Institute of Biological Resources, Dagestan Federal Research Center, Russian Academy of Sciences, Makhachkala, Russia

*e-mail: anna.vazhova@gmail.com

Received February 2, 2021; revised March 10, 2021; accepted April 8, 2021

Abstract—The article analyzes differences in the vertical structure of waters and hydrochemical parameters at three oceanic stations in the northeastern Pacific. Data on the species composition of mesopelagic fishes, squids, and gelatinous organisms making diurnal vertical migrations to the epipelagic zone are given. Differences in their ratio and size composition at different stations are analyzed. The species ratio and size and total biomass of micronekton and macroplankton change in the southwestern direction, which is primarily determined by the variability of the oceanological characteristics of the subsurface layer.

Keywords: Northeast Pacific, hydrology, hydrochemistry, epipelagic zone, vertical water structure, mesopelagic fishes, cephalopods, gelatinous organisms, micronekton, macroplankton

DOI: 10.1134/S0001437022010076

INTRODUCTION

In the open ocean, the vertical and horizontal temperature, salinity, light, and pressure gradients, and the hydrochemical characteristics govern the peculiar life features at different depths [14]. One of the most densely populated and species-rich zones in the World Ocean is the mesopelagic; mesopelagic micronekton and macroplankton (fishes, squids, gelatinous organisms, etc.) are widespread at depths of over 200 m from Svalbard and the northern Bering Sea to the Antarctic ice shelves [10, 14]. The mesopelagic zone fauna is extremely rich in species [2, 18, 20, 23]. There are about 200 mesopelagic fish species in the Subarctic part of the Pacific Ocean alone [19]; among them, there are over 50 lanternfish species (family Myctophidae) in the Pacific [14].

Vertical diurnal migrations from the mesopelagic to the epipelagic zone are a distinctive feature of many mesopelagic species [9]; this determines the relationship between the meso- and epipelagic zones via the transfer of matter and energy [9, 17, 19, 25, 34, 36, 37, 39, 40].

According to the estimates of many authors, the resources of the mesopelagic zone in the World Ocean (except squids) are enormous and can reach 1 billion tons; in the Pacific Ocean, they are estimated at more than 300 million tons [7, 23, 24, 27]. Taking into account the most recent acoustic studies, their abundance may be even higher, since estimates derived by trawl may actually be two orders of magnitude higher [26]. The resources of the mesopelagic zone are currently considered promising for fisheries as a source of feed for aquaculture [32].

Despite a high interest in mesopelagic micronekton and macroplankton and a large volume of related studies, the species of this group are still poorly studied. The features of their spatial distribution, biology, state of stocks, species structure, and relationship with certain water masses of mesopelagic fauna remain largely unclear [2, 20, 25, 35, 36]. This is especially typical of the open oceanic waters of the East Pacific, where studies are carried out extremely rarely and irregularly.

The objective of this research is to obtain new data on the composition, ratio, and size of species and bio-

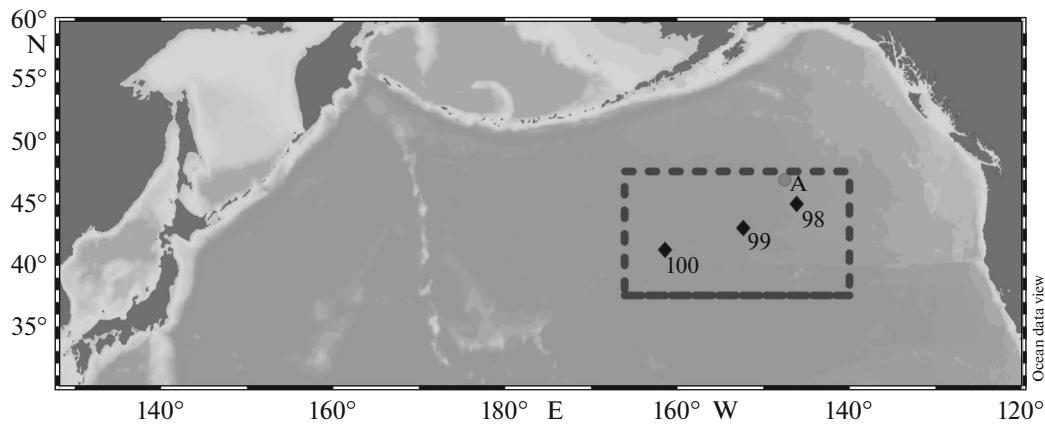


Fig. 1. Sketch map of stations in open waters of Northeast Pacific (numbers indicate number of integrated stations; A, oceanological station for comparison of hydrological parameters).

mass of mesopelagic micronekton and macroplankton in the open waters of the northeastern Pacific, taking into account their habitat conditions.

MATERIALS AND METHODS

This communication is based on the results of studies performed in March 2019 in the open waters of the Northeast Pacific on the R/V *Professor Kaganovsky* (Fig. 1), carried out while sailing between Vancouver (Canada) and the area of the Emperor Seamounts [13].

CTD data were acquired with a Sea Bird Electronics hydrological set (model 25) (SBE 25) at a depth of up to 500 m; samples were collected at standard depths to determine the concentration of dissolved oxygen, silicates, and mineral forms of phosphorus and nitrogen. Chemical measurements were carried out according to standard methods recommended for studying waterbodies and World Ocean areas promising for fishing [12]. Data were processed with the standard SBE 25 software and Ocean Data View v.4.7.1. The geostrophic map of the Northeast Pacific was made using data from analysis of OSCAR satellite information (https://podaac.jpl.nasa.gov/dataset/OSCAR_L4_OC_third-deg), as well as Surfer 11 software (Golden Software, Inc.).

To analyze the oceanological situation in the study area, we also used the average monthly values from analysis of satellite data on the physical parameters for March 2019 from <http://marine.copernicus.eu>. Comparative analysis of the vertical water structure was based on sounding data from stations 99 and 100. At station 98, sounding was not carried out for technical reasons; therefore, the vertical temperature and salinity distributions at this station were estimated from satellite data on the physical parameters of water (GLOBAL_ANALYSIS_FORECAST_PHY_001_024). To use the model data for the vertical structure at station 98, we compared the instrumental and model temperature and salinity data for stations 99, 100, and A.

The data of ichthyological studies are based on the results of 1-h-long trawl hauls using a mid-water RT 80/396 trawl with a fine-mesh (10 mm) insert; trawls were successively performed at three strata (60–90, 30–60, and 0–30 m), 20 min per stratum (Table 1). Each station was sampled during the twilight period (when mesopelagic fish and squids actively migrate to the epipelagic zone).

A total of 1700 animals were studied: 201 specimens were subjected to biological analysis and 1499 specimens were measured. The relative abundance/biomass of hydrobionts was calculated using the areal method [1], which takes into account the opening of the horizontal trawl, average trawl speed and duration, abundance/weight of the particular species in the catch, and catchability coefficient for each species [3].

Comparison of the species and numerical composition of squids was based on the materials from the Marine Biology database, corresponding to the stations near the study area.

RESULTS

Hydrological and Hydrochemical Studies

Water dynamics. The study area is located in the zone of the North Pacific (Subarctic) Current, which slows down as it approaches North America (Fig. 2). Weak cyclonic and anticyclonic gyres can be observed in this zone due to slowing of the current. The current map (see Fig. 2) in the Northeast Pacific makes it possible to determine the elements of the field of geostrophic currents (eddy formations) within the survey. All the sampled stations are in areas with low current velocities. The highest current velocities (up to 0.15 m/s) were recorded near station 100, while the lowest current velocities (0.05 m/s) were observed near station 98. The scheme of the geostrophic component of currents on the surface of the study area shows that station 99 is

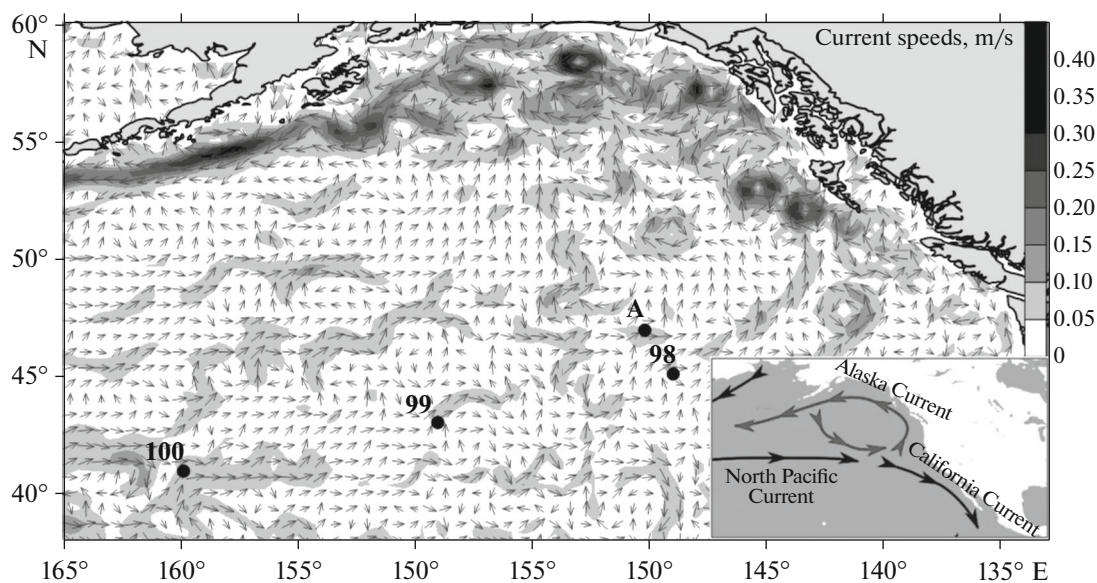


Fig. 2. Diagram of currents in Northeast Pacific (March 29, 2019), calculated using OSCAR model.

located on the border of the anticyclonic gyre with current velocities within 0.1 m/s.

Spatial distribution of hydrological parameters.

Satellite data of temperature and salinity distribution on the surface, modeled to a 250 m depth, demonstrate a wide range of thermohaline parameters in the studied area (Fig. 3). Thus, the average temperature values from the surface to 100 m varied from 7 to 12°C and average salinity values from 32.5 to 33.5‰, thereby forming a fairly uniform upper layer. The map of spatial distribution of surface temperature shows that the studied stations 98, 99, and 100 were approximately in the same temperature field of 8.7–9.2°C; however, the salinity in the surface layer varied from 32.5 to 33.2‰. At station A, which was selected for the comparison as a point with a Subarctic water structure, the values of temperature and salinity on the

surface were 7.5°C and 32.5‰. In the subsurface layer (250 m), the water masses clearly differed in temperature (from 6.5 to 8.5°C) but were almost homogeneous in salinity (33.9–34.1‰) (see Fig. 3).

Vertical distribution of hydrological parameters. To use the model data for the vertical structure at station 98, we compared the instrumental and model data on temperature and salinity for stations 99, 100, and A (Fig. 4). The correlation coefficient of vertical variation of the parameters was 0.91–0.99 for temperature and 0.94–0.99 for salinity. The model data are presented as average monthly averaging. Therefore, although the values differed slightly, the vertical structure of the model thermohaline parameters for stations A and 98 proved to be very similar in the presence of a homogeneous mixed layer up to the 100 m horizon and in an increased subsurface salinity below the density jump. The model estimates and in situ thermohaline values also proved to be similar for stations 99 and

Table 1. Characteristics of stations and trawls during studies in open waters of Northeast Pacific

Trawl number	Date	Trawl start time	UTC	Trawl end time	Trawl coordinates	Speed, knots	Course, deg	Depth, m	Surface temperature, °C	Vertical trawl opening, m	Horizontal trawl opening, m
98	26.03	18:32 (+14)	04:32	19:32	45°02.0' N 143°18.6' W	4.3	194	4500	9.2	32.7	45.2
99	28.03	18:37 (+13)	05:37	19:37	43°10.0' N 152°24.0' W	3.9	258	5100	9.1	33.7	44.5
100	31.03	18:38 (+13)	05:38	19:38	41°16.2' N 161°20.0' W	4.0	253	5500	8.7	33.7	43.0

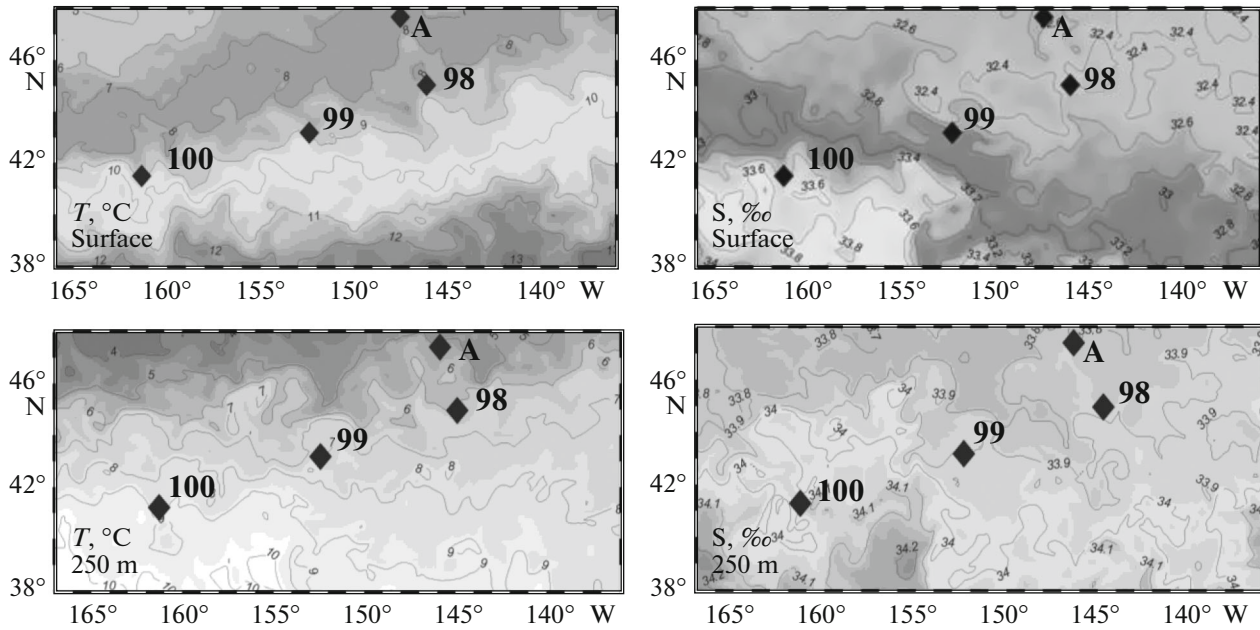


Fig. 3. Distribution of thermohaline parameters on surface (top) of studied area and at 250 m layer (bottom).

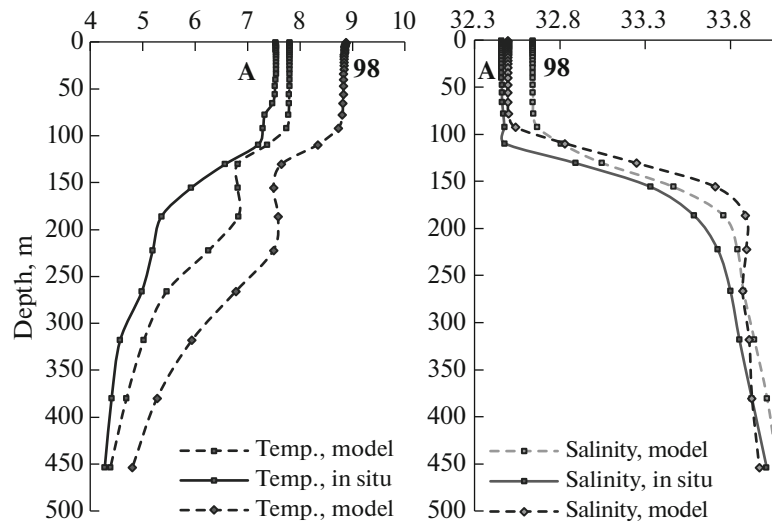


Fig. 4. Comparison of vertical profiles of temperature (left) and salinity (right) for stations A and 98 (dots indicate values on horizons).

100, which makes it possible to compensate the absence of model data with the respective values from station 98.

The vertical temperature profiles at stations A, 98, and 99 are interpreted as a Subarctic structure typical of this area, although the SST and salinity values were higher at station 99 than at station 100 which is located southward (Fig. 5). However, the increase in salinity values in the subsurface layer at stations 99 and 100 indicate the subtropical origin of waters. The surface water at stations 99 and 100 had a rather low temperature (typical of Subarctic water) but still a high salinity (typical of subtropical water).

At stations A and 99, the predominantly Subarctic origin of water masses is also confirmed by the measured hydrochemical parameters: a high dissolved oxygen concentration (6.5–6.9 mL/L) in the upper 100-m layer and a high concentration of mineral phosphorus typical of subpolar waters (0.6–1.5 $\mu\text{M/L}$) and nitrogen (6.8–9.5 $\mu\text{M/L}$) (Table 2).

The features of the vertical thermohaline structure at station 100 indicate a subsurface increase in the dissolved oxygen concentration (by 0.1–0.2 mL/L) at this station due to the spread of Subarctic surface waters causing subtropical waters to veer to the south. The recorded southwestward decrease in the hydrochemi-

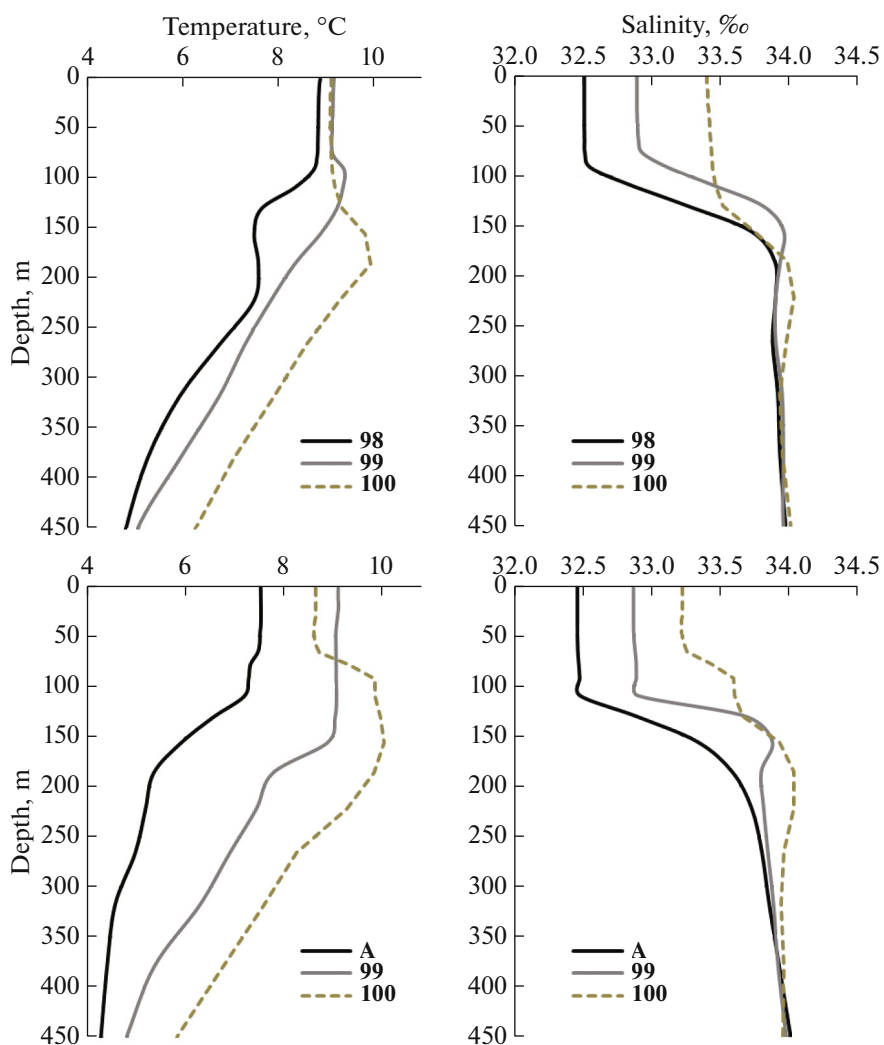


Fig. 5. Vertical profiles of temperature (left) and salinity (right) at studied stations according to model estimates (top) and in situ (bottom).

cal parameters below the thermocline (from station 98 to station 100) also indicates a change in the water structure in the subsurface layer in the studied frontal zone.

Species composition and ratio in catches. Catches from the three oceanic stations included 14 fish species, six cephalopod species (squids), and three gelatinous species (jellyfish and ctenophore). The maxi-

Table 2. Values of hydrochemical parameters at studied stations (O_2 , dissolved oxygen; Si, dissolved silicon (silicates); DIP, dissolved inorganic phosphorus (phosphates); DIN, dissolved inorganic nitrogen (nitrites + nitrates))

Depth, m	O_2 mL/L			$O_2\%$			Si, $\mu\text{M/L}$			DIP, $\mu\text{M/L}$			DIN, $\mu\text{M/L}$		
	A	99	100	A	99	100	A	99	100	A	99	100	A	99	100
0	6.85	6.64	6.65	101.5	101.6	100.9	12.57	12.06	19.24	0.89	0.69	0.66	11.54	7.09	9.15
25	6.56	6.66	6.73	97.2	102.0	102.1	13.85	11.29	16.67	0.89	0.58	0.62	13.15	6.39	9.20
50	6.95	6.46	6.69	103.0	98.7	101.4	12.83	11.03	16.93	0.89	0.62	0.62	13.46	7.59	9.54
100	6.78	6.93	6.82	99.7	106.0	106.5	15.13	11.29	12.31	0.97	0.66	0.54	13.23	7.31	6.76
150	5.90	5.16	5.47	84.5	79.2	85.9	28.73	23.60	16.16	1.27	0.97	0.69	20.85	16.57	11.59
250	4.99	5.40	5.33	69.7	79.4	81.5	41.55	35.65	27.45	1.62	1.31	1.04	28.13	22.18	19.46
500	1.92	1.88	2.76	26.2	26.0	39.0	80.54	82.08	67.72	2.32	2.39	2.05	36.25	39.25	33.25

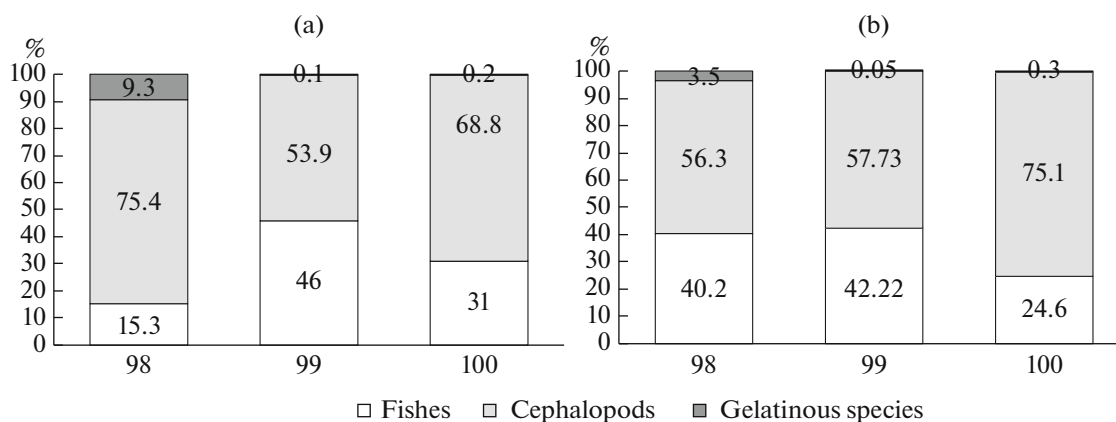


Fig. 6. Ratio of main groups of organisms in catches by abundance (a) and biomass (b) at different stations.

imum abundance and biomass of all hydrobionts were recorded at the central station (99), except *Onychoteuthis borealijaponica* and *Corolla calceola* (Table 3). Squids prevailed in all trawl catches both in abundance and biomass; their maximum abundance was observed at the easternmost station, while their biomass was maximal at the westernmost station. The fish abundance and biomass in catches was 16–45 and 25–41%, respectively. The proportion of jellyfish was low in catches; their abundance and biomass decreased from east to west (Fig. 6).

Among captured fishes, *Lestidium ringens* (mainly juveniles) dominated in abundance (31.8% of the total number of individuals) and *Nannobranchium ritteri* dominated in biomass (19.2%). Among squids, the highest abundance and biomass in catches were recorded for *Abraliopsis felis* (81.1 and 90.7% of the total number and weight of squids in catches and 48.6 and 57.1% in the total catch, respectively). Among gelatinous species, *Corolla calceola* dominated in abundance and biomass—89.2 and 58.9%, respectively.

Table 3. Species composition of catches and distribution density of micronekton and macroplankton in upper epipelagic zone of open waters of northeastern Pacific on March 26–31, 2019 (relative abundance, ind./km²/relative biomass, kg/km²)

Species	Station no.		
	98	99	100
<i>Diaphus theta</i>	2639/2.9	57 340/102.9	27 814/38.7
<i>Nannobranchium ritteri</i>	83/0.2	47 073/150.7	628/0.6
<i>Lestidium ringens</i>	69/0.1	29 884/15.5	16/0.2
<i>Nansenia candida</i>	1972/12.8	16 490/50.8	2606/7.8
<i>Notoscopelus japonicus</i>	—	6783/44.9	4175/24.0
<i>Stenobranchius leucopsarus</i>	1500/1.4	36713/73.5	—
<i>Symbolophorus californiensis</i>	28/0.1	560/1.4	22 069/48.6
<i>Tarletonbeania crenularis</i>	1722/4.3	15 307/48.9	1381/4.2
<i>Congriscus megastomus</i>	1667/75.3	2178/36.7	1570/36.4
<i>Abraliopsis felis</i>	37 042/114.9	209 794/662.0	105 585/453.8
<i>Boreoteuthis borealis</i>	7195/16.7	10 236/22.1	188/11.3
<i>Okutania anonycha</i>	3612/3.1	31 735/31.7	27 940/30.1
<i>Onychoteuthis borealijaponica</i>	83/2.2	31/0.8	157/6.2
<i>Atolla wyvillei</i>	28/0.3	62/0.1	31/0.3
<i>Corolla calceola</i>	5584/6.1	156/0.2	126/0.1
<i>Hormiphora cucumis</i>	306/2.2	124/0.4	157/1.3
Total	63 531/242.8	431 597/1227.2	194 442/663.5

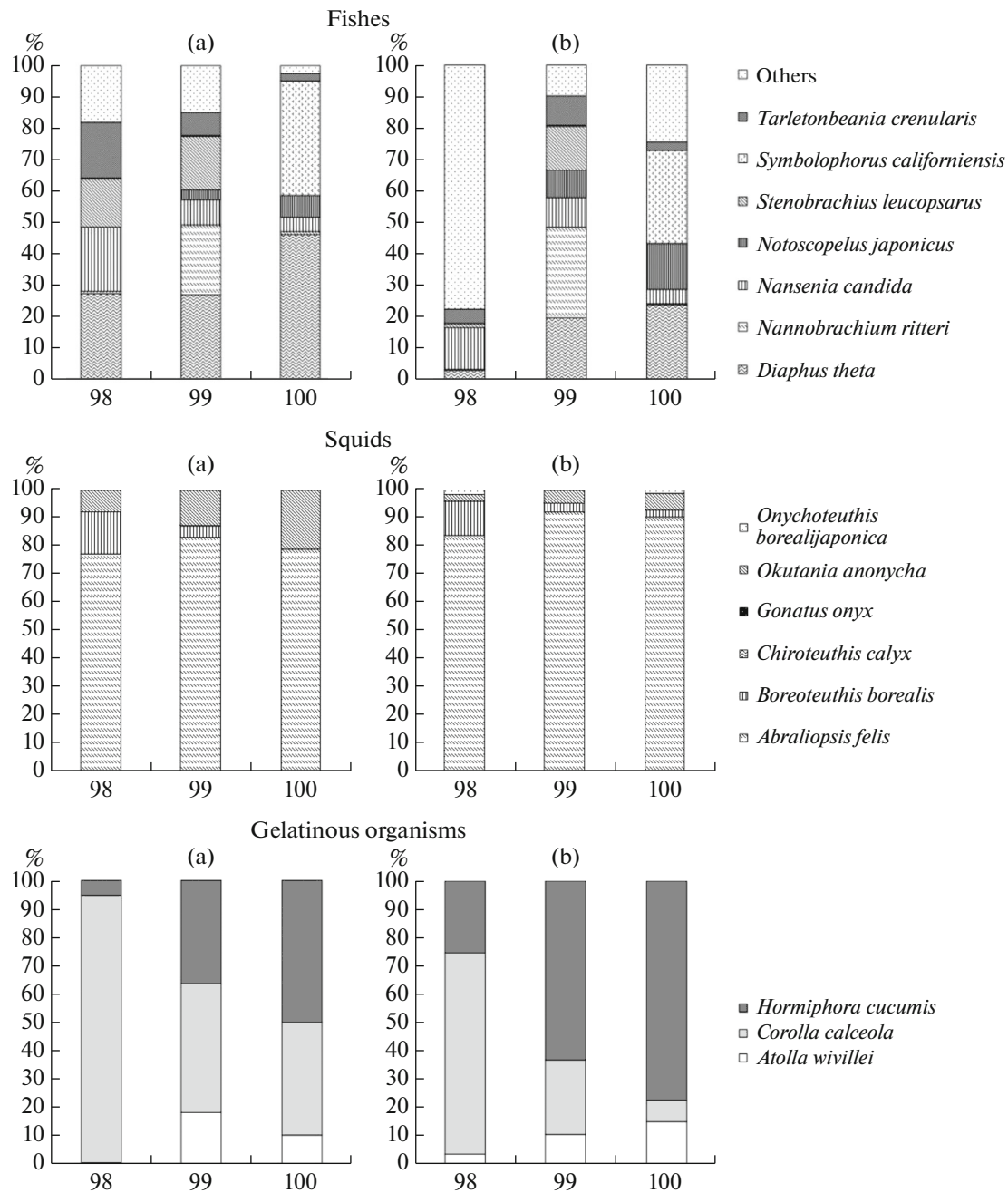


Fig. 7. Longitudinal changes in abundance (a) and biomass (b) of fishes, squids, and gelatinous organisms in catches.

The proportion of *Nansenia candida* in catches consistently decreased from east to west both in abundance and biomass, while the proportion of three species, *Diaphus theta*, *Notoscopelus japonicus*, and *Stenobranchius leucopsarus*, increased in this direction. High abundance and biomass of *Nannobranchium ritteri* was recorded at the central station (99). *Symbolophorus californiensis* was almost completely absent at the first two stations (98 and 99) (Fig. 7).

Among squids, the proportion of the dominant species, *Abraliopsis felis*, did not significantly change

in all catches both in terms of abundance (77–82%) and biomass (83–92%), while the proportion of other squid species varied greatly. The abundance and weight percentage of *Boreoteuthis borealis* gradually decreased from east to west, while those of *Okutania anonycha*, on the contrary, increased in this direction (Fig. 7).

From east to west, the abundance and weight percentages of the jellyfish *Corolla calceola* decreased from 94.4 to 40% and from 71.1 to 7.5%, respectively, while those of ctenophore *Hormiphora cucumis*, on the

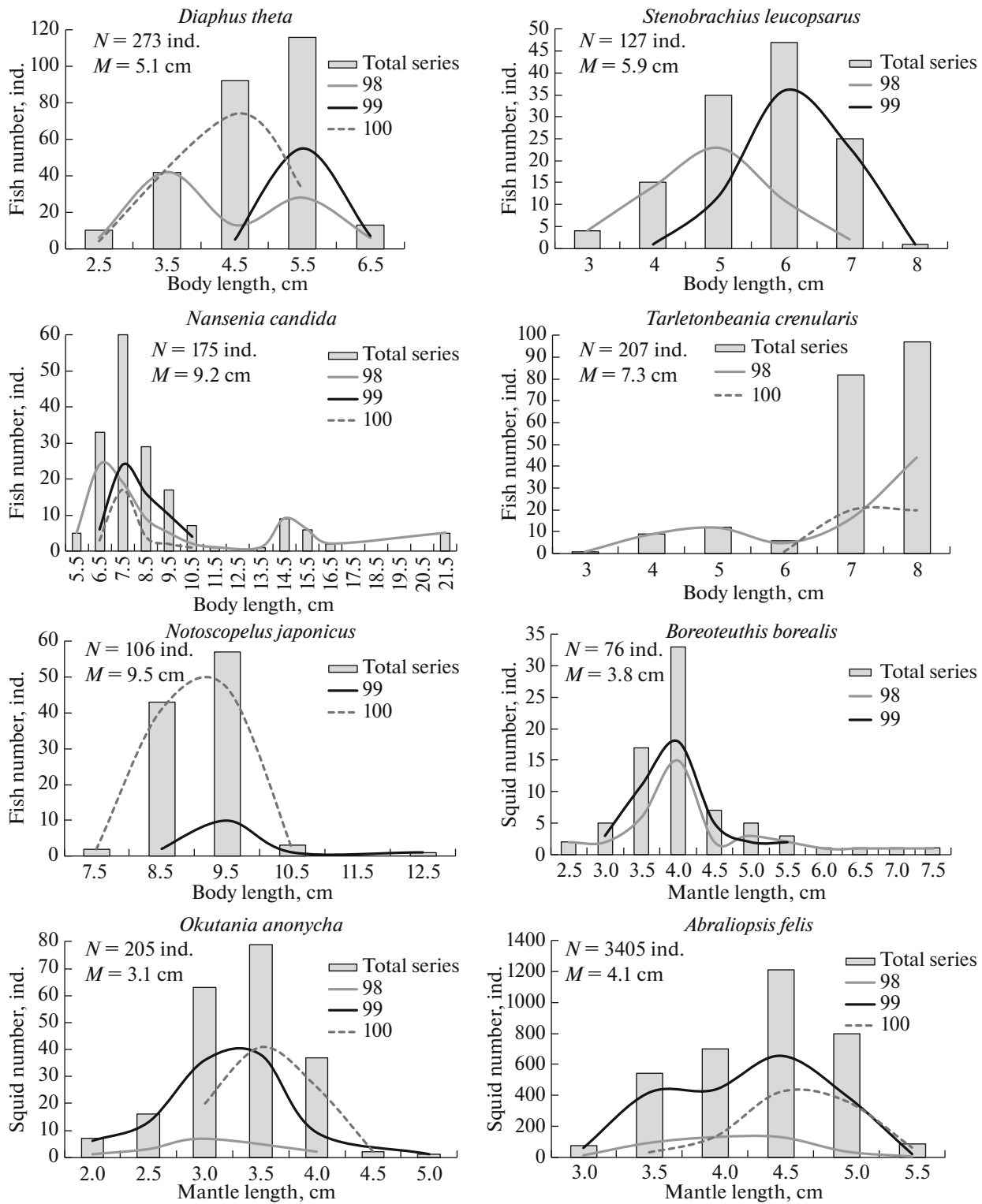


Fig. 8. Size composition of hydrobionts in catches at different stations (N , number of measured individuals; M , their average length).

contrary, increased from 5.2 to 50% and from 24.4 to 77.4%, respectively. The weight percentage of the jellyfish *Atolla wivillei* also increased from 3.5 to 15.1% (Fig. 7).

Size composition. The largest known body length of California headlightfish *Diaphus theta* is about 9 cm [2]. In our catches, this is the second largest species with respect to the relative abundance and biomass, repre-

sented by individuals 2.5 to 6.5 cm long (mean 5.1 cm) (Fig. 8). Individuals with a length of 4.5–5.5 cm dominated in catches (76.2%). The average fish length was lower at the eastern and western stations (4.6 and 5.0 cm) than at the central one (5.8 cm).

The largest known body length of northern lampfish *Stenobrachius leucopsarus* is about 9 cm [2]. It was the third largest species in catches with respect to the relative abundance and biomass and represented by individuals from 3 to 8 cm long (mean 5.9 cm), among which the size group of 5–7 cm prevailed (84.3% of the total fish abundance) (Fig. 8). The average body length increased from east to west. It was 5.1 cm at the eastern station (99) and 6.4 cm at station 98.

The maximum known length of bluethroat argentine *Nansenia candida* is 24 cm [28]. Its proportion in catches consistently decreased from east to west; it was represented by individuals with a length from 5.5 to 21.5 cm and dominated by the size group of 6.5–8.5 cm (69.7%). The proportion of larger individuals with a length of 14.5–15.5 cm was also noticeable (8.6%) (Fig. 8). The average body length of *N. candida* decreased from east to west. Thus, it was 10.1 cm at the eastern station, 8.5 cm at the central station, and 8 cm at the western station. At the same time, there was a clear sexual dimorphism in body length and weight: females were much longer and heavier than males. Thus, their average length was 14.3 and 10.3 cm and body weight was 24.4 and 8.4 g, respectively.

The western blue lanternfish *Tarletonbeania crenularis* reaches the maximum length of 8.4 cm [21]. In our catches, this species was represented by individuals from 3 to 8 cm long (mean 7.3 cm) and dominated by the size group of 7–8 cm (86.5%) (Fig. 8). The lowest average body length of the fish was recorded at the eastern station (6.9 cm), while it was the same at the central and western stations (7.6 cm). The females prevailed in catches (76%); at the same time, there was no significant sexual dimorphism in size: the average length of males and females was 7.3 and 7.2 cm and body weight was 3.4 and 3.5 g, respectively.

The largest known body length of Japanese lanternfish *Notoscopelus japonicus* is about 15 cm [2]. In catches, this species was represented by individuals from 7.5 to 12.5 cm long (mean 9.5 cm); among them, individuals of the size group of 8.5–9.5 cm dominated numerically (94.3%) (Fig. 8). Japanese lanternfish occurred at two stations and its average length decreased from east to west. Thus, it was 10.1 cm at the central station and 9.4 cm at the western station. At the same time, females were slightly longer than males (on average, 9.4 and 9.0 cm, respectively) at an equal body weight (on average, 6.0 g).

Being a polymorphic species, boreopacific squid *Boreoteuthis borealis* in the North Pacific is represented by two intraspecific groups, the small-sized and large-sized groups [29]. The maximum mantle length (ML) of mature squids reaches 17.9 cm in the

small-sized group and 30.0 cm in females and 27.8 cm in males from the large-sized group [6]. In our catches, this species was represented by immature individuals with ML from 2.4 to 7.2 cm (Fig. 8). The average ML was almost the same in boreopacific squid from the eastern and central stations, being 3.9 and 3.7 cm, respectively, while it was significantly longer at the western station (5.2 cm). In addition, three larger feeding females with mantle lengths of 12.5, 14.7, and 14.9 cm and one male with ML 13.7 cm were caught at station 100.

Okutania anonycha is characterized by a small size; its maximum mantle length is 15.0 cm [30]. At all stations, it was represented by juveniles with ML from 2.0 to 4.8 cm (Fig. 8). An increase in the average length of the mantle of this squid was observed from east to west. Thus, its average ML was 2.7 cm at the eastern station, 2.9 cm at the central station, and 3.3 cm at the western station.

The maximum length of the mantle of *Abraliopsis felis* is 5.7 cm [16]. The catches contained individuals with ML from 2.8 to 5.3 cm (Fig. 8); its average value increased from east to west. It differed little at the eastern and central stations (3.9 and 4.0 cm, respectively) and was 4.4 cm at the western station.

DISCUSSION

The sampled stations were a great distance from each other on different sides of the Subarctic front, in the dynamic frontal zone of mixing of Subarctic and subtropical waters. Geographically, the study area belongs to the Subarctic front, which is a boundary between different water mass structures [4]. In this frontal zone, waters of different structures mix with each other, which leads to a transfer of warm surface waters to the Subarctic zone and a reverse transfer of deep cold Subarctic waters [11].

Vessel and satellite sounding data from the study area show that the stations were in the high-gradient part of the Subarctic front: at the northern station (98), water masses had a clearly defined Subarctic structure, station 99 was located in the water mixing zone, and the southernmost station (100) was on the southern periphery of the front with the transition to the transit domain [22]. It is the subsurface layer that was characterized by the main differences; as will be shown below, this is more important than the characteristics of near-surface waters during estimates of the composition and abundance of micronekton and macroplankton.

The features of the vertical thermohaline structure at stations 99 and 100 may be determined by the fact that the surface Subarctic waters in this area were distributed far to the south and covered subtropical waters. As shown above, the surface water at stations 99 and 100 had a rather low temperature (typical of Subarctic water) but still a high salinity (typical of subtropical water). This results from the “double diffusion” effect [8], i.e., when

the temperature exchange under the condition of horizontal turbulence interaction is faster than the salinity exchange due to the difference in the coefficients of turbulent exchange. On the whole, analysis of the water structure at all studied stations indicates the crossing of the dynamic frontal zone during the study period.

As shown on the geostrophic map, the velocities of the current on the surface in the frontal zone, where all the stations were located, varied from 0.05 to 0.15 m/s during the study period; however, it should be borne in mind that currents are not so clearly defined below the 100-m layer, where mesopelagic migrants generally live [8]. Therefore, it can be assumed that the species distribution is more influenced by the vertical structure of waters below 100 m: subtropical waters at stations 99 and 100 and Subarctic waters at station 98. The unsteady anticyclonic eddy formed near station 99 can influence the quantitative composition of micronekton, since planktonic organisms serving as food items for different pelagic fishes are concentrated in eddy systems [5, 31].

Therefore, it is likely that the vertical structure of subsurface layer waters has a greater effect on the species composition of micronekton and macroplankton. At the same time, the biomass and size distribution is partially influenced by currents and eddies, since these species rise to the upper epipelagic layer at night, when trawlings were conducted.

The results of ichthyologic studies suggest that the features of the vertical structure of waters in the subsurface layer and eddy formations on the surface of the studied area influenced the characteristic longitudinal variability in the composition of catches. Thus, the data on the species biomass and ratio indicate the variability in the composition of catches, which was expressed in the biomass/abundance ratio both between the main groups (fishes, squids, and gelatinous organisms) (see Table 3, Fig. 6) and within the particular group. These longitudinal changes can be illustrated by the example of the fish group and are most clearly seen from the example of gelatinous macroplankton (see Fig. 7).

Although it is difficult to assess the significance of the influence of a certain environmental factor on the composition of micronekton and macroplankton catches based on the data from the three stations, our own and literature data suggest the relationship between the abundance and composition of their communities and pattern of water masses. Thus, comparable data on mesopelagic fishes from the Pacific Ocean were obtained in 1989 during the cruise of the research fishery vessel (RFV) *Poseidon* [7]. Analysis of the resources of the mesopelagic fishes from the North Pacific based on the classification of water masses [22] identified cenotic complexes. According to this classification, five domains were identified in the study region. Our stations were apparently located between

the zones of the central Subarctic domain and transit domain (according to [22]) or between the northern and southern zones of the Pacific drift (according to [7]). The main characteristics of this section between the Subarctic and transit domains are extensive incursions of cold freshened water along the northern boundary and warm saline water along the southern boundary [22]. We observed similar phenomena in our section; in particular, this was typical of the subsurface layer, since the near-surface temperature was almost identical at all stations.

Comparable data on squids were also obtained during the already mentioned cruise of RFV *Poseidon* in 1989; however, these data were not highlighted in the literature. According to the materials of the Marine Biology database, *O. anonycha* generally prevailed in catches in 1989 (in contrast to our data); its concentration in the water area covered by our study varied from 22 to 480 kg/km² during that time. In 2019, cephalopods were dominated by *A. felis*; their concentrations varied from 114.9 to 662 kg/km². In both 1989 and 2019, the maximum squid and mesopelagic fish concentrations were observed in zones with the highest gradient.

According to Karedin [7], the following dominant species were identified for the studied water masses: *Diaphus theta* (53%), *Stenobrachius leucopsarus* (22%), and *Nannobrachium ritteri* (13%) in the zone of the North Pacific drift and *Ceratoscopelus warmingi* (49%), *Diaphus perrispicillatus* (21%), and *Stenobrachius leucopsarus* (5%) in the zone of the South Pacific drift. According to our data, the species composition of mesopelagic fishes differed slightly. The ratio of mesopelagic fishes at the three stations was as follows: *Nannobrachium ritteri* (22%), *Diaphus theta* (21%), *Stenobrachius leucopsarus* (16%), and *Notoscopelus japonicus* (15%). If we compare only the data from trawl hauls performed in 1989 near our stations, the similarity of the species composition increases significantly. However, the proportion of *Tarletonbeania crenularis* and *Nansenia candida*, which were recorded among the dominants in 2019, was insignificant in 1989. It should be noted that the results of research in the Gulf of Alaska in February–March 2019 also showed the biomass dominance of *T. crenularis* among mesopelagic fishes.

The average concentration of mesopelagic fishes was 236 kg/km² (21.8–488.6 kg/km²) at three stations in 2019, while it was 442 kg/km² at stations located close to our stations in 1989. However, it should be noted that catches on RFV *Poseidon* in 1989 were performed using an experimental RT 93/500 mid-water trawl with a small-mesh insert (10 mm) along the entire length of the trawl net [7], rather than only in the codend (as in our case), which might affect the trawl catchability. In addition, trawl hauls in 1989 were performed in summer, while we conducted them in March. Although seasonal changes are not so clearly

defined in the remote areas of the ocean (the Subarctic front zone) [15] as in the marginal seas, this might also influence the abundance of mesopelagic fishes.

Since longitude and water masses are of great importance among various factors influencing the geographical distribution of interzonal species in the open ocean [33, 38], analysis of the species structure of mesopelagic fish catches [19] revealed its clear correspondence to the characteristic water masses. However, trawls in our study covered the boundary zone with an extremely high variability of oceanological characteristics. Although the stations were at a relatively close distance from each other (400 NM is a relatively small distance on the oceanic scale), the hydrological and hydrochemical parameters differed rather significantly at the sampling points, especially in the subsurface layer (deeper than 100 m), which is more important than the characteristics of the surface layer during estimates of the composition and abundance of micronekton and macroplankton. This probably determined significant variations in the abundance and species and size composition of catches, although trawl hauls were performed according to the same scheme and at the same time. Based on the results of our research, we believe that, in addition to the random component, the species abundance and ratio in catches were largely determined by the water structure.

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Translated by D. Zabolotny