

## THE BERING SEA BENTHOS

*Prepared by TINRO*

**The Bering Sea.** The study of the bottom fauna of the Bering Sea has become the subject of numerous works published at various time periods (Deryugin, Ivanova, 1937; Makarov, 1937; Belyaev, 1960; Neyman, 1963, 1964, Loos, Kuznetsov, 1961; Loos, 1970; Koblikov, Nadtochiy, 1992; ect.). Macrozoobenthos of the Bering Sea has received the most study, all bathymetric zones of the sea, including the abyssal zone, being embraced by the studies to one extent or another at different time periods. But up to date there is still little quantitative data available as for the coastal part of the upper sublittoral zone. In quantitative distribution of each individual group and taxon of bottom organisms the regional specific features can be clearly traced subject to biotope conditions in each region in question. This results in noticeable changes in the composition of benthic communities even on the level of large taxa.

Table 41

Average shelf benthos biomass in various regions of the Bering Sea, g/m<sup>2</sup>  
(Shuntov, 2001)

Region	Neyman, 1961, 1963		Belyaev, 1960	Alton, 1974	Koblikov, Nadtochiy, 1991
The Chirikov Basin	843	905	843	905	808.5
Shallow waters of Nunivak and St. Lawrence Islands	123	169	-	169	-
The Gulf of Anadyr	419	468	439	468	382.4
The Anadyr shelf	243	323	184	323	-
Southeast part		55	-	55	-
The Koryak shelf	220	246	-	220	297.5
The Karagynsky Bay	369	410	258.3	410	315.9
The Olyutorsky Bay	320	359	378	320	561.1

As a rule, one and the same animal groups dominate by biomass in benthic communities in different regions, but their proportion varies greatly. Recent studies (1980s) suggest that on the shelf of the western part of the Bering Sea the main benthos biomass volume (up to 70-80%) is formed by three animal groups – echinoderms, bivalves and polychaetes. The only exclusion is the Chirikov Basin where *Balanus* are added to the indicated groups. The distinctive feature of the benthos of this region is also the high biomass of amphipods.

The conclusion about the three aforementioned groups being predominant in the Bering Sea was as well drawn based on the results of the earlier stage of research (Zenkevich, 1963). But the order of the major groups forming the total biomass of the benthos was somewhat different: the leading group was bivalve mollusks and brittle stars prevailed among echinoderms. Currently, on the contrary, sea urchins are predominant among echinoderms. Taking into account the data of all surveys we estimate the total stock of bottom fauna in the Bering Sea to be 321,107 thousand t with average biomass estimates for the whole sea being 139 g/m<sup>2</sup>. Up to 92% of this amount is concentrated on the shelf zone where the biomass is estimated to be 286 g/m<sup>2</sup>. More than 60% of the total benthos biomass of the Sea is concentrated in its western and northwestern parts. The Anadyr shelf is remarkable in this respect where up to 30% of the total macrozoobenthos stock of the Bering Sea is concentrated.

Some of the data on composition, structure, productivity and dynamics of the benthic communities of the Far Eastern Seas, accumulated before 2000, were published, including in special monographic reviews (Shuntov, 2001; Dulepova, 2002).

In early 2000s on the Bering Sea shelf a series of benthos surveys was conducted allowing to assess current resources of bottom invertebrates and to compare their present state with that of the 80s. During 2000 studies the benthic macrofauna of only three regions was analyzed: Korfa-Karaginsky region, the Gulf of Anadyr and the Koryak coastal shelf. The notable feature of the studies was that the location of benthos sampling stations in 2000s was almost the same as in 1980s (Nadtochiy and al.).

In August 2001 “TINRO-Center” expedition using “Professor Kaganovsky” research vessel carried out a benthos survey in Korfa-Karaginsky region. In 2005 the samples of benthos were collected in the Gulf of Anadyr and on the Koryak shelf using “TINRO” research vessel.

**The Gulf of Anadyr.** In August and September in the Gulf of Anadyr and adjacent to it from the south relatively shallow water off-shore zone the depths ranging from 19 to 190 meters (mainly 40-80 meters) were surveyed. 47 benthos stations were sampled from which 83 quantitative samples were collected. The total biomass varied from 24.4 to 3,655.1 g/m<sup>2</sup>. The most part of the seabed was occupied by the colonies of animals with biomass of 100-500 g/m<sup>2</sup>. The average total biomass for the whole region was estimated to be 426.6 ± 87.8 g/m<sup>2</sup>, and gross biomass of macrobenthos – approximately 45 million t. The resulting average total biomass fully (to one tenth of a gram!) coincide with the data of N.G. Vinogradova (1954) and is little different from the data of G.M. Belyaev (1960) – 439 g/m<sup>2</sup> and A.A. Neyman (1961, 1963) – 419-468 g/m<sup>2</sup>. Figures 1 and 2 show the index map of stations and biomass distribution in the Gulf of Anadyr in 2000s and 1980s.

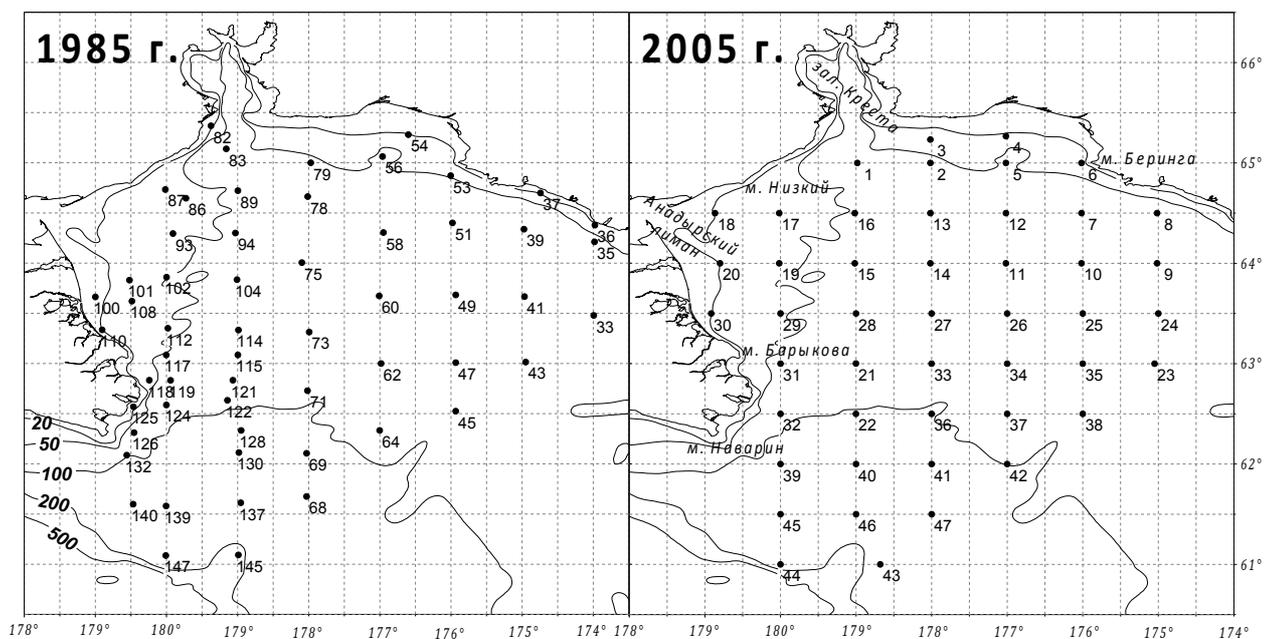


Figure 1. The index map of benthos sampling stations in the Gulf of Anadyr.

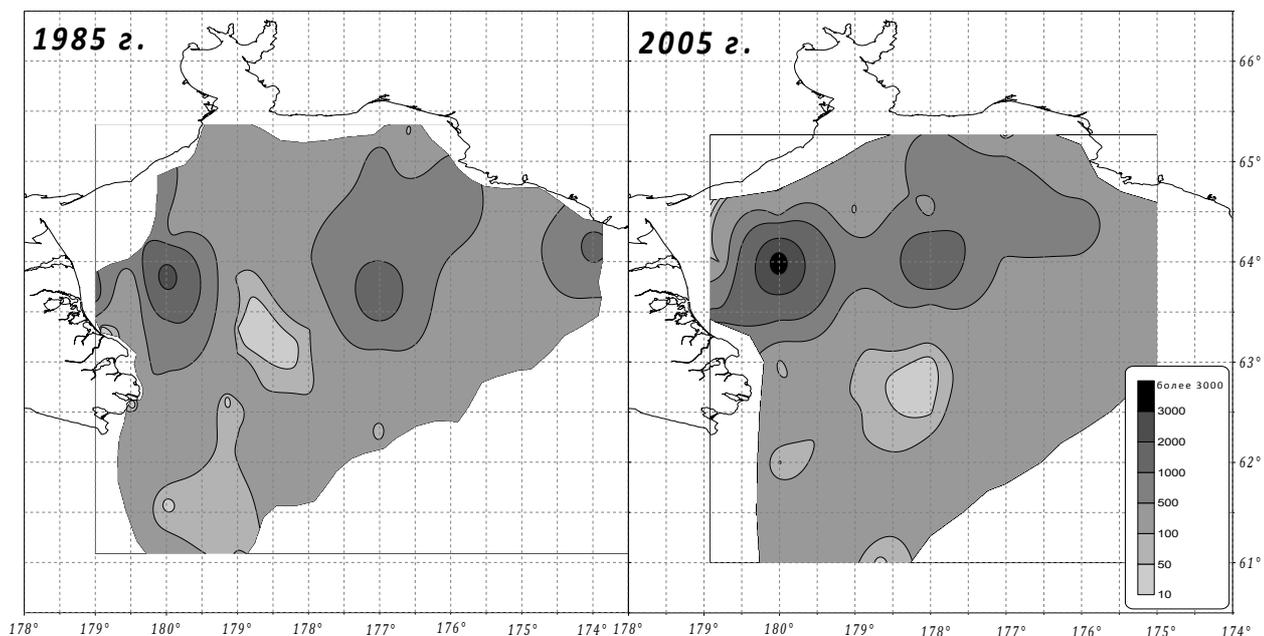


Figure 2. Distribution of the total macrobenthos biomass ( $\text{g}/\text{m}^2$ ) on the Gulf of Anadyr shelf.

Taxonomic composition of the Gulf of Anadyr benthos is quite diverse; 27 groups are registered there, but only three of them - bivalve mollusks, sea urchins and polychaetes – form the main volume (88%) of the Gulf biomass (see Table 7).

In 2005 bivalve mollusks ranked first in contributing to total benthos biomass of the Gulf of Anadyr (56.7%). Their biomass varied from a few fractions of a gram to  $1,880.0 \text{ g}/\text{m}^2$ , the average biomass being  $208.6 \pm 48.3 \text{ g}/\text{m}^2$ . Gross biomass was estimated to be about 25.6 million t. They were distributed more or less throughout the surveyed region.

N.G. Vinogradova (1954) gives a similar pattern of mollusks distribution with *Macoma calcarea* dominating by biomass; however, according to her data the quantitative index of this species was lower (up to 200 g/m<sup>2</sup> and 900 specimen per m<sup>2</sup>). The increase in bivalves proportion in total benthos biomass can also be confirmed by comparison of 2005 and 1985 data. In 1985 their maximum biomass reached only 1,491 g/m<sup>2</sup> and the place of their concentration was located one degree more East (Figure 3). In 1980s according to E.P. Dulepova's calculations (Shuntov, 2001, p. 431) average bivalves biomass was estimated to be 134.5 g/m<sup>2</sup>, or 34.4.% of the total biomass (whereas in 2005 it was 48.9%), and their stock was 13,840 thousand tons. Thus, our data shows that the number of mollusks have risen recently 14.5% and their stock has gone up 1.85 times.

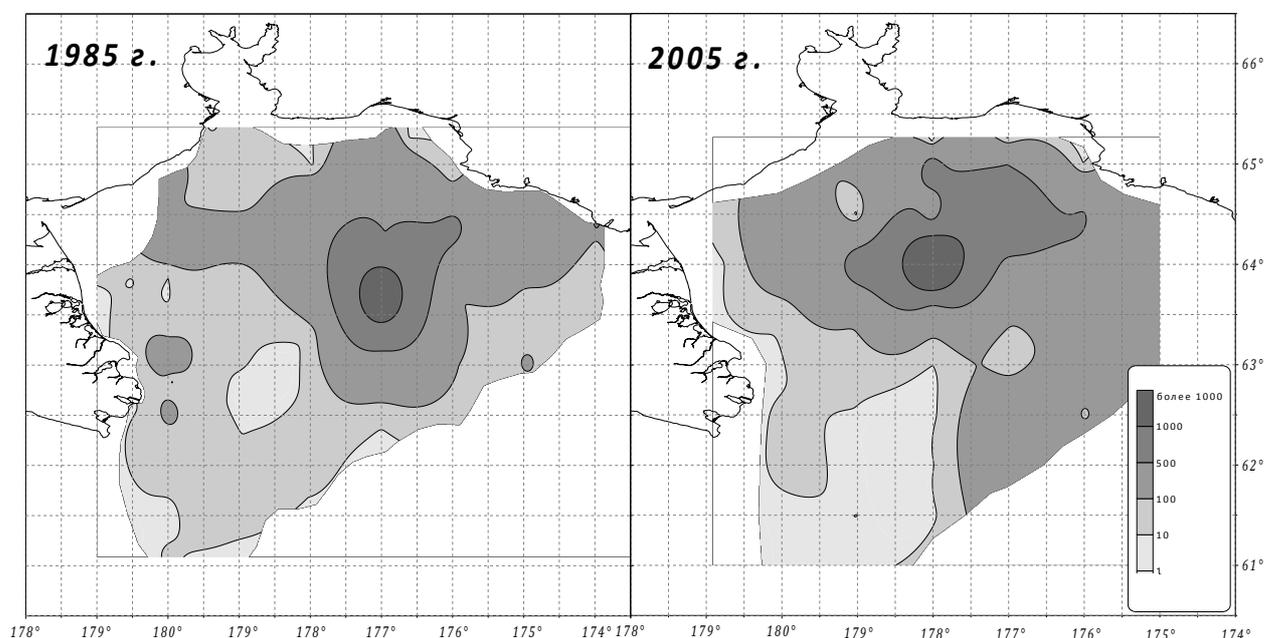


Figure. 3. Distribution of bivalve mollusks biomass (g/m<sup>2</sup>) on the Gulf of Anadyr shelf.

Echinoderms rank second in contributing to total benthos biomass (27.3% - 12,300 thousand t), sand dollar *E. parma* making up the biggest share in the biomass (24.4% - 11,000 thousand t). Its biomass varies greatly from a few fractions of g/m<sup>2</sup> to 3,400.0 g/m<sup>2</sup>, the average biomass being  $119.15 \pm 78.5$  g/m<sup>2</sup> (see Table 9). The maximum biomass (3,400.0 g/m<sup>2</sup>) was registered in the western part of the Gulf at depth of 41 meters on fine sand. The distribution of sea urchins was local and limited to fine sand zones of the bottom (Figure 4). N.G. Vinogradova (1954) pointed out mass development of sea urchins in this place as well and distinguished biocenosis of *E. parma* with biomass of up to 2,000 g/m<sup>2</sup> and population density of up to 320 specimen per m<sup>2</sup>. In 1985 echinoderms, and sea urchins in particular, similarly ranked second in supplying total benthos biomass (27.6%) and their average biomass was 107.8 g/m<sup>2</sup>. In

comparison to echinoderms biomass in 1985 (Koblikov, Nadtochiy, 1991; Shuntov, 2001) the stock of brittle stars and holothurians decreased 1.9 times and that of starfish increased 2.9 times. The echinoderms biomass levels hasn't changed over the past 20 years though the spaces they occupy shrank considerably with the sites of their maximum concentration remaining invariable.

Comparison with 1985 data (Koblikov, Nadtochiy, 1991; Shuntov, 2001) makes it obvious that the average polychaetes biomass virtually hasn't changed (47.3 g/m<sup>2</sup> in 1985 and 47.8 g/m<sup>2</sup> in 2005); for the major part of the region their biomass is estimated to be 10-100 g/m<sup>2</sup>, and even more considerable concentrations of polychaetes are found in the north-eastern part of the Gulf. Some slight differences in biomass distribution can be probably explained by several reasons: patchy distribution and dynamics of the bottom organisms population, small discrepancy in coordinates of sampling stations in the years of study and possible consumption of polychaetes by fish and other aquatic organisms.

**Koryak region.** In September and October 2005 on Koryak shelf (between Navarin Cape and Olyutorsky Cape) 53 stations were sampled at depths ranging from 19 to 201 meters (mainly 30-100 meters) and 76 quantitative samples were collected.

Total benthos biomass level in this region ranged from 6.6 to 1,978.0 g/m<sup>2</sup>, the average biomass being  $530.4 \pm 55.9$  g/m<sup>2</sup>. The most part of the seabed was occupied by the colonies of hydrobionts with biomass of 100-1,000 g/m<sup>2</sup> (Figure 4). Gross benthos biomass of this region was estimated to be 13,000 thousand t. Much lower average biomass was observed on the Koryak shelf previously: according to A.A. Neyman's data (1961) it was only 220 – 246 g/m<sup>2</sup>, V.N. Koblikov and V.A. Nadtochiy's estimates are 297.5 g/m<sup>2</sup>, E.P. Dulepova (Shuntov, 2001, p. 430) estimates it to be 306 – 314 g/m<sup>2</sup>.

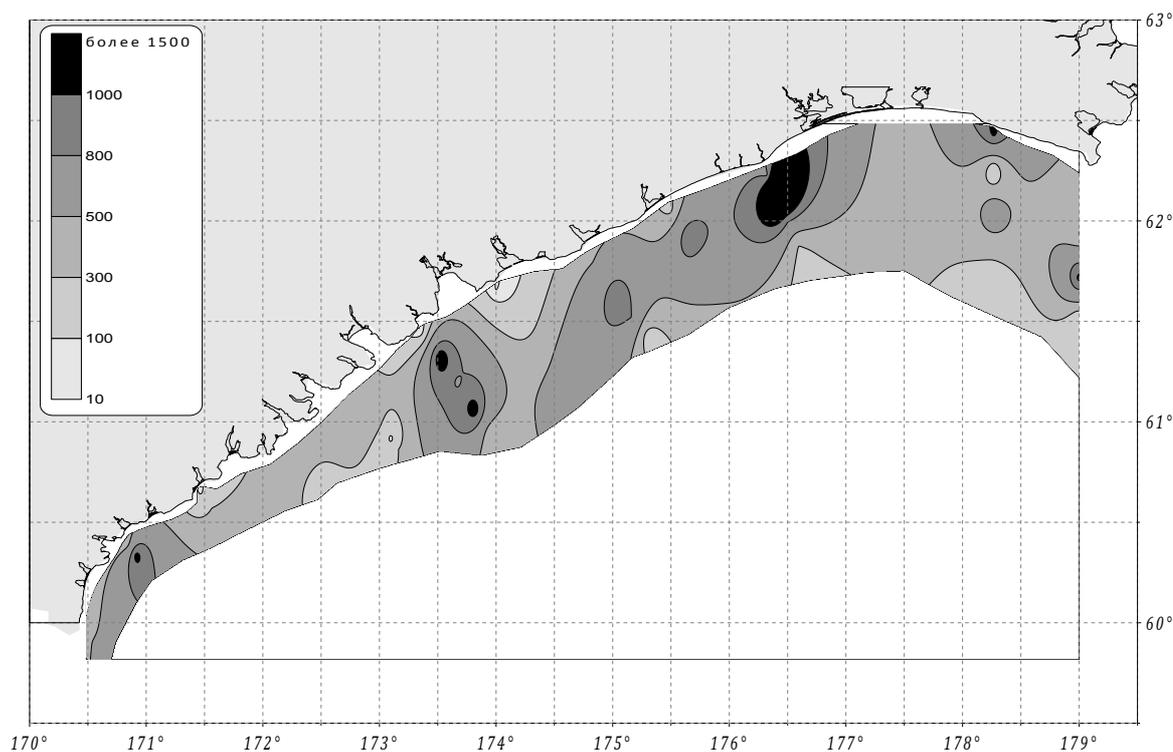


Figure 4. Distribution of the total macrobenthos biomass ( $\text{g/m}^2$ ) in Koryak region, September-October, 2005.

The maps of benthos biomass distribution in earlier periods are given in A.A. Neyman's work (1961) and partially (for south-west only) - in G.M. Belyaev's work (1960). Unlike the patchy distribution of benthos seen on our maps, benthos distribution on the maps of the above mentioned authors is of a belt nature. To our opinion, given biomass distribution scheme is more precise because it was built based on the data from a more compact network of stations, whereas A.A. Neyman's map (1961) is based on the sampling of 17 stations only and therefore can be considered generalized.

The taxonomic composition of the benthos of the Koryak shelf includes representatives of 28 animal groups. According to our data the most numerous ones, playing the key part in forming the total biomass, are sea urchins (35.6%), barnacles (9.7%), sponges (10.0%), bivalve mollusks (9.6%) and polychaetes (7.3%). They account for 72.2 % of the total benthos biomass of the region.

V.N. Koblikov and V.A. Nadtochiy (1991) distinguished only three dominating animal groups in the region: sea urchins (40.6%), bivalve mollusks (17.3%) and polychaetes (11.8%). Accordingly, though the three groups were previously mentioned as leading ones, their contribution to the total biomass was somewhat different; moreover, in 2005 the leading groups also included sponges and barnacles whose contribution to the total biomass used to be rather

small (4.3% and 5.1% respectively). We view this fact as a result of more detailed sampling from a more compact network of stations which allowed discovering new concentrations of stationary animals unregistered previously.

Pale sea urchins *S. pallidus* rate first in contributing to average total biomass (39.7%). Their biomass ranged from a centigram to 720.0 g/m<sup>2</sup>, average biomass being 202.4 ± 30.3 g/m<sup>2</sup>. Gross biomass of this group is estimated to be 4.8 million t. The earlier data (Koblikov, Nadtochiy, 1991) suggests that their average biomass reached as little as 120.8 g/m<sup>2</sup>, but their contribution to average total biomass was virtually the same and made up 40.6%. In 2005 these animals were broadly distributed throughout the territory of the shelf excluding some coastal regions of lower salinity between Navarin Cape and Anastasia Bay. In comparison with 1985 data (Koblikov, Nadtochiy, 1991) it was found that the proportion of other echinoderms in the total benthos biomass of the region increased. For example, the number of starfish increased almost 5 times, and that of brittle stars doubled. Previously the biomass of holothurians was so small that it wasn't even taken into account, but in 2005 it was estimated to be 78 thousand t.

Bivalve mollusks supplied quite a considerable biomass in 2005. It accounted for 8.9% of the average total biomass ranging from a few fractions of a gram to 336,0 g/m<sup>2</sup> (47.4 ± 10.4 g/m<sup>2</sup> on the average). Gross biomass estimates almost reached 1,300 thousand t.

In 1985 the average biomass of bivalves was only a little higher - 51.6 g/m<sup>2</sup> but their share in the total biomass was two times bigger – 17.3% (Koblikov, Nadtochiy, 1991). Bivalves can be found almost everywhere excluding some coastal territories in the south-west of the region. The maximum biomass of bivalve mollusks (336.0 g/m<sup>2</sup>) was registered in 2005 at depth of 19 meters on sandy-pebble-gravel bottom to the west of Navarin Cape. *Macoma calcarea* were dominating.

In 2005 sponges were found to be ranking third in contributing to the average total biomass of the benthos (9.5%). Their biomass varied from 0.5 до 1,580.0 g/m<sup>2</sup>, the average estimates being 50.3 ± 31.5 g/m<sup>2</sup>. Gross biomass of the group was estimated to be 159 thousand t. According to 1985 data (Koblikov, Nadtochiy, 1991) they contributed 4.3% to the total average biomass and their average biomass estimate didn't exceed 12.7 g/m<sup>2</sup>. Sponges are broadly distributed on the shelf, they are absent only in some areas to the west of Navarin Cape, to the north of Khatyrka Cape, in the region of Dezhneva Bay and Glubokaya River, in the foreshore of Expedition Bay (Figure 37). The maximum biomass (580.0 g/m<sup>2</sup>) was registered at depth of 32 meters on pebble and small boulders in the region of Khaiidin Cape.

**Korfa-Karaginsky region.** 45 stations were sampled (70 samples were collected) in Korfa-Karaginsky region in August 2001 at range of depths from 20 to 200 meters (Figure 5). The total macrobenthos biomass varied from 12 to 1,691.6 g/m<sup>2</sup>. The average total biomass was estimated to be  $422.8 \pm 56.0$  g/m<sup>2</sup>. The most part of the seabed was occupied by the colonies with biomass of 100-500 g/m<sup>2</sup> (Figure 6). Our estimate of the gross macrobenthos biomass in this region is 8,000 t (see Table 9). Previously the average biomass in Korfa-Karaginsky region was estimated by V.Ya. Loos and A.P. Kuznetsov (1961) to be 389 g/m<sup>2</sup> and by V.A. Nadtochiy and V.V. Bukin (1991) – 315 g/m<sup>2</sup>.

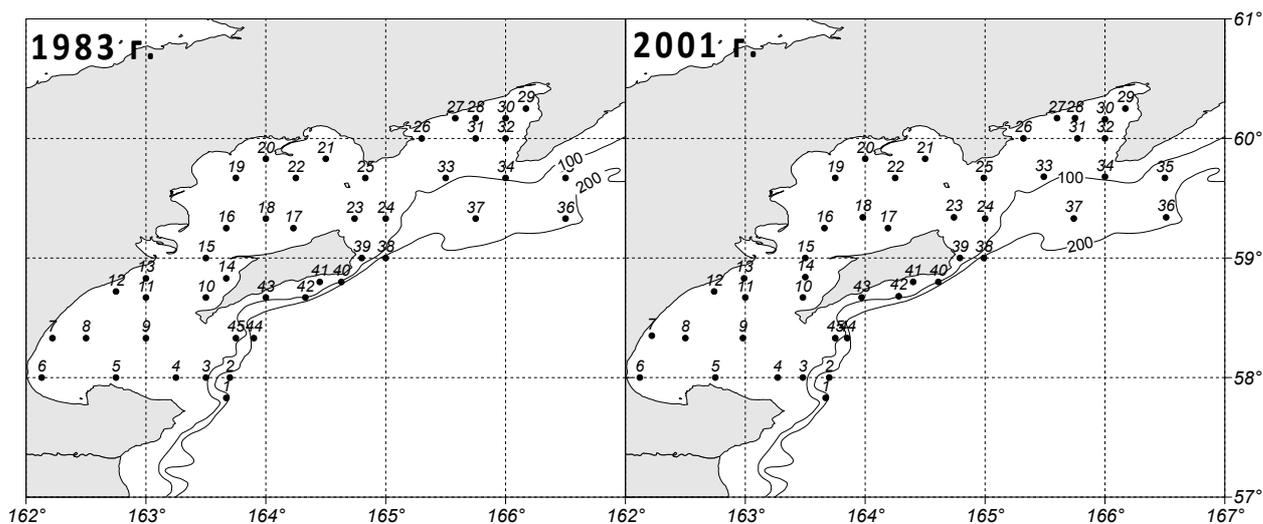


Figure 5. The map of benthos sampling stations in Korfa-Karaginsky region.

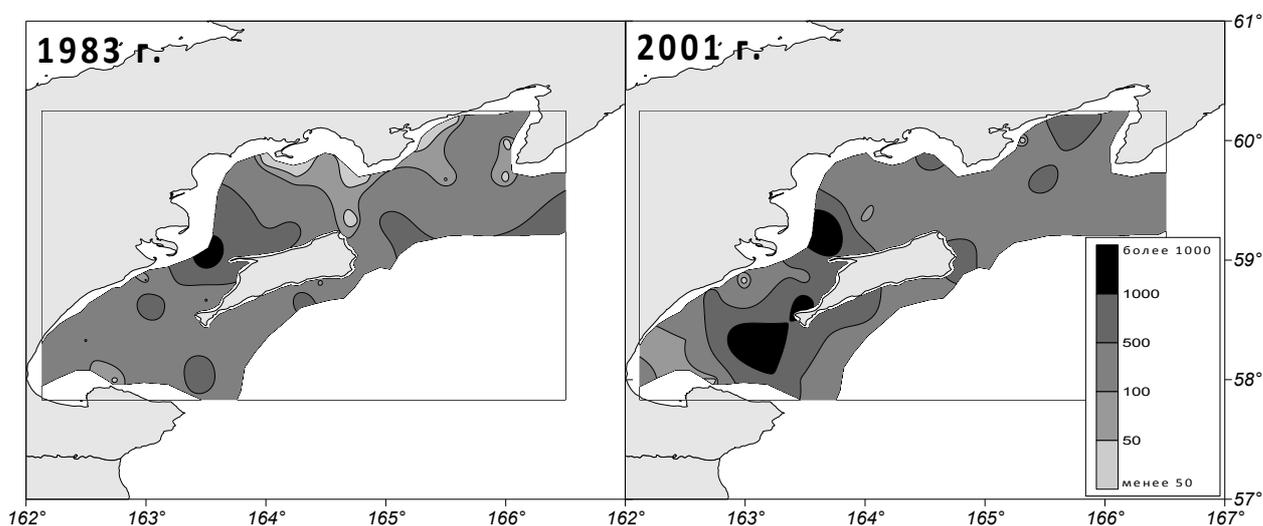


Figure 6. Distribution of the total macrobenthos biomass (g/m<sup>2</sup>) in Korfa-Karaginsky region.

The major taxonomic groups of the Gulf, playing the key part in forming its total biomass, are sea urchins, bivalve mollusks and barnacles, accounting for more than 75% of the macrobenthos biomass of the Gulf.

In 2001 sea urchins ranked first in contributing to the total benthos biomass of Korfa-Karaginsky region (36.6%). Their biomass varied in a broad range from less than 1 to 1,040.4 g/m<sup>2</sup>, the average estimates being 154.3 ± 39.1 g/m<sup>2</sup>. On the main parts of the surveyed region it didn't exceed 500 g/m<sup>2</sup> (Figure 42). The gross biomass was estimated to be 25.6 million t. In 1983 sea urchins ranked second in contributing to total benthos biomass (22.0%) with average biomass of 68.2 g/m<sup>2</sup>. In comparison to echinoderms biomass in 1983 (Nadtochiy, Bukin, 1986) the average biomass of brittle stars almost doubled, holothurians biomass increased 2.5 times and that of starfish decreased 4.7 times. The average biomass of sea urchins went up 2.2 times.

The second important group in benthos population of the region are bivalves, accounting for 28.6% of the total macrobenthos biomass with average biomass of 120.7 ± 27.9 g/m<sup>2</sup>. The gross biomass of this group was estimated to be about 2 million t. The major share of the average biomass (87%) is constituted by 9 mollusk species - *Macoma calcarea*, *M. middendorffi*, *Yoldia myalis*, *Megayoldia thraciaeformis*, *Cyclocardia crebricostata*, *C. ventricosa ovata*, *Crassocardia crassidens*, *Peronidia lutea* и *Tridonta borealis*, the first species on the list accounting for almost half of it (44%). The total biomass estimates varied in a broad range from a few fractions of a gram to 1,055.3 g/m<sup>2</sup>. The most parts of the seabed are occupied by the colonies of animals with biomass of 100-500 g/m<sup>2</sup>.

Barnacles are the third important group in the composition of the bottom population of Karaginsky Gulf (11.6% of the total macrobenthos biomass or 48.8 ± 11.6 g/m<sup>2</sup>). Their biomass varied from 0.3 to 489.2 g/m<sup>2</sup> and was distributed more or less evenly throughout the water area. Still, on the most part of the surveyed region biomass of 10-100 g/m<sup>2</sup> was registered. We estimated the gross biomass to be slightly exceeding 800 thousand t.

The highest concentrations of the representatives of this group of animals with biomass exceeding 100 g/m<sup>2</sup> could be found in the northern part of the surveyed region: in the shallow waters of Korfa Gulf on oozy sediment with a dash of pebbles, often having hydrogen sulfide odor; to the west of Ilpinsky Peninsula, on oozy grounds with a dash of sand, at depth of 23 meters (here the maximum biomass of the group was registered – 489.2 g/m<sup>2</sup>); and in the offshore part of the region to the south of Goven Peninsula on aleuritic ooze contaminated with hydrogen sulfide. The minimum biomass levels of polychaetes are limited basically to hard rocks and medium sands. V.Ya. Loos and A.P. Kuznetsov registered (1961) the average biomass of

polychaetes of 25.4 g/m<sup>2</sup> which accounted for 6.9%. In 1983 this estimates were a bit lower - 18.2 g/m<sup>2</sup> and 6.0% respectively.

Therefore, as a result of our study it was established that the average total biomass of the benthos of Korfa-Karaginsky region equals to 421.9 ± 56.1 g/m<sup>2</sup>, and the gross biomass on the whole surveyed territory of 18,700 km<sup>2</sup> was estimated to be about 8 million t.

Echinoderms (sea urchins predominantly), bivalves and barnacles play the key part in the biomass supply accounting for more than 75% of the total biomass of the region.

Comparison of the obtained data with the earlier findings revealed:

Spatial bottom distribution of the large concentrations of both benthos and of individual taxonomic groups representatives remains rather stable at different time periods. In all Far Eastern Seas the main taxonomic groups of benthos constituting the major part of the biomass include: echinoderms - sea urchins predominantly (up to 37% of the total biomass), bivalves (up to 49%) and polychaetes (up to 16%). In different parts of the shelf some other groups are actively developing too: barnacles, sponges, amphipodas, echiuras and sipunculidas. In different seas at different times the biomass levels and, consequently, the percentage of the groups can vary subject to seasonal and year to year dynamics of hydrobionts population which, in its turn, is dependent on climate and oceanologic conditions variability.

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