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CONDITIONS OF BOTTOM DEPOSIT CONTAMINATION IN NORTH-EASTERN CASPIAN FIELD

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A B S T R A C T

The fields developing on the shelf of the northern Caspian Sea, which belongs to the shallow water zone, are where the breeding and nagulation of semi-passable fish mainly occurs. In this regard, studies of bottom sediments where macrozoobentos is concentrated, which is a feed of benthic fish, are a problem that requires research into the state of not only pollution of bottom sediments but also the state of macrozoobenthos. In this regard, this article is aimed at detecting the state of pollution of bottom sediments by heavy metals and the state of macrozoobenthos, the number and biomass distribution. The leading approach to the study of this problem is the «The guide to methods of hydrobiological analysis of surface waters and bottom sediments» and the «The methodological manual for hydrobiological fisheries research of Kazakhstan reservoirs». The article presents the results of the state of pollution of bottom deposition by heavy metals on the structures of Kashagan, Aktoty, Kairan and the number and species composition of macrozoobenthos. The article revealed that the content of metals in bottom sediments in the studied areas was quite stable and mainly changed in a small range in all seasons of 2019. The species composition of macrozoobenthos was quite homogeneous throughout the surveyed area of the sea. The number of bottom invertebrates varied within relatively small limits, with a more expressed range of biomass fluctuations.

Keywords: bottom sediments; Kashagan; Aktoty; Kairan; heavy metals; macrobenthos.

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Introduction

The environmental problems of the Caspian Sea are directly related to water pollution from oil extraction and transportation, the flow of polluting water from the Volga and other rivers flowing into the Caspian Sea, the vital activities of coastal cities, as well as flooding of certain objects during sea level rise in the period 1978-1995 [1].

The problem of the use of the natural resources of the Caspian Sea is closely adjacent to the problem of marine pollution, which in recent years has become threatening. During oil development in the Caspian Sea, about a million tons of oil go into the water annually [2].

Since the resumption of production in 2016, Kashagan has been consistently growing. According to the Ministry of Energy of Kazakhstan, in 2018 13.2 million tons of oil were produced at the field, and the volume of production increased to 14.1 million tons in 2019. In March 2020, the volume of accumulated production since the restart of the field reached 40 million tons [3].

As noted above, oil production in the Caspian Sea is steadily increasing, and marine pollution can reach a point where cleansing the sea will require immeasurably more effort than is needed to apply reasonable preventive measures.

The Caspian Sea is an inland sea located in a vast mainland depression on the border of Europe and Asia. This is the largest enclosed reservoir in the world, and only isolation from the world's oceans distinguishes it from the interior and peripheral seas. All other features of the reservoir: dimensions, depths, features of the thermohaline structure and water circulation - allow it to be classified as a type of deep inland seas [3]. One of the main distinguishing features of the Caspian Sea is the significant variability of its hydrometeorological and hydrodynamic regimes, which are influenced by both natural and anthropogenic factors. Currently, much attention is paid to the ecological state of the Caspian Sea, which is primarily associated with the intensive development of oil production [4] in its water area. Particularly relevant is the task of studying the dynamics of the Caspian Sea, which makes it possible to assess the transboundary transfer of pollutants, predict the development of emergency situations on oil production platforms and ports. According to these authors, up to 90% of the total pollution goes to the Caspian Sea with river runoff. Every year 2.5 km^3 of untreated and 7 km^3 of conditionally treated wastewater are discharged into the Volga basin. Shipping and transportation of oil by water is another source of pollution in the Caspian Sea. Significant sources of pollution of the Caspian Sea are offshore oil fields in Russia, Kazakhstan, Azerbaijan and Turkmenistan. The isolation of the Caspian Sea exacerbates the increased danger of pollution of water and coasts with petroleum products, surfactants, etc. At the same time, pollution is possible both as a result of direct discharge of the relevant substances into the sea, and by contamination of its coastal strip during subliming events. Under the influence of man-made and natural factors, against the background of the lack of adequate meas-

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Table 1

The average concentration of heavy metals by seasons for 2019, mg/kg in the licensed territory of Kashagan field [19, 20]

Season	Cd	Cr	Cu	Fe	Ni	Pb	Zn
Spring	0.07	6.8	1.94	3067	5.47	2.51	6.37
Summer	0.02	8.84	2.7	1955	6.35	2.33	7.55
Autumn	0.07	6.52	2.68	2653	6.11	9.13	6.54
Average	**0.05**	**7.3**	**2.44**	**2555**	**5.98**	**4.65**	**6.82**

Table 2

The average concentration of heavy metals by seasons for 2019, mg/kg in the licensed territory of Aktoty field [19, 20]

Season	Cd	Cr	Cu	Fe	Ni	Pb	Zn
Spring	–	7.44	3.13	3986	6.26	2.10	6.57
Summer	0.07	11.46	3.09	2638	6.40	2.60	9.33
Autumn	0.07	9.18	2.87	1960	4.90	2.25	6.28
Average	**0.05**	**9.36**	**3.03**	**2861**	**5.85**	**2.31**	**7.4**

Table 3

The average concentration of heavy metals by seasons for 2019, mg/kg in the licensed territory of Kairan field [19, 20]

Season	Cd	Cr	Cu	Fe	Ni	Pb	Zn
Spring	0.07	9.64	3.34	3449	8.26	3.57	12.60
Summer	0.07	12.97	3.63	3360	7.91	2.72	10.48
Autumn	0.07	9.02	3.22	2234	6.31	2.36	5.36
Average	**0.07**	**10.54**	**3.4**	**3029**	**7.5**	**2.9**	**9.5**

ures in the Caspian Sea region, significant negative socio-economic and environmental changes can occur.

The contaminants going into the sea eventually go into bottom deposition, given that the northern Caspian is shallow, then with stormy winds these substances from the bottom again go into water [5].

The work [6] investigated the conditions of heavy metals in the bottom sediments of the deposit of the north-eastern part of the Kazakhstan sector of the Caspian Sea, and in [7, 8] examines the status hydrobiological communities of bottom sedimentation in island D and other fields in the study area.

The present work is devoted to the study of the dynamics of bottom deposit contamination in the area of oil structures of Kashagan, Aktota and Kairan by heavy metals and the state of bottom vertebrate, i.e. macrozoobenthos.

Object and methods of research

The object of the research was the licensed territory of the Kashagan, Aktoty and Kairan fields, as well as the area of islands located on the territory of these fields. The content of heavy metals in bottom sediments was determined using inductively coupled plasma mass spectrometry in aqueous solutions after decomposition of sediments and bottom sediments [9-12]. Studies of the state of macrozoobenthos, sampling of bottom deposit was carried out according to [13]. Determination of the species composition of macrozoobenthos using [14-18].

Results and discussion

The article provides the results of the study on the state of contamination of bottom sediments of licensed territories in the Kashagan, Aktota and Kairan fields by heavy metals and the state of macrozoobenthos living in them and being fodder for fishes.

The results of the heavy metals study are listed in Tables 1-3 and shown in figure 1.

On the licensed territory of the Kashagan field in 2019, the content of most of the determined metals in all observation periods was approximately at the same level. Significant fluctuations in the seasons of the year were practically not observed. The content of cadmium and copper in the spring of 2019 was lower than in the spring of 2018. In the fall of 2019, the concentrations of heavy metals, except cadmium and mercury, were higher than the values of the previous year for the same period.

In the Kairan field area, the higher content of nickel, lead and iron was observed in the spring and chromium and copper was observed in the summer. In autumn, the average concentrations of all certain metals were minimal.

In spring and summer, the average concentrations of

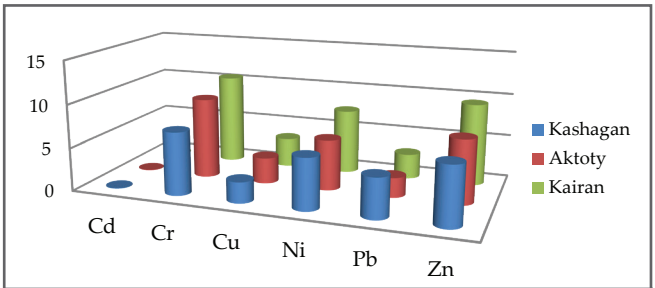

Fig. 1. The average concentration of some heavy metals in bottom deposits in contract territories of oil and gas structures

most metals around Kairan island were higher than in the licensed territory of the Kairan field. In 2019, the average concentrations of heavy metals in the Kairan field varied slightly. In the spring of 2019, the content of chromium, iron, nickel, zinc was higher than in the spring of 2018.

In the autumn observation period, a decrease in concentrations of the following metals - cadmium and iron was recorded compared to the same period in 2018. Concentrations of other metals were higher or at the level of the previous year. In spring and summer, the concentrations of most of the detected metals were distributed evenly among the observation stations. In the water area of the Aktoty field in the spring of 2019, iron concentrations were higher than summer values. In spring, the average concentration of chromium, nickel, zinc in the island area was higher than in the stations of the licensed territory. In autumn, the concentrations of most metals on the licensed territory were higher than around the island. The concentrations of most of the determined metals in the spring of 2019 were higher than the spring values of 2018.

The condition of average values of macrozoobenthos abundance and biomass in licensed territory of Kashagan, Aktoty and Kairan fields are given in tables 4-6.

At the Kairan field, from spring to autumn 2019, the biomass of benthos increased significantly, on the background of seasonal growth of the main structural indicators. The number of bottom hydrobionts in spring and autumn was characterized by almost the same values, declining in the summer. The total number of species was maximum in summer, the smallest in spring. In terms of numbers, worms occupied a dominant position in the community in spring and summer. Autumn abundance was equally due to worms and crustaceans. Biomass in the spring was formed by the joint contribution of worms and mollusks, in the summer and autumn worms prevailed. In 2018, seasonal dynamics were characterized by a number increase from spring to autumn, on the background of stable biomass values. Worms formed the basis of abundance in both seasons and they dominated in biomass only in the spring, losing the leading position to crustaceans in the fall. The seasonal increase in species richness and diversity of bottom cenoses was accompanied by a decrease in the average individual weight of the individual. The values of this indicator, as in 2019, increased from spring to autumn. In the spring of 2018, the number of benthos was lower than a year later, biomass was at the level of spring indicators in 2019. Autumn numbers differed to a lesser extent, while biomass in the fall of 2018 was significantly lower than in the same period of 2019.

At the Aktota field, from spring to summer 2019, the total number of benthos species increased, with a slight decrease in its number. By autumn, at a time its number increased, the total number of species decreased, returning

Table 4

The condition of average values of macrozoobenthos abundance and biomass by seasons in the licensed territory of Kashagan field [19, 20]

Season	Abundance, sp./m²					Biomass, mg/m²				
	Vermes	Mollusca	Crustacea	Insecta	Others	Vermes	Mollusca	Crustacea	Insecta	Others
Spring	3924	284	2307	-	38	3355	9219	1018	-	4
Summer	5247	545	2100	-	44	10872	14550	2068	-	3
Autumn	4104	271	1039	-	9	11365	7855	2686	-	1
Average	**4425**	**366.7**	**1815.3**	**-**	**30.3**	**8527**	**1054**	**1924**	**-**	**2.7**

Table 5

The condition of average values of macrozoobenthos abundance and biomass by seasons in the licensed territory of Aktoty field [19, 20]

Season	Abundance, sp./m²					Biomass, mg/m²				
	Vermes	Mollusca	Crustacea	Insecta	Others	Vermes	Mollusca	Crustacea	Insecta	Others
Spring	3387	427	1517	-	-	526	106	318	-	-
Summer	3702	120	3384	-	-	4952	1170	1152	-	-
Autumn	1680	60	4067	-	273	1671	3830	1326	-	8
Average	**2923**	**202**	**2989**		**91**	**2383**	**1702**	**932**	**-**	**2.7**

Table 6

The condition of average values of macrozoobenthos abundance and biomass by seasons in the licensed territory of Kairan field [19, 20]

Season	Abundance, sp./m²					Biomass, mg/m²				
	Vermes	Mollusca	Crustacea	Insecta	Others	Vermes	Mollusca	Crustacea	Insecta	Others
Spring	4929	378	4087	-	-	2279	3673	889	-	-
Summer	6636	122	4922	-	-	5629	3968	1404	-	-
Autumn	3198	860	2898	-	53	9185	6325	2827	-	1
Average	**4927**	**453**	**3969**	**-**	**17.6**	**659.8**	**465**	**171**	**-**	**0.33**

to the level of spring period. The seasonal dynamics of biomass were characterized by steady growth from spring to autumn, with a similar trend for all structural indicators of macrozoobenthos. Diversity was moderate throughout the year, increasing by the fall, and accompanied by an increase in species richness. In spring and summer benthos, the basis of quantitative indicators was formed by worms, in autumn crustaceans led in numbers, and mollusks in biomass. From spring to autumn, the community experienced an increase in the average individual weight of the individual. In 2018, the dynamics of community indicators had a slightly different character. From spring to autumn, the abundance increased slightly, biomass - decreased. The basis of the number of benthos, both in spring and autumn, was formed by worms. Spring biomass was mainly formed by worms, autumn biomass - mollusks and worms in equal ratios. The seasonal increase in species richness was accompanied by a slight decrease in diversity and a noticeable decrease in the average individual weight of individuals. In the spring of 2018, the abundance, species richness and diversity of benthos were lower, biomass - noticeably higher than in 2019. In autumn, the quantitative and structural indicators of the community were lower than in the same period of 2019.

At the Kashagan field, from spring to autumn, biomass values and several structural indicators increased, when the abundance and total number of species decreased. Species richness and diversity were at a moderate level, increasing from spring to summer and decreasing in the autumn period. Throughout all three seasons, worms dominated in number, the main contribution to biomass was made by mollusks, with the subdominating position of worms. The pattern of species dominance was characterized by the close arrangement of abundance and biomass curves, possibly indicating the initial stage of stress in the bottom community. In 2018, the dynamics of quantitative and structural indicators of macrozoobenthos was characterized by growth from spring to autumn. The dominant position of worms remained in all seasons of the year, both in number and in biomass. The diversity of the bottom community was at a moderate level, increasing slightly in the autumn period. But unlike 2019, there was a decrease from spring to autumn, against the background of seasonal strengthening of the role of small-sized species. In the spring of 2018, the number and biomass of bottom animals were lower than in the corresponding season of 2019. Autumn benthos was characterized by close values in both years of observation, biomass in 2018 was slightly lower than in the same season of 2019.

The seasonal dynamics of macrozoobenthos had common and specific features, depending on the research area. In most of the water area, the abundance of benthos decreased from spring to autumn. Changes in biomass were different: at some sites (Kairan, Aktota, Kashagan) there was a seasonal increase in the indicator, at others - a decrease of various extent. At the same time, everywhere from spring to autumn, in bottom communities there was an increase in the average individual mass of an individual. In all seasons of 2019, the species composition of macrozoobenthos was fairly uniform throughout the surveyed sea area. The number of bottom invertebrates varied within relatively small limits, with a more pronounced range of biomass fluctuations.

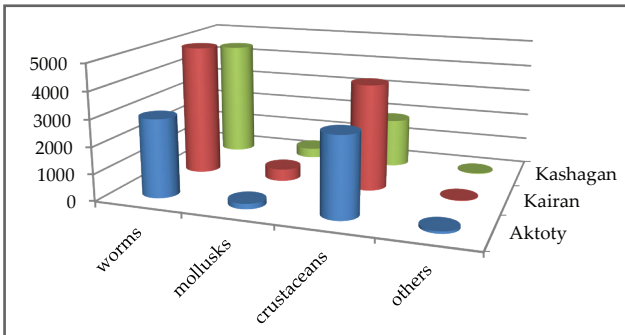

Fig. 2. The abundance (sp./m²) of macrozoobenthos in the licensed area of the north-eastern Caspian field

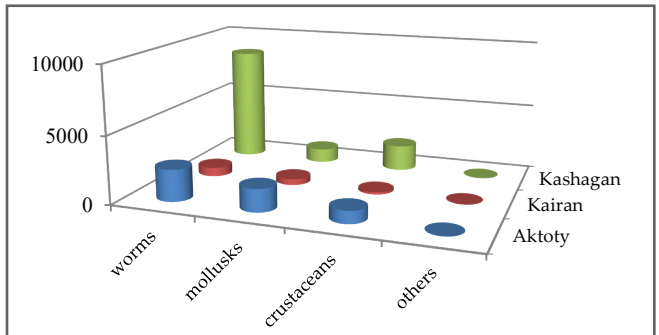

Fig. 3. The biomass state (mg/m²) of macrobenthos on licensed territory of northern-eastern Caspian field

Conclusion

- The content of metals at the study sites was quite stable and mainly changed in a small range. Fluctuations in the concentrations of most of the defined metals reflect annual and seasonal variability, in addition, the results of the studies are greatly influenced by the mosaic characteristic of bottom sediments. The obtained results of concentrations of heavy metals are at the level of data of long-term observations and are characteristic of the Northeast Caspian Sea.
- The highest biomass, formed by bottom cenoses from the studied field, was occupied by the macrozoobentos of the Kashagan structure, due to the approximately equal contribution of mollusks and worms to the formation of total biomass. In other areas, the biomass of macrozoobenthos was an order of magnitude smaller and was formed mainly due to worms, when subdenominating mollusks or crustaceans.
- The seasonal dynamics of macrozoobenthos had common and specific features, depending on the research area. In most of the water area, the number of benthos decreased from spring to autumn. Changes in biomass were different: at some fields (Kairan, Aktota, Kashagan) there was a seasonal increase in the indicator, at others – a decrease in various extent. At the same time, everywhere from spring to autumn, in bottom communities there was an increase in the average individual mass of an individual.

Литература/References

1. Nesterov, E. S. (2016). Water balance and Caspian Sea level fluctuations. Modelling and forecasting. *Moscow: Triada Ltd.*

2. Kaplin P.A., Ignatov E.I. (1997). Geo-ecological changes in the Caspian Sea level fluctuations. Vol. 1. Geoecology of the Caspian Sea. *Moscow: Moscow State University.*

3. Neftegaz.RU https://neftegaz.ru/news/dobycha/539689-nakoplennyy-obem-dobychi-nefti-na-kashaganskom-mestorozhdenii-v-kazakhstane-s-momenta-perezapuska-do/

4. Kostianoy, A. G., Kosarev, A. N. (2005). Physico-geographical conditions of the Caspian Sea. The Caspian Sea environment. Vol. 5. Part P. Berlin, Heidelberg, *New York: Springer–Verlag.*

5. Zonn, I. S., Zhiltsov, S. S. (2008). New Caspian: geography, economics, politics. *Moscow: AST Vostok-Zapad.*

6. Kenzhegaliev, A., Kanbetov, A. S., Abylgazieva, A. A., et al. (2019). Condition of bottom sediment in the area of artificial islands of the Kashagan field, Kazakhstan. *South of Russia: Ecology, Developmen*, 14(3), 144-153.

7. Kenzhegaliyev, A., Orazbaev, B. B., Zhumagaliev, S. Z., Kenzhegaliyeva, D. A. (2013). Researches of an ecological condition of hydrobiological communities of the Kazakhstan sector of the Caspian Sea in preparation of oil and gas fields for development. *Life Safety*, 10, 39-44.

8. Orazbaev, B. B., Zhumagaliev, S. Z., Kenzhegaliyeva, D. A. (2017). The state of hydrobionts in the area of the artificial island «D» Kashagan field. *Oil and Gas*, 1, 77-90.

9. (2003). ISO 17294-2:2003 «Water quality. Application of inductively coupled plasma mass spectrometry (ICP-MS) - Part 2: Determination of 62 elements, IDT.

10. (2009). ISO 5667-15:2009. Water quality. Sampling - Part 15: Guidance on the preservation and handling of sludge and sediment samples.

11. (2004). ISO 5667-19:2004. Water quality. Sampling - Part 19: Guidance on sampling of marine sediments.

12. (2007). ISO 19493:2007. Water quality — Guidance on marine biological surveys of hardsubstrate communities.

13. (1983). Manual of methods for hydrobiological analysis of surface water and bottom sediments. *Leningrad: Gidrometeoizdat.*

14. (2000). State of biodiversity in the Kazakhstan part of the Caspian Sea. *Atyrau: National Report of the Republic of Kazakhstan.*

15. Romanova, N. N. (1983). Methodical instructions for the study of benthos of the southern seas of the USSR. *Moscow: VNIRO.*

16. Mordukhai-Boltovskaya, F. D. (1975). Methodology of studying biogeocenoses of inland water bodies. *Moscow: Nauka.*

17. (2006). Methodological manual for hydrobiological fishery research of water bodies of Kazakhstan (plankton, zoobenthos). *Almaty.*

18. Bernstein, J. A. (1968). Atlas of invertebrates of the Caspian Sea. *Moscow: VNIRO.*

19. (2018). Marine impact monitoring. Report on research and development (final). *Almaty: Kazakhstan Agency of Applied Ecology LLP.*

20. (2019). Marine impact monitoring. Research and development report (final). *Almaty: Kazakhstan Agency of Applied Ecology LLP.*

Состояния загрязнения донного отложения месторождений Северо-Восточного Каспия

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Реферат

На шельфе северной части Каспийского моря, который относится к мелководной зоне, разрабатываются месторождения, где в основном происходит размножение и нагул полупроходных рыб. В связи с этим изучение донных отложений, в которых концентрируется макрозообентос, являющийся кормовой базой бентосных рыб, представляет собой проблему, требующую исследования не только загрязнения донных отложений, но и состояния макрозообентоса.

Данная статья направлена на выявление загрязнения донного отложения тяжелыми металлами и состояния распределения численности и биомассы макрозообентоса.

Исследования проводились согласно «Руководство по методам гидробиологического анализа поверхностных вод и донных отложений» и «Методическое пособие при гидробиологических рыбохозяйственных исследованиях водоёмов Казахстана».

Представлены результаты состояния загрязнения донного отложения тяжелыми металлами на структурах Кашаган, Актоты, Кайран а также численность и видовой состав макрозообентоса.

В статье выявлено, что содержание металлов в донных отложениях на исследуемых участках было достаточно стабильным и в основном изменялось в небольшом диапазоне во все сезоны 2019 года. Видовой состав макрозообентоса был достаточно однородным на всей исследованной акватории моря. Численность донных беспозвоночных варьировала в относительно небольших пределах, при этом диапазон колебаний биомассы был более выраженным.

Ключевые слова: донное отложение; Кашаган; Актоты; Кайран; тяжелые металлы; макрозообентос.

Şimal-Şərqi Xəzər yataqlarının dənizdibi çöküntülərinin çirklənmə vəziyyətləri

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Xülasə

Xəzər dənizinin dayazsulu zonaya aid olan şimal hissəsinin şelfində yarımanadrom balıqların əsasən çoxaldığı və qidalandığı yataqlar işlənilir. Bu baxımdan, qıjovçu - bentik balıqların yem bazası olan makrosobentosun cəmləşdiyi dənizdibi çöküntülərin öyrənilməsi yalnız dənizdibi çöküntülərin çirklənməsinin deyil, həm də makrozobentosun vəziyyətinin öyrənilməsini tələb edən bir problemdir. Bu məqalə dənizdibi çöküntüsünün ağır metallarla çirklənməsini və makrozoobentos sayının və biokütləsinin paylanma vəziyyətini müəyyənləşdirməyə yönəlmişdir. Tədqiqatlar «Yerüstü suların və dənizdibi çöküntülərin hidrobioloji analizi metodlarına dair Təlimat» və «Qazaxıstan su hovuzlarının hidrobioloji balıq təsərrüfatı tədqiqatları üçün metodik Vəsait»ə uyğun olaraq aparılmışdır. Kaşaqan, Aktotlar, Kayran strukturlarında dənizdibi çöküntünün ağır metallarla çirklənmə vəziyyətinin nəticələri, eləcə də makrozoobentosun sayı və növ tərkibi təqdim olunur. Məqalədə tədqiq olunan ərazilərdəki dənizdibinin metal miqdarının kifayət qədər sabit olduğu və əsasən 2019-cu ilin bütün mövsümlərində kiçik diapazonda dəyişdiyi müəyyən edilib. Makrozoobentosun növ tərkibi tədqiq olunan bütün dəniz akvatoriyasında kifayət qədər bircinslidir. Dənizdibi onurğasızların sayı nisbətən kiçik həddə dəyişirdi, eyni zamanda biokütlənin rəqs diapazonu daha qabarıq idi.

Açar sözlər: dənizdibi çöküntüləri; Kaşaqan; Aktotlar; Kayran; ağır metallar; makrozoobentos.