Variability of the food potential of the Kerch strait and the black sea pre-strait zone as a prospective area for the development of mollusks Mariculture

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Abstract. Based on the data of integrated observations, the variability of phytoplankton, the amount of suspended organic matter and zooplankton of the pelagic zone of the Kerch Strait and the pre-strait zone of the Black Sea is considered. The algal flora of the entire Black Sea, the Kerch Strait and the pre-strait is characterized by the predominance of diatoms over pyridineas (pyrrophytes or dinoflagellates). The study of the species range, number and biomass of the phytoplankton community during several periods of the year showed that its dynamics is largely dependent on seasonal weather changes (climate). In the process of phytoplankton development, several phases of autogenic succession were revealed. It is expressed in a sequential change in phytoplankton forms, changes in its abundance and biomass typical of the eastern shelf of the Black Sea. The zooplankton community of the Kerch Strait is represented by micro-, meso- and macro- zooplankton typical of the Black Sea. Microzooplankton is represented by zooflagellates and protozoa, as well as by early larval stages of planktonic crustaceans, apendicularia and mollusks. Its total biomass averages about 80 mg/m3.The above analysis of the collected material allows us to conclude that the distribution of suspended matter and larvae is related primarily to the peculiarities of water circulation in the strait. In the case of low concentrations of larvae, the dynamic factor can be decisive in the process of sedimentation intensity. The amounts of suspended matter can reach 20 mg/m3, which is 2-3 times higher than on average for the Black Sea. It further demonstrates the high productivity of waters and the prospects of the latter to be the area for commercial growing of mussels.

1 Introduction

The most important characteristic of an area planned for the development of mollusks mariculture is its biological productivity, i.e. the ability of a given reservoir to form (reproduce) a certain amount of living matter per unit of time (day, month, year). The initial (basic) characteristic is the production of phytoplankton, where organic matter is created

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from inorganic elements and transferred to organisms of higher trophic levels (zooplankton, mollusks, fish).

The main food for mollusks, including mussels, is phyto- and bacterioplankton, suspended and dissolved organic matter (SOM and DOM). Their content in the mollusks diet varies significantly, and their proportion, depending on the season, physiological state, and other factors, can vary significantly.

By its physical and geographic location, the Black Sea is one of the most promising pools for growing mollusks. Favorable climatic conditions, high trophicity of the shelf zone of the Black Sea and the presence of natural populations of these organisms ensure the marine economy with seed material [1].

The objective of the article is to study the variability of the species and quantitative composition of the phyto- and zooplankton of the Kerch Strait and the Black Sea pre-strait zone in order to draw conclusions [3] about the possibility of growing mollusks on an industrial scale in the study area.

The investigations were carried out in the shelf zone of the Kerch Strait and the Black Sea pre-strait zone, namely in the transition zone of the southern part of the Kerch Strait to the pre-strait zone (Cape Takil – Cape Kyz-Aul) and the shelf zone from Cape Kyz-Aul to Cape Chauda. The collection of material was carried out by field observations and field tests [2].

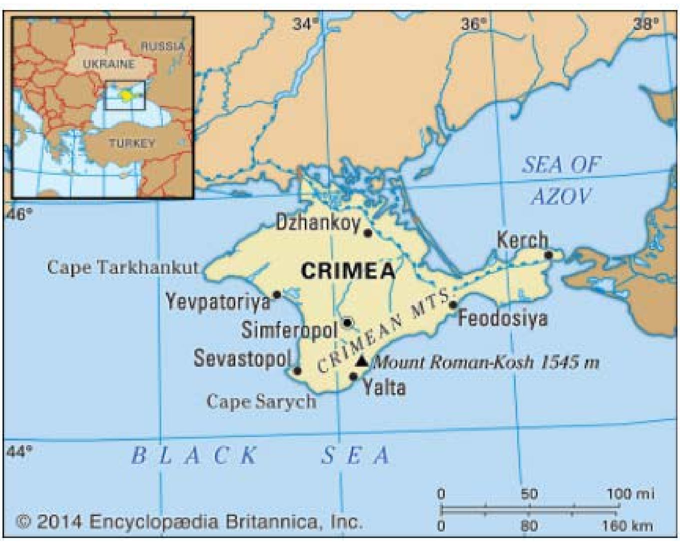

Fig. 1. The investigated water area for the creation of a marine farm for growing mollusks from the southern part of the Kerch Strait (from Tobechik Lake) to Cape Takil and Cape Chauda.

Phytoplankton of the pelagic zone of the Kerch Strait and pre-strait zone. Phytoplankton is the main food supply for growing mollusks. The prevalence of microalgae species available for nutrition in the food variety of mussels and oysters largely determines the efficiency of marine farming. Data on the structure of phytoplankton are also used to assess the water quality in the area of mariculture [4]. The algal flora of the Kerch Strait and pre-strait was mostly represented by the main three types of algae. The first group includes diatoms (Bacillaariophyta), especially the representatives of the genera Chaetoceros, Sceletonema, Nitzschia, etc. The second largest group is Pyrrophyta or Dinophyta which includes Ceratium, Exuviella, Prorocentrum, etc. A much smaller number of species is represented by golden algae – coccolithophorids (Chrysophyta). Green (Chlorophyta) and blue-green (Cyanophyta) species were even less common; other groups were represented by single species.

2 Research area analysis

The study of the species composition, number and biomass of the phytoplankton community during several periods of the year showed that its dynamics is largely dependent on seasonal weather changes (climate). In the process of phytoplankton development, several phases of autogenic succession were revealed. It is expressed in a sequential change in phytoplankton forms, changes in its abundance and biomass typical of the eastern shelf of the Black Sea (Table 1).

Phytoplankton vegetation starts in the late winter and early spring, i.e. from February to March. At this time, there is a sharp increase in the phytoplankton number and biomass. This is followed by a phase of decline in these indicators, i.e. a period of recession due to the depletion of nutrients. After partial biogenic regeneration, a short-term inhibition phase begins. This phase is inferior to the first one both in terms of scale and time characteristics. The next phase of successional changes begins in July and continues until the end of August. This is a period of recession of the phytoplankton community. Then in autumn a slight increase in species diversity, abundance and biomass begins.

Table 1. Quantitative indicators of phytoplankton development in the Kerch Strait.

Year	Species richness	Population. mln.cells/m^3			Biomass. mg/m^3		
		min	average	max	min	average	max
2001	44	10.7	113.5	221.3	14.1	281.9	463.4
2004	58	7.7	72.1	272.6	26.7	355.1	1515.3
2008	81	126.6	275.6	943.5	547.2	1842.7	5233.7
2010	46	19.0	87.3	251.4	106.0	378.6	853.3
2013	63	8.4	63.1	242.6	26.7	336.	1257.4

Hydrobiological surveys carried out in the pre-strait and the coastal sea area from Cape Takil to Cape Chauda showed that the distribution of phytoplankton is uneven and exposed to significant fluctuations even within a month, which largely depends on the current system. In general, the phytoplankton biomass in the autumn months remained at a high level. Thus, in September, near the coast in the area of Cape Kyz-Aul, it fluctuated at different points from 145 to 938 mg/m3. In the sea, at some points, it reached 1257 mg/m3. In October, near Cape Kyz-Aul, the biomass was only 64 mg/m3. In the deep-water zone it was 38 mg/m3 (Figure 2). In the area of Cape Opuk, phytoplankton biomass varied from 900 mg/m3 in September and to 600 mg/m3 in October. Near the village of Chernomorskoe at depths of up to 10 m, the phytoplankton biomass ranged from 172 to 696 mg/m3, at depths over 20 m – up to 437-578 mg/m3. In October, the phytoplankton biomass decreased to 35 mg/m3 and 335 mg/m3, respectively. In the area of Cape Chauda at depths over 20 m, the phytoplankton biomass ranged from 293 to 512 mg/m3, while near the coast it reached 1309 mg/m3 (Figure 2).

In August, the biomass of algae in plankton remained at the same level as in July – 234 mg/m3 (130 million cells/m3). Diatoms accounted for 177 mg/m3 and peridinium – 46 mg/m3. The dominant species were Nitzschia closterlim, Chaetoceros curvisetus, Phaeodactium tricornutum.

In September, there is a sharp increase in the phytoplankton biomass in the area of Cape Opuk – up to 904 mg/m3 (94 million cells/m3). Plankton is mostly consists of diatoms 894 mg/m3, while the share of peridiniums is only 10.4 mg/m3. Such a high biomass is due to the predominance of the diatom Sceletonema costatum in plankton (861 mg/m3). The same species predominated in plankton in October, when the total phytoplankton biomass in the area of Cape Opuk was 582 mg/m3. On the average for the area, the phytoplankton biomass in September was at a high level – 494 mg/m3 (547 million cells/m3). According to long-term data, in the most productive northwestern region of the Black Sea, the average phytoplankton biomass is 300-600 mg/m3 [5], which is two to three times higher than in most of the remaining area of the Black Sea. Given this fact, we can talk about a fairly good production of phytoplankton to provide food for mussels in the area under study, where at some points the biomass of algae exceeded 1 thousand mg/m3.

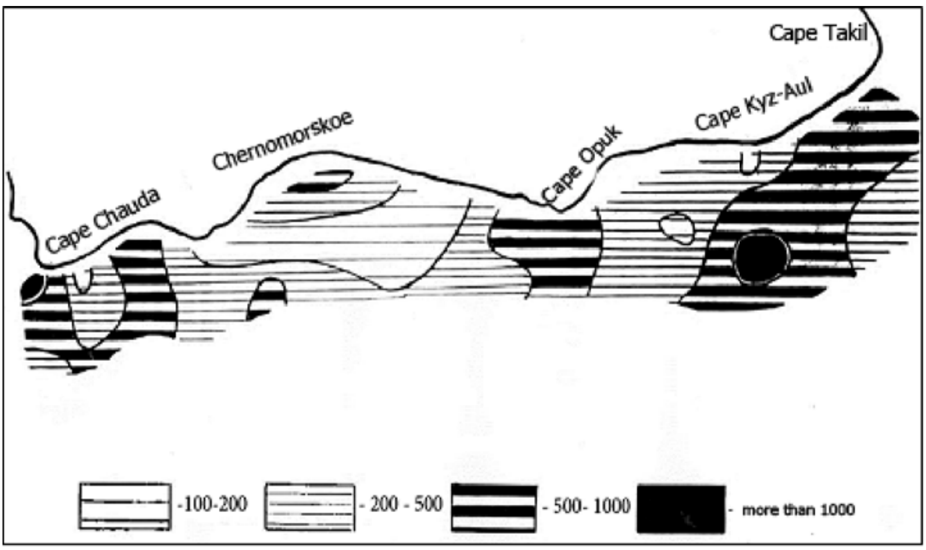

Fig. 2. Distribution of phytoplankton biomass in the Kerch pre-strait of the Black Sea.

Thus, in terms of primary productivity, the Kerch region is more advantageous than almost all other regions of the Black Sea, including the northwestern part of the Black Sea, where the phytoplankton biomass could reach 7.5 g/m3 [6]. Such a significant concentration of algal flora is significantly higher (2-3 times) than across the Black Sea and along its coastal zones.

This is also confirmed by comparative data with other regions of the Black Sea, in particular, with the South Coast of Crimea (Laspi Bay). There changes in the average values of phytoplankton biomass varied from 35 to 687 mg/m3, which is considered satisfactory for the food supply of cultivated mussels [7] ... Therefore, based on the phytoplankton abundance and biomass in the spring-summer and autumn periods in the Kerch Strait waters and the pre-strait of the Black Sea, this area can be considered highly trophic and recommended for industrial cultivation of mussels.

Suspended matter in seawater. Special attention should be paid to the content of suspended organic matter (SOM) in water. This component is one of the most important indicators of the food supply of mollusks. Thus, according to the data of numerous Russian and foreign authors, SOM makes up 80% of the total diet of mollusks. The concentration of suspended matter is an important indicator for assessing the purity of the water of coastal shallow sea areas. Moreover, suspended matter can be of both organic and mineral origin. It

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can contain polluting components and nutrients, as well as mussel larvae that determine the efficiency of the marine farms activity.

Let us consider the distribution of the total indicator of the concentration of suspended matter in the southern part of the Kerch Strait based on the research materials of Southern Scientific Research Institute of Marine Fisheries and Oceanography (YugNIRO) [7]. When Azov current prevailed, the average concentration of suspended matter in the surface horizon ranged from 8.5 to 16.8 mg/l. In the bottom water layer, the content of suspended matter was within the range of 5-36 mg/l (the average concentration was 21 mg/l). The spatial distribution of suspended matter, as well as in the surface layer, was heterogeneous. In the western part of the area, an increase in the concentration of suspended matter from 21 to 27 mg/l was observed. To the east, an increased suspended matter up to 25 mg/l was seen.

With the prevailing Black Sea current, the background concentrations of suspended matter did not exceed 1 mg/l in the surface horizon and 2 mg/l in the bottom layer of waters.

3 Modeling the state of component structures

The presence of mixed Azov-Black Sea water masses was characterized by a relatively uneven distribution of suspended matter. In the north, in the region of the Azov waters, the suspension content was 1-3 mg/l. In the southern part of the region, where the Black Sea water mass was observed, amid the low content of suspended matter (0.5 mg/l), a high concentrations of suspended matter (up to 5 mg/l) was clearly seen. The shots made in 2008 - 2009 show the concentration and distribution of suspended matter corresponding to the previously observed operating characteristics. Under the conditions of the Azov currents in February 2008, the concentration of suspended matter decreased from north to south from 25 to 5 mg/l in the surface layer of water and from 28 to 16 mg/l in the bottom layer (Figure 2). With unstable Black Sea currents in March 2009, the maximum concentrations of suspended matter (up to 10 mg/l in the surface layer and up to 18 mg/l in the bottom layer) were observed in some areas (Figure 3).

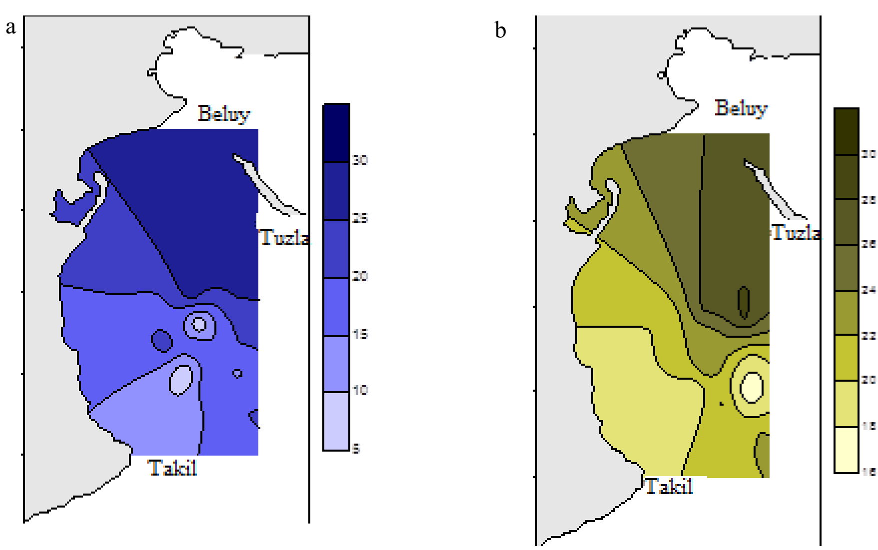

Fig. 3. Spatial distribution of suspended matter in the Kerch Strait in February 2008, where: a – surface horizon; b – bottom horizon.

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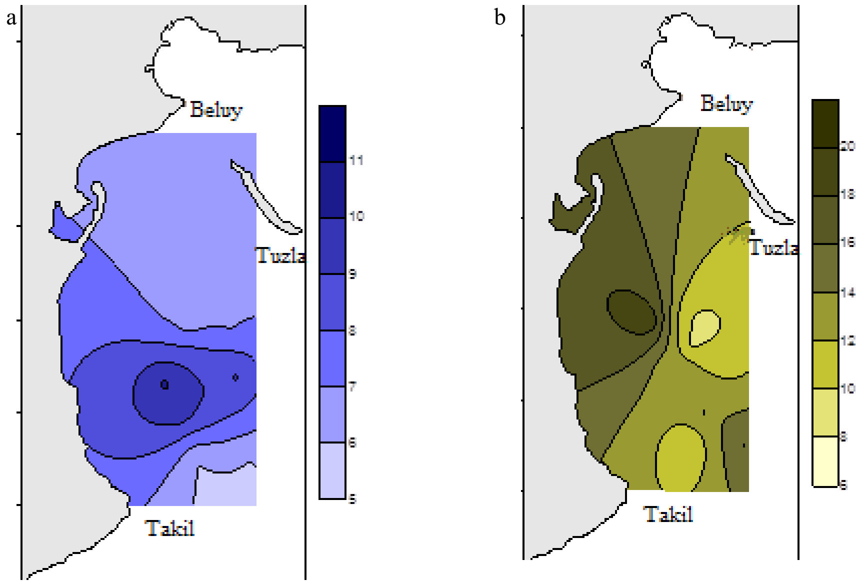

Fig. 4. Spatial distribution of suspended matter in the Kerch Strait in March 2009, where: a – surface horizon; b – bottom horizon.

In both cases, the concentration of suspended matter in the south of the strait was minimal. Comparison of the suspended matter content in the area of the transshipment roadstead in the southern part of the strait with the background value from the shots determines the presence of excess suspended matter due to the transshipment operations.

Studies of the distribution pattern of suspended organic matter (SOM) and larvae of mussels over the water area of the southern part of the strait showed that with the Black Sea current, SOM was concentrated in the central part of the strait, and with the Azov current – in the coastal. The distribution of larvae as an integral part of the SOM was the same. With the Black Sea currents, in the coastal zones, the concentration of larvae is several times lower than in the central part of the strait.

In the case of the Azov Sea and unstable currents, such obvious patterns in the distribution of larvae, as in the Black Sea, were not revealed. However, there is a slight increase in the concentration of larvae near the western coast during the intense Azov current.

The diagrams of the currents compiled in these studies on the distribution of surface water salinity indicate that in the southern part of the strait, both Black Sea waters and the Azov ones are more actively transported along the western (Crimean) coast of the strait.

The western intensification, as well as the peculiarities of the distribution of SOM and mussel larvae, suggest that anticyclonic vorticity flow are formed in the southern part of the strait with the Black Sea currents, and cyclonic one with the Azov currents.

The above analysis of the collected material allows us to conclude that the distribution of SOM and larvae is associated, first of all, with the peculiarities of water circulation in the strait. In the case of low concentrations of larvae, the dynamic factor can be decisive in the process of deposition intensity.

In relation to aquatic organisms, SOM acts as a food source. Therefore, its high content indicates good trophic conditions. High concentrations of SOM with a weak water exchange in the summer months can cause local freezing phenomena around the plantations.

In general, the data obtained indicate that the content of SOM can reach 20 mg/m3, which is 2-3 times higher than the average for the Black Sea. It further demonstrates the high productivity of waters and the prospects of the latter to be the area for commercial growing of mussels.

Zooplankton of the pelagic zone of the Kerch Strait shelf and pre-strait. In addition to phytoplankton and SOM, larvae of different families of zooplankton are found in the digestive system of mussels. In this regard, we briefly characterize the main types of planktonic organisms, since these animals are of interest for calculating the ecological capacity of the possible scale of cultivating species [8].

The zooplankton community of the Kerch Strait is represented by micro-, meso- and macrozooplankton typical of the Black Sea. Microzooplankton is represented by zooflagellates and protozoa, as well as by early larval stages of planktonic crustaceans, apendicularia and molluscs. Its total biomass averages about 80 mg / m3. In addition to microzooplankton, the Kerch Strait is characterized by a significant species richness of meso- and macrozooplankton [11]. The proximity to the desalinated Sea of Azov is characterized by the presence of freshwater and brackish-water plankton - daphnia, bosmin, diaptomus, cyclops, while the saltier Black Sea waters give rise to the development of several mass species of phytophages and euryphages – Calanus, Parecalanus, Centropages, Acartia, etc. cladocerans – Penilia, Podon, Pleopis, etc. The average biomass of meso- and macrozooplankton ranges from 76 to 213 mg/m3, which is much higher than in the open sea.

Taking into account that noktiluk, jellyfish, sagitta, and comb jellies actively develop in the strait in certain seasons of the year, the total biomass of zooplankton is very high. It indirectly indicates the high production potential of the waters of the Kerch Strait. The study of the state of zooplankton in the shelf area of the reserve showed that it contains typical forms of plankters, peculiar to the eastern part of the Black Sea.

4 Conclusion

The most typical representatives found near the coast of the strait are Acartia clausi, Paracalaanus pervus, Calanus helgollandicus, and other representatives of the Calanoida suborder. Oitona aaiimilis, Cyclopins gracilis (Cyclopoida). The representatives of harpacticides, ostracods, mollusk larvae, worms (polychaetes, nematodes), as well as protozoa (Protozoa) are also common. At the same time, it should be noted that the amount of zooplankton biomass in the pre-strait area was not so high and varied from month to month within 62.4-258.7 mg/m3.

The algal flora of the Black Sea, the Kerch Strait and the pre-strait is characterized by the predominance of diatoms over pyridineas (pyrrophytes or dinoflagellates). The study of the species range, number and biomass of the phytoplankton community during several periods of the year showed that its dynamics is largely dependent on seasonal weather changes (climate). In the process of phytoplankton development, several phases of autogenic succession were revealed. It is expressed in a sequential change in phytoplankton forms, changes in its abundance and biomass typical of the eastern shelf of the Black Sea.

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Based on the abundance and biomass of phytoplankton in the spring-summer and autumn periods in the Kerch Strait waters and the pre-strait of the Black Sea, this area can be considered highly trophic and recommended for industrial cultivation of mussels.

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