

# ОСТРІВ ЗМІЇНИЙ



Екосистема прибережних вод



## Summary

The main part of the monograph contains generalised data on the main characteristics of the Zmiinyi Island coastal waters' ecosystem collected by the researchers of Odessa National I. I. Mechnikov University during the last years. The main attention was paid to assessment of the current state of the coastal biocoenosis and ecosystem's abiotic component. Bacterioplankton, phytoplankton, macrozoobenthos, fish and algae-macrophytes were considered the main links of biocoenosis. Major part of studies of the ecosystem's abiotic compound was focused on the coastal waters hydrological and hydrochemical regime peculiarities, bottom sediments accumulation conditions and the particular properties of sediments.

The ecosystem of the Zmiinyi Island coastal waters is unique for the North-Western Black Sea from the biodiversity viewpoint. Here the hydrobionts can be observed that have disappeared from the Black Sea coastal zone long ago. Such biodiversity concentration area is the source of the North-Western Black Sea flora and fauna gene pool conservation and enrichment under the conditions of further restriction and lifting of anthropogenic pressure for the entire Black Sea zone between the Danube Delta and the Zmiinyi Island.

As the result of the studies the following results are received and conclusions made:

1. Historical materials available on the sources of bottom sediments to the Black Sea shelf adjacent to the Zmiinyi Island and the main sources and ways of sedimentary material inflow are generalised. It is shown that the age of current sediments is about 10 years. The main sources of sediments to the Zmiinyi Island area are: suspended matter brought by the Danube, abrasion fragments of the island coast and biological processes taking place in the coastal waters. Conditions of bottom sediments formation on the coastal shelf are depending on waves, currents and characterized by two combinations of sediments: group of fine-grained fractions (less than 0,25 mm) that are genetically connected with the Danube discharge and concentrate the main portion of organic carbon, and group of coarse-grained fractions where carbonate material prevails and which is genetically connected with marine ecosystem functioning. The results of mineralogical characteristics' studies have shown that the most typical depositions are clayey silts and shall stones. However, sand and

shelly detritus prevail on the underwater elevations and in the coastal zone. According to the results of grain-size analyses the main lithologic types of bottom sediments in the Zmiinyi Island area were classified (shell-stone, fine sands and aleuro-pelitic silts) and the detailed studies done of the average content of particle-size fractions and the degree of their sorting. Comparative analysis of bottom sediments from near the Zmiinyi Island and from the coastal waters near the Danube has shown that the shell stones near the island are more diverse, contain shall stone and detritus and a considerable portion of biogenic material. Sandy and aleuritic fractions are mostly composed of quartz, carbonates and contain feldspars, micas and chalcedony in insignificant quantities. Clayey fractions mainly consist of montmorillonite and kaolin. Studies of the current process of sediments accumulation have shown that fragments of stone and shell stone do not practically stay on the underwater slopes of the island down to 12–15 m and are carried to bigger depths. Sediments accumulation begins at the depths exceeding 15 m. According to the data of experimental observations and analyses the scheme of lithologic types of bottom sediments was built, the analysis of which enabled us to make the main conclusion that current bottom sediments on the Black Sea shelf near the Zmiinyi Island had formed as the result of biogenic and terrigenous sedimentation, at that the biogenic processes prevailed. Composition of bottom sediments has been studied for the first time. The results have shown that with the depth fine sand, aleurite and pelite are mixing with the shell stone material to different extents. Today's bottom sediments on the shelf adjacent to the island are formed as the result of combination of biogenic and terrigenous processes of sediments accumulation. Biogenic processes prevail practically all over the site and there shell stone and detritus shell stone are being formed with different quantities of fine sand, pelite and, more rarely, aleurite material.

2. As the result of hydrological studies of marine coastal waters near the Zmiinyi Island it was revealed that such parameters as sea level, wave conditions, transparency and salinity have seasonal and inter-annual changeability caused by changes of weather (short-term) and of climate (long-term), to which the changes in the Danube river discharge were added. It is shown that water level in the Zmiinyi Island area changes during year from maximal in spring (March-April) to minimal in autumn-winter (October-February) with amplitude of annual variations of 46 cm. Comparison of the results received by the authors with the historical data has shown that the growth of the Black Sea level near the Zmiinyi Island was observed for the last 50–60 years, its speed being about 0,4–0,5 cm per year. The main characteristics of wave

conditions in the Black Sea area adjacent to the island is the fact that in 90 % of cases they were caused by wind. Maxima of such wave characteristics as wave height were observed during cold part of year. Maximal wave heights (about 4 m) were registered on January 20 and July 2, 2006. Transparency of sea water in 2004 – 2007 varied within 1,0 and 9,5 m with maximum in autumn and minimum in summer, which was caused by phytoplankton development and advection of sweetened water from the Danube Delta. At that, abnormal changes of transparency were registered in 2006 when its values from March to June were significantly lower and in July – significantly higher compared to the data of many years' for this region. Temperature regime of the surface sea waters were characterized by vividly expressed seasonal changes with maximum in June – August and minimum in January – March. Absolute maximum of sea water temperature in the area of the Zmiinyi Island for the period of observations was registered on August 4, 2005 and equalled to 28,5 °C, and absolute minimum of 0,92 °C – on February 12, 2006. Comparison of the results received by the authors with historical data for 1950 – 1993 is evidencing the present increase in temperature of surface sea water from 2 °C (2004) to 4 °C (2005-2007), which might testify the influence of global warming on the Black Sea western part. Salinity of the coastal waters near the Zmiinyi Island was characterized by vivid seasonal changes with maximum in October and minimum in April – May. Absolute minimum of salinity for the period of observations 2004-2007 made 10,4 ‰ and was registered on July 20, 2006, while absolute maximum of 19,1 ‰ – on October 22, 2005. Stable growth of 2-3 ‰ in salinity of the surface level of coastal waters was registered in 2004 – 2007, which could result from changes in the Danube River water balance and/or fluctuations in the system of currents in the western part of the Black Sea. Abnormally low levels of sea water salinity were registered in the immediate vicinity of the island (not more than 100 – 150 m far from the island coast) compared to more distant stations of observation, which evidenced the inflow of sweet waters with low mineralization accumulated in the body of the island and its influence on the coastal ecosystem.

3. The results of main hydrochemical characteristics' observations in the coastal waters near the Zmiinyi Island have shown well expressed seasonal changes of pH values and dissolved oxygen content. Distribution of pH values were characterized by maxima in summer-autumn and minima in winter. In general, average monthly pH values coincided with historical data for the North-Western Black Sea, however, last 4 years of observations in the Zmiinyi Island area have shown a slight trend towards decrease in pH values. Observations of oxygen regime in the coastal waters, which in general



was satisfactory, enabled us to register several times oxygen deficiency in the 500 m zone around the island, i.e. in the marine part of the National General Zoological Wildlife Reserve “Island Zmiinyi”, and those oxygen deficiencies were accompanied with mass mortality phenomena confirmed by results of hydrobiological studies. No visible changes in the general picture of oxygen regime of surface waters near the Zmiinyi Island were observed compared to the historical data. No visible seasonal changes were observed in the results of nutrients — compounds of nitrogen and phosphorus — content studies in sea waters near the Zmiinyi Island; however, their concentrations changed throughout the period of observations several orders of magnitude. At that, 3–4 times’ decrease in phosphate average concentrations in the Zmiinyi Island area was observed during the last 20 years. Significant variations of nutrient compounds concentration were mainly connected with advection of sweetened waters from the Danube Delta and local pollution of the water area as the result of human activities on the island.

4. Regular detailed studies of marine biocoenosis near the Zmiinyi Island enabled us to receive unique information on the state of communities of phytoplankton, bacterioplankton, macrozoobenthos and ichthyofauna. Species composition of phytoplankton community in the Zmiinyi Island area was much richer if compared with other coastal areas in the North-Western Black Sea. For the first time over 300 microalgae species of seven divisions were registered: *Bacillariophyceae*, *Dinophyceae*, *Chlorophyceae*, *Cyanophyta* (*Cyanobacteria*), *Cryptophyceae*, *Chrysophyceae*, *Euglenophyceae*. For the first time in the Zmiinyi Island area presence of special group of microalgae was registered — 23 potentially toxic algae that developed annually in the island water area in 2003–2006. No abnormalities were revealed in the seasonal and succession cycles of population characteristics. Chlorophyll “a” content corresponded to “eutrophic” water level in all seasons of studies. Tendency of chlorophyll “a” content threefold growth was revealed in the surface sea waters near the island for the last three years. Average monthly maximum of chlorophyll “a” falls on June-July. Average monthly values changed 3–4 times during a year. It was revealed that maximal concentrations of photosynthetic pigments were connected with marine water salinity near the Zmiinyi Island. The highest concentrations of chlorophyll “a” for the three years of studies were registered in the water area near the Zmiinyi Island in June 2005 — 28,03 mkg/l. It is revealed that at present abundance of bacterioplankton in sea waters near the island is lower than in the first part of the 90<sup>th</sup>. Bacteria special distribution, according to the conclusions of authors, is caused first of all by river discharge and human activities on the island. It is shown that

phytoplankton is the main source of organic matter for bacterioplankton development in the sea waters near the Zmiinyi Island, but the vivid growth in bacteria number within the 100 m coastal zone is also an evidence of influence from human activities on the island. For the first time detailed study of fish species composition was carried out, which was characterised by unique species' biodiversity: 49 fish species of 28 genera. The majority of them (60 %) were demersal (bottom and near-bottom) species. Three fish species enlisted in the Red Data Book of Ukraine (*Hippocampus guttulatus microstephanus* Slastenenko, *Umbrina cirrosa* (Linnaeus), *Huso huso* Linne) and 15 species from the Black Sea Red Data Book were registered in the coastal waters of the island in 2007. 13 fish species registered in the coastal waters of the island were included into the list of rare and threatened species to the Black Sea Biodiversity and Landscapes Conservation Protocol. *Gobius paganellus* Linnaeus was registered in the coastal waters of the island which was the first finding of this species in the North-Western Black Sea and in the Ukrainian waters at all. It was proved that from the viewpoint of fish fauna biodiversity the Zmiinyi Island coastal waters were unique natural complex of the Black Sea. Thus, the task of utmost importance for biodiversity conservation and anthropogenic pressure minimization is to impose restrictions in the zone of at least 1,5 km around the island and to regulate strictly all economic and commercial activities in the buffer zone, at least 5–6 km far from the coast. Three species of the Black Sea dolphins were registered in the coastal waters of the Zmiinyi Island in 2007 (*Delphinus delphis*\*, *Phocoena phocoena*, *Tursiops truncatus*\*). They are enlisted in the list of rare and threatened species of the Black Sea Biodiversity and Landscapes Conservation Protocol. Two of those species, common dolphin and the Black Sea bottle-nosed dolphin are also enlisted in the Red Data Book of Ukraine. For the first time the detailed list of benthic species found in the coastal waters of the Zmiinyi Island was compiled. Altogether 55 macrozoobenthos species were registered. Five of them were rare crab species enlisted in the Red Data Book of Ukraine, seven species — in the Black Sea Red Data Book. For the first time the stock of mussels and predatory species rapana was assessed in the coastal zone of the Zmiinyi Island, which made 5755 and 320 tons respectively. Analysis of the current state of benthos has shown that the sharpest problem is the growth in number of rapana. The total number of rapana in the coastal zone of the island is still growing. Some individual rapanas were registered at the depths down to 2 m. The current state of mussel communities is assessed as very unsatisfactory, that is why it is recommended to bring down the rapana number urgently (at least 50 %). In the coastal waters of the Zmiinyi Island altogether 42 species of algae-macro-

phytes were registered, among them *Cladophora hutchinsiae* — a new species for the algal flora of Ukraine. Annual plants prevail in the species composition (69 %). It is shown that two formerly dominant species *Phyllophora truncate* and *Cystoseira barbata* practically disappeared from the Zmiinyi Island area. Detailed analyses of the state of algae-macrophytes show that the conditions for the development of their phytocoenoses degraded and became unstable.

Thus, we have to point out that the unique marine ecosystem had formed in the coastal waters adjacent to the Zmiinyi Island. It requires protection and much care, first of all imposing of severe restrictions for all economic activities in the coastal waters of the Zmiinyi Island. The following priority steps should be planned and implemented at the national and regional levels to protect and improve the ecosystems under study:

- to establish on the basis of the current General Zoological Wildlife Reserve of national significance a national marine nature park “Island Zmiinyi” that would help to upgrade the conservation status of the protected area and improve the regime of Red Data Book species protection and conservation; to introduce special and stricter rules for protection of this unique piece of Ukrainian nature;

- to reconsider the boundaries of the marine protected area towards its extension. At that, there should be a joint massive of terrestrial and water protected areas, at least 2 km around the island. Reservation regime should be provided for the remaining phyllophora in the area of the Zmiinyi Island and migration of rare fish species in the western part of the sea secured;

- to introduce special rules of living water resources harvesting in the area adjacent to the island, focused on complete prohibition of catching fish and molluscs and regulated harvesting of rapana within the 5 km zone around the island;

- to study and map the areas of phyllophora distribution around the island. To find out the exact location of the Mediterranean endemic species phyllophora, which could be found near the Zmiinyi Island at the depth down to 40 m, and to do this obligatory under optimal temperature conditions of 6–10°C. Depending on the actual state of these unique algae to ground the expediency of permanent prohibited area establishing with respective co-ordinates, where any economic activity would be prohibited;

- to minimise negative anthropogenic influence caused by economic activities on the Zmiinyi Island and in its coastal waters by means of strengthening the controlled restriction of economic development and people stay from the viewpoint of the unique properties of the island and its adjacent shelf protection;

- to activate research activities and improve the integrated monitoring system, first of all towards conservation in general of separate populations of living water resources having commercial value, as well as separate taxa enlisted in the Red Data Book of Ukraine or candidates for enlistment out of endangered and endemic species;

- to formulate special ecological requirements for all the facilities on the island as for minimisation of coastal waters and air pollution as the result of economic activities.

The above measures aimed at the active protection of water environment, which could only be implemented under close co-operation of researchers representing different branches of science, economists and authorities would help to:

- conserve the unique stone site of sea bottom, which is not typical of the north-western part of the sea;

- protect biodiversity of marine flora and fauna, including the rare species enlisted in the Red Data Book of Ukraine and the Black Sea Red Data Book;

- restrict anthropogenic influence on the ecosystem, first of all pollution and uncontrolled harvesting of mussels, fish, crustaceans etc.;

- establish natural testing site for studies and observation of the isolated marine ecosystems' changes;

- implement strictly scientific approach to ecotourism organisation;

- contribute to attraction of foreign grants and international specialists for studies in the unique natural site of the Black Sea.