Geomorphological research as basis for spatial integrated marine ecosystems monitoring

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SUMMARY

Study of geomorphological features of the areas of marine ecosystems monitoring in the coastal waters of Odesa Bay and the Zmiinyi Island in 2016-2017. Data and Methods. Echo-sounding has been performed with sonars «Lowrence LCX-15CT» and «SeaCharter 640cDF». Visual observations done by our divers have been additionally used to compile maps of bottom relief and substrate types. Results. The maps of bottom relief and substrates built based on the echo-sounding and visual observations have been presented and discussed. The results of study have shown that monitoring areas in Odesa Bay (MHBS) and near the Zmiinyi Island (ZMN) have very mosaic bottom relief and substrates spatial distribution. The presented results showed that in the MHBS area stony substrates (stones + shelly ground + silt) prevailed (55.6%). In the ZMN area soft substrates dominated: silt (30.4%), silt + sand (28.5%) and sand + shelly ground + silt (23.5%). Only 5.2% of the ZMN area was covered with stony substrate. Conclusions. The geomorphological studies performed have helped us optimise the network of macrozoobenthos, macrophytobenthos and fish sampling stations and are recommended as a mandatory initial stage of marine monitoring activities planning and programming in coastal zones.

Introduction

In the framework of the Association Agreement with the EU [AA, 2014] Ukraine has undertaken to implement the main provisions of Marine Strategy Framework Directive [MSFD, 2008] by 2020, in accordance with which the main sources of information for managerial decision-making are the results of research and monitoring of marine ecosystems state. It is known that the main drivers of changes in marine ecosystems are the state and changes of abiotic part of the ecosystem, such as natural meteorological conditions, hydrology and hydrochemistry, state of coastal zone and bottom geomorphological characteristics determining the peculiarities of biocoenoses functioning in the studied area. That is why special attention during the MSFD implementation [MSFD, 2008] is paid to such descriptors as D6 (Sea floor integrity) or D7 (Hydrographical conditions), which are determining the criteria and standards of monitoring and assessment of the state of seabed integrity and the impact of bottom substrates relief and structure on benthic communities functioning [COM DEC 2010/477/EU, 2017] and are the basic for national monitoring programmes development [Monitoring, 2012]. It is known [Ivanov & Belokopitov, 2012] that the Black Sea bottom is divided into three main forms – the shelf, the continental slope and the deep-sea trough. The shelf occupies 25 % of the sea area and 1.5 % of water volume (up to isobathic curve 200). The Black Sea north-western shelf (NWBS), whose main part is within the exclusive economic zone of Ukraine, occupies 16 % of the water area (68390 km^2) and 0.7 % of water volume (3555 km^3) within the boundaries from cape Chersonese to cape Caliacra.

In the framework of the EMBLAS Project [EMBLAS-II, 2020] Odesa National I.I. Mechnikov University (ONU) research team developed and implemented in 2016-2017 the National Pilot Monitoring Surveys (NPMS) programme in two areas of the north-western Black Sea part (coastal waters of Odesa bay (MHBS area) and the Zmiinyi Island (ZMN area). At that, geomorphological study of the polygons of integrated marine monitoring in the MHBS and ZMN areas was one of the most important parts of our programme.

Purpose of the work was to study geomorphological features of marine ecosystems monitoring areas in the coastal waters of Odesa Bay and the Zmiinyi Island, which had to be taken into account when studying the bottom biocoenoses.

Data & Methods

The ONU NPMS programme implementation was carried out from April 2016 to June 2017 in 2 areas of the Black Sea (Zmiinyi Island and Odesa Bay), where Odesa National I.I. Mechnikov University had own research stations located in the marine areas experiencing significantly different anthropogenic impact (Fig. 1).

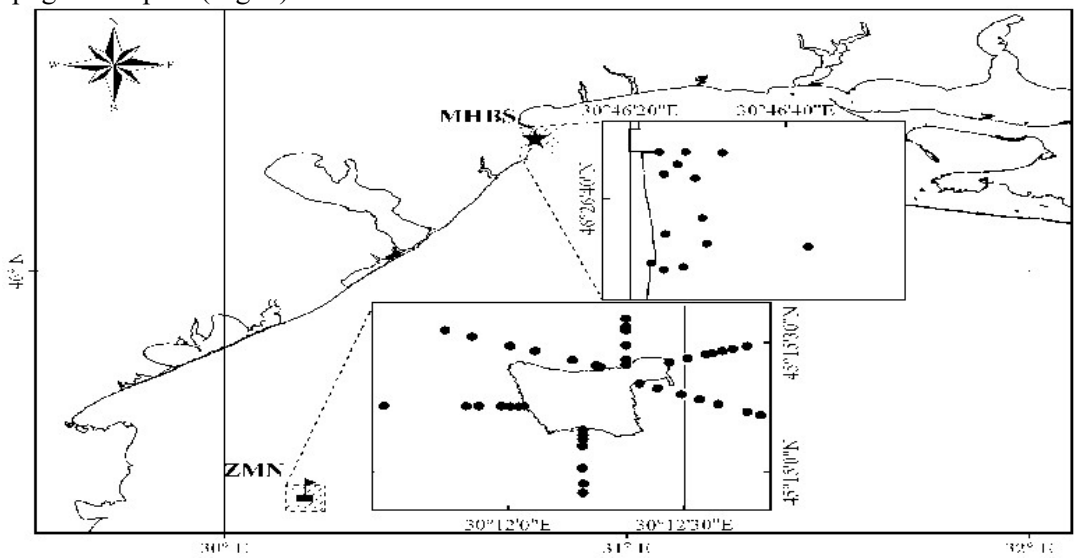

Figure 1 *Monitoring polygons in the Odesa Bay (★ MHBS) and the Zmiinyi Island area (⚑ - ZMN)*

The ONU Pilot Monitoring study sampling and observations sub-programme was fulfilled at both abovementioned sites using national and international sampling and collection methods.
The Pilot studies were performed in special micropolygons in the coastal waters of Odesa Bay with depth from 0 to 12-15 m and the Zmiinyi Island with depth from 0 to 30 m isobaths. The Programme comprised observations and sampling grouped into separate categories: bathymetric surveys and bottom relief mapping; hydrology and standard hydrochemistry; pollution in water, bottom sediments and hydrobionts; hydrobiology etc.
Planning a network of stations for biological characteristics monitoring, we took into account the features of relief and types of bottom substrates, which were assessed based on the maps of relief and substrate types compiled based on echo-sounding survey results (using Lowrence LCX-15CT and SeaCharter 640cDF echo-sounders, accuracy of depth determination - 0.1 m) and visual observations made by our divers. To construct these maps, we used the techniques described in detail in the papers [Gazyetov, 2014; Kozlova et al., 2020; Cherkez et al., 2020].

Results

Based on the echo-sounding results in Odesa Bay and the Zmiinyi Island coastal waters the detailed bathymetric maps of the MHBS and ZMN polygons (Fig. 2, 3) were made. The MHBS area of pilot studies is located in Odesa bay within the zone affected by Odesa city and occupies about 1x1 km of Odesa resort zone. Analysis of bathymetric map of the MHBS area (Fig. 2) showed that the sea bottom relief in the MHBS area was continental slope in the south-eastern direction.

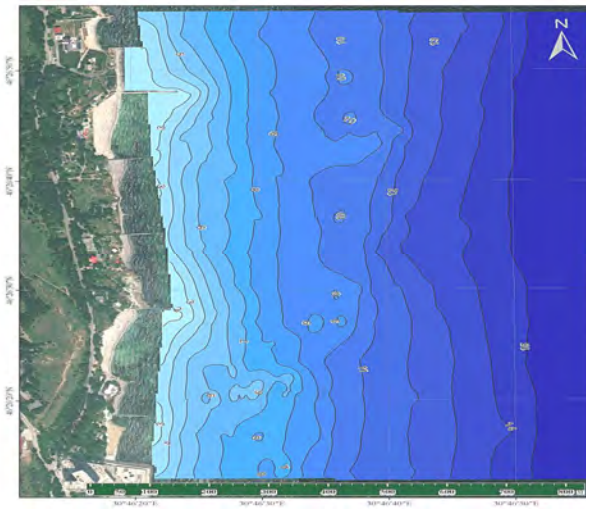

Figure 2 *Bathymetric map of Odesa bay area adjacent to the MHBS*

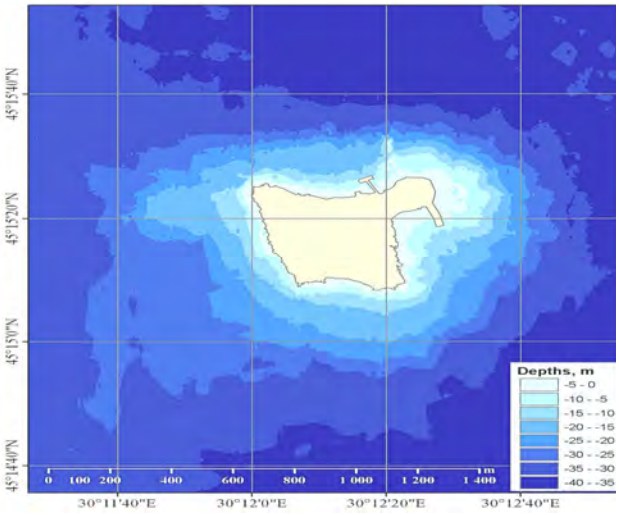

Figure 3 *Bathymetric map of the Zmiinyi Island (ZMN) area*

Bottom relief in the MHBS area is characterized by quite monotonous decline from 0 to 15 m depth with an eastward slope of about 4.3 degrees. Several forms of relief can be distinguished – shelve rocks, which interrupt the monotonous decline. Their origin is probably connected with coastal land-slides. The consequences of the land-slides in the form of elongated tongues can be registered down to 11-meters isobathic line, while below that depth monotonous relief is no more interrupted by anything.
The ZMN area with depths up to 30 m covers 500-m zone of the Black Sea adjacent to the Zmiinyi Island. Analysis of the bathymetric map of the area (Fig. 3), which was done using the results of many years' echo-sounding surveys performed by the ONU (2004-2017), showed that the Black Sea shelf zone relief in the Zmiinyi Island area at the distance of up to 1 km from the island was characterized by sharp depth drop-off in the northern and southern directions and much smoother changing of depth in the eastern and western directions.
The elevation and bottom landscapes maps, which included the results of bathymetry and

observations made by our divers, were used to select the areas for the observation stations in Odesa bay and the Zmiinyi Island coastal waters (Fig. 4, 5).

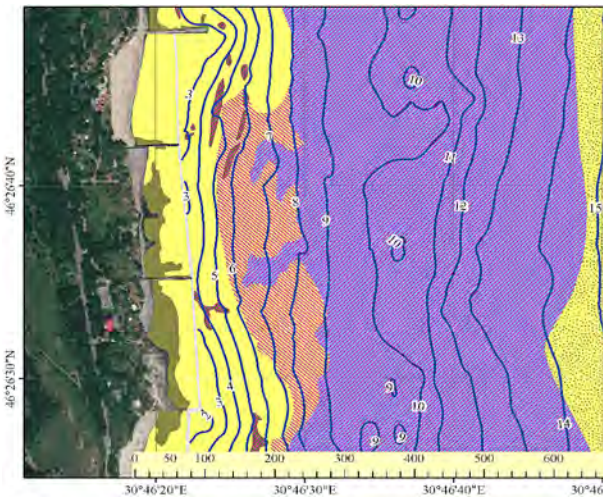

Figure 4 *Elevation and bottom landscapes map of the coastal zone of Odesa bay. Bottom substrate type: - stone substrate; - sand; - shelly ground + stone substrate; -shelly ground + sand + stone substrate; - shelly ground + stone substrate+ silt)*

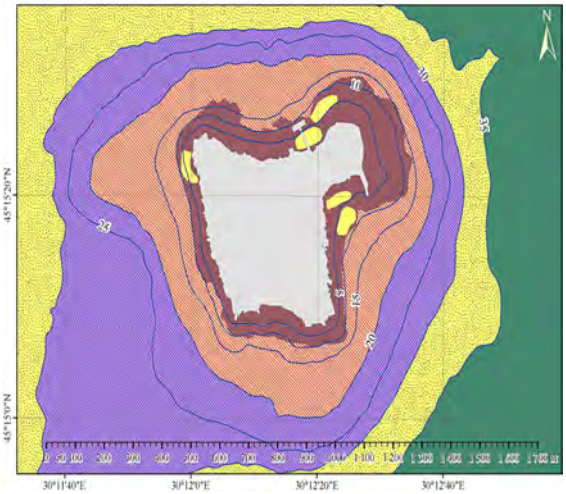

Figure 5 *Bottom elevation and landscapes map of the Zmiinyi Island coastal shelf.*
Bottom substrate type: Stones + shelly ground Sand + shelly ground Sand + shelly ground +silt Sand + silt Silt Sand

The following distribution of substrate types was revealed for the above studied areas (see Table 1). For the purpose of analysis the substrates 'Stones, Stones + shelly ground', 'Stones + shelly ground + sand' and 'Stones + shelly ground + silt' were combined into one type - 'Stony substrate', as the samples in such cases were collected from stones with frame sampler; 'Silt + sand', 'Sand', 'Sand + shelly ground', 'Sand + shelly ground +silt' and 'Silt' were also combined into one category – Soft substrate. In such cases to take samples the frame sampler was pressed into the substrate penetrating down to 5 cm.

Table 1 *Distribution of substrate types on the sea bottom (%) within the 750 m coastal zone in the MHBS area and near the Zmiinyi Island*

	Bottom substrate type		MHBS	ZMN
1	Stony substrate	Stones	2.0	0.0
2		Stones + shelly ground	1.0	5.2
3		Stones + shelly ground + sand	7.3	0.0
4		Stones + shelly ground + silt	55.6	0.0
5	Soft substrate	Silt + sand	16.7	28.5
6		Sand	17.4	0.5
7		Sand + shelly ground	0.0	11.8
8		Sand + shelly ground +silt	0.0	23.5
9		Silt	0.0	30.4

Analysis of the above table showed that in the MHBS area Stones + shelly ground + silt substrate prevailed (55.6 %). In the ZMN area soft substrates dominated: silt (30.4 %), silt + sand (28.5 %) and sand + shelly ground + silt (23.5 %). Only 5.2% of the ZMN area was covered with stony substrate.
The maps (Fig. 4 and 5) were used to find more effective locations for observation and sampling stations for macrozoobenthos, macrophytobenthos and fish surveys in the MHBS and ZMN polygons

for optimisation of monitoring stations network.

Conclusion

The performed geomorphological studies made it possible to optimize the network of stations for sampling and analysis of macrozoobenthos, macrophytobenthos and fish in two monitoring areas and were a mandatory stage of marine monitoring planning and programming activities in the coastal areas. The studied geomorphological features helped us select the types of samplers for each substrate type and assess quantitative and spatial characteristics of macrophytobenthos and macrozoobenthos for typical bottom landscapes and substrates.

Acknowledgements

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