# Tools of Engineering and Environmental Survey of the Territory and Bank Protection Structures (On the Example of the Crimean Coast)

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**Abstract**. The urgency of improving methods of engineering and environmental survey of shore protection objects is determined by their existing disruptions, which violate environmental safety as a whole and create a danger for organization of tourism on the coast. The purpose of the study is to specify method of processing information on ecologically significant regularities of processes on the coast, which should be taken into account in the design of biopositive shore protection structures, based on in situ examination of coastal zones and the state of shore protection structures in the Crimea. During the monitoring, methods of field photo-fixation (in dynamics for 2015-2018), mathematical modeling (in determining the area of coast and beach loss), statistical generalizations (when identifying trends in the state of the coast ecology) are used. As a result, the nature and extent of deformations of the coastal zone of the sea and shore protection structures on the coast of the Kalamita Bay of the Black Sea in the area of the village of Peschanoe are identified. The loss of the coastal zone as a result of violations of reinforced concrete shore protection structures by 70-90%, as well as changes in beach areas (erosion, shortening of width, change in the quality of beach material) are revealed. The modeling of the process in the cliff in the zone of influence of the shore protection structures is performed. Studies have made it possible to assess the degree of influence of the technospheric elements (slope-step wave exclusion design) on the ecological state of the coastal zone and to determine the parameters of the organization of engineering and environmental monitoring in the development and operation of shore protection structures, using software.

## 1. Introduction

The development of approaches to engineering and environmental design of shore protection structures for the territories of the Crimean coast is based on the theoretical positions of the geomorphology of the surface and underwater parts of the coast, hydrophysical regularities of sea parameters in the coastal zone, climatic and seismic conditions (Zenkovich, 1955) (Longinov, 1063), (Makheeva, 1968), (Esin, 1980), (Shyiskii, 1986), and should also take into account the impact of anthropogenic factors on the ecological parameters of the coastal zone (Goryachkin,2016) (Vetrova, 2017) Romanyik, 2015). Regarding to the Crimean peninsula, it should be noted that the coast has a rather diverse geomorphological structure, which is determined by natural factors, and parts of the territories differ in parameters (north-western, western, southern, northeast and southeast coasts). An

important anthropogenic factor is the recreational specialization of territories, which is formed precisely in the coastal zone of the sea and has a significant influence on the transformation of parameters of coastal zones, coastal tract and undersea slopes of the coast (Tlyavlina, 2013), Ydovik, 2014).

Taking into account the existing recreational orientation of the western coast of the Crimea in the Kalamita Bay, the task of the comprehensive study was undertaken in the context of monitoring the ecological state of the coast in the area of the village of Peschanoe on the Kalamita Bay coast. This territory wasn't chosen accidentally, as far as it has recreation facilities, tourist camps, and up to 20-30 meters width of sandy beaches. Initially, the shore was protected by erecting vertical reinforced concrete walls, as well as shore protection structures (buns). The beach was formed by the solid flow of the river Alma and by the 80s of the 20th century, as a result of the construction of the Alminsky and Partizansky reservoirs, the solid flow decreased sharply.

Recreational specialization of the coast required the implementation of a complex of bank protection measures and by 1990 construction of 15 buns was finished. Its length was from 50 to 85 meters, and the distance between buns was from 50 to 500 meters. To consolidate the coastal slope and organize the descent to the beach (elevation difference - 4-5 meters), a reinforced concrete structure was built (a sloping-stepped wave-sweeping embankment (SSWSE). The complex of objects has a shore protection function. In the process of operation of this complex, it is necessary to take measures to keep it in working condition. As a result of a sharp decline in funding SSWSE was destroyed by 2006-2007. In the same years fragments of the destroyed embankment were partially dismantled for 60 meters.

On the embankment site, where fragments of concrete structures were dismantled for a number of years, a pebble beach up to 8 meters wide was formed as a result of the destruction of the cliff. The degradation of the coastal area has been continuing until now (Goryachkin, 2016), (Ryzhii, 2015), (Sapronova, 2013), (Ivanenko, 2016). It has determined the need to monitor the ecological state of the shore of the village of Peschanoye to identify problems of engineering and environmental provision of shore protection.

In 2015, the team of researchers conducted a survey on the program of ecological monitoring of the shore protection structures on the western coast of the Crimean peninsula on the territory of "Volna" recreation complex, Repblic of Crimea (Fig. 1) by using method of photographing, surveying territory with GIS (geographic information system) technologies and designing of diagrams with the help of BIM (building information system) technologies. The result is the following:

- reinforced concrete bunks were preserved in the explored area, although the metal parts of fences and structures were absent due to corrosive destruction;

**Figure 1.** A picture of the embankment area near "Volna" recreation complex, 2015 (obtained using GIS technologies - satellite photography).

- since 2006 the degradation of the beach as a result of along coastal currents has continued. It has led to the erosion of the basis of SSWSE, which is located to the north of the bun zone (the

territory of "Volna" recreation complex and adjacent recreational facilities). It's in emergency state now . There's a threat to people's life and health while staying near these structures;

- on the parts of the shore area, where unstable units of the SSWSE were dismantled, natural beach has being formed from the soils of the eroded coastal slope (a sizeable reduction in the recreational area), promoting the destruction of other constructions and buildings in these areas of the shore.

Project of reconstruction of the shore protection constructions was not implemented due to lack of funding. The processes occurring on coastal area were periodically registered in 2015 - 2017.

In 2018 field observations were carried out again: the width and location of beach stripes, condition of the cliff, shore protection structures and embankment area in the village of Peschanoe were explored.

The following tools of engineering and environmental monitoring were used: method of GIS technologies (for satellite photography of the coast), method of fixing with unmanned aerial vehicles (DJI Phantom 4 PRO) with video equipment (for aerial photography of the shore), BIM technologies (for designing the model of current morphological processes on the shore). Attention was paid to the beach formation process, identified in 2015 as a result of erosion of the cliff by wave load on the shore after dismantling of the destroyed SSWSE elements in the area of "Volna" recreation complex.

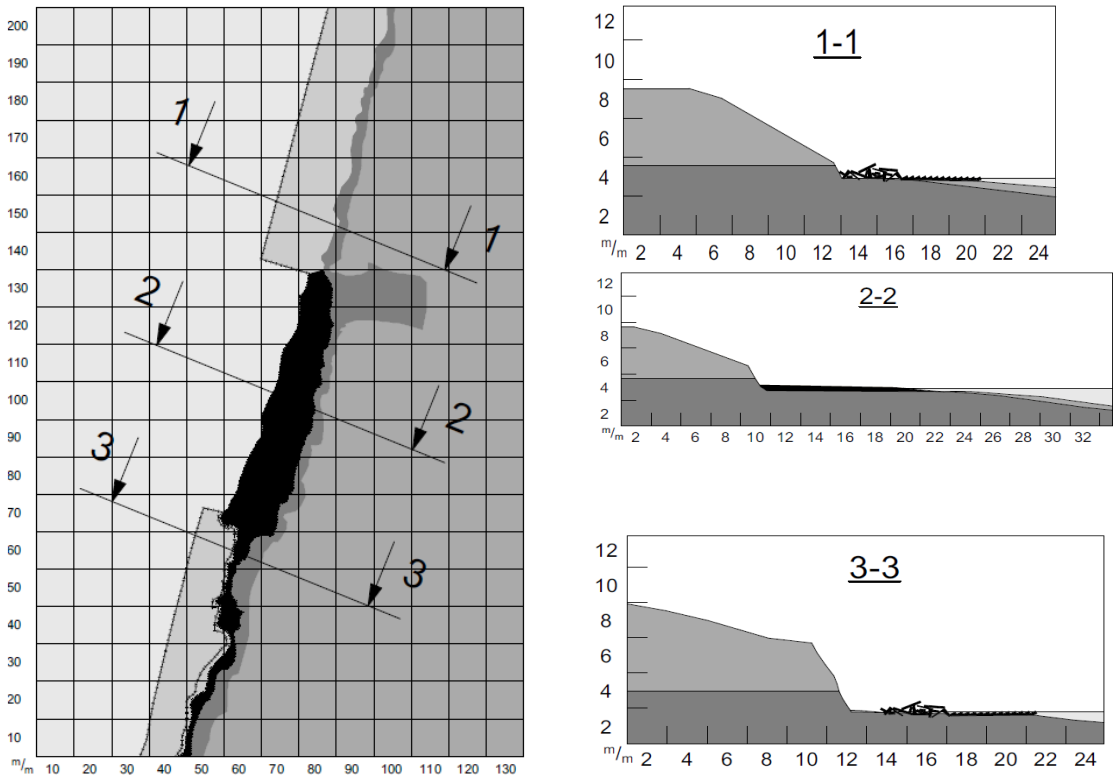


**Figure 2.** Diagram of the coast zone in the area of "Volna" recreation complex. 2015.

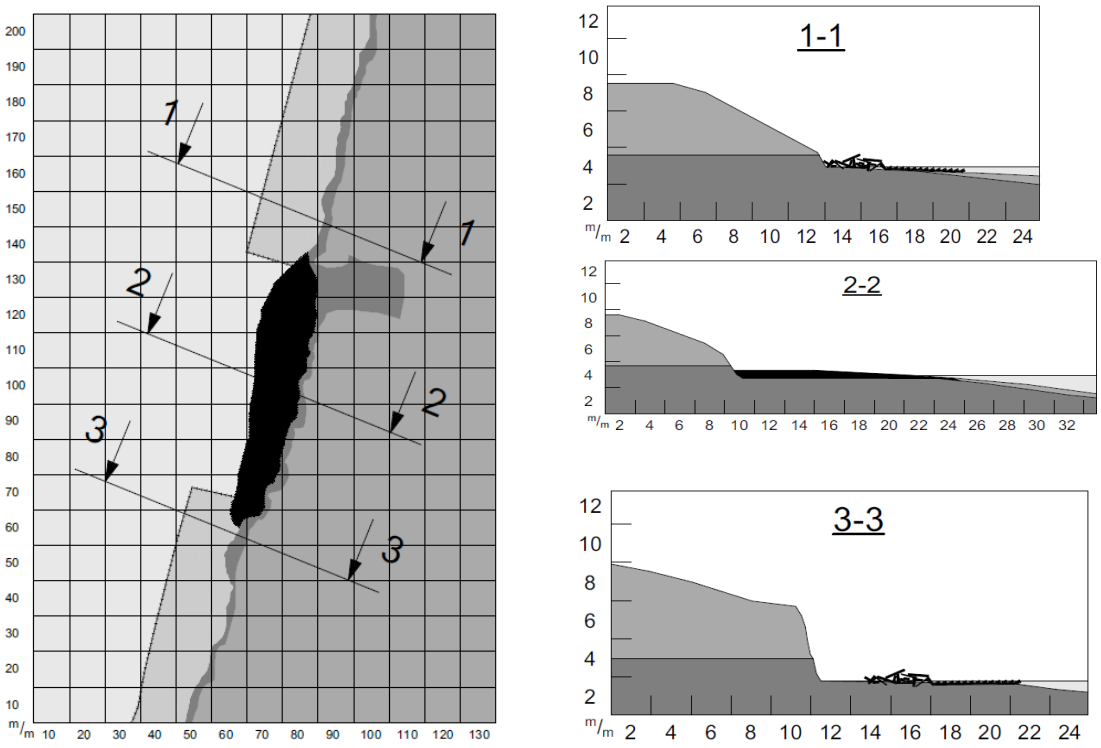


**Figure 3.** Diagram of the coastal zone in the area of "Volna" recreation complex. 2018.

Analysis of data on beach formation processes, condition of SSWSE and shore protection walls, collected in 2015 – 2018 for designing of models, allows to note the following:

- in the area of dismantling of destroyed SSWSE the slope destruction, beach formation and reallocation of the beach material was taking place: in the northern part of the area the width of the beach was increasing, but in the southern part the width of the beach was decreasing ($\Delta S_b$ = -10,3%). Judging by the nature of reallocation of sediment in this area of the beach, it may be resumed that reinforced concrete staircases remained on both sides of the area and have formed a kind of costal buns, which partially stabilized the degradation of the formed beach. However remained SSWSE concrete constructions, adjoining the available area of the beach, have sunk because of washing out of the base, which led to the destruction of the adjacent coastal slope by 0.2-0.4 meters;

- on the area of the beach of "Volna" recreation complex, where destroyed and sunk SSWSE constructions remained, they have formed breakwaters, that have reduced destructive load of waves on the shore cliff. Until 2015 the destruction of the cliff was insignificant. But from 2015 to 2018 washing out and sinking of the base under SSWSE reinforced concrete structures reduced their wave breaking features and, therefore, accelerated destruction of the cliff.

Such a situation of beach erosion in recreational zones has been observed on most part of the western coast of the Crimean peninsula. If it goes on like this we can lose sizeable area of the shore without taking appropriate shore protection engineering-environmental measures, which since 1905, according to experts (Goryachkin, 2015) has reduced by 100 meters now on the entire length of coastline due to the sea incursion.

## 2. Summary

Using of tools (method of GIS technologies, method of fixing with video equipment on unmanned aerial vehicles (DJI Phantom 4 PRO), BIM technologies) in engineering-environmental survey made it possible to create a database on the following processes of changing the ecological state of the Kalamita Bay coast in the Crimea:

- transformation process of beach areas in different parts of the coast;
- transformation process of coastal slopes (erosion velocity, coastal slopes failure);
- changes of coastal area used for recreation in the zone of existing and destroyed shore protection structures.

Obtained data allow to design measures for shore protection, including making biopositive solutions (underwater wave extinguishers, shoreline stabilization using plants, etc.) and confirm the appropriateness of tools, proposed for engineering and environmental survey.

## 3. References

[1] Zenkovich V 1955 Geomorphology of Sea Coasts and Seabed *Moskva, izdatel'stvo MGY* 380 p
[2] Longinov V 1963 Dynamics of the Coastal Zone of the Tidal Seas *Moskva, izdatel'stvo AN SSSR* 379 p
[3] Makheeva T 1968 To the geomorphology and dynamics of the shores of the western Crimea *Sbornik Geologiya poberezh'ya i dna Chernogo i Azovskogo morei v predelakh YSSR* vol **2** pp 160-167
[4] Esin N, Savin M, Zhilyaev A 1980 Abrasion process on the seashore *Leningrad, Gidrometeoizdat* 200 p
[5] Shyiskii Iy 1986 The problems of investigation of sediment balance in the coastal zone of the seas *Leningrad, Gidrometeoizdat* 240 p
[6] Goryachkin Y 2015 Current State of the Crimean Coastal Zone *Sevastopol': EKOSI-Gidrofizika* 252 p
[7] Vetrova N, Mennanov E 2017 Violations of the ecological situation in the coastal zone of the western Crimea *Stroitel'stvo i tekhnogennaya bezopasnost'* vol 59 pp 147-152
[8] Romanyik O 2015 State of the study of the Crimean coast and the task of its restoration *Pyti resheniya problemy sokhraneniya i vosstanovleniya plyazhei Krymskogo polyostrova*, Sevastopol' pp 14-16
[9] Tlyavlina G, Tlyavlin R, Yaroslavcev N 2014 Problems and prospects of construction of bank protection structures and recreational beaches on the Black Sea coast of Crimea *Gidrotekhnika*, no 3 pp 28-39
[10] Ydovik V, Goryachkin Y 2013 Interannual variability of the long-range sediment flow in the coastal zone of the western Crimea *Nauchnaya elektronnaya biblioteka periodicheskikh izdaniy NAN Ukrainy*, Sevastopol' pp 363-368
[11] Goryachkin Y 2016 Crimean Bank Protection: West Coast. Chapter 2 *Gidrotekhnika* **2** pp 38-43
[12] Ryzhii M 2015 Problems of engineering protection of the Crimean coasts and ways of their solutions in modern conditions *Proc. of the Scientific and Practical Conference "Ways to Solve the Problem of Preservation and Restoration of the Crimean Peninsula Beaches*", Sevastopol' pp 13-14
[13] Sapronova Z 2013 Experience in the design and construction of bank protection structures in the Crimea and an assessment of their effectiveness *Building and technogenic security* vol 45 pp 108-114
[14] Ivanenko T, Vetrova N 2013 Complex of ecologically safe technical solutions for the development of coastal recreational areas *Problems of Ecology*, vol 31, no 1, pp 89-97