

UDC 574 (477.75)

## COASTAL MANAGEMENT OF THE BLACK SEA (ON THE EXAMPLE OF THE CRIMEA)

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In the article factors of abrasion processes acceleration are considered, including natural (storms, sea level rise) and human factors (beach sand usage for building purposes, water reserves, decreasing alluvial material accumulation, cutting slopes and others). It is proven that abrasion processes and destruction of the coastal area are very dynamic and not enough investigated, requiring system approach in its research and management. The coast zoning by geomorphology and morphodynamics, vulnerability these zones to abrasion are given. The technics of coastal management in Crimea (beach replenishment, groynes), its effectiveness and its influence on the coastal shores biodiversity are shown. It is offered to conduct further assessment of coast protection constructions influence on the coastal shores ecosystem, have cooperative work of scientists, architects, engineers, government representatives to make and use coastal management constructions with minimal influence on the coastal shores ecosystem according to the sustainable development conception.

*Key words:* the Black Sea, coastal management of Crimea, abrasion of the seacoasts, zoning of the Crimean coasts, biodiversity.

### INTRODUCTION

Sea coasts, coastal zone and located in it natural and man-made landscapes are very sensitive to excessive influences such as abrasion processes. Its protection from destruction always was one of the most important problems in development of sea coastal zones, during the seacoast use in military, industrial, recreational and other purposes. It is even more important problem, considering of Sea level arise and increasing anthropological influences on the natural objects, including the coastal zone. Half of the world population lives in the coastal areas, and the migration from continental zones continues increasing [1]. The intensive recreation and tourism development also strengthen the human influence on the nature of coastal area. As a result there is a conflict between the immediate consumption of the coastal area natural resources and necessity of reservation them for long-time term. That's why protection of coastal area and beaches from destruction and pollution is a very serious and important problem.

The aim of this investigation was to identify the most erosion-vulnerable areas on the Crimean coast of the Black Sea and coastal management techniques influence on the biodiversity of the coastal shores ecosystem, to offer ways of its optimization.

### MATERIAL AND METHODS

To reach the aim of the investigation such methods as literary-analytical method of comparative geography, cartographic method were used.

### RESULTS AND DISCUSSION

**Factors of abrasion processes acceleration.** Waves, generated by storms or fast moving motor craft cause coastal abrasion, which may take the form of long-term losses of sediment and rocks, or merely the temporary redistribution of coastal sediments; erosion in one location may result in accretion nearby [8].

Sea waves can be considered as the main factor of shoreline dynamics, influencing on the creation of geomorphological hazards. They can stimulate all abrasion processes: accelerate the creation of landslides, coastal caves, collapses and land subsidence.

The domination of southwestern, southern, northwestern and northern storms can be notices all around the year, just in summer they aren't so intensive, there are often small waves. The most repeated severe storms are from western and southern directions [7].

Since nineties of XX century, the frequency of storms has been increased. From 1990 till 2005 the amount of days with storms from the most dangerous direction (considering degradation of beaches) increased in 3–4 times, that is the most noticeable during cold season, a little less during warm season [4].

For example, in November 2007 the strong storm caused the 11 shipwrecks, oil pollution in the Kerchenskiy Strait. In October 2010 Alushta and Partenit tourism infrastructure got serious damage and required big finance investment for its reconstruction because of big storm. Small storms can accumulate and later have abrasive action. But only big hazard storms can cause disbalance and big beach destruction. The example of it can be village Privetnoye, which coasts were affected with sea abrasion [5]. That's why we need the complex system approach for investigation and optimal choice of coastal management methods.

The Sea level arise, and tendency of coast lowering, started in the late Holocene, also provides the intensive coast destruction. The average speed of the Black sea level arise is 0,25 sm per year [6].

The human factor is the main factor of abrasion intensification. Building heavy constructions (houses, tourism infrastructure and so on) on the slopes, making roads with cutting slopes, and watering rocks of slope during garden works caused landslides and mudflow. The construction of water reservoirs, regulating river flow, dramatically decreased the provision of accumulative particles for beaches. All these factors, as well as using of beach sand, gravel and sand from bay bottom for construction and building purposes (e. g. Evpatoriya coast) destroyed the natural balance of beach self-reconstruction. For example, the width of Evpatoriya beaches (Solnyshko, New beach, radio navigation station beach and others) for 3 years from 1995 to 1998 decreased on 3–10 m [5].

**Geomorphological and morphodynamic zoning of the Crimean Black Sea coast.** The general length of the Crimean coastline is 720 km, the length of the coast, which has been destroyed or has been influenced by landslides or destructive sea processes (abrasion), is about 520 km.

As you can see from fig. 1 the northwestern part of Crimean peninsula has many abrasive-accumulative coasts; Tarhankutskiy peninsula (on the west of Crimea), consisting of Sarmat limestone, has abrasive coast.

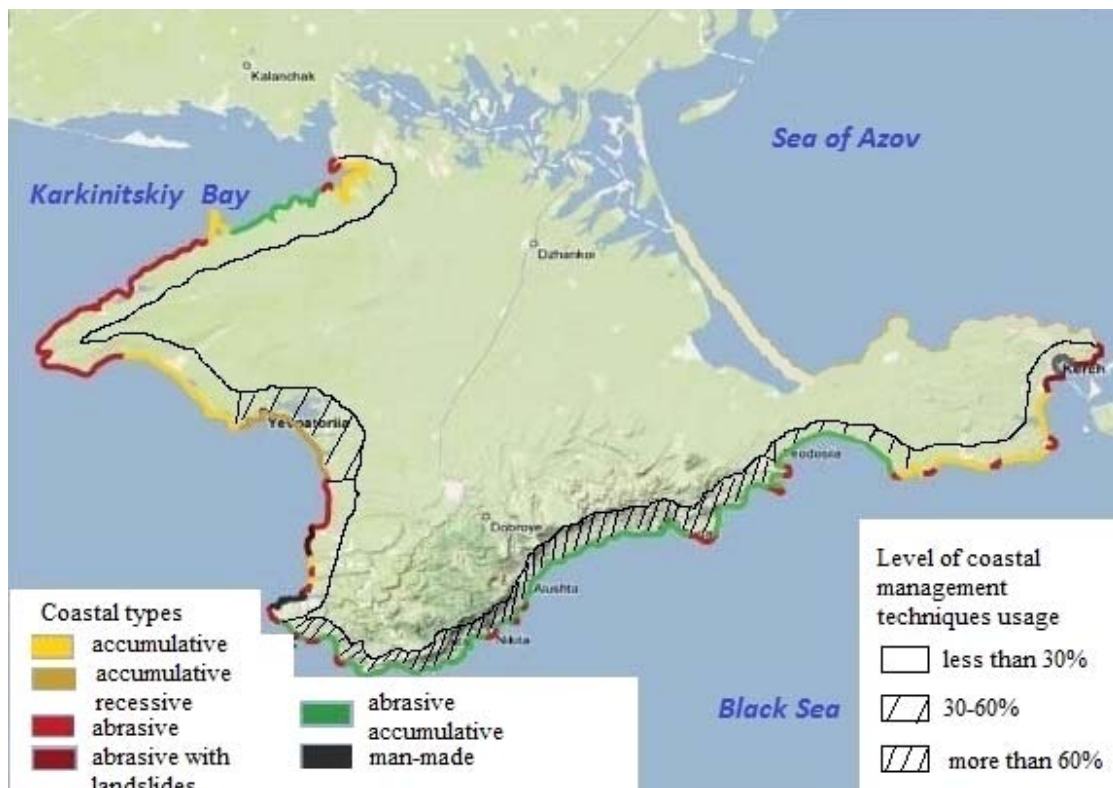


Fig. 1. Genetic types of the seacoasts and the level of coastal management technics usage in the Black sea coast of Crimea

To the east and south from Yevpatoria city, the coastal area is on the lowland. There are several firths (Sasykskoye lake, Saks koye lake, Kizil-Yarskoye lake and others), and to the south there is an abrasive coast.

The coast of Gerakleyskiy peninsula are abrasive-accumulative because of erosion processes. They are the combination of abrasive and accumulative areas of plain coast.

The southern coast of Crimean peninsula spread from Fiolent cape to Feodosiyskiy bay. The special feature of this area is high mountains proximity to the seacoast. All southern coast of Crimea is the combination of rock capes, small half-round gulfs, where there are pebble and gravel beaches. In this area abrasion and denudation dominate.

The coasts of Feodosiyskiy bay are abrasive almost everywhere. Plain coasts of Kerchenskiy peninsula (without river network) are the combination of big gulfs (accumulative areas) and rock capes (cape Takyl, Ak-Burun) [4].

The Black sea coasts can be divided into 3 main morphodynamic categories (Panin and Kosyan, 1996):

- Low accumulative coasts (for example, Karkinitskiy bay). They consist of complex sandy barrier beaches with strong longshore sediment drift systems. These coasts are the most influenced by global changes, specifically by sea level fluctuations and changes in the river sediment inputs due to anthropogenic activities. A decrease in sediment supply into the coastal zone and arise in the sea level could, under certain conditions, result in an active and almost continuous retreat of the beach line.

- Erosive coasts within low-standing plateau plains, with active cliffs (may be affected by erosion, but rates of coastline retreat are smaller (only 1–2 m per year).

- Mountainous coasts with cliffs, marine terraces, landslides, sometimes with sandy or gravely beaches. This category is the least affected by the erosion processes as the littoral of this type consisted of consolidated rocks, which are difficult to erode (e. g. the Southern coast of Crimea) [11].

**Ways of coastal management in Crimea, its effectiveness and influence on biodiversity of the coastal shores ecosystem.** Maintenance of those structures or soft techniques can arrive at a critical point (economically or environmental) to change adopted strategy.

- Structural or hard engineering techniques, i. e. using permanent concrete and rock constructions to “fix” the coastline and protect the assets locate behind. These techniques seawalls, groynes, detached breakwaters, and revetments – represent a significant share of protected shoreline in Europe (more than 70 %).

- Soft engineering techniques (e. g. sand nourishments), building with natural processes and relying on natural elements such as sands, dunes and vegetation, are used to prevent erosive forces from reaching the backshore. These techniques include beach nourishment and sand dune stabilization [9].

Coastal beach protection and landslides activation solutions requires high financial outcomes, sometimes many times exceeding the cost of defended objects.

At the foot of the Crimean Mountains Main ridge on the southern coast, almost everywhere resort sanatoriums were built. The destruction of the beach is one of the reasons of the landslides activation and hence the destruction of buildings, roads, power lines, water pipelines, damage to orchards and vineyards. That’s why coastal management is a very important.

In different regions of Crimea the level of coastal management technologies usage varies. On the South coast it is close to optimal, in Sevastopol and Kerch coast – only 6 %, on the southeastern coast is about 30 %. On the extreme western and the northwestern coast, because of the low resort development, it does not yet require protective engineering techniques [3].

In Crimea soft as well as hard engineering techniques are used.

On the place of narrow stripe of the coastal chaos now there are well-equipped gravel-pebble beaches, divided with cross bun breakwaters made of reinforced concrete. But there is another way of shore protection. It is the method of beach replenishment. For the first time in Crimea it was used in Koktebel Bay on the south-east of Crimea. The main feature of the project is its efficiency and the consideration of natural laws. Artificial three-kilometer beach combined with concrete promenade, which in this case is not only a place for walking, but also bearing landslide; it does not give the sea to intensify

its downward movement and keeps its buildings and communications stable. The beach, in its turn, decreases the energy of the waves.

It was discovered that in Koktebel bay sea moves sediment along the coast. Therefore, finely crushed stone material was unloaded into the sea in one place, and, being moved, it gradually distributed throughout a three-kilometer stripe, while the stones became more round, forming a beach.

But in total all these coastal management technics are used locally, not systematically, just partly resolving the problem of abrasion.

In Crimea groynes are also popular method for protecting the shore from erosion. However, their construction can cause an environmental problem. If during its construction rocks are destroyed, mussels and oysters have nowhere to escape from *Rapana venosa*, marine biocenosis can be destroyed, rapidly deteriorating environmental situation in the semi-enclosed space between the groynes. Here mostly one green algae species settle, being broken by waves from smooth concrete during big storms. Rotting algae causes the oxygen contain decrease in the upper layers of water and the mass destruction of plankton – the so-called secondary pollution [3]. In addition to that, the groynes can be a barrier to fish migration in coastal zones. Groynes also created stagnant zones in the sea between traverse and breakwaters where sand became silted, and the bottom biocenosis changed. The natural rocks (shell limestone) on the bottom became covered with a layer of sand and the new built concrete structures became new substrates for the attached organisms. In each case the changes in the biota were far from positive [12].

Most of the time the sand brought to the beaches proved to be of a different composition (more fine-grained) than the original, which produced a significant deterioration in the living conditions of interstitial fauna. Some previously abundant organisms disappeared from the overwash zone [11].

Ports ships, the transportation of goods and passengers in the sea cause the biological and environmental problems in the sea. An example would be Sevastopol, Kerch, Yalta ports, where it changed the biocenosis due to the intense maritime traffic.

So, we need to have integrated coastal management approach, learning from another countries experience and have common strategy for all coasts of Crimean Black sea [10].

## CONCLUSIONS

Consequences of human influence on the coastal area ecosystems can be reduced by following ways:

1. Coastal area of the Black sea in Crimea has got the intensive development of the abrasion processes, that leads to the destruction of accumulative beaches and coastal benches. These processes are very dynamic.

2. The processes of coastal line change and abrasion in this region is not enough investigated, there is no a system approach of its research.

3. The abrasion processes caused negative consequences such as destruction of buildings and recreational objects, decrease of beach width and, as a result, less attractiveness of Crimean sea resorts for tourists, big investments in protection of coastal areas from abrasion.

4. The coastal management should be aimed at:

- Reducing the sediment load of rivers in the coastal area, it is necessary to add the supply of sediment by artificial filling, and choose clastic material, for example: a) from those places where stocks have accumulated as a result of previous human intervention in natural processes (from reservoirs, where the sediment discharge of the upstream was deposited, from the dump pits, enrichment factories and other objects of a mining and processing enterprises); b) places where accumulative sediments have accumulated as a result of natural processes and where their removal should not significantly affect the nature balance. For example, the following activities can be done: 1) periodically move macro-grained rock and boulder material from the upper zone of the beaches (where this material is aesthetician and represents a considerable danger to the people with the possibility of serious injury such as bruises and fractures) to vulnerable zone at a depth of about 1,5–2 m and deeper, where this material will have protection functions and because of gradual fragmentation due to abrasion, it will replenish recreation beach area with pebbles, gravel, sand; 2) periodically move macro-grained rock material of his accumulations in the mountains, where it can't be naturally removed (by slope-gravity, fluvial and other

processes), to the range of water streams and turn into the sediment (for example, from the foot of the steep rock, where its removal will not disturb the stability of slopes and, in addition, will help growing the forest at the lifeless before place of stone rubble).

- If necessary, mining of debris beach-creating materials (for artificial replenishment of the beaches), pits for its production should be placed with consideration of local conditions, in particular: 1) in remote areas from recreation zones; 2) not on the mountain slopes and valleys (where the removal of rocks may impair the strength and stability of adjacent slopes), and, if possible, in uplands places and in closed depressions (to less influence on the regime of the surface and ground water). It is sensible to arrange the ponds and lakes for recreation, fish farming and retention on the place of formed pits recesses. When conducting blasting operations in quarries, it's necessary to limit the capacity of explosives charges to an acceptable level of risk. To save biodiversity of coastal area, when it's planned to replenish beaches, it's important to check the new beach particle to have the same properties and characteristics as the original beach particles.

- Considering the unique importance of the Crimean coast, it may be aesthetically and sometimes financially appropriate activities such as equipment of coastal management engineering constructions, artistic draping and decoration of coast protection constructions, which allows to hide the unattractive protection structures and to reduce their danger to humans [2].

- Creation of groynes from another material that will not be attractive for green algae, attached species but at the same time will be strong enough to defend from abrasion for a long time.

- Port zones should not be increased anymore. In nearby areas there should be limited fishing and other anthropogenic interruptions into coastal shores ecosystem.

- Sand particles for beaches should be checked for reconcilability with the original beach, should have similar properties for easy adaptation of coastal flora and fauna.

- It's necessary to conduct further assessment of coast protection constructions influence on the coastal shores ecosystem, have cooperative work of scientists, architects, engineers, government representatives to make and use coastal management constructions with minimal influence on the coastal shores ecosystem (e. g. creation of new design of biologically positive hydro technical constructions) according to the sustainable development conception. It is also important to apply the integral coastal management system, successful experience of the coastal management in other countries consistently and constantly, avoiding mistakes and failure, that have already happened in the history of coastal management.

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**Котолупова Ю. П. Менеджмент берегової зони Чорного моря (на прикладі Криму) // Екосистеми, їх оптимізація та охорона. Сімферополь: ТНУ, 2014. Вип. 11. С. 76–81.**

У статті були досліджені фактори посилення абразійних процесів, в тому числі природні (шторми, підняття рівня моря) і людські фактори (використання пляжного піску для будівельних цілей, будівництво водосховищ, що зменшують накопичення алювіальних матеріалу, підрізка схилів та інші). Доведено, що процеси абразії і руйнування прибережної зони дуже динамічні і не досить досліджені, вимагають системного підходу в їх дослідженні та управлінні. Було дано районування узбережжя по геоморфології та морфодинаміке, схильність цих зон абразії. Були показані методи управління прибережними зонами в Криму (відновлення пляжу, будівництво бун), їх ефективність та вплив на біорізноманіття прибережних зон. Було запропоновано проводити подальше оцінювання впливу методів берегового менеджменту на стан екосистеми прибережної зони, що представляє собою спільну роботу вчених, архітекторів, інженерів, представників уряду щодо створення і використання конструкцій берегового менеджменту з мінімальним впливом на екосистему прибережної зони відповідно до концепції сталого розвитку.

*Ключові слова:* Чорне море, прибережний менеджмент Криму, абразія морських берегів, зонування кримських берегів, біорізноманіття.

**Котолупова Ю. П. Менеджмент береговой зоны Черного моря (на примере Крыма) // Экосистемы, их оптимизация и охрана. Симферополь: ТНУ, 2014. Вип. 11. С. 76–81.**

В статье были исследованы факторы усиления абразионных процессов, в том числе естественные (штормы, поднятие уровня моря) и человеческие факторы (использование пляжного песка для строительных целей, строительство водохранилищ, уменьшающие накопление алювиальных материала, подрезка склонов и другие). Доказано, что процессы абразии и разрушение прибрежной зоны очень динамичны и не достаточно исследованы, требуют системного подхода в их исследовании и управлении. Было дано районирование побережья по геоморфологии и морфодинамике, подверженность этих зон абразии. Были показаны методы управления прибрежными зонами в Крыму (восстановление пляжа, строительство бун), их эффективность и влияние на биоразнообразие прибрежных зон. Было предложено проводить дальнейшее оценивание влияния методов берегового менеджмента на состояние экосистемы прибрежной зоны, представляющую собой совместную работу ученых, архитекторов, инженеров, представителей правительства по созданию и использованию конструкций берегового менеджмента с минимальным влиянием на экосистему прибрежной зоны в соответствии с концепцией устойчивого развития.

*Ключевые слова:* Черное море, прибрежный менеджмент Крыма, абразия морских берегов, районирование крымских берегов, биоразнообразие.

*Поступила в редакцию 18.04.2014 г.*