ENVIRONMENTAL AND ECONOMIC ASPECTS OF COASTAL STUDIES ON THE BLACK SEA

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ABSTRACT

SHUISKY Y. D. Environmental and Economic Aspects of Coastal Studies on the Black Sea.

An analysis of extensive and diverse information on the Black Sea environmental condition within Ukraine suggestes the priority of the three main problems in the use of coastal resources: 1. Shore abrasion and shoreline retreat. 2. Sea pollusion.3. Possible negative impact of the "greenhouse effect" on he coasts in the nearest 100 years. each of these problems is analysed with numerical data on the development of natural coastal systems, and possible negative consequences are estimated in their economic aspect.

Key words: Ukraine,Black Sea, coastal zone, abrasion, sea water, pollusion, level rise, greenhouse effect, economy.

1. INTRODUCTION

The total length of the Black Sea shores is 4,431 km and includes coastal areas of the Ukraine, Russia, Georgia, Turkey, Bulgaria,and Rumania. 2,112 km of these shores, or 47.7% of their total length, are built of active cliffs subjected to abrasion of different rates. Besides, more than 50% of the length of accumulative shores experience shoreline retreat. Destructive phenomena are widely observed today even along the marine margin of large river deltas such as the Danube, the Kizyl-ı Irmak, or the Eshyl- Irmak.

The wide scales of the destructive phenomena are mostly caused by considerable drifts deficit in the shore zone. This is particularly evident along the Ukrainian coast where it endangers ports, recreational and residential facilities, and leads to losses of nearshore land (9).

Previously, the qualities of nearshore water were favourable for high biological productivity of benthos, plankton, and necton. Nearshore water had a high level of self-cleaning, and this was raising the recreational quality of the Black Sea coasts. Numerous recreational centres, holiday homes, motels, and individual summer houses

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have been built there not only by Ukraine, but by other countries as well. Presently, the quality of nearshore water has been largely deteriorated by the growth of pollusion.

Water pollusion develops simultaneously with atmospheric pollusion. Ukraine, like all other countries in the Black Sea basin, contributes its share to the changes of the atmospheric air composition and the global climatic changes on the planet. The growing concentration of the "greenhouse gases" (chiefly, carbon dioxide) is reported to enhance changes in the Global Ocean water balance (1).As a result, the new supplies of water into the Global Ocean cause a very quick rise of the sea level. Different calculation techniques allow to predict a possible rise of the sea level by 0.5 to 6.0 m over the next 100 years. As the coastal relief of the Black Sea is predominantly flat, this means that the economic, cultural, and natural rescurces on the coast in Ukraine and other countries are in danger.

Thus, the countries of the Black Sea basin are confronted with three environmental and economic problems of major importance:1) shore abrasion and shoreline retreat; 2) water pollusion near shores and in the open sea; 3) possible negative impact of the "greenhouse effect" on shores in the nearest 100 years.

2. SHORE ABRASION AND SHORELINE RETREAT

The negative impact of shore abrasion is mostly illustrated here with examples from Ukrainian Black Sea coast. This coast is inhabited by approximatel 20% of the country's population. A number of important cities (such as Odessa with 1.2 million residents, Illichevsk with 70 thousand residents, Nickolayev with 550 thousand residents, Evpatoria with 150 thousand residents, and others) and industries are located there. Many of these cities-Odessa, Yuzhni, Ochakov, Skadovsk, Yalta, Feodosia, and others- have seaport facilities (Fig.1). Important railroads and highways stretch along the coasts. About 10% of the shorelines are protected with hydrotechnical constructions.

About 25% of the shore length is occupied by recreational facilitlies which are used by nearly 20 million people each year. In addition to sea water and air, the resources used for recreation and healthcare are mineral water, medicinal mud from the limans' bottom, sea baths and a wide selection of vegetables and fruits. Hundreds of holiday homes, motels, and healthcare centres (sanatoriums) have been built in four main areas on the coast (Fig.1). Many of them are threatened with abrasive-landslide processes, particularly near Illichevsk, Yuzhni, Ochakov, Yalta, and Kerch.

Shore abrasion leads to losses of valuable nearshore land. The basic land resource here is chernozem as the most fertile soil in the world.

This list of problems shows the economic significance of environmental aspect in coastal studies on the Black Sea.

Ukraine's territory is washed by the Black Sea from the Danube delta in the west to the Kerch Srait in the east (Fig. 1). The shoreline is 1,628 km long. Out of these, 486 km(29.9%) is occupied by active cliffs, 589 km(39.1%) are represented by retreating shorelines of accumulative forms, and553 km (34.0%) belong to stable abrasive and stable accretive accumulative forms(6).

The biggest environmental interest is attracted by retreating and abrasive shores. They make up 1,075 km, or 69% of all Ukraine's Black Sea shores. The rates of abrasion vary a lot and depend on the coast's geological structure, the shore zone energy potential, the nearshore bottom inclination, the shoreline contour, the amount of drifts, and the type of active cliffs. Abrasion rates may vary from a few millimetres to 6 metres per year, as shown by direct field measurements over the several recent decades. Thus, for instance, repeated surveys of cliffs showed the average abrasion rate of clayey cliff of 3.1 m/year near Cape Burnas over 1967-1992, of 1.2 m/ year near Cape Sanzheiski over 1953-1992, of 2.86 m/year at the proximal side of the Tendra spit between 1968 and1991, of 2.14 m/year in the Kalamit Bay over 1965-1991, and of 1.32 m/year near Cape Chauda in the Feodosia Bay in 1951-1991.

Drifts deficit in the shore zone of the Black Sea has caused the retreat of shorelines on most of the accumulative forms (spits, barriers, terraces). Accreting shorelines make up about 5% of the length of Ukraine's shores. Average retreat rates and the character of deformations over the recent 100 years have been studied on such spits as Zhebrinskaya, Lagernaya, Kinburnu, Tendra, and Bakal which are the biggest on the Black Sea. A suitable example of this kind is the barrier of a small lake, theUstrichnoye Feg.1) on the proximal side of the Jarylgach spit. One can see (Fig.2) that the average retreat rate for the recent 40 years has been 1.62 m/year. The highest rates of retreat were found along the sandy terrace of Shagany(2.95 m/year). on the flanks of the Donuzlav Lake barrier(0.64 m/year), and on the Tobechik liman barrier(1.87 m/year).

Abrasion leads to the losses of significant coastal territories. A map of shoreline retreat has been plotted where one stationary section of observation characterizes a five kilometre stretch of the shore. The results have shown that an average of 24 hectares per year is taken up by the sea between the Danube delta and the Crimean Peninsula, Plus another 22 hectares per year on the shores of the Crimea. The coast of the Sea of Azov is 824 km long within Ukraine, and 484 km(58.8%) of it is eroded by waves. This causses losses of an overage of 19 hectares a year of coastal land(8). Thus,all in all, Ukraine loses 65 hectares of its land a year on account of marine wave abrasion. This is an average figure for a period of many years, and may vary from only a few hectares in some years to 2-4 times the average in some others.

The losses of land, naturally, ruin various economic objects listed above. The economic damage amounts to approximately 180 million US dollars a year, at price rates of 1992.

To prevent the material, financial, moral and other damage, various methods of shore conservation are employed. There are more efficient methods used in some parts of Ukraininan shores, than those employed in Western Europe and North America(2). the choice of the specific method of shore defence is based on the regional principle (7,9).

Thus, for example, the territory of Odessa has long suffered from coastal landslides and lost a stretch about 300 meters wide along its shore between 1974 and 1955. In 1959 basic coast protective work was started: the smoothing of landslide slopes, the drainage of underground water, and the building of wave breaking hydrotechnical constructions and artificial beaches(Fig. 3). Currently, the protective installations cover 12 km of the shore which has been stabilized and recreationally developed. The artifical beaches can receive 450,000 holiday- makers at a time, which had a positive effect on the city's economic activities. Such protective constructions have been built on more than 100 km of Ukraine's shorelines, all in all (Fil. 1). Using artifical beaches is considered to be of particular importance(7). Environmental and economic feasibility studies for nearshore territory management and shore-protective constructions building are carried out on the basis of the principles proposed in our investigations. The investigations have also allowed to elaborate reliable techniques of shore protection with the help of natural materials, artificial beaches, ground terraces, spread breakwaters, and artificial landscapes.

3. SEA WATER POLLUSION

It is possible to distinguish two groups of polluters within Ukraine: direct and indirect.

Direct polluters are those objects on the sea shore which dispose of their sewage right into the sea. This includes flows of industrial waste and domestic sewers of cities and villages; soil and other substances eroded from fields; waste dumping from ships; etc. There are several focal points of dirrect pollusion(Fig. 1). The major of them are around Odessa, Ochakov, the top of the Karkinit Bay , Eupatoria, the southern coast of the Crimea, and Kerch. Together, they account for about 80% of all direct pollusion.

Thus, for instance, the total amount of polluded flow from industrial and domestic sewage in Odessa is 132 million cubic meters per year. Besides this, the sea is polluded each year with 8,750 tons of dry waste, 410 tons of oil products, about 70 tons of active substances from surface, 5800 tons of iron, and 430 tons of phosphorus. The index of absorbed oxygen in sea water, which directly depends on the sources of pollusion, exceeds the sanitary norm by 20% for sea bathing and 60 times for medicinal use of sea water in sanatoriums and recreational swimming pools.

A similer situation is observed in Ochakov. Anthropogenous flows into the sea there make up about 8,200 thousand cubic meters per year. Out of these, 7,300 thousand (89%) are only half-cleaned. An average pH value for the sea water is 7.7-7.8; the proportion of chlorides is 2,300-9,600 mg/litre; of sulphates, 300-1000 mg/litre; of ammoniac nitrogen, 0.16-1.05 mg/litre; of copper, 0.02-0.08 mg /litre. In the places where polluders are discharged, unusual smells of the sea water exceed 4 points of intensity in calm weather. The same thing is also observed around Evpatoria, Sevastopol, Feodosia, and Kerch.

The indirect polluders are mostly rivers, primarily the Danube. Most of the rivers flow into limans (nearshore lakes). To a certain extent,this slackens sea pollusion. Polluded water of the rivers is accumulated in reservoirs which are sometimes hundreads of kilometers away from the sea. Since the assimilation capacity of the river water in the Dniester, the Southern Bug,the Dnieper and other major rivers has already reached its utmost, polluders are going throught the rivers quite freely. For instance, in the steppe and wooden steppe zones of Ukraine, asignificant proportion of fertilizers applied to the soil is washed off into small rivers: 15-25% of all the nitrogen, 2-9% of the phosphorus, and 10-15%of the pesticides. The discharge of fertilizers has grown in the recent years due to the natural cyclic growth of the water flow in small rivers. While this flow was reducing in the cycle of 1945-1965 compared to the previous cycle of 1921-1945, it has grown 2 or 3 times in the current cycle of 1965-1990 in such river basins as the Southern Bug, the Kodyma, the Siniukha, the Zgara, or the Ingul. This indirect influence raises the pollusion level of the sea and cuts down the assimilative capacity of the sea water.

Another way of indirect pollusion is through atmospheric air. It takes place as the atmosphere interacts with the sea, and also when submarine waters are delivered to the sea. The most conspicous in this respect are major industrial centers: Odessa, Nikolay, Krasnoperekopsk, Saky, Sevastopol, or Kerch. For instance, the industrial enterprises of Armiansk and Krasnoperekopsk supply various substances into the air at the top of the Karkinit Bay. Air tests showed the presence of 1-13% of toxic dust, 1-3% of carbon dioxide, 12-26% of nitrogen dioxide, 17-24% of muriatic acid, about 3% of sulphuric acid, 4-30% of fluoric hydrogen, and 4-18% of ammonia.

This unfavorable situation is caused by several reasons, the most important of them being imperfect manufacturing technology and absence of reliable cleaning devices. This is why the water coming into the sea between the Danube and the Crimea may be divided into three categiries:1) polluded and insufficiently cleaned-13%; 2) cleaned mechanically, physically, chemically, and biologically-17%; 3) conventionally clean and without cleaning-70%.

As a result, the level of pollusion of nearshore water is highly unfavorable for recreation use. The peaks of pollusion occur during summer bathing season, in periods of calm weather, in conditions of stable thermocline, especially in shallow and half-closed bays, near bigindustrial centers.It is not unusual, therefore, that beaches are closed for considerable time.

4. POSSİBLE NEGATIVE İMPACT OF THE "GREENHOUSE EFFECT" ON THE SHORES

The issue of global change, including sea level rise, is in the forefront of the international scientific community. The International Council of Scientific Unions (ICSU) is stressing the International Geosphere Biosphere Program, UNESCO has its Environmental

Program which is incorporating aspects of changes, and there is the recently enacted International Panel on Climatic Change (IPCC) of the United Nations. The U.S Environmental Protection Agency advises to pay attention to the three groups of possible changes: natural, economic, and cultural(5). The International Ecologic Congeress in Rio de Jeneiro(June, 1992) acknowledged this problem as a major priority for the world community.

This phenomenon is due to the fact that the humanity is gradually setting in motion a global warming mechanism caused by the concentration of some gases in the atmosphere: carbon dioxide, methane, nitrogen protoxide, carbon tetrachloride, and others (Fig.4). If the current trends continue, our planet is likely to warm 3 to 5 C in the next century- as much as it has warmed up since the last ice age. This warming up will cause a restructuring of the global Ocean's water balance and increase the amount of water in the Ocean, which can raise its level by a meter or more (1,5,11).

Such an elevation by the end of the 21st century(up to 6m, according to some prodictions) is considered catastrophic, if we take into account that the Black Sea level on the shores has only risen by 0.3 m(up to 1.0 m in some places) over the recent 200 years. This is threatening some low shore lands which only stand 1-2 m above the average Black Sea level. Since the shores are of different types (by their relief, geological composition, drifts supplies, the values and signs of the coastal forms' deformatios, etc.), their response to to a possible catastrophic sea level rise will be different, too (8,11).

Sea level changes over many years are observed at different shore points of Ukraine. All in all, they are27, i.e.one pointcharacterizes about 60 km of the shore length. An analysis of the observation data allows to get an idea of the level changes in different parts of the shoreline. The resulting level change consists of the eustatic component E and the tectonic component T. 16 combinations of these components have been found, in which they are characterised by different signs and rates(8). In most parts of Ukraine, eustatic rise is combined with tectonic subsidence of nearshore land. The result is a relative uplift of the sea level with different rates. The permanent observations data was processed on the basis of monthly average, minimum,amc maximum values at each of the 27 points. The monthly values were used to calculate the annual values for each point. In particular, the observations have been carried on since 1870 at "Odessa" point, since 1878 at "Tarkhankut" point, since 1882 at "Kerch" point, and since 1945 at "Bugaz" point.

As an example, let us look at the data obtained at "Bugaz" point located on Dniestrovsky liman barrier (Fig.1, 5). For maximum levels, the average rate of the rise is 5.44 mm/year(Fig. 5,1).

This is a pretty high value comparable to high rates observed on the US coasts, in Italy, Egypt, and China(1, 10). The tendency towards relative increase of the rise rate was also observed on the average monthly values and was calculated to be 7.31 mm/ year. The correlation of curves 1 and 2 in Fig. 5 can be estimated as a stable tendency to a more intensive sea level rise for the adjoining region. Calculations from average monthly values allowed to obtained the average annual values over the whole period of observations. The average rate proved to be 6.51 mm/year. If this tendency remains till the end of next century and is combined with the growing impact of "green house gases" concentration in the atmosphere(Fig.4), the scale of the rise will be more than 1.5 m by the year2100. Similar phenomena have been found for other points in the region between the Danube delta and the Dniestrovsky liman. In other parts of the Black Sea coast within Ukraine, a more or less intensive relative(E T) level rise is observed.

The example of the currently continuing level rise in the Caspian Sea Shows, hov sensible may be the shore zone's response to such changes(4). An analysis of these changes, as well as predictions made for the shores of many countries(1,5,10,11,) show that the Ukrainian coasts of the Black Sea can respond in three main scenarios:

1.A relatively catastrophic sea level rise will lead to insignificant changes of the shore, without a visible damage to the natural, cultural, and ecomomic resources.

2. The rise will lead to a restructuring of the equilibrium profile, and the shores will adjust to the new conditions. Limited damage to the natural, economic and cultural resources may be caused.

3. Simple passive submemrgence of nearshore land may occur. Although the damage may be limited, it would be more significant than in scenario 2. A possible variant of scenario 3 might be intensive submergence of nearshore land, in whic the sea level's relative rise shifts the strong astion of gale waves further inland. In this case, land resources are damaged most of all.

It is scenario 3 that is best studied on the coast of Ukraine. The other variants are yet to be studied in future.

Passive submurgence of land may take place, when the shore is very low, and the nearshore bottom is very shallow (0.007). Such regions inculude delta sections of the Danube, the Dniester, the Dnieper, the coasts of limans, and the coasts of the Egorlyk, the Tendra, and the Karkinit bays, and some others. For instance, there are seven limans between the Danube delta and the Dnestr liman with the todal water surface of 483 sq.km. According to field surveys of relief and measurements on a map of the scale 1:10,000, a level rise of 1m may cause the submergence of 60.09 sq.km on the shores of limans and adjoining portions of the sea coast. This means the average specific proportion of 0.182 sq. km per 1 km of shoreline length. If the sea level rises by 2 m by the end of the 21st century, passive submergence will cover 110.3 sq. km, and a 3-meter rise will cover 162.4sq.km--all on the 90- kilometer stretch from the Danube delta to the Dniester liman only.

The greatest potential danger of passive submergence exists between the Dnieper estuary and the Crimean peninsula (Fig. 1). The length of the coast that can be submerged in the first turn, is 457.4 km, or 28.1% of the total length of Ukraine's coast. With a possible 1-meter level rise caused by the "greenhouse effect", the flooded area of nearshore land will be about 2300 sq. km(5.028 sq km per 1 km of shoreline length, and a 2-meter level rise will cause flooding of 4800 sq. km (10. 494 sq. km. per 1 m of shoreline length). It is essential that this flooding may go along with an increased wave impact on shores and economic 1988I) facilities.

In 1988 calculations were made to estimate the amount of possible damage that a 2- meter level rise would cause to the Black Sea shores within Ukraine, Georgia, and Russia. The amount obtained was over 2 billion of Soviet roubles (or 2.6 billion US dollars in 1988 exchange rate). In the case of an unfavorable scenario, the protection of the US coasts alone will require from30 to 100 billion US dolars in the prices of 1988(10).Similar estimates are available on the shores of such countries as the Netherlands, France, and Italy. This problem requires a multiside study in order to find out the probability of the rise and its causes in different parts of the coast, critical situations Timing, their possibli consequences, and the protection strategies in accordance with different scenarios. If the negative predictions are justified, the above-mentioned steps will allow to extend the spending for a longer course of time and to work out the priorities and best techniques of protection.

5. CONCLUSION

The current state of the natural resources of the Black Sea is not very favourable, which results in corresponding economic consequinces. Various environmental problems require detailed economis study; it has to be done in a joint international effort, first of all, in the framework of the Black Sea economic union.While this paper deals with the Black Sea coast within Ukraine, the problems discussed here are just as topical for all the countries that have access to this sea.. The theree main problems are:1) shore abrasion and shoreline retreat; 2) sea water pollusion; 3) possible negative impact of the "greenhouse effect" in the nearest 100 years. The consequences of these phenomena cause great economic damage. They are constantly in the focus of attention of national and international agencies.

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CAPTIONS

TO FIGURES IN YURI D. SHUISKY'S PRESENTATION " ENVIRONMENTAL AND ECONOMIC ASPECTS OF COASTAL STUDIES ON THE BLACK SEA"

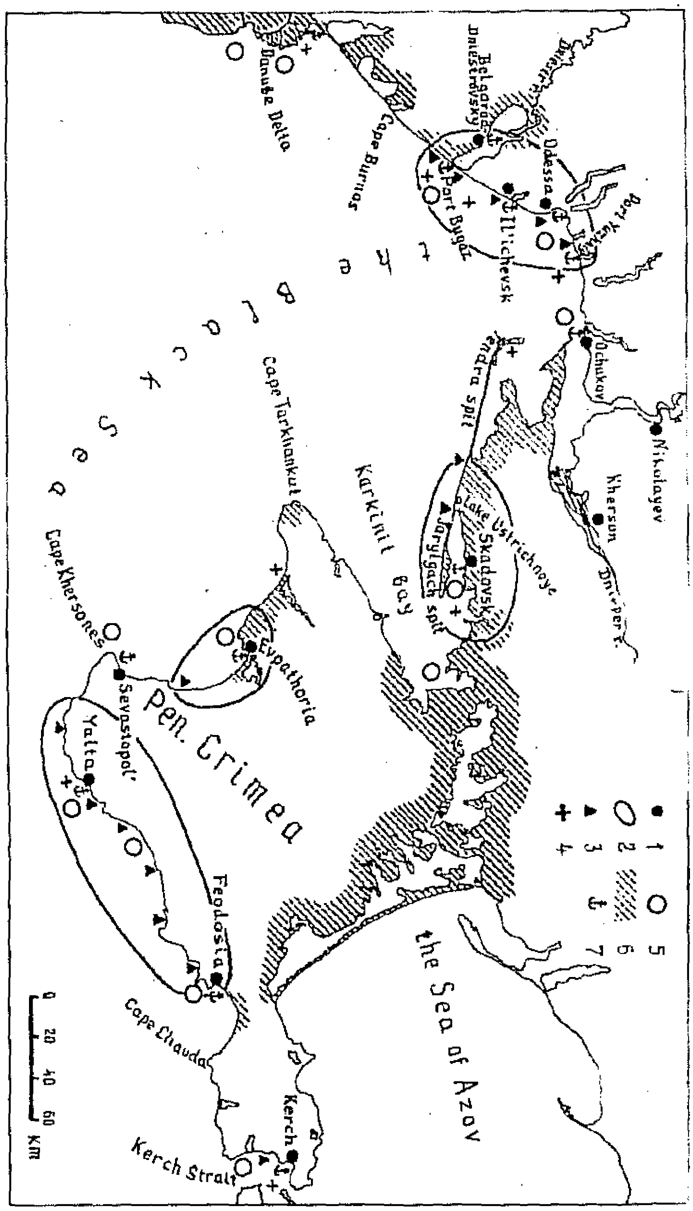


Fig. 1. Black Sea coast within Ukraine: 1- cities; 2- major recreation are... 3- major shore protections; 4- sites of mineral resources excavation; 5 zones of the most polluted water; 6- most dangerous ... for the "greenhouse effect" manifestation; 7- sea ports.

Fig. 2. Dynamics of the Ustrichnoye Lake barrier on the Blask Sea shore Between Tendra and Jarylgach spits from surveys data: a- 1952; b 1990; 1- sandy sediment of the barrier; 2- clayey deposits.

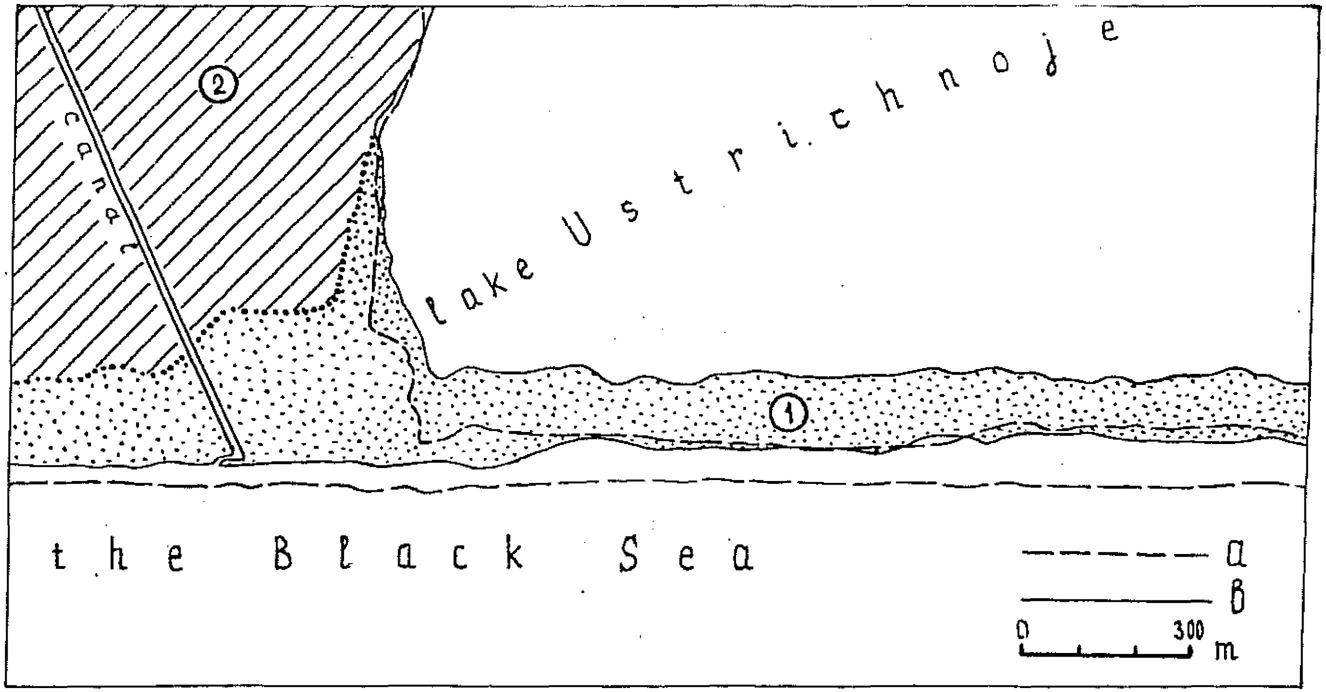
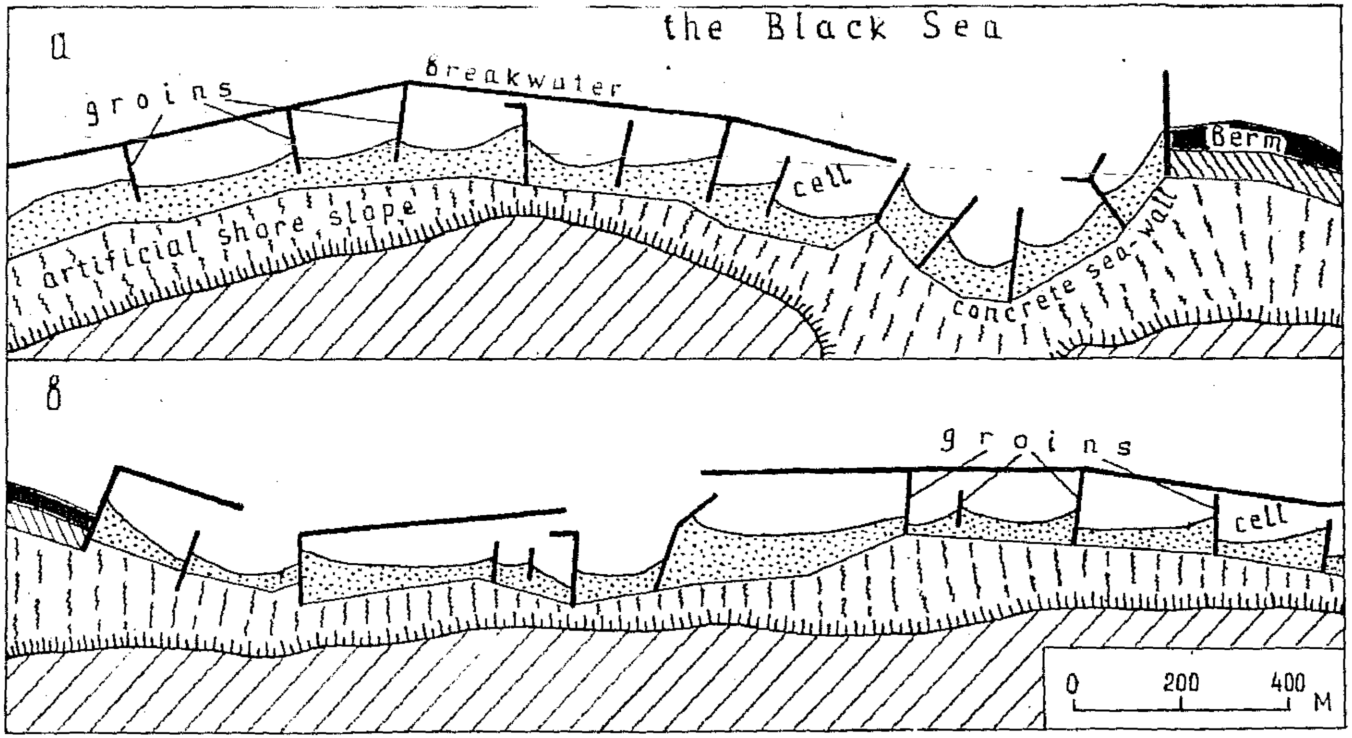


Fig. 3. Fragments of coast protecting construction; b- second stage of construction.



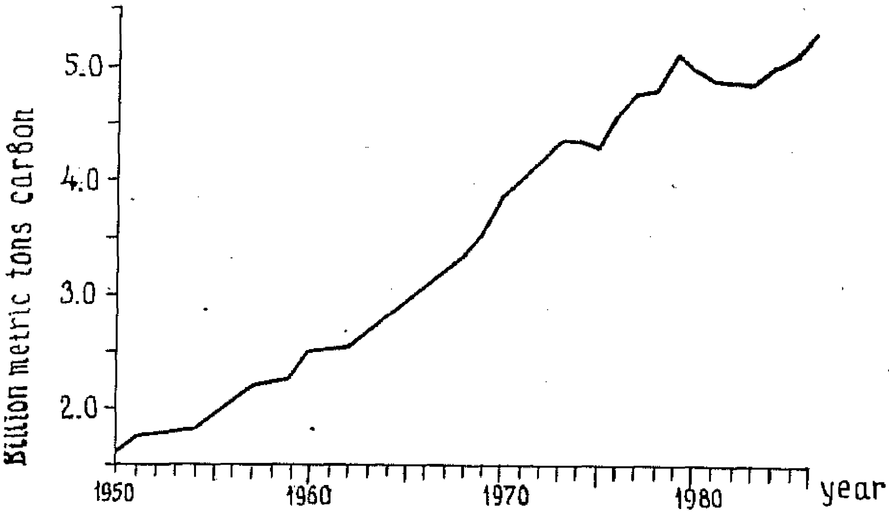


Fig. 4. Total global cinission of carbon dioxide from fossil fuel combustion.1950-1986 (3)

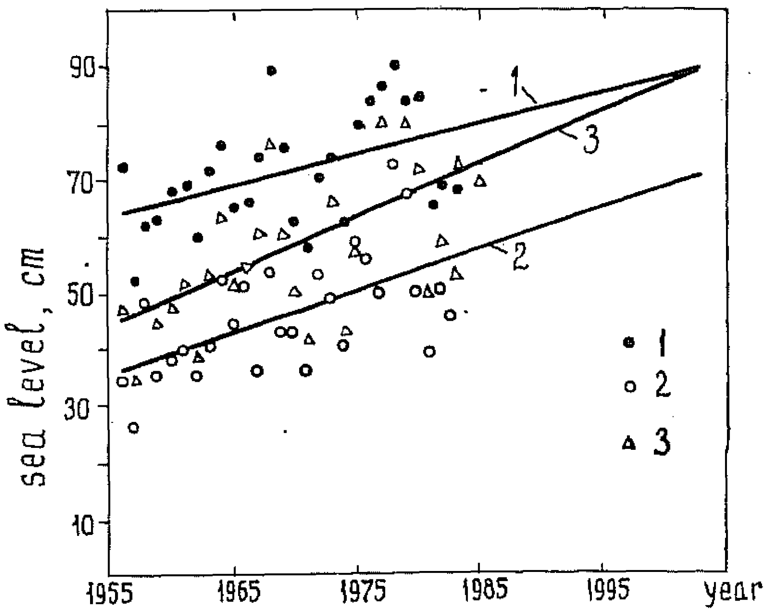


Fig. 5. Changes of maximum(1). minimum (2) and average (3) yearly measurements of the Black Sea level at point "Bugaz" over the period of 1955-1985.