The Results of the Investigation of Nearshore Lakes of the Adriatic and Black Seas

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Abstract

Along the shores of the Black Sea (Ukraine) and the Adriatic Sea (Albania) lakes of various origin are widely spread: lagoons, limans, riases, etc. On the coastal territory of Albania their number is around 20 with the total area of 152 km^2, on the territory of Ukraine - around 150, with the total area being 5 524 km^2. In Albania lagoons prevail, and in Ukraine limans, with greater genetic variety of shore lakes. According to the difference in geological history, natural evolution, climate, modern morphology and dynamics of the coastal zone, total relief features and other conditions, differences in the nature of lagoon and limanic systems were also observed and measured. They are found in the origin and development of the bottom, composition of water, and nearshore lake barriers. The process of liman formation on the Black Sea coast consisted in the ingression of the sea water in the nearshore lowering of the indigenous relief, after which barriers of various origin appeared; on the Albanian coast at first there appeared barriers which in the process of formation separate aquatoria of lagoons from the sea. The abundance of sediments in the coastal zone of the Adriatic Sea favours prevailing of accumulative processes and shoreline growth, including the majority of barriers. On the Black Sea the acute deficit of sediments causes the shoreline retreat and breaking of the liman barriers.

In Ukraine economic development of nearshore lakes is stronger. In Albania lagoons are used for fish breeding, extraction of salt, in agriculture, as units for tourism and recreation. In Ukraine these kinds of development also take place, but they are more intensive. Besides, nearshore lakes are used as a source of mineral material, medicinal mud, for construction of sea ports, for navigation, extraction of building material. As in Albania, a lot of lakes in Ukraine are included in the territories of reserves and other protected natural systems.

Introduction

Lagoons, limans, riases and other types of nearshore lakes are widely spread along the shores of the Adriatic and Black Seas. The natural systems of nearshore lakes are unique and are widely used in economic activities (sea transport, recreation, tourism, fishery, etc.). At present they are influenced by potent anthropogenic pressure, which leads to transformation of their nature, and this phenomenon often undermines their natural restoration abilities and results in the loss of numerous useful properties in natural resources.

But the main nature features of nearshore lakes of the Adriatic and Black Seas differ first of all in geographic position, geological structure, relief, climate. These differences cause the action of different wave regime, the presence of different inclination and relief of nearshore sea slope, different conditions and sources of drifts, hydrological and chemical regime of water in lagoons and limans, the ways of aeolian process formation on the shores, and others. All of the above leaves the marked imprint on the nature, development, modern morphology and dynamics of coastal zone that, in the end, influences planning, management and development of natural resources. The goal of this paper is to determine first the comparative natural and anthropogenic characteristic for the coasts of the Black and Adriatic Seas. The attention is principally paid to modern actual conditions of natural systems of nearshore lakes using some examples within Albania and Ukraine.

This paper is based on concerted investigations of authors along Albanian coast, on wide discussion of research materials in Ukraine and Albania, and on application of results obtained by other authors.

General Characteristics of Shores

The general length of shores of the Adriatic and Ionian Seas within Albania is 385 km, from the border with Montenegro in the north to the Stylos cape in Kerkira strait in the south, to Greek border (fig. 1). Accumulative shores prevail, their general length is 225 km (58% of general length). In this context, the growing accumulative forms occupy 110 km (28%), and the growing process towards the sea is continued throughout the last 100 years, at least; the dynamically stable forms occupy the shore along the length of 115 km (30%). The length of abrasive shores is around 160 km (42%), and they reveal the quickest retreat along 65 km (17%). The retreat rates of cliffs, 95 km (25%) in length, do not exceed 0.2 m/year.

The shores of the Black Sea within Ukraine occupy 1628 km, beginning from Old-Stambulskiy branch in the Danube delta, to Kerch strait (fig. 2). The abrasive retreat shores occupy 486 km, or 29.9% of general length; the hard and dynamically stable shores occupy 553 km (34%), and the remaining 589 km (39.1%) are the retreating and growing accumulative forms.

Figure 1. - Diagram of the Adriatic and Ionic Seas coasts within Albania. Main lagoons are shown in black colour.

Types of Nearshore Lakes

Both in Albania and in Ukraine, limanic and lagoon coasts are widely spread. In this case we distinguish the types of nearshore lakes on the genetic basis - on origin and development of lake basin occupied by water. In accordance with V.P. Zenkovich [8J. they may be defined as;

— *limans:* nearshore lakes with erosive origin of basin, water recipient;

— *lagoons:* nearshore lakes of tectonic origin, they usually occupy hollows of sloping folds and are created under the influence of smooth lowering in sloping surface of nearshore land;

- *riases:* nearshore lakes or bays, with the bottom of tectonic origin - usually this is a break of earth crust treated by erosion processes;

— *fjords:* nearshore lakes, the hollows of which were laid by inlet or displacement of earth crust and treated by aeration during flowing of covering glaciers down to »erosion basis«;

- *coralline lagoons:* lakes the hollows of which were separated from sea by coral barriers;

- *intra-delta lakes:* create under the influence of formation of river-beds or nearshore-sea ridges within river deltas, and relief lowerings between them are filled with water;

- *remanent shore lakes:* form as a result of creation of barriers, sand-bars and spits of different origin and the lakes separate from the seas and from each other by these shore accumulative forms.

There are nearshore lakes of the other types, but the above are widely spread and well known. In most cases, hollows of nearshore lakes are of mixed origin: denudative-tectonic, erosive-tectonic, glacial-erosive and other combinations. But the leading factor always reveals and gives a name to either type of lake. It should be also noted that in most cases lakes in contemporary coastal zone have formed in Holocene and their hollows of different origin and structure in native land are filled with water under the influence of Post-Pleistocene relative increase of sea and ocean levels. If the lake hollow is of sculpture form, mainly under the influence of sedimental accumulation (nearshore, lake, delta and others), water remains there after division from sea or appears under the influence of water flow from land. Limans, riases, fjords change to nearshore lakes usually after division of their areas from sea by barriers, sand-bars and spits in accordance with the regimes of along-coast sedimental flows in coastal zone.

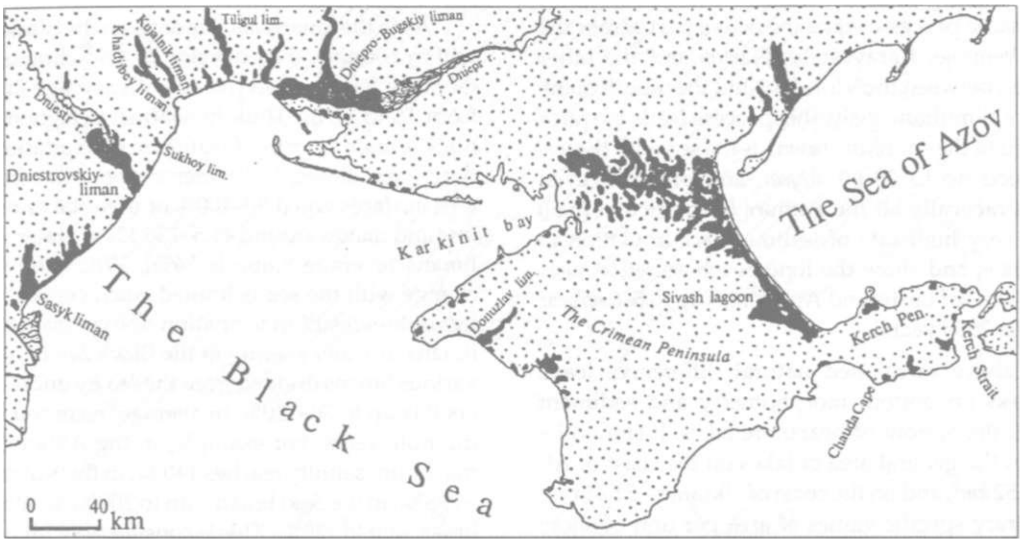

Figure 2. **- Diagram of the Black Sea coast within Ukraine. Main nearshore lakes are shown in black colour.**

The expounded concepts and conformities to natural laws correspond both to Ukraine and Albania.

Factors and Conditions of Creation of Nearshore Lakes in Ukraine and Albania

In the light of the above stated, on the shore of Ukraine liman type prevail as a result of active erosive process of indigenous relief generation in the past, under the influence of pronounced shortage of sediments in coastal zone, comparatively with the quick rise of the Black Sea level during the Holocene transgression, dry climate during late millennia.

On the shore of Albania there is prevalence of lagoon type, often of polygenetic origin. This is related to strong alluvial flows of terrigenous sediments (65.75 x 10^6 *t/year* in sum, or on the average 171 *t/m* along the shore), and rather quick relative increase of the Adriatic Sea level (up to 3-6 *mm/year)* [1,4]. The increased number of sedimental flows results in quick growing of shoreline along the entire area to the north of Vlore bay and in creation of shore accumulative terraces, that is not observed on the shores of Ukraine. The quick rise of sea level and plentiful underground flow promotes the process of filling the relief lowerings on the surface of these terraces with water.

Besides, in due course many new lagoons form on the shore of Albania. This process is similar to the formation of intra-delta lakes and can be described as follows: Lagoon barriers stabilise after regular stage of formation. Under the influence of river sediment flow on both sides of lagoon, the sea coastal zone feeds with sediments. Simultaneously, under the influence of mouth accumulation, mouths of these rivers move towards the sea, and the created forelands begin to break stronger and stronger the alongshore drift flow. This leads to formation of nearshore sand-bar or spit, which aspire to bound mouth forelands on nearshore bottom at the different off-shore with the sea from the last barrier. In due course, the nearshore spit or sand-bar increases its dimensions andrises above water. This is a way to create a semi-closed or closed water area (lagoon), behind the previous one. This is also promoted by the increase in the rate of relative rise of the Adriatic Sea level. So, in contrast to the shore of Ukraine, at the Albanian lagoon coast and the accompanying spits and barriers get a water area from the open sea, continiously dividing the parts of nearshore bottom.

For example, on the southern coast of Albania in the southern part of the Drin bay, the lagoon Patku is situated. The Mat river enters into it northward/= prema sjeveru; nije li mozda trebalo »sa sjevera« = »from the north« / (sediment flow is 2.5 x 10^6 *t/year,* 20% of them are settled), and river Ishem - southward (it has nearly the same sedimental flow). It turns out that annually around 5.1 x 10^6 *t* of alluvium concentrate here along rather a small area of nearly 25 km in average, during many years, not counting the sediments from the Drin river northward (sediment flow equals 16.6 x 10^6 *t/year).* The northern winds (alongshore) prevail in recurrence, and the western winds - in energy [3,4]. So, this huge sediment mass pressures the shore (average inclination of nearshore slope is near 0.0005) and it actively occupies the shore concavity between mouths of rivers Mat and Ishem. In this connection, the disjunction of any more new lagoon depression and water areas takes place very quickly when nearshore slope is very shallow: the new ridge as a prototype of the new barrier for the Patku lagoon began to form actively in 1988. Now its small parts are already drained on water surface, 1.5-2.0 km from the old barrier.

The same processes take the active part across the lagoons Velipoje, Karavastase, Nartes and the other small ones, between the Vlore bay and the mouth of the Drin river. Simultaneously, this process leads to quick movement of the shoreline towards the sea with the average speed up to 50-60 *m/year,* and probably even quicker. Practically all the authors (in particular [5,6]) note the very high rate of sediment accumulation in coastal zone, and show the long beach accretion near ancient towns of Lezhe and Apollonia (up to 5-6 *m/year* during last 2000 years).

The above mentioned natural differences leave their marks on bottom morphometry and sediment content at the bottom of nearshore lakes. It should be noted that the general area of lakes on the coast of Albania is 152 km^2, and on the coast of Ukraine - 5 524 km^2. The arbitrary specific values of area per unit of shore length equal 0.4 and 1.95 km^2/km, respectively. Hence, »lakiness coefficient is higher on the Ukrainian coast in comparison with the Albanian coast, but mainly owing to large limans and lagoons: Sivash, Sasyk, Molochniy, Dnieper-Bugskiy, Berezanskiy and others. And at the same time, the shore length of the Black and Azov Seas within Ukraine is by 7.3 times higher.

General Peculiarities of Nearshore Lakes Nature

Practically all the lagoons on the Albanian Adriatic coasts are small in area, their depths are frequently equal to 1-2 m, rarely up to 3-5 m, and they display the above mentioned peculiarities of creation and development. The deeper parts of lagoon bottom are created by erosive hollows, pools, remains of inlets or river-beds. In general, bottom is gentle, smooth, in most cases resembling a saucer. This is caused by high rates of sediment accumulation, mainly silt, mud or sand drifts, which come from river branches or from nearshore bottom through inlets of barriers. In the Patku lagoon bottom, the rates of sediment accumulation reach 10-20 *mm/year,* and in the Karavastase lagoon - up to 15-16 *mm/year* in average during multiple years, which is in general 3-20 times less than in limans on the coast of Ukraine.

The rates of drift accumulation are considerably lesser in small lagoons within sedimentary-coastal terrain along the nearshore hilly Irencit ridge - usually 1-5 *mm/year,* as in most limans and lagoons on the coast of Ukraine. This is related to the fact that river mouths do not usually fall into such lagoons. These nearshore lakes have now lost the bonds with the sea. Gradually they turned into swampy lowerings, often with thin layers of peat. The similar situation is observed in seaside parts of river valleys Dukatit, Bistrice, Pavlle and others.

As to the limans and lagoons on the Black Sea coast within Ukraine, they develop in arid climate. Most of them are fed by small rivers, with average flow values from 0.5 to 1.0 *l/s.* Thus, in contrast to lagoons in Albania, the main sources of water are precipitation and underground flows. But water evaporation from liman area surfaces equal 90-100% of the total annual water loss and makes around 41.5-130.1% of water volume in limans (average value is 74%). When the water exchange with the sea is limited, such considerable values of loss result in formation of hypersalted water in limans. If water salinity in the Black Sea is 14-22**‰,** in various limans divided from the sea by unbroken barriers it is up to 70-120**‰** in average, recorded for recent multiple years. For example, in the Alibey liman the maximum salinity reaches 140‰, in the Kujalnik liman - 296‰, in the Saki liman - up to 200‰, in the Chokrak liman - up to 320 **‰** . This is considerably higher than in lagoons of the Albanian Adriatic coast, where salinity reaches 25-90 **‰** when water salinity of the sea equals 32-35%.

Regional Characteristic of Nearshore Lakes in Ukraine

As an example we give the brief characteristics of some significant limans on the shore of the droughty Kerch Peninsula (value of precipitation is up to 415 *mm/year* and evaporation is up to 900 *mm/year)* (fig. 3). All of them show relatively low influence of anthropogenic activity.

Liman Kachik. Length is 3.5 km, average width is 2.5 km, area - 4.52 km^2, average depth - 0.2 m, maximum depth - 1.4 m. The hollow is developed of the bottom of gentle fold. It is fed mainly by filtration of the sea water through narrow (up to 100 m) sand barrier and by precipitation. It often dries up in summer. Water has the chemical composition which is similar to the sea. Salinity of water in the liman clearly changes depending on the seasons, and its maximum value is around 250‰. During some years the natural salt grain occurs. Fauna and flora are poor, typically the hypersalted one.

Liman Koyashskiy (Opukskiy). It is divided from the Black Sea by a narrow (width up to 250 m) sand barrier, which developed in acute drift deficit in coastal zone. Its hollow occupies also the bottom of the gentle fold developed by erosive-denudative processes in early Holocene. Its length is 3.7 km, average width - 2 km, area - 1 0 km^2, average depth - 0.6 m, maximum depth - 2.2 km. It is fed mainly by underground waters and by filtration of the sea water through the barrier, especially during storm surges. The salinity of the lake water reaches 210‰, its maximum value is registered in August-September and minimum value from December to March, in accordance with distribution of precip-

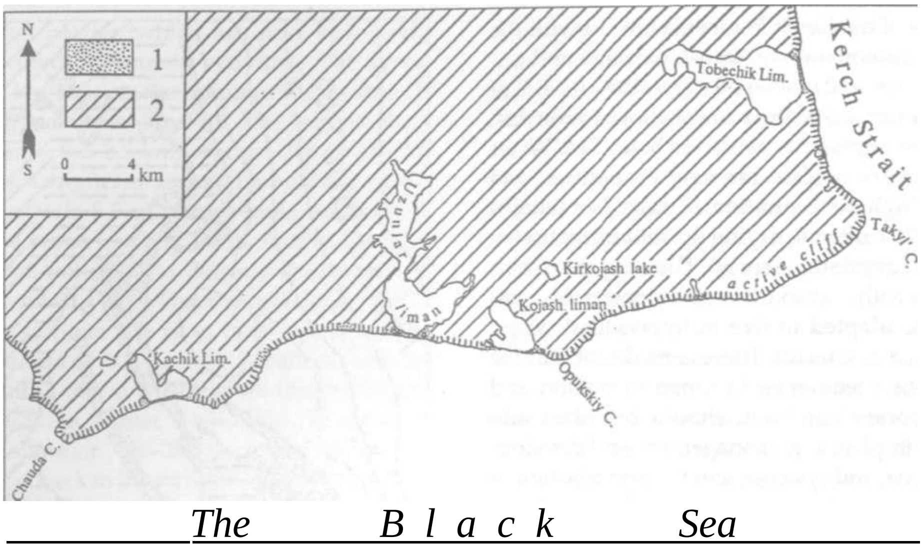

Figure 3. - The Southern part of Kerch Peninsula the (Crimea, Ukraine) and the location of basic limans: 1 - coastal accumulative forms (barriers and terraces); 2 - indigenous mainland that composed continental clays, limestones, sandstones, marls.

itation during the year. This lake is self-graining, salt layer forms every year with the average thickness of 3.5 cm. Its bottom is covered with black or grey mud with thin (up to 2 mm) gypsum layers, like in other limans and lagoons of the Kerch Peninsula. Its flora and fauna are significantly poor, typically hypersalted one.

Liman Tobechik. Its lake hollow occupies the lowering of erosive origin and irregular form, which was previously created on the bottom of the gentle fold. Its lenght is 9 km, width reaches 4.5 km (minimum value - 0.5 km), depth - 0.1-0.8 m, average depth is 0.3 km. It is devided from the sea by a sand barrier with the width of approximately 200 m and height - up to 1.6 m above zero water level. Its bottom is formed by black mud (with medicinal characteristics), with salt and gypsum thin layers. Total thickness of mud layer reaches 20 m and is substrated by the l,5m-thick salt seam. This nearshore lake was formed the same as other limans and lagoons of the Kerch Peninsula, in the process of sea water ingression upon erosive-tectonic structural lowering during the Holocene transgression and then divided from the sea under the influence of an alongshore drift flow. It is fed by sea water filtration through barrier sand or swashing through barrier by the seawaves. The portion of precipitation is considerable. Salinity changes depending on the seasons of the year; in summer it usually reaches 150-180‰ and in winter - 40-50‰. Chemical content of lake water is similar to the sea water. In summer, the water surface area decreases 2-3 times, and the natural grain of salt is observed. Flora and fauna are poor and hypersalted.

Liman Uzunlar (fig. 3) occupies the bottom cup of irregular form and erosive-tectonic origin. It is divided from the sea by a narrow sand-shelly barrier. The liman length reaches 10 km, average width equals 1.5 km (maximum value is 5.5 km), 21.2 km^2 in area. The bottom is covered by a layer of black and grey mud, its thickness up to 10 m. The black mud has medicinal characteristics, and some sanatoriums and recreation hotels use it for their patients. Liman is fed by underground and sea water, and in small amounts - by surface fresh water. Limanic water is believed to be of chloride-sulphate type. Its salinity changes from 15 ‰ in winter to 260 ‰ in summer. A 6-7 years liman can dry up to such a condition that its area averages 30-60% of the winter-spring area, and then the salt crust forms with a speed up to 4 *cm/year.* Up to the thirties of the 20th century, salt was mined in this liman. Flora and fauna are significantly poor, with mainly hypersalted body forms live in water.

As it can be seen from the given examples, all nearshore lakes have beds bound with bottoms of gentle folds, which in Pleistocene were considerably treated by erosive processes in native rocks (mainly clay, limestone and sandstone). During Holocene transgression of the Black Sea, the water ingressed into these lowerings of bed terrain and sank the lower reaches of erosive negative forms. Bays are formed, on the bottoms of which the muddy-aleuritic deposits are gradually accumulated. The Middle-Holocene stabilisation of the Black Sea level promoted activation of abrasive processes on the shore and nearshore bottoms, many sediments were drawn into alongshore flows, that barrier formation was found to be possible and they divided the ingressive bays from the sea. After this, the rates of sediment accumulation on the liman bottom increased, and during the last 2500 years they averaged to 1.3-3.4 *mm/year* in various limans.

All limans of the Kerch Peninsula are fed with the sea (filtration through or over swash barriers) and underground waters, and by a small (up to 20%) receipt of surface freshwater. All of them are shallow, in contrast to limans in the northern coast of the Black Sea. Water in them heats very quickly, strongly evaporates, and this leads to high concentration of salts (sometimes more than 300‰), often to drying up, and formation of salt crust with considerable speed. The unique ecological system with absolute prevalence of micro-organisms, adapted to live in hypersalted water, has been created as a result. There is no doubt that the above mentioned tendences in liman formation and their contemporary condition should be taken into consideration in planning, management and development of liman natural systems, and the optimisation of nature usage.

Regional Characteristics of Nearshore Lakes in Albania

The brief description of the development of some nearshore lakes on the coast of the Adriatic Sea has been already given above. Besides, one of the typical lagoons of the Albanian coast is the Karavastase lake (fig. 4). Here the growing of sea shore under the influence of contemporary sediment accumulation becomes apparent. Lagoon area does not exceed 43 km^2, and average depth equals 1.6 m. At present it is not fed by flows of neighbouring rivers Shkumbin and Seman. Old channels of the Shkumbin river maintain the water regime of the nearby Kularit lagoon, but in the next decades it will be preceded by a new (from the sea side) lagoon; its mouth migrates rather intensively, and this has considerable influence on the conditions in neighbouring lagoons, especially the largest of them - Karavastase [1,2].

According to [4], water level in the Karavastase lagoon reaches its minimum in summer, correspondingly to the river minimum liquid run-off and maximum evaporation. Simultaneously, the maximum salinity (up to 50 ‰) is reached, and it is 27 times less than on the coast of the Kerch Peninsula. As it is seen already in the Black Sea limans, the maximum salinity values are measured at the end of summer, in the eastern part of the lagoon (55‰), and the minimum (20‰) in winter and also in the eastern part, where the influence of the water tide (the value does not exceed 0.5 m) is minimal. In the layer of lagoon sand barrier three inlets are formed (Fig. 4), through which the water exchange with the Adriatic Sea takes place [2]. The total water flow volume through them is 5.5-15.5 m^3/sec. Near inlet mouths, on the side of the sea, the water salinity is 28.5-36.2 ‰. The lowest concentration of dissolved oxygen in the lagoon was observed in the warmest and driest months (9.50-9.85 *mg/l)*, and the highest values (11.28-12.75 *mg/l)* were observed during the dampest and coldest months, as it is the case on the coast of Ukraine. As the Karavastase lagoon is rather shallow, the average monthly water temperature values are nearer to average monthly temperature values of air: from 6 °C in winter up to 30 °C in summer (the average value is 22 °C in July) [2]. The lagoons and limans of the Black Sea coast mainly freeze in winter, in spite of very high water salinity, and the lagoons of the Albanian coast practically never freeze. Besides, their flora and fauna is richer and more abundant because of the other salt-related changes and salinity values. It creates more appropriate conditions to use them for fisheries and industry.

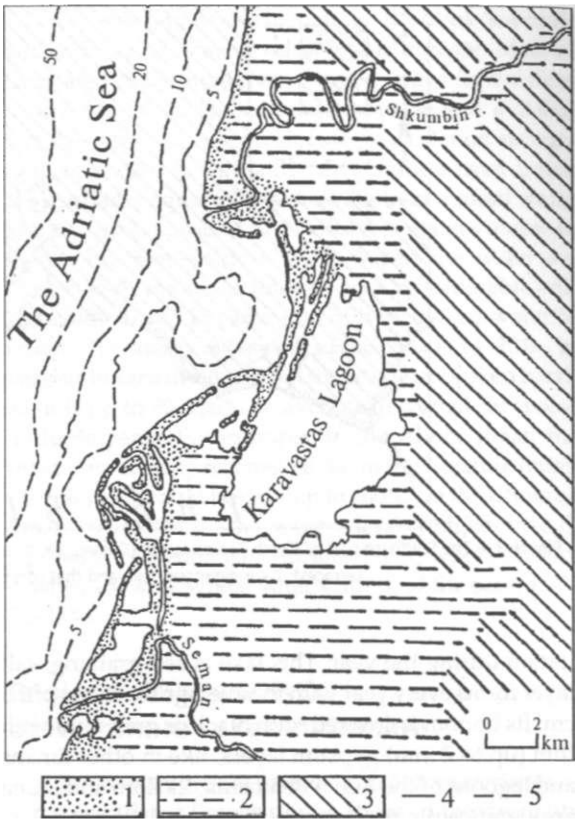

Figure 4. - Scheme of Karavastase lagoon and the adjoining coasts of the Adriatic Sea: 1 - contemporary coastal accumulative forms (spits, barriers, beaches); 2 - low alluvial-marine plain; 3 - indigenous high mainland with hills and mountain ridges; 4 - izobaths, depths in metres.

Economic Significance of Nearshore Lakes

We give the characteristics of the *Kujalnik liman* as one of the economically most significant on the Black Sea coast within Ukraine. During more than one century it has already undergone considerable anthropogenic influence. It is separated from the sea by a

800m-wide sand barrier, which has now been completely transported by human activities. The liman area equals 19 km^2 during the minimum level, and 74 km^2 during the maximum level fill. The length equals 25-30 km, width - 0.2-2.5 km, average depths 1.0-3.9 m, respectively. Long-term seasonal amplitude of the level changes equals 5.5 m, the average sea level is higher than the liman level by 4.1 m. Besides, temporary water flows fall into the Bolshoy Kujalnik river which gives about 60 x 10^6 *m^3/year,* especially in winter and spring. In summer the river dries up, as a rule, what cannot be said of rivers on the Albanian coast. So the water salinity limit in the Kujalnik liman changes from 50 to 296‰: in winter - 61-245 ‰, in spring - 50-208 ‰, in summer - 53-296‰, and in autumn - 61-289 ‰, dating back to the mid previous century. Water can be believed to be of chloride-sodium class. The receipt of water from the sea is very low, in contrast to limans on the Kerch Peninsula and the Albanian coast.

In the hypersalted Kujalnik liman, the number of algae and water plants species does not exceed 99, hypersalted (ultrasalted) amount to 20%, typical marine species - 16%, saltish-water /brackish-water??/ marine - 20%, and **??saltish**-water species - 44%. Some species of *Chladophora* and *Amphora* are widely spread. As concerns **zooplankton content,** 5 **species** can be marked out, **with** prevalence of **Crustacea (in particular,** *Artemia).* The content of ichthyofauna is very poor: the longer the liman is isolated from the sea (under the other unchanged conditions), the poorer its ichthyofauna, which also characterises Bolshoy Adjalyk, Sasyk (in Crimea), Uzunlar, Tobechik, Koyash and other limans of the Ukrainian coast. The Kujalnik liman is therefore not adapted to mariculture, fishery, mollusc cultivation, usage of water in agriculture and human activities, etc.

Many lagoons and limans on the coasts of Albania and Ukraine are widely used in different spheres of economy. For example, in Karavastase, Velipoye and Butrintit lagoons fish is bred, which doesn't take place in all of the nearshore lakes of Ukraine. In particular, fish breeding is carried out in Alibey, Burnas, Budaki, Tiligul limans. Since the Sasyk (Kunduk) liman has been desalinated and fish introduced in 1978, it has been successfully used for fishing, and its efficiency reaches up to 15-20 *kg/hectar,* whereas in the previous »salted« period it often did not exceed 0.3-0.5 *kg/hectar.* Now the freshwater zoobenthic organisms are very active in the liman, and rapid reproduction of different species of *Chironomus* and other water-mosquitos takes place, which testifies of the good feeding basis. Water of the Sasyk liman in the nearest mouths of Kogilnik and Sarata rivers is used for irrigation, which does not occur on the Albanian coast.

Around lagoons Velipoye, Karavastase, Nartes in Albania there are the large rest and recreation areas, visited by numerous tourists. On the coast of Ukraine tourists visit liman shores not very often, but recreation areas exist around most of them. In contrast to Albania, in Ukraine such areas were formed mainly because of medicinal muds and natural mineral waters. For instance, on the bottom of Khadjibey liman the reserves of medicinal mud exceed 14 x 10^6 tonnes. The considerable mud-beds are found in Shagany, Tiligul, Moinaki, Karadzha, Uzunlar limans and others. The medicinal mud on the bottom of the Kujalnik liman is of the higher quality, where it occupies the area of 53.5 x 10^6 m^2 with total estimated reserves of more than 24 x 10^6 tonnes. They comply with the standard values in the international testing list. The medicinal characteristics of natural mineral waters, mainly of the chloride-sodium type, are of great significance, and these waters are found everywhere around nearshore lakes in Ukraine and Albania.

A number of limans are used as mineral resources. Up to the 1930s, table salt was mined in Burnas, Saki, Kujalnik, Tobechik limans. At present, salt is mined in Sasyk (Crimea) and in the southern part of the Sivash lagoon. Brine, from which magnesium, sodium, iodine, titanium and other chemical elements are produced, is mined in Sivash, Aigul' and Kirleut lagoons. The same application takes place in some coastal lagoons in Albania: for instance, the Nartes lagoon. About 75% of total table salt in this country is produced, the rest salt is mining in the mainland, in one salt mine solely.

In contrast to the Albanian coast, in Ukraine the nearshore lakes are rather widely used for sea-port construction and navigation. This is connected with the fact that major rivers, i.e. Dniestr and Dniepr, discharge into limans. Shipping from the sea to rivers results in construction of artificial navigation canals with depths up to 6-11 m, which evidently disturbs ecosystems of limans and the mouth areas. Shipping is of great significance for Berezan' and Budaki limans as well. In Albanian lagoons this type of anthropogenous impact is absent, and too the application of lagoons to construct sea-ports.

In Ukraine, nearshore lake sea-ports were built in Sukhoy, Maliy Adjalyk, Dniestrovskiy, Bugskiy, Berezan' and Donuzlav limans. And if in Donuzlav (up to 27 m) or in Berezan' (up to 17 m) limans the depth allows to do it without difficulties, the bottoms of other lakes should be deepened up to 7-18 m. In particular, previously in the Malyi Adjalyk liman, the natural depths were 1-3 m, and after ground gathering from the bottom the depth increased up to 16 m, and as a result around 20 x 10^6 tonnes of the ground mass was removed. Limanic aquatorium was connected with the sea by cutting a navigation canal through the barrier, which separated the liman from the sea in natural conditions. This changed the limanic barrier and the nearshore sea bottom relief radically. The minimum bottom deepening was done in the Berezan' liman, where the natural depths reach 15-17 m. The barriers of most limans mentioned here were solid (besides Dniestrovskiy, Dnieprovskiy, Bugskiy, Berezan' limans). During the port construction the navigation canals were dragged through these barriers. Thus the limanic waters were connected with the sea, and this considerably changed the hydrological and geochemical regime of liman waters, species content and biomass of water organisms, resulting in the increase of pollutant concentration. Such limans usually lost their fishing significance, for example Malyi Adjalyk, where the fish productivity was up to 10 *kg/ha* before dragging and hydrotechnical works. Very inauspicious conditions arised for recreation usage of such limans, for application of natural lands for tourism, for the mud and table salt mining; deposited medicinal mud layer is destroyed. This experience is very useful for Albania and other countries.

Not only liman waters and bottom, but barriers too are of great economic importance. They are used as land to construct industrial facilities and dwelling places, railways and roads, resort complexes, navigation equipment, etc. At present in Ukraine about 50% of liman and lagoon barrier and spit areas are developed, in contrast to Albanian coast, where around 15% of the area are opened up. On sand barriers, shore dunes are a characteristic element of landscape. Their size is small because of prevalence of seaward winds and sediment deficit in coastal zone, and a peculiar response of the surface landscape structure to wind influence [7]. Any construction in sand barriers or spits and artificial disturbance of the landscape structure leads to destruction of dune systems, process of sediment exchange between the sea and limans (lagoons), and correspondingly to barrier (spit) degradation.

At present the barriers of Dniestrovskiy, Gribovskiy Sukhoy and others, more than 50 of them in total, are completely built up. This essentially decreased the species diversity and flora and fauna mass, activates the intensity of shore erosion, and unexpected expenses for shore-protection. To keep the existing dune systems and liman and lagoon barriers (spits), they should be given the status of natural reserves or some other type of protected territory.

Possible Sea Level Rise Impact to Shores

This problem is best of all studied in Ukraine where there is quite abundant information about climate and oceanic processes. Relative oscillations of the Black Sea level during past 150 years are characterised by an integrated rise (fig. 5 and 6). In general, in the majority of shore sectors rise rates of 1-2 mm/year prevail, though during shorter periods the picture is more variegated [7]. Such regularity is conditioned by the fact that from the mid-19th century to the 1920s the relative level sinking prevailed, for instance, according to the instrumental survey on mainland hydrometeorological stations »Varna«, »Sulina«, »Odessa«, »Ochakov«, »Sevastopol'« and others (fig. 5 and 6). Such changes we connect mainly with climate changes and accordingly with usual rhythmical oscillations of water balance of the Black Sea as well as of other seas of the Mediterranean basin [2, 6].

General elevation of the Black Sea level became more active during the 1930s. Since then continuous growth of rates has taken place. For instance, at »Odessa« station in the period 1921-1997 the average continuous series of 1949-1997 gave 7.1 mm/year; which is higher than at other hydrometeorological stations. But it can be explained: this station is located in the axial zone of a very active fault; therefore tectonic constituent of relative rate is much stronger in comparison with other stations. At the same time, in the period 1949-1997 at »Ochakov» station the average rate constituted 4.39 mm/year; at »Tendra Lighthouse» - 4.11 mm/year, at »Khorly» station - 3.45 mm/year. It is 1.7-7.5 times greater than the trend values calculated by 150-year periods, but 2.0-3.8 times less than the minimum limit of catastrophic level rise. This limit is taken to equal 13 mm/year, and during 1985-2100 it assumed the value that could cause great damage to natural and anthropogenic resources, estimated as catastrophic [2,3, 6, 7]. Nevertheless, prognoses suggested by a number of other authors estimate rates of sea level rise at >18, and even 24 mm/year.

Along Albanian coasts of the Adriatic Sea the average rates of the level rise most often equal 1-3 mm/year, though they could be 5-6 mm/year during the 20th century [1, 3]. The greatest rates were fixed in the sectors of low alluvial-maritime plains between Viosa and Drin rivers (fig. 4). There are reasons to claim that along the Albanian shores the relative level rise will be less intensive during the next 100 years than along the Ukrainian ones, as in the end of the last century within Albania in general slower, rates were formed. The temperature background of the sea water is higher there. The impact of drift sedimentary material and changes of the bottom volume in the Mediterranean Sea are lesser. Evaporation is stronger and fresh water flowing off is lesser per unit of water area. These and other reasons can nevertheless (if nothing interferes), continuing the last regularity (fig. 5 and 6), elevate the level of both the Black and Adriatic Seas by 1-2 m in comparison to the zero water level of 1985.

The consequences of the rise of the Black, Azov, Adriatic, Ionian and other Seas given above influence the coasts. In general, it was established that the existing rates on the Black and Azov Seas are not able to increase the intensity of cliff retreat by abrasion activity. It

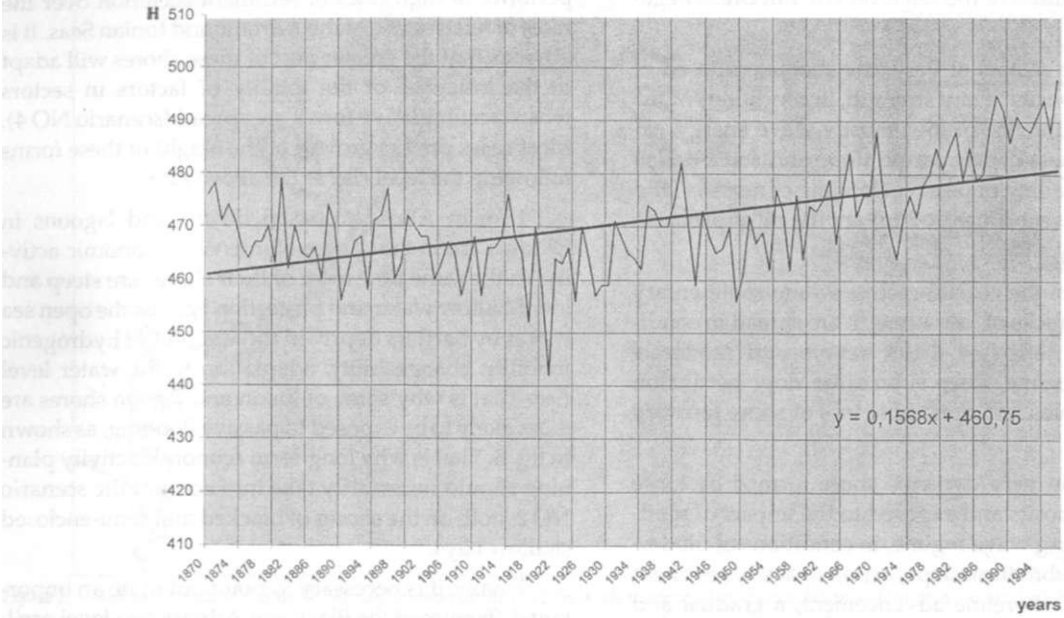

Figure 5. – Diagram of the change of the average annual values of the Black Sea level according to the instrumental data of »Odessa« station surveys in 1870–1997.

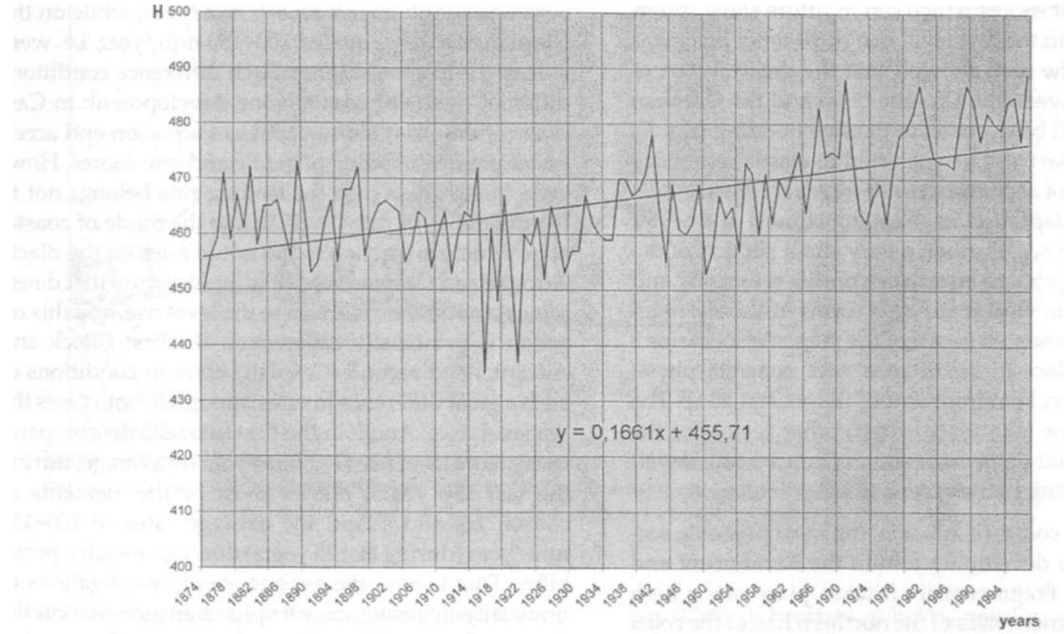

Figure 6. – Diagram of the change of the average annual values of the Black Sea level according to the instrumental data of »Ochakov» station surveys in 1874–1997.

is obvious that the same phenomenon will develop in the coastal zone of other seas. In general, in natural conditions Y.D.Shuisky [7] singled out 4 scenarios of how sea level elevation can influence the coasts. The ambiguity of each scenario is conditioned by the corresponding coastal zone structure.

1 - In the sectors of high, steep, precipitous cliffs composed of very hard rocks which are not exposed to exogenous destruction by waves of any force (energy),

ordinary elevation of the sea level will not cause negative results.

2 - In the sectors of very low shore composed of rocks and deposits of any strength, in conditions of the permanent influence of low, mostly wave energy, extreme gentleness of submarine slope and acute deficit of drifts, prevailing of passive flooding of nearsea land within the lowest shore (< 2 m) are the most probable result.

3 - Within the coastal sectors where sedimentary deposits and rocks of low strength are spread in conditions of the deficit of drifts, severe and moderate hydrogenic regime, steep submarine slope oscillation of abrasion rates and noticeable loss of shore territory are expected.

4 - Within very dynamic shore formed by loose rocks and deposits and exposed to the impact of moderate and strong wave regime, in conditions of moderately gentle submarine slope, action of active sediment accretion and shoreline advancement, a gradual and continued adaptation of coastal zone profile to processes of activation of relative sea level rise is the most likely.

According to the first experience, now only in a small sector of the Black Sea, the map of geographical distribution of shores which can in future show different response to the fast level rise (< 10 mm/year) was composed. The map showed that the greatest part of the shore between the Danube delta and the Crimean Peninsula will be exposed to passive flooding (fig. 7). The smaller part will be subjected to elastic reforming of the profile of accumulative shore relief forms and its permanent adaptation to changing climate and water balance of the sea. Further, a very small portion of the shores will be able to experience profile reforming and cliff adaptation within abrasive forms of the shore relief. On the presented sector of the map, the scenarios 3 and 4 take place in accordance with concrete physical-geographical environment of the coastal zone. The other scenarios take place within other sectors of the sea-coast of Ukraine where other conditions are developing, according to the spread of other scenarios.

As to the coasts of Albania, the most probable scenario NO 1 is developing within the Karaburuni and Epir regions. Fragmentarily it takes place along high and steep promontories of the northern half of the coast (northward from the Viosa river mouth). Like the shores of Ukraine, in Albania passive flooding will display itself to the maximum extent on the coasts of lagoons and limans (e.g. lagoons Nartes, Karavastase, Patku, Velipoya and others), in the peaks of the semi--enclosed bays and gulfs. However, scenario NO 2 is quite unlikely to develop on very quickly growing gentle and low shorelands between the Vlora harbour and the Drin river mouth - we see the reason in obvious superiority of high rates of sediment accretion over the rates of relative rise of the Adriatic and Ionian Seas. It is obvious that the greater part of these shores will adapt to the influence of the totality of factors in sectors where accumulative forms are spread (scenario NO 4). Most cases predict growth of the height of these forms following the level rise at the above rates.

Like in Albania, coastal limans and lagoons in Ukraine are in the sphere of intensive economic activity. At the same time most of their shores are steep and low. Shallow water and protection against the open sea waves by barriers deprived these shores of hydrogenic mobility, changeability, adaptation to the water level rise. That is why some of liman and lagoon shores are most likely to be exposed to passive flooding, as shown in fig. 8. That is why long-term economic activity planning should necessarily take into account the scenario NO 2, both on the shores of blocked and semi-enclosed shallow bays.

Finally, it is necessary to point out quite an important difference of the Black and Adriatic Sea level oscillations, on one hand, from the Caspian Sea level oscillations, on the other hand. This difference is in the development of different rates of the level rise. Thus, during the last quarter of the 20^{th} century the average relative rates of elevation on the Black and Adriatic Seas were not higher than 6-9 mm/year, while on the Caspian Sea they equaled 100-150 mm/year, i.e. were at least 11-25 times higher. Such difference conditions different trends of coastal zone development: in Caspian conditions it mainly activises abrasion and accelerates passive flooding of gentle and low shores. However, in the given case the leading role belongs not to the difference of rates itself, but to the mode of coastal zone structure reaction to the noted rates on the Black, Adriatic and Caspian Seas. It is the structure that determines coastal zone reaction to the level rise, and this reaction is principally different in the first (Black and Adriatic) and second (Caspian) cases in conditions of such a great difference in rates, though in both cases the sea level rises. And if in the first two seas the comparatively slow level rise (1-3 mm/year on average, during the last 150 years) allows most of the elements of coastal zone to adapt, the average rates of 100-150 mm/year (during last 25 years) don't give such a possibility. That is why the experience of investigations of unusually intensive, catastrophic transgression on the Caspian Sea in 1976-2000 can be used with essential, serious stipulations, assumptions and caution to predict the Black and Adriatic Seas state for the period 2100-2125, in the environment of continuing and growing changes of climate and the World Ocean water balance.

Further to the noted above sequences of comparatively quick modern growth of the Black (within Ukraine) and Adriatic (within Albania) Seas, in some

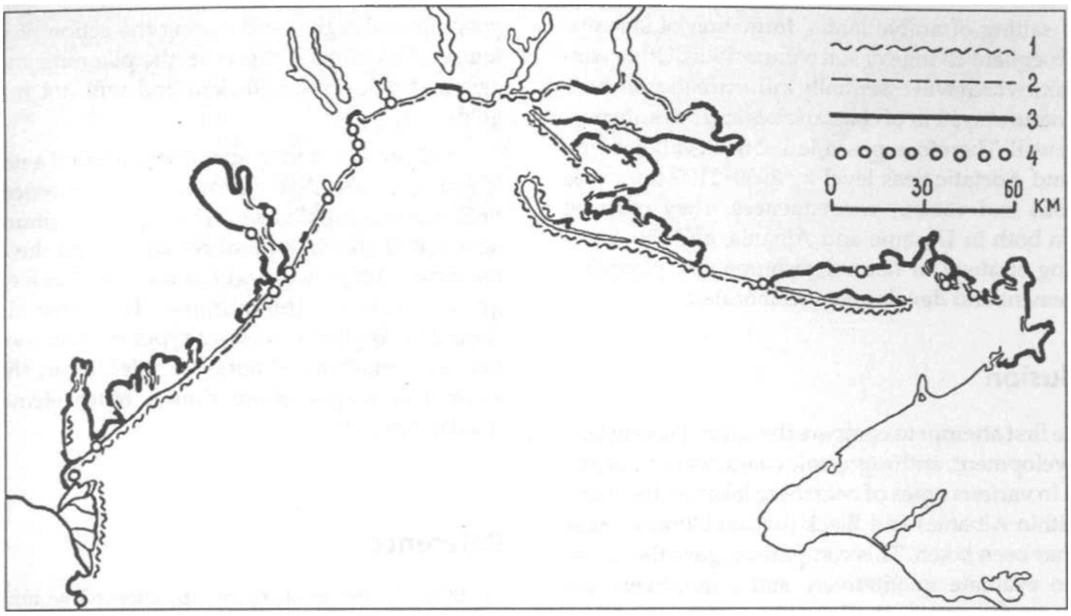

Figure 7. - Northern coasts of the Black Sea. Distribution of sectors differently reacting to modern quick rise of the level under the influence of contemporary climate changes: 1 - synchronous reformation and adaptation of accumulative forms of shore relief prevail (scenario No 4); 2 - synchronous reformation and adaptation of abrasive forms of shore relief (scenario No 4); 3 - passive flooding of gentle and low shore prevails (scenario No 3); 4 - sectors with hydrotechnical constructions and reformed shores.

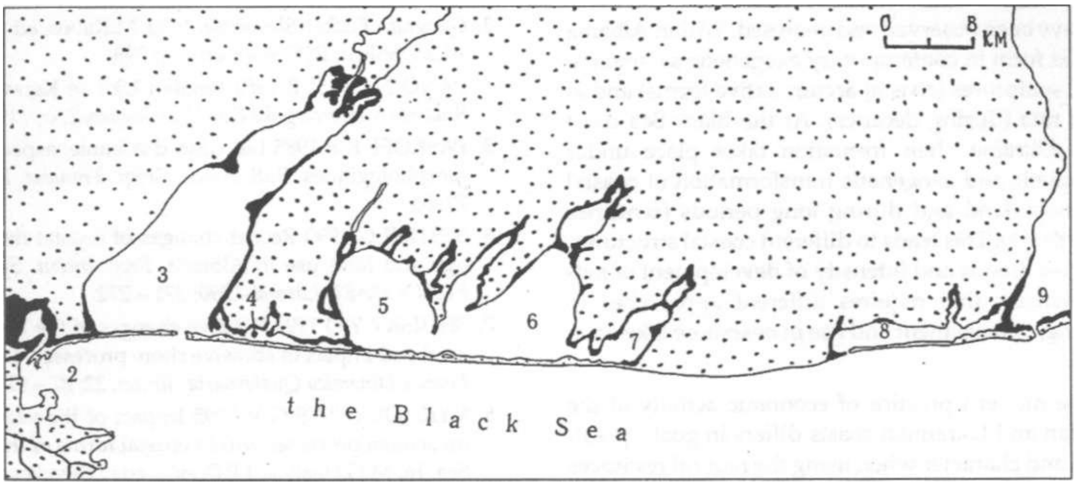

Figure 8. - Scheme of location of gentle and low shores which can be flooded (under the impact of 1 m level elevation in conditions of climate changes) within limans located between mouths of the Danube and Dniester rivers: 1 - the Danube delta; 2 - Jebriyan bay. Limans: 3 - Sasyk (Kunduk); 4 - Djentshey; 5 - Shagany; 6 - Alibey; 7 - Burnas; 8 - Budaki; 9 - Dniestrovskiy.

coastal sectors breaking of limanic and lagoonal barriers and bars, and confluence of their waters with the sea water are possible. Such phenomenon will inevitably lead to the change of hydrochemical regime of limanic and lagoonal waters, loss of salt-water, brine and medicinal mud quality, stopping of natural deposition of salt layers. At the same time some spits and bars separating coastal lakes from the sea could disappear. This goes together with the destruction of beaches, shore dunes, terraces and destruction of unique brushwood, habitats of birds, reptiles, arthropoda. If coastal lakes are intradeltaic, passive flooding can cause a disturbance of their development, change of depth, area and form. On the lake shores (particularly Tobechik, Uzunlar, Kizyl-Yar, Berezan, Dniestrovskiy, Karavastase, Nartes, Butrinti), elevation of underground water level will lead to restoration of old and ancient landslides, appearance of new ones, and therefore to the loss of arable land. In many lowland areas, a gentle limanic and lagoon shore elevation of water will