

## **Littoral concentration of life in the Black Sea area and coastal management requirements**

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### **Abstract.**

The biological diversity, numbers and biomass of plants and animals in the Black Sea coastal zone up to 5 m depth are at least twice as much than deeper. This phenomenon is due to presence of many permanent inhabitants and to adlittoral breeding and feeding migrations of fish. Predominance of early stages of development of marine organisms is very characteristic for this ecologic zone. Adjoining coastal wetlands are also very rich in marine, brackish water and salt water organisms. Different human activities in coastal zone are the reason of various ecological conflicts. Presented matrix of these conflicts in the Black Sea area can be useful for Integrated coastal zone management purposes.

### **Key words.**

Black Sea, contours, littoral concentration of life, adlittoral migrations, ecological conflicts, matrix

### **Introduction**

Littoral concentration of living organisms at the interfaces of three major subdivisions of the biosphere – land, salt water and fresh water is an overall biogeographical and ecological rule (Vernadsky, 1945, 1968). These interfaces are typical ecotones. An ecotone is a transition between two or more diverse communities as, for example, between a soft bottom and hard bottom marine community. It is a junction zone or a tension belt which may have considerable linear extent but is narrower than adjoining communities areas themselves. Often, both the number of species and the population density of some of the species are much greater in the ecotone than in the communities flanking it. The tendency for increased variety and density at community junctions is known as the edge effect (Odum, 1971).

The Black Sea area is not an exception to this general rule. There are many corroboratory data of this (Zaitsev, 1980, 1986, 1992, 2005).

Therefore in the Black Sea coastal zone (CZ) up to 5 m depth the biological diversity, numbers and biomass of plants and animals are at least twice as much than deeper. Distribution of the

main part of population of mass shallow water species is limited virtually by the 5 m depth line, or isobath (Zaitsev, 2005).

### **Material Sources**

Personal investigations of contour communities of Seas and Oceans and many published data (Sieburth, 1976, Aizatullin et al., 1979, Vinogradov, 1968, Zaitsev, 1961, 1970, 1980, 2005) shows that large numbers and biomasses of plants and animals are developing just on the boundaries of the pelagic zone. This is the result of intensive physico-chemical processes take place on the outer borders of the sea and leading to the concentration of dissolved and particulate non-living organic matter. The external biotopes, or contours, of the sea interfaces with the atmosphere, rocky, sandy, muddy shores and river waters are active surface areas providing the most advantageous conditions for the development of life-forms. Due to their location, the contour communities are exposed to negative external influences, including chemical and radioactive pollutions, much more heavily than the communities inhabiting the water column (Gerlach, 1985, Polikarpov, 1992, Polikarpov et al., 1977, On this evidence the conception of Contour communities, composed by organisms-contourbionts was proposed (Zaitsev, 1980, 1986). The thought that contour communities are important objects in marine monitoring is particularly accentuated.

### **Results and Discussions**

In the Black Sea coastal zone many key species are developing. Maximum density and biomass of green algae is noted at 3 m depth (Eremenko, 1969). The mass brown alga *Cystoseira barbata* is the most common at 2-4 m depth along rocky shores. The sea grasses *Zostera marina* and *Z. noltii* are inhabiting sandy beaches mainly at 0.5-3 m depth. At depths up to 5 m are most common dominant bivalves like *Corbulomia maeotica*, *Donacilla cornea*, *Cerastoderma lamarcki lamarcki*, *Mytilaster lineatus*, gastropods like *Patella tarentina*, *Melaraphe neritoides*, *Setia valvatoides*, *Hydrobia acuta*, *Gibbula divaricata*, Decapoda crustaceans, including shrimps and crabs, and other plant and invertebrate species, both pelagic and bottom organisms, including even insects (Diptera), like *Cricotopus vitripennis*, *Clunio marinus* and *C. ponticus*. This list includes also endemic and pontian relic species of amphipods (e.g. *Pontogammarus maeoticus*) and mollusks (*Hypanis colorata*, *H. pontica*) (Vinogradov, 1967, Eremeev, Gaevskaya, 2003).

Emphasizing this littoral accumulation of life, not less than 90 species of Black Sea fish (from about 125 species breeding in this sea) migrate to the CZ for breeding (adlittoral migrations). Among them there are species of many families: gobies (Gobiidae), silversides (Atherinidae), flatfishes (Scophthalmidae, Pleuronectidae, Soleidae), garfish (Belonidae), and other (Zaitsev, 1959, Dekhnik, 1972)..

According to author's estimation, the CZ is the main feeding ground for young and adult specimens of about 95 species of Black Sea fish.

Anadromous migrations from the sea into rivers to spawn through the CZ are inherent for 13 species of fish appertaining to families: Acipenseridae (sturgeons), Clupeidae (clupeids) and Salmonidae (salmonids). The young of this anadromous fish are feeding mainly in the CZ area.

Through the CZ pass over wintering migrations of fish and dolphins.

Black Sea coastal wetlands (CW) are very rich both in pelagic and benthic species (phytoplankton, zooplankton, benthos) and more than 30 species of marine fishes representatives of Mugilidae, Atherinidae and Gobiidae families are feeding here.

Black Sea CW are nesting grounds of about 150 species of birds feeding on aquatic organisms. Seasonal migrations of about 300 species of birds nesting in Europe and Asia are passing through Black Sea coastal area. Many of them are staying and feeding in the CZ and CW. Black Sea CZ is attractive also for some birds feeding on both marine and terrestrial organisms, which are nesting here, e.g. rook (*Corvus frugilegus*), hooded crow (*C. cornix*), jackdaw (*C. monedula*), bee-eater (*Merops apiaster*), roller (*Coracias garrulus*), Lesser kestrel (*Falco naumanni*). The CZ is obviously attractive also for terrestrial mammals, such as the wild boar (*Sus scrofa*), wild cat (*Felis silvestris*), raccoon dog (*Nyctereutes procyonoides*), roe deer (*Capreolus capreolus*), spotted deer (*Cervus nippon*), jackal (*Canis aureus*), different rodents etc.

So, the Black Sea CZ is, on the one hand, an area of high agglomeration of plants and animals of marine, fresh water and terrestrial origin, and on the other hand, a set of habitats crucial for natural reproduction of living organisms. This significant biosphere role of CZ is in diagram form presented in the Figure1.

In this connection is fully explainable the traditional human aspiration for the CZ, regarding permanent settlements, including large cities, intensive economic activities, tourism and recreation. In ecological terms, this is the main reason of strong man-made impact on this area with diverse negative consequences and appearance of an acute ecologically critical zone (Zaitsev and Polikarpov, 2002).

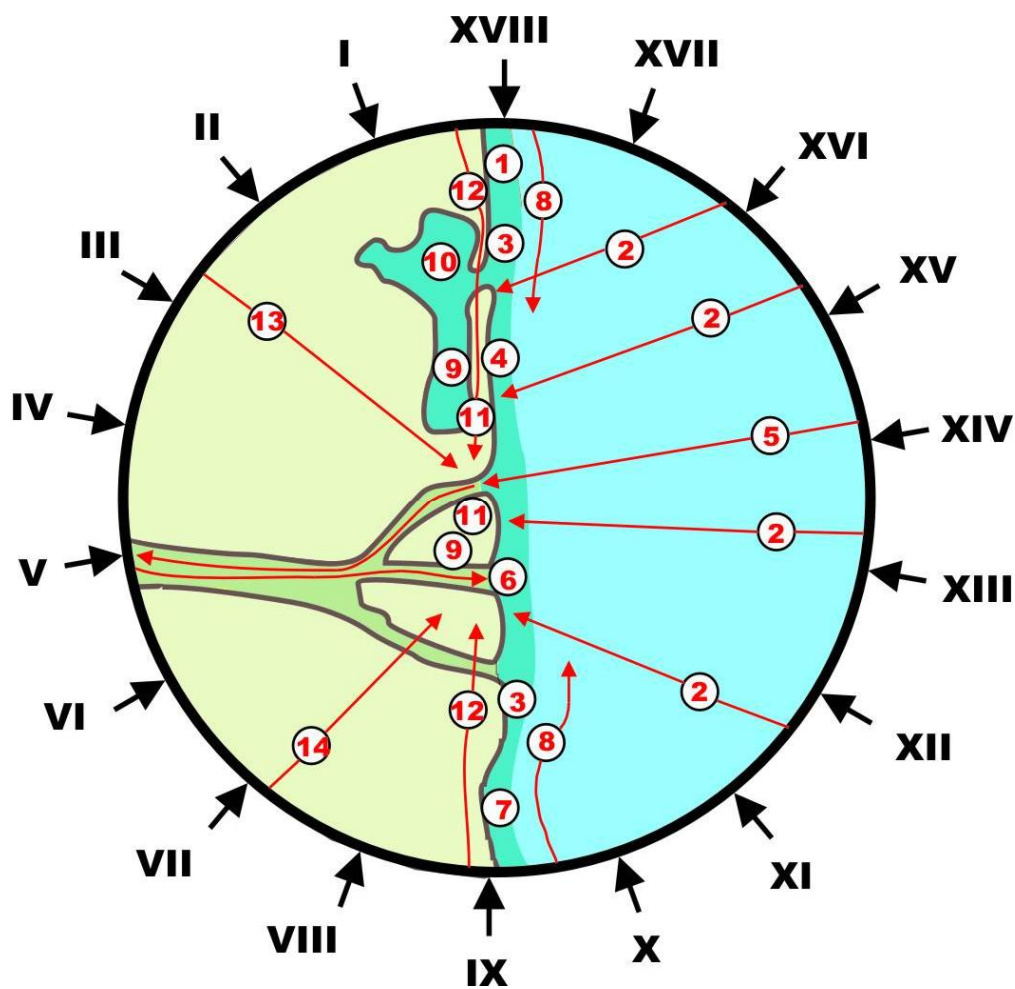


Figure 1. Concentration of life and man-made impact in the Black Sea coastal zone (an original scheme).

Natural factors. 1- High biological diversity, numbers and biomass of living organisms in contour (marginal) habitats of the sea; 2- Breeding migrations of fish from the open sea to the coasts (more than 95 species); 3- Fattening of young fish in the CZ (about 100 species); 4- Fattening of adult fish in the CZ (about 115 species); 5- Breeding migrations of anadromous fish from the sea into rivers (13 species); 6- Fattening of young fish of anadromous species in the CZ (13 species); 7- Wintering migrations of adult fish from the CZ (about 115 species); 8- Wintering and feeding migrations of young fish in the CZ (about 100 species); 9- High numbers and biomasses of living organisms in coastal limans, lagoons and river deltas; 10- Fattening of marine fish (young and adult) in limans and lagoons (more than 30 species); 11- Nesting of aquatic colonial and other birds on deltaic islands and on sand bars (up to 150 species); 12- Seasonal birds migrations with landing in the CZ (up to 300 species); 13- Tendency of terrestrial birds to the CZ (more that 15 species); 14- Tendency of terrestrial mammals to the CZ (more than 15 species).

Man-made factors. I- Industry; II- Agriculture; III- Animal husbandry; IV- Fish-breeding; V- Hydro-power engineering; VI- Municipal economy; VII- Seaside resorts; VIII- Night recreational activities;

IX- Fishery; X- Shelf mining; XI- Artificial reefs; XII- Sea transport; XIII- Dumping; XIV- Anti-landslide and cost protection works; XV- Nature conservation; XVI- Environmental control; XVII- Environmental Education and Environmental Ethics; XVIII- Integrated CZ Management (ICZM).

In the Black Sea CZ both negative (for the most part), and positive (few examples) effects of human activity were revealed. There are following main anthropogenic factors, having influence on the marine environment and first of all on the CZ (Figure1).

I – **Industry**. Large-scale industrial centers are located in or nearly large cities or in coastal areas rich in raw materials. Such are Odessa, Sebastopol, Kerch, Novorossisk, Batumi, Constanta, Varna, Burgas, Trabzon, and some other. (Note: The largest urban agglomeration and industrial center in the Black Sea area is Istanbul, but its industrial and domestic wastes are carried by water current practically only to the south – in the Sea of Marmara). Depending on specialization, different coastal situated industries can be sources of chemical, oil and radioactive pollution by mineral and organic substances. Extractive industry, first of all, sand mining on the shelf is a factor of destruction of sea-bed and devastation of communities of benthic organisms, including commercial species (mussels, clams, oysters and bottom fish).

II – **Agriculture** is a source of fertilizers, which causes man-made eutrophication of marine coastal waters and of different pesticides harmful for marine organisms. Especially rich in pesticides (insecticides, fungicides, herbicides) are sewage waters from rice culture (rice paddies), which are developing in Danube river delta, Dnieper river delta, northern Crimea, lower Cuban river, which flows into the Sea of Azov and some other areas of the Black Sea CZ. Soil erosion causes silting of sea bottom.

III – Large-scale **Animal husbandry** in coastal zone is a source of organic materials, which causes eutrophication, microbial and helminthological pollution of marine coastal waters.

IV – **Fish-breeding**. Artificial breeding of fishes is a real way to increase populations of commercial species. This is the case of yellowtail (*Seriola quinqueradiata*) in Japanese coastal waters and of salmon (*Salmo salar*) in the Norwegian Sea fjords. In these cases all cultured fish are used and possibly the only important negative effect of such kind of mariculture technology is local eutrophication of coastal waters by residual foods. The Black Sea sturgeons, which are cultured, for instance, in lower Don river area, from artificially fertilized eggs and released as young fish in the sea, pisciculture can be a reason of degeneration of fish population because of interbreeding of a few number of parents.

V – **Hydro-power engineering**. Construction of dams and reservoirs in rivers (especially in Danube, Dnister and Dniper rivers) strongly impacts hydrological and hydrochemical processes

in deltas, limans, CZ and are serious (usually insuperable) impediments for migrating anadromous fishes, like sturgeons, herrings and Black Sea salmon.

VI – **Municipal economy.** Discharge of insufficiently treated sewage waters, of rain water and water of melted snow leads to organic, chemical, bacteriologic and viral pollution of coastal waters, to silting of sandy beaches, to contamination of marine organisms, including edible ones. Municipal garbage to beaches is another impact on the CZ. Intensive and chaotic building in the CZ leads to the overload of coasts and threat of landslide. Apart from the worsening of aesthetic qualities of the CZ. The latter is a much-needed condition for successful development of tourism and recreation activities.

VII – **Seaside resorts.** Development of corresponding infrastructure and resort activities leads to pollution of beaches and coastal waters by organic and chemical substances, bacteria, plastic materials, different garbage, to worsening of life conditions in the beach and in the water.

VIII – **Night recreational activities.** Such activities just on the coast, as disco, loud music, bright light etc. leads to noise and light pollution of the nocturnal marine media and disturb the normal behaviour of marine organisms in the CZ.

IX – **Fishery.** Inadequate living resources management, overexploitation and pollution of coastal areas are reasons of decline of Black Sea commercial fish stocks like sturgeons (Acipenseridae), turbot, or calcan (*Psetta maeotica*) and some other species.

X – **Shelf mining.** Extraction of sand and gravel from the sea bed means devastation of benthic communities (e.g. mussel and oyster beds, sea grasses and algal communities), feeding grounds of commercial fish, like gobies, grey and red mullets, turbot, flounder, sole.

XI – **Sea transport.** This kind of human activity has many negative ecological effects in the Black Sea CZ. Enlargement of existent ports means devastation of coastal communities, exclusion of corresponding habitat from breeding and feeding grounds areas, and appearance of new sources of pollution in CZ. Construction of new ports in limans leads to deep hydrological transformation and threatening of relic fauna and flora inhabiting these water bodies. Deepening of sea bed is devastation of bottom communities. Discharging of ballast water in coastal areas leads to introduction of exotic organisms harmful for native species. Shipwreck is a threat for plants, animals and birds in CZ.

XII – **Dumping** is a factor of devastation of benthic communities in corresponding bottom areas and silting of surrounding waters.

XIII – **Anti-landslide and coast protection activities.** Reinforcement of beaches by addition of sand leads to change of life conditions of sand fauna (psammofauna), which is crucial for biological cleaning of sandy beaches. Different engineering constructions in the sea leads to creation of habitats with stagnant waters and barriers for migrations of young fish in CZ.

XIV – *Artificial reefs*. These constructions can be used both as elements of coastal protection and for CZ amelioration of aquatic environment.

XV – *Nature conservation* - mainly positive effects in CZ.

XVI – *Environmental control* - mainly positive effects in coastal zone.

XVII – *Environmental Education and Environmental Ethics* – only positive effects in CZ.

XVIII – *Integrated CZ Management (ICZM)* - only positive effects in CZ.

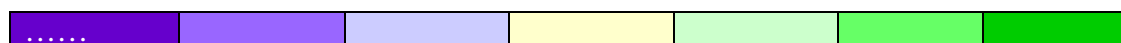
Spatial coincidence in the Black Sea CZ of maximum amount of living organisms (especially of the most vulnerable their early stages of development) and of strong human impact causes different types of ecological and economic conflicts, which are presented in a matrix (Figure 2).

As illustrated in the matrix, some coastal uses are incompatible with others. For instance, coastal fishery, fish-breeding, nature conservation, tourism and recreation, recovery of health are evidently incompatible with industrial, agricultural and urban waste discharge, destruction of bottom sediments, introduction of harmful exotic species. But all these occupations are traditional lines of work and the immediate task is to combine them with the most effectiveness for each. This is the destination of Integrated CZ management (ICZM), a very complicate but urgent task. One of important reasons of complexity of ICZM is the lack of scientific information and general poor understanding of coastal processes (Özhan, 1998).

Each portion of coast has its specific environmental conditions, its factors and effects and needs special investigations. Presented illustration (Figure 2) is a very generalized matrix, which can help the disclosure of the most conflicting activities to be taken into consideration.

## Generalized matrix of expert assessments of ecological processes in the Black Sea Coastal Zone

Response		Changes of life conditions							Biological and general changes						
		Salinity	Currents	Transparency	Pollution	Trophicity	Bottom sediments	Oxygen content	Disturbance	Concentration	Biological diversity	Bottom hypoxia	Stocks	Health risks	Marine food quality
I	Fishing														
	Mimimig														
	Industrial wastes														
II	Pesticides														
	Soil erosion														
	Agricultural runoff														
III	Residual foods														
	Genetic degeneration														
IV	Ports development														
	Deepening, Dumping														
	Ballast waters and exotic species														
	Shipwrecks														
V	Urban sewage														
	Rain waters														
VI	Addition of sand														
	Coast protection constructions														
VII	Dams														
	Reservoirs														
VIII	Resort development														
	Resort sewage														
	Recreational activities														
IX	Nature conservation														
	Environmental control														
	Artificial reefs														
X	Environmental education														
	Field trips														
	Books, posters, films														
Integrated Coastal Zone Management															



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Consequences: 1- Very negative; 2- Negative; 3- More negative than positive;

4- Uncertain; 5- More positive than negative; 6- Positive; 7- Very positive.

I. Industry, II. Agriculture, III. Pisciculture, IV. Sea transport, V. Municipal economy,

VI. Coast protection, VII. Hydro-power engineering, VIII. Tourism, Resorts, IX. Nature Conservation, X. Environmental Education and Environmental Ethics.

To date, ICZM in the Black Sea area is more a good intention than an accomplished fact. The developing of coasts is not as a rule enough managed and many ecological, economic and social conflicts are committed. Therefore positive examples of coastal management in other coastal regions are useful and instructive.

In the Mediterranean Sea area the most advanced scientist in the field of Coastal management is Prof. Erdal Özhan (2002) from Muğla University (Turkey) . Yearly International Training Programme on Integrated Coastal Management in the Mediterranean & Black Sea, organized by E. Ozhan, are a good example of dissemination of ICZM ideas. Some progresses in solution of existing local shoreline practices there are in Spain, France, Italy and Greece. Many very interesting examples from different European coastal areas are given in the EUCC Coastline magazine

Integrated management means an ecosystem approach to near-coastal ecological processes. Unfortunately, biological and ecological constituents of this approach remain the less investigated. Proposed matrix is an attempt to fill in part this gap in our knowledge. It is very generalized one but it allows to obtain an overall view of the environment and to emphasize the most critical aspects, which needs special additional investigations in case under consideration.

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