

## **Joint Marine Science Program of Studies in the Black Sea (CoMSBlack)**

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### **Introduction**

Studies of the Black Sea conducted by different institutions of several states, including the Soviet Union, have not been coordinated by a common program for many years. This has seriously delayed and lessened investigative results. The all-union program of studies was drafted in 1990. It was not launched because of the USSR disintegration. At present, the program has been prepared anew, as two national projects (Russian and Ukrainian).

Meanwhile, the necessity of a mutual program of the Black Sea studies, comprising all the states working in the basin, have become more obvious. This has brought a decision to draft a cooperative program, which was approved at the international meeting in Sofia (April, 1991). The program was called Cooperative Marine Science Program (CoMSBlack).

The report on the program draft and the works within its framework was presented to the IOC (UNESCO) by the national coordinators in 1993. Here, we give an account of the report.

### **What is CoMSBlack?**

CoMSBlack is an international program for the exploration of the Black Sea. The main objective of the CoMSBlack is to create a scientific basis for efficient and integrated management of the Black Sea ecosystem, including preservation and protection of the natural environment and optimum exploitation of the resources. This can be gained through the following thrusts: (1) the study of the fundamental physical, biological, chemical, and geological processes, determining the natural environment state, and the spatial and temporal variability of these features; (2) the study of the role of the anthropogenic pressure and the long-term climatic variability in ecosystem changes both in specific locations of the sea area and in the whole basin; (3) the development of feasible ecological models providing for the main and regional circulation dynamics; and (4) the development of a long-term database concentrating on fluxes of nutrients and other substance from rivers, atmosphere and bottom, coming via the Bosphorus and the Kerch Straits, as well as via river runoff.

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### **Motivations**

The Black Sea is a unique natural sea basin, which is almost completely separated from the ocean. It holds the world's largest amount of anoxic water, lying below the oxic surface layers. Thirteen percent of the Black Sea waters is rich in oxygen, while the rest, more deep waters, hold hydrogen sulfide. There is no life except bacteria below 100–200 m. The particularities of the basin are determined by river discharge, atmospheric features, thermohaline circulation, strait currents, and bottom topography. The circulation is generally driven by the Main Black Sea Current (MBSC), which develops a cyclonic gyre spreading over the whole basin and limited by the continental slope on the periphery, where unstable vortices, and small transient eddies occur. Convective and/or isopycnal mixing causes the formation of the Cold Intermediate Waters (CIW) which largely determine the basin ecology. Double diffusion can be observed as the Mediterranean waters sink and spread in the bottom layer of the deep sea.

Newly emerging problems of political and economic change in eastern Europe cause anxiety about the Black Sea environmental changes, which accelerate the growth of danger of ecosystem degradation. Recent data have confirmed the drastic changes in the structure and functioning of the ecosystem. Thus the previous vast area inhabited by the marine alga, phyllophora, has sharply decreased; benthos has almost disappeared in the spacious shelf regions (data based on summer measurements in the northwest part of the sea); the fishery yield has declined drastically; phytoplankton species variability has lessened; and the Black Sea population of the introduced Ctenophore *Mnemiopsis leidyi* has bloomed and quickly spread, etc. This biological crisis illustrates changes in the ecosystem biogeochemistry, i.e., increased flux of nutrients, heavy metals, pesticides, hydrocarbons, and other organic matter, causing a considerable eutrophication and toxicity, especially at the northwest shelf and along the coastline of the Black Sea.

The Black Sea shows a large range of both temporal and spatial biological variability. Thus primary production is characterized by sharp seasonal quantitative deviations, as diatoms generally bloom in winter/spring and flagellates in summer, while coccolithophora bloom is usually observed in summer and autumn. On the long-term scale, the climatic changes are the most significant ones, changes of the large and small river runoff,

in particular. The spatial deviations range from plankton patches to the basin global changes caused by a strong horizontal advection. Physical processes should be named first among different evidences of changes. Thrusts should be pointed at studies of processes both in the whole basin and of individual locations. The MBSC meandering, as well as the interaction of eddies and with the mean circulation form the basis for the dynamics of shelf - deep water exchange. Consequently, the role of dynamic processes in horizontal and vertical transport should be investigated in estuaries and coastal waters, as well as in central waters of the sea. Studies of fluxes across the shelf edge and their physical causes shall better explain the origin of heterogeneity of biological features.

The compactness of the Black Sea makes the basin a unique natural study area for synoptic studies. The variability of processes on numerous and superpositional scales actually makes the Black Sea a small-scale laboratory for studies of a number of oceanological features common to different parts of the World Ocean. These studies can be both field and theoretical. The closed nature of the sea and the observation of the whole basin are good reasons to use the Black sea as a test basin for comparison of physical and ecosystem models.

The Black Sea is also an ideal basin for studies of long-term hydrophysical variability climatic change, water balance components, and hydrophysical characteristics, which influence different biological and hydrochemical processes. Due to the Black Sea's unique characteristics (susceptibility to changes of water and salinity balance, almost complete separation and compactness), the basin is especially sensitive to climatic changes and land impact. Small deviations in the amount of precipitation evaporation, river discharge, or intensity of water mass exchange via the Bosphorus Strait during a relatively short period of time can influence processes on the whole basin scale.

The Black Sea is under considerable anthropogenic pressure. The Black Sea has a much higher ratio of drainage area to the water surface than any large sea basin. Consequently, it is more susceptible to anthropogenic processes on land. The majority of the population of the surrounding states lives in the coastal areas, and such rivers as the Danube and the Dniepr bring pollutants from a larger part of Europe. The growing demands of the ever-increasing industrial development influence live and inanimate marine resources more and more severely. Contemporary investigations show that physical, chemical, and biological characteristics of the sea, and, consequently, its ecological state, are continuously changing under the anthropogenic pressure. Hence the Black Sea is an unbalanced ecosystem and is especially interesting for science.

Thus fast changes of the Black Sea natural environment are reflected by the eutrophication of the greater part of the photic layer, the frequent anoxia in shelf waters, and the deterioration of water quality in estuaries, the microbiological and chemical pollution of water and live objects.

The estimation of environmental variability driven by anthropogenic pressure, or natural climatic trends and fluctuations, demands long-term studies. The whole basin eutrophication and the consequences are the most dangerous and irreparable among the processes influencing the environment. The assessment of the eutrophication sources, nutrient fluxes and their origin at land, redistribution in the Black Sea due to dynamic, and biochemical processes should be thorough and can be only obtained with precise monitoring.

The spatial and temporal transformation of carbon, nutrients, organisms, pollutants, and particulate matter and their transport across coastal and shelf waters and the shelf edge to open waters should be studied at great length. The role of the land input in the total flux of nutrients to the photic waters should be clarified. The nutrient flux across the boundary layer of interaction between oxic and anoxic waters is unknown and should be quantitatively determined, considering physical and chemical processes. The nutrient input via precipitates and from the atmosphere, as well as via straits should be also assessed. The anthropogenic and natural factors influencing the planktic species composition and abundance should be determined to obtain spatial and temporal trends of communities' response to changes of the environment. On this basis, quantitative characteristics of physical and biochemical processes and nutrient fluxes, influencing the whole basin productivity, are the most important.

The Black Sea compactness and internal dynamics provide for close interrelation of the individual regions. The right perception of the processes continuing in the basin demands general integrated explorations both in the individual regions and the whole basin. These studies are possible within the CoMSBlack framework.

## The Main Objectives

The main objectives of CoMSBlack are as follows: (1) to assess the natural and anthropogenic changes of all data available; (2) to determine the fluxes of water, particulate matter, nutrients, carbon, heavy metals, hydrocarbons, and other substances coming via rivers and straits, the input from atmosphere and bottom deposits at present and in the past; (3) to determine the fluxes of carbon, nutrients, organisms, and pollutants from coastal and shelf waters to the open sea; (4) to understand the fundamental physical and biogeochemical processes driving the transfer and transformation of carbon, nutrients, and other substance; (5) to provide for a quantitative estimation of the physical and biogeochemical processes and nutrient fluxes influencing the rates of primary production; (6) to assess the anthropogenic and natural impact on the structure and functioning of the aquatic (phyto- and zooplankton) and benthic (characteristic organisms) ecosystems; (7) to support modeling illustrating the main circulation patterns, ecosystem dynamics, and regional processes on different scales; and

(8) to assess the spatial and temporal characteristics of the main circulation and of the mesoscale characteristics of circulation energy, as well as the processes causing the development, spreading, and transformation of the cold intermediate waters.

## Program Development on the International Level

CoMSBlack was initiated by the ad hoc committee of the Sofia Conference (Bulgaria) in April, 1991. Scientists from the former Soviet Union, Bulgaria, Rumania, Turkey, the United States and members of the International Oceanographic Committee (IOC) became the founders. The Bulgarian conference was followed by international meetings in Constanta (Rumania, June, 1991) and in Erdemli (Turkey, July, 1991), which were aimed at the formation of international research working groups and the conduct of main field studies. The international working group met in Varna (Bulgaria, September 30 to October 6, 1991).

The Varna working group was attended by 125 scientists and representatives of the local administration to discuss the Black Sea state and possible reasons of degradation of the sea's natural environment and to assess the level of the contemporary knowledge. The scientific part of the project was developed at the meetings of several working groups in Turkey, Ukraine, Rumania, Bulgaria, and Russia.

The CoMSBlack program got the support of the IOC at the last session of the Executive Committee (IOC). The program was listed as a special research project with the International Committee on scientific investigations in the Mediterranean Sea.

## The Field Studies Program

The first important CoMSBlack field studies were the HYDROBLACK'91 cruises (September 2-29, 1991). Five research vessels from three Black Sea states took 300 stations. HYDROBLACK'91 was a quasi-synoptic

study of the sea and included measurements of salinity, temperature, oxygen, hydrogen sulfide, nutrients, and water transparency.

CoMSBlack'92 studies were conducted by five vessels in July, 1992. The main thrusts were to estimate the ichthyoplankton and populations of *Aurelia* (Ctenophora) and *Mnemiopsis leidyi* along the whole basin. The August (1992) survey by the two vessels was aimed at obtaining samples for the studies of the Chernobyl radionuclide distribution in the Black Sea. The rest of the investigations were planned to carry out a hydrophysical survey.

The CoMSBlack field studies were completed in 5 years. Now three different projects of integrated field studies have been proposed to include general surveys, studies of the dynamics, and fluxes of the coastal-open water circulation. All the field projects provide for a comprehensive assessment of phyto- and zooplankton, including fish eggs and larvae, characteristic benthic organisms, and predators.

## Conclusions

The CoMSBlack is an international interdisciplinary research project aimed at high quality oceanographic science, which shall provide for efficient and integrated management of the Black Sea ecosystem. A coordinated program of scientific investigations has been developed due to efforts by the major marine research institutions of the Black Sea states and of the Woods Hole Oceanographic Institute (United States), as well as other western research institutes. All working groups, symposia, and regular meetings were held to clarify the CoMSBlack role both in studies of the Black Sea and the major international scientific projects (JGOFS, WOCE, CoOp, etc.). Recent changes in the Black Sea states make such joint investigations possible and important for the efforts to ameliorate the Black Sea environment. The CoMSBlack is open for participation to all nations. The program's objective is to include new aspects of oceanography in current projects, and to further the activity of the present members, institutions, and states.