NEW APPROACHES IN THE ASSESSMENT OF THE BLACK SEA ECOSYSTEMS

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Motto: "*Days go past and days come still,*
All is old and all is new,
What is well and what is ill,
You imagine and construe…"
(Mihai Eminescu: Gloss)

INTRODUCTION

As it is already known, in the last 10–15 years the Black Sea has attracted special attention from the international community represented by members of governments, parliaments, academic institutions and non-governmental organizations in numerous countries and first of all in the riparian ones, all of them animated by the wish to save this sea from the ecological collapse revealed both by the facts and data of scientific research and by the economic decline.

After the Black Sea ecological crisis was confirmed worldwide, studied and managed equally by the scientific community, political factors and civil society, and numerous publications appeared as a final proof, today specialists think that the ecosystem ecological state witnesses a slight recovery. A positive fact, giving us hopes for an improved future of the benthic ecosystems, is the reappearance of some species considered extinct or extremely rare nowadays in the Black Sea. Among them species of sponges – *Suberites, Adocia*, mollusks – *Calyptrea chinensis*, tunicata – *Asciedella aspersa*, forms sensitive to disturbing factors, some of them extremely valuable for the economy of the sea.

May we speak of a gradual recovery of the Black Sea? Do we witness an improvement of the ecological situation of this sea? A betterment of the planktonic and benthic ecosystems? A redressing of the fishing resources? Is the economic decline of the riparian countries really saving the Black Sea?

Nevertheless, let's hope the ecological pressure will decrease simultaneously with the diminishing fertilizers and other chemicals used in agriculture or with the reduction of the fishing effort. But this is far from being all. There are also the manipulations of the hydrologic regime of Black Sea tributaries. There are also the large-scale variations. There are the global changes. There are so many steps to set, to know, without which it is hard to predict the Black Sea evolution.

In order to asses and answer if and to what extent the state of the Black Sea ecosystem has improved in comparison with the final decades of the 20th century, a new approach is necessary, which should be expressed in an Integrated Programmme of Studies and Management of the organic link between natural systems and socio-economic systems (Fig. 1). An alliance is necessary in order to achieve integrated systems of people and nature. This means holistic approach vs. sectional approach, the holistic approach being an integrative ecological approach.

For experts, managers and stakeholders the conclusions which come out consist in the following goals:

- the necessity of reaffirming the principle of applying the integrative holistic approach to the knowledge and management of the Black Sea ecosystem;
- considering the importance of benthic eco-systems as barometer of the ecological health state of the sea, which generates resources and services for socio-economic systems;
- highlighting the importance of developing basic ecological concepts – complexity of ecosystems, resilience, vulnerability, distur-bance, integrality of natural systems and socio-economic systems etc. in order to improve knowledge and management of the Black Sea;
- the necessity of thorough understanding of the Black Sea biodiversity process and building human resources in the field.

We shall continue by discussing only one aspect that concerns benthic life assessment of the Black Sea.

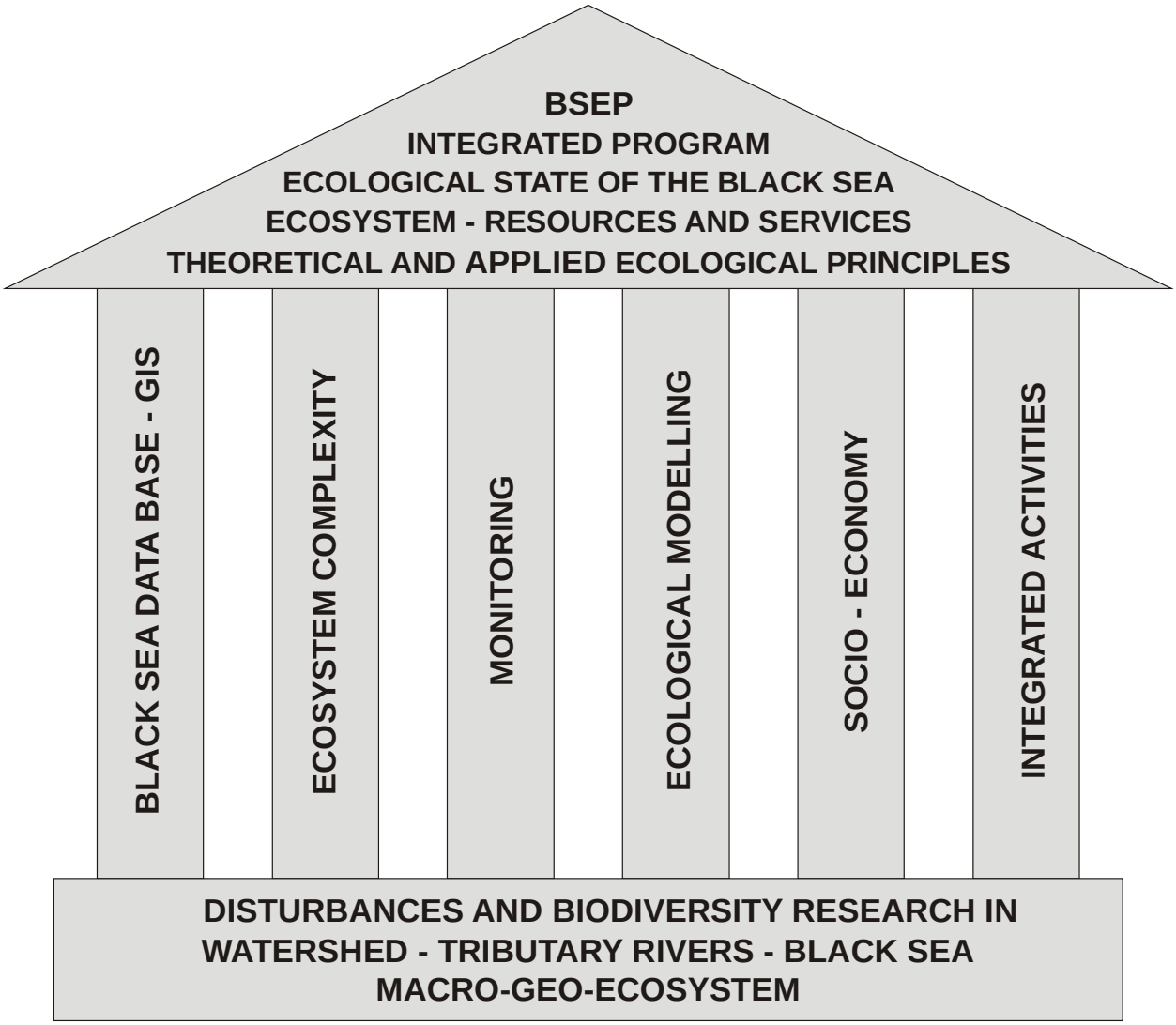

Figure 1 Conceptual framework for the integrated Program Impact, Disturbance**,** Resilience and Rehabilitation on the Black Sea Biodiversity and Health of Ecosystems

BENTHOS AS A BAROMETER FOR ECOLOGICAL PRESSURES IN MARINE ECOSYSTEMS

As mentioned above, in the last decades the Black Sea has suffered major changes induced by human activities. Pollution, eutrophication process and immigration of some non-native species produced irreversible changes in the structure of the autochthonous biocoenoses (BOX 1 and BOX 2).
The most visible changes occurred in planktonic communities, where the introduction of the predator ctenophore *Mnemiopsis leidyi* produced a dramatic decline of the fish stocks and in the benthic communities of the shallow water bottoms, where the North-Atlantic bivalve *Mya arenaria* became dominant species.

At the same time the present state of Black Sea benthic ecosystems, at least for those on the north-western continental shelf may be briefly characterized as follows:

- drastic decrease of the specific diversity;
- simplification of vegetal and animal benthic communities structures – biocoenotic homo-genizing;
- decrease of the numeric abundance and biomass of benthic populations;
- diminution of the biofilter strength by reduction of the filter – feeder populations;
- qualitative and quantitative worsening of benthic biological resources, especially molluscs, forms playing an important ecological part and with great economic importance;
- thriving of opportunistic forms (especially worm populations causing sediment bioturbation – *Melinna palmate*) and, temporarily, some exotic

species recently pervading Black Sea (*Mya, Scapharca, Rapana* etc.);
– great quantitative fluctuations of all benthic populations.

The state of Black Sea ecodiversity at the end of a long period of "ecological stability" was well known at the beginning of the 1970s, when the first signs of disturbance appeared, thanks to the issuing of a monographic volume in Romanian "Benthic ecological researches in the Black Sea – Qualitative, quantitative and comparative analyses of the Pontic benthic fauna" (Bacescu *et al*., 1971). However, there have been large gaps in the knowledge of the present state of the benthic populations in the last 10 years. Fortunately, the autumn of 2003 marks an advance in the study of the Black Sea benthos, thanks to GEF/BSEP which supported an international project (*"Control of eutrophication, hazardous substances and related measures for rehabilitating the Black Sea ecosystem: Phase 1: RER/01/G33 - BENTH0S RECOVERY" 2003 Cruise, Leg 1 - R/V Akademik*) in the North-Western part of the Black Sea, along the continental shelf between Burgas-Bulgaria and the Dniestr-Ukraine. The almost 400 quantitative samples, which are still processed, were taken from 61 stations on the bottoms situated between 15 - 130 m depth.

From this point of view, a special study of benthic biocoenoses – especially of those in deep water bottoms – is a necessity in order to estimate the human impact in marine environment. The scientific community of the marine researchers from the countries surrounding the Black Sea should focus on the following issues:

- holistic approach of benthic systems including
  - the complex structure/processes – functions
  - different spatial and temporal scales
  - biodiversity/sediments/near-bottom water masses;
- improvement and standardization of benthic methodology;
- supporting taxonomical revision; redescription of biocoenosis.

Goals:

- assessment of benthic populations state in the NW Black Sea;
- knowledge of the present structure and distribution of benthic organisms (specific determinations, occurrence, density, biomass, etc.);
- evaluation of benthic biological resources;
- inventory monitoring of the benthic species;
- better understanding of the whole Black Sea Ecosystem health and of its values.

Tasks:

The main tasks of the benthic studies which must give an answer to the question "Has the benthic system of the Black Sea begun to recover ?" should be as follows:

- general knowledge of the habitat: sediment characterization (grain size, chemistry including pollutant screening), physico-chemical characterisation of the near-bottom water;
- assessment of the qualitative and quantitative structure of benthic communities: specific biodiversity (including new introduced species), benthos abundance (density and biomass), macrobenthos/meiobenthos ratio;
- distribution of benthic populations as a function of gradients (bathymetric, salinitic, distance from freshwater sources) and depositional zones;
- spatial (vertical and horizontal) micro distributions in selected areas;
- knowledge of the population dynamics and succession, their behavior, vulnerability and resilience;
- understanding the complexity of the ecosystem.

A special attention should be accorded to the *Mytilus galloprovincialis* population status. The blue mussel is an important *characteristic* and *structuring* species and therefore has a key influence on the associated community at the proposed sampling sites. A change in the population status of the species may indicate a change/trend in the host biotope, and/or the sediment community as a whole. According to Zaitsev (1993, 1998) a drastic fall in the blue mussel stocks and associated benthic assemblages has occurred owing to eutrophication. The biological losses due to hypoxia on the north-western shelf are estimated at 100 to 200 t per square kilometer of seabed. Knowledge concerning the population dynamics of the species can be obtained by assessment of:

- extent and spatial pattern of *Mytilus galloprovincialis* beds;
- percentage cover of mussel patches, proportion of mussel patches/silt areas;
- size structure of population;
- filtration power, energetic value and capacity of bioaccumulation.

CONCLUSIONS

The evaluation of the Black Sea ecosystem state represents a complex, laborious, time consuming and rather imprecise process. What is the state of an ecosystem? An open, dynamic ecosystem, which in a shorter or longer period of time, in its succession, is and is not in the same structure, form and functioning. The experience in this field points to a one way path:

- developing a better understanding of the impact of disturbance on biodiversity and resilience by combining empirical and expert knowledge.
- identifying indicators of vulnerability, to improve monitoring methodology of changes in biodiversity, due to disturbance**.**
- developing simulation models on various spatial and temporal scales, that allow a) basic ecological understanding across different ecosystems and b) socio-economic assessment of disturbance and biodiversity management options.
- developing a multi-disciplinary scientific support for a) appropriate policy on prevention, need and public awareness of disturbance, b) testing and demonstration.
- translating the results into tools (i.e. handbook, generic decision support System) for ecosystem management in support of the "Black Sea Strategic Plan" and for the implementation of the European Biodiversity Strategy.

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BOX 1

CHANGES IN THE NW BLACK SEA ECOSYSTEMS

- increasing quantities of inorganic and organic nutrients
  - rapid eutrophication of the coastal waters
    - chronic algal bloomings;
      - increasing quantities of organic matter in sea water and sediments;
    - hypoxia and anoxia;
    - mass mortality of benthic organisms;
    - reduction of biodiversity;
    - qualitative and quantitative impoverishment of populations etc;

- increase in sea pollution and extension of contaminated zones from coastal to the off-shore waters;

- intensification of coastal morphodynamic processes, erosion dominating.

The major causes of the changes are closely connected with the Danubian System – the river, its whole catchment area including its Delta.

This system has a great influence upon marine ecosystems in the NW Black Sea generally and at the Romanian littoral particularly.

Formerly this system was healthy and wholly beneficial fertilizing the sea, favouring a high productivity at all trophic levels.

The rich fisheries, the red or brown algae meadows, the mussel and other living resources were nothing else but gifts of the Danube bestowed upon the sea.

BOX 2

IMPACT OF THE DANUBE RIVER DISCHARGE UPON NW BLACK SEA ECOSYSTEMS

Under the influence of numerous anthropic pressures in the last fifty years, the Danube river system is completely disturbed. The direct impact upon the river (hydrotechnical work – dams and embankments of the flooded zones, fluvial transport, wastewater discharge etc) and the indirect impact in the catchment (urbanization, industry development, intensive agriculture, reclamation works on the main tributary rivers, etc) were severe and complex and resulted in profound changes of the hydrology, hydrochemistry, the quantity and quality of biological resources on the other hand.

Loading of inorganic nutrients in the Danube water have been increased and eutrophication processes are usually common in many sectors. In comparison with the situation of the 1960's, the present nutrient concentration of the Danube is greater: approximately 1.7 times for nitrates and 1.5 for phosphates. In parallel with the nutrients, the concentration of pollutants increases as well (heavy metals, pesticides and contaminants).

The Danube discharges annually into the sea about 1.76 x 10^6 t nutrients (93.6% NO_3, 2.7% NO_2, and 2.4% P-PO_4), which represent 99.525% of the total nutrient influx at the Romanian shore (0.475% is the contribution of effluents). On the basis of the average values of some parameters and the mean multiannual water discharge of the river (6050 $m^3.s^{-1}$) the Danube River discharges into the Black Sea the following quantities (tones*10^3*$year^{-1}$): phytoplankton – 286.189, zooplankton – 6.212, solid suspension – 3221.673, NO_3 – 1062.334, PO_4 – 23.057, Cu – 1.355, Ni – 0.359, Fe – 117.624, Mn – 8.443, As – 2.601, detergents – 3.116.

The ecosystems in the lower sector of the Danube River are strongly affected, being characterized by:

- low diversity – uniformity, general dominance of 2-3 forms, both in plankton and benthos and existence of very few "islands" of higher diversity and abundance
- distribution of the population in patches,
- quantitative scarcity in more than 50% of the biotopes.

The effects of human activities in the catchment of the great "diagonal" of Europe cause disturbances in marine ecosystems. The major consequence of these disturbances is the drastic reduction of specific diversity.

In the present-day simplified structure of the Black Sea with opportunistic recent immigrant species, the new mechanisms of biological production are less understood at present. The new ecological balance remains delicate, fragile, unforeseeable, dominated by the Danube influence; consequently measures are necessary for ecological restoration, protection and conservation, both in the Danube and NW Black Sea ecosystems.