Marine environmental assessment of the Northwestern Black Sea area

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Introduction

Black Sea has suffered major changes induced by human activities. Pollution, the eutrophication process and immigration of some exotic species produced irreversible changes in the structure and function of the autochthonous biocoenoses. These changes, consisting mainly in:

— drastic decrease of the specific diversity;

— simplifying of vegetal and animal benthic communities structures — biocoenotic homogenizing;

— decrease of the numeric abundance and biomass of benthic populations;

— replacement of some strong and quiet large benthic populations by metapopulation of small extension;

— 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 worms 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.

This is reached a climax in the NW Black Sea, a restricted part of the sea under the stress of a huge discharge of freshwater, representing the most interesting and complex sector of this semi-enclosed sea and largely dictating the environmental state of the entire Black Sea.

However, in the last years, some signs of recovery were repeatedly signalled. In an attempt to confirm or infirm this recovery the present study intends to assess the actual tendencies of the ecosystems and the present environmental conditions of the bottoms from the NW Black Sea.

During the 2003 cruise of R/V Akademic, performed within the framework of the GEF/UNDP Black Sea Ecosystem Recovery Project "Control of eutrophication, hazardous substances and related measures for rehabilitating the Black Sea ecosystem: Phase 1: RER/01/G33", bottom waters and sediments were sampled with a Mark II-400 multicorer in 61 stations distributed on 8 transects, from Burgas (Bulgaria) to Dnieper (Ukraine). The bottom water samples were analysed on shipboard for DO concentration and saturation, salinity (conductivity), pH and Eh. The recovered sediment cores were subsampled for sedimentological, geochemical and biological laboratory analyses, the obtained data being used to evaluate the ecological state of NW Black Sea. Older data, from previous National Institute of Marine Geology and Geoecology GeoEcoMar cruises, were used as comparison terms.

Bottom waters

The results of the bottom waters analyses usually indicate a good oxygenation at water depths lower than app. 75 m. The hypoxia (O_2 concentration <4 mg/l) installs around 90 m water depth (fig. 1) and accentuates rapidly at greater depths, O_2 concentrations being <0.5 mg/l at water depths of 120-130 m.

At shallower depths (<40 m) O_2 concentrations indicating a slight hypoxia were recorded only in the Odessa Bay and in front of the Dniepr River. Lower, near-hypoxic concentrations were also signalled at shallow depths on the Varna, Sf. Gheorge and Sulina transects. Despite these lower concentrations, the general situation marks a significant improvement compared with the 1991 situation, when anoxic waters were identified in Odessa Bay, while hypoxia occupied extended bottom surfaces in front of the Danube mouths.

Due to the increase of CO_2 partial pressure, the pH values show a normal, statistically significant, exponential decrease with depth (fig. 2). Intensive

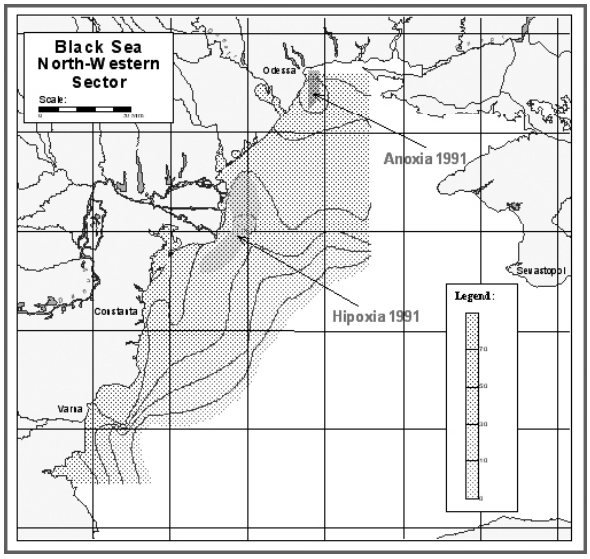

Fig. 1. O_2 saturation in the NW Black Sea bottom waters

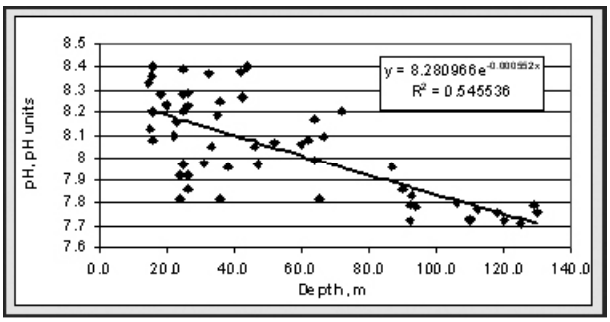

Fig. 2. Depth — pH relation in the bottom waters from the NW Black Sea

biological processes, both producing and consuming CO_2, induce a much higher dispersion of pH values at shallow depths (<40 m). The pH calculated average value for 0 m depth (8.28) is roughly similar to the previously calculated value of 8.22 (Secrieru, 1992).

Salinity (and conductivity) show normal increasing tendencies southward and eastward, as the influence of the massive freshwater discharge of Danube decreases. Still this influence may be identified as far as Burgas (slightly lower salinities in the depth interval 35-45 m).

Sedimentological and geochemical characterization

The sediments range from typically terrigenous, with <10% $CaCO_3$ to highly carbonated biogenous sediments with >50% $CaCO_3$, from pure sand to pure clay. Most biologically controlled components, highly mobile components (manganese) and all the trace elements with high technophyllic indices have coefficients of variation well over 55%.

The analyses of the sedimentological data identified four main facies separated by litho-structural characteristics.

The ***„fluffy" layer*** (FL), as a low calcareous to calcareous dark semiliquid layer, representing the sediment-water interface (at water depths greater than 180 m), greenish gray, with suspended greenish-gray flocks in liquid suspension, density increases downward, jelly like towards base.

The ***hemipelagic strata*** (HPS), consisting in clayey silt to silty clay sediments, massive or laminated (marked by small shell fragments), with randomly distributed shells and shell fragments, appear on the shelf area of Ukraine and Romania (Danube Delta Front and Prodelta, Dniester and Dnieper discharge areas — Panin et al., 1999). The sediments are mostly terrigenous, characterized by high organic carbon and heavy metal concentrations, reflecting strong anthropic influences.

The ***shell hash strata*** (SHS) composed from shell fragments and unsorted shells into an organic sandy or muddy matrix, soft or compact, develops as continuous or lenticular layers especially on the sediment starving continental shelf. Chemically, the sediments are characterized by the dominance of organogenous calcium carbonate. Consequently, the terrigenous components including most heavy metals have low concentrations. The area is characterized by active post-depositional migration of manganese towards the sediment-water interface. Here, favourable conditions (Eh, presence of favourable surfaces offered by the *Modiolus phaseolinus* shells) boosts the manganese hydrated oxides precipitation which forms crusts of hydrated oxides on the surface shells. As a result the surface sediments from the area may be strongly enriched in MnO (up to 4.4% at 90 m water depth on the Sulina transect). The crusts are also significantly enriched in Ba, Co and Ni, locally increasing significantly the total metal concentration in the surface sediments.

The ***terrigenous sandy strata*** (TSS), represented by continuous or lenticular layers (1-7 cm thickness), composed from terrigenous sand to clayey sand, massive or parallel laminated, compact to semicompact, penetrated by traces of organic activity in different positions, with sharp limits or scour base is well represented on the Bulgarian shelf zone. The dominance of the coarse fraction is the result of the higher energy relief of the Bulgarian coast. The sediments are characterized by relatively high contents of heavy minerals, reflected in Ti and Zr concentrations.

Normal horizontal distribution patterns of the chemical components show a gradual offshore decrease of the terrigenous components concentrations and increase in concentrations of biogenic calcium carbonate and its associated trace element Sr. Statis-

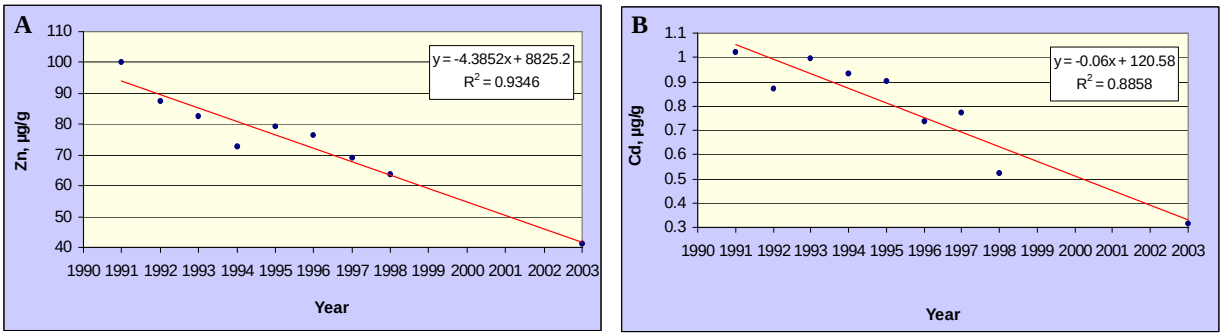

Fig. 3. Time variation of average metal concentration in the uppermost layer of sediment: A — average Zn concentration, B — average Cd concentration

Table 1. Tendency of NW Black Sea benthic ecosystem evolution in the last decade

Indicatives	1995 – 2003	1995	1997	1998	2003
Group	33	20	25	15	33
Taxa	359	125	118	70	305
Species	338	117	110	66	284
Macrobenthic	270	74	83	44	240
Meiobenthic	89	51	35	26	65
D indvs.m^{-2}	107470	29394	191244	43194	166049.40
B g.m^{-2}	197.05	196.23	158.14	36.51	397.32
D_{macro} indvs.m^{-2}	10544.01	3067.46	16736.00	9529.00	12843.58
B_{macro} g.m^{-2}	199.89	209.16	164.00	33.25	393.14
D_{meio} indvs.m^{-2}	97167.78	26531.03	175269.27	33665.00	153205.83
B_{meio} g.m^{-2}	2.51	1.02	1.60	3.24	1.184

tical graphical and mathematical analyses of chemical data show abnormally high concentrations of most heavy metals at some stations. The upper 25-30 cm of sediment were measurably enriched in all of the considered heavy metals, excepting Cr and V, with a strong increasing tendency of metal excesses toward the sediment-water interface. The Danube prodelta is one of the most heavy metal polluted area, almost the entire sampled sediment column showing heavy metal anthropic excesses, the high contamination degree witnessing the importance of the Danube as the main transporter of pollutants. The second heavily polluted area, the sediment starving continental shelf was related to off-shore drilling activities, as determined by intensive Ba contamination (>1000 ppm in sediments from the Constanta and Sf. Gheorghe transects). As sediments are normally poor in terrigenous components, the anthropic excess may be higher than in Danube Delta front. The intensity of heavy metal pollution seems to be decreasing in the recent years, the average concentrations in the uppermost layer of sediment decreasing gradually over the last decade (fig. 3a, 3b). The decrease is probably related to the economical decline resulting in lower industrial discharges in the riparian countries.

Benthic fauna

The comparative analysis of data from several cruises, including the GEF 2003 cruise, on the benthic communities, one of the most sensitive barometers of the pressures and ecological changes within the ecosystems (Table 1) indicates a slight recovery of the NW Black Sea ecosystems, concretised in:

— Biodiversity, with a little higher number of species is slightly better than in the last decades, 305 taxa (284 species and 21 supra-specific taxa — *Nematoda* and *Nemertini worms*, *Harpacticoida crustacians*, *Bryozoa*, *Chironomida* etc.).

— Abundance of benthic populations is regular towards better, the general average values for the NW Black Sea, 0-125 m being 166,049 indvs.m^{-2} for numerical density and 397 g.m^{-2} for biomass.

— There is a large variation of the abundance of benthic populations from one station to another, but the average values of the three continental shelves (Ukraine, Romania, Bulgaria) are similar: 9246-

12660 indvs.m^{-2} and 462.14-465.2 g.m^{-2} for macrobenthos and 149795-164376 indvs.m^{-2} and 5.6-20.9 g.m^{-2} for meiobenthos.

— The occurrence of some recurrent species, considered almost extinct 2-3 decades ago, represents a positive event, promising for the future recovery of the ecosystem.

— Benthos populations have a random distribution, in patches, being characterized by occurrence of some meta-populations.

— The existence of two-year old mussels in this area is also promising and contrasts with the situation in the late 1980s where all new recruits were killed by the annual appearance of the dead zone.

Despite all these gladdening improvements signs, sustained by a certain improvement of the environmental conditions (less pollution, better oxygenation of bottom waters), the recovery of the benthic system is rather weak. There are still uncertainties and it is too early to draw a high confidence conclusion on the recovery, the evaluation of the Black Sea ecosystem state representing a complex, laborious, time consuming and rather imprecise process for the moment

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