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# Long term changes and recent state of Macrozoobenthic communities along the Bulgarian Black Sea coast

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## Abstract

*The analysis of macrozoobenthic samples collected from 34 stations along the Bulgarian Black Sea shelf at depths ranging from 12 to 83 m yielded 103 taxonomic units. The average abundance established in the present study was over 5000 ind/m$^2$ with nearly 70% dominance of the polychaetes. The number of species, Shannon-Wiener diversity index (H') and Pielou's evenness (J) were the lowest in Varna and Burgas bays, indicating that they are the most ecologically threatened areas along the Bulgarian Black Sea coast. The quantitative and qualitative data were compared to published data from the pristine period 1954-1957 and from the period 1982-1985 with intensive anthropogenic pressure. The comparison revealed an increase of the share of molluscan species and a decrease of the contribution of crustacean species in the total number of species. A 7-fold increase of the total average abundance was established compared to the pristine period 1954-1957. During the recent period the polychaetes are the most dominant group in the benthic abundance, while during the pristine period 1954-1957 the most abundant were the molluscs with nearly 61% of the total abundance. These changes in the benthic communities are attributed to the process of eutrophication. While in the pelagic environment signs of recovery have been observed, we deem that up to 1997 no such signs are valid for the benthic communities.*

**Keywords:** Black Sea, Macrozoobenthos, Recent state and changes.

## Introduction

Benthic communities have long been studied as a measure of environmental quality (HOLME & MC INTYRE, 1971). Since most macrofauna species are relatively long-lived (over 1 year) and sessile, they act as integrators of the effects of environmental stresses whether or not the stresses are natural or anthropogenic.

Anthropogenic eutrophicaton has been identified as the major problem for the Black Sea ecosystem and the main reason for the degradation of the marine environment in the basin (BELBEROV & KONSULOV, 1993; GOMOIU, 1992; ZAITSEV, 1993; ZAITSEV & MAMAEV, 1997). The period prior to the mid-1960s is considered a relatively pristine period, when the Black Sea communities were comparatively undisturbed by anthropogenic factors. The period from the late 1960s to the beginning of the 1990s is recognized as a period of huge eutrophication of the marine environment with far-going consequences for the marine biota (KONSULOV *et. al.*, 1998).

Macrozoobenthic communities, in particular, suffered from the hypoxia in the bottom water layers that resulted in annual mass mortatlities of the zoobenthos and nektobenthic fish (GOMOIU, 1998; KONSULOVA *et. al.,* 1991; MONCHEVA *et. al.*, 1995; ZAITSEV, 1993).

During the 1990s due to the economic recession of the former socialist countries in the Black Sea region the land- based sources and river input of nutrients and contaminants to the basin have been reduced. Some researchers have detected signs of recovery in the pelagic ecosystem in the recent period, especially in the phytoplankton communities (KONSULOV *et. al.*, 1998; SHTEREVA *et. al.,* 1998).

The objective of the present research is to investigate the long-term changes in terms of both taxonomic diversi ty and quantitative parameters (abundance) and study the recent state of the soft bottom macrozoobenthic communities along the Bulgarian Black Sea coast.

## Materials and methods

In the period from June 1996 to June 1997 macrozoobenthic samples were collected from 34 stations along the Bulgarian Black Sea coast - 15 of them from the open coastal zone and 19 from the largest Bulgarian bays: Varna bay and Burgas bay (Fig.1). Van Veen grab with sampling area 0.1 $m^2$ was used. The depth of the sampling stations varied from 12 m to 83 m. The samples were sieved through 0.6 mm mesh and preserved in 4% formaldehyde. In the laboratory the samples were sorted and macrofaunal organisms were identified and enumerated at the species level (except for the following taxonomic groups that were identified at higher taxonomic level: Turbellaria, Nemertini, Oligochaeta, Acarina, Chironomidae).

Shannon-Wiener community diversity index H' (SHANNON & WEAVER, 1963) and the associated evenness of distribution index J (PIELOU, 1966) were calculated on

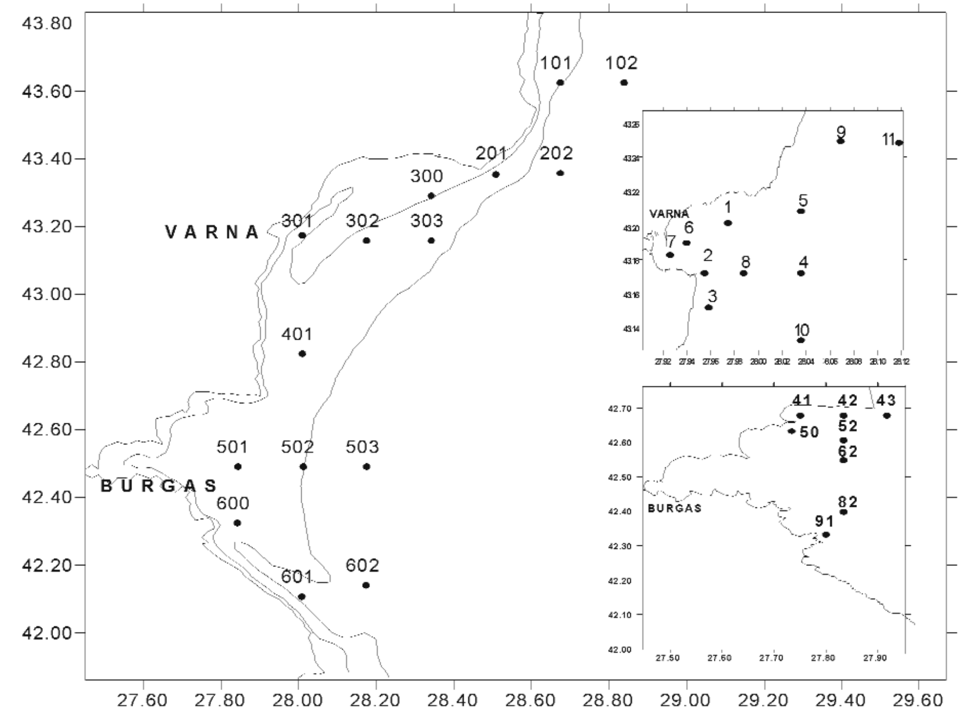


*Fig.1:* Map of sampling locations.

the raw abundance data for each sample.

The Bray-Curtis similarity index (BRAY & CURTIS, 1957), based on log (x+1) transformed abundance data, was calculated to assess the similarity between the sampling stations. To delimit communities a classification of stations was performed on the similarities matrix by using the average-linkage clustering technique (SOKAL & SNEATH, 1963). Multidimensional Scaling (MDS) ordination analysis (FIELD *et al*., 1982) was performed with the same configuration as the cluster analysis with respect to similarity index and transformation in order to reveal the gradation of the community structure and the relationship between the community and the depth. Cluster analysis and MDS were performed with PRIMER software package (developed in Plymouth Marine Laboratory).

In order to reveal some long-term changes in the macrobenthic communities the qualitative composition and the abundance data obtained in the present study were compared to historical data from the periods 1954-1957 (KANEVA-ABADJIEVA & MARINOV, 1960) and 1982-1985, (MARINOV & STOJKOV, 1990). The first of the periods was chosen as representing the ecological background of the relatively pristine environment and the second- as exemplifying the most intensive anthropogenic pressure over the Black Sea.

## Results and discussion

### Fauna and abundance

103 species and higher taxa were identified. The major taxonomic groups were Polychaeta - 33 species (32.04 %), Mollusca - 31 species (30.09 %)and Crustacea - 25 species (24.27 %). The rest of the taxa belonged to Anthozoa, Nemertini, Oligochaeta, Acarina, Insecta, Phoronidea, Echinodermata and Ascidiacea.

A comparison of the contribution of the three major taxonomic groups to the total macrofauna composition with the periods 1954-57 and 1982-85 is given in figure 2. The absolute number of species is not taken into consideration because of the different sampling effort during these three periods. The percentage share of the polychaetes main - tains almost the same level during the three compared periods, but there is a decreasing trend in the crustaceans' contribution: from 36.8 % in 1954-1957 to 27.5 % in 1982-1985 and to 24.27 % in 1996-1997. The opposite increasing trend is noticeable for the share

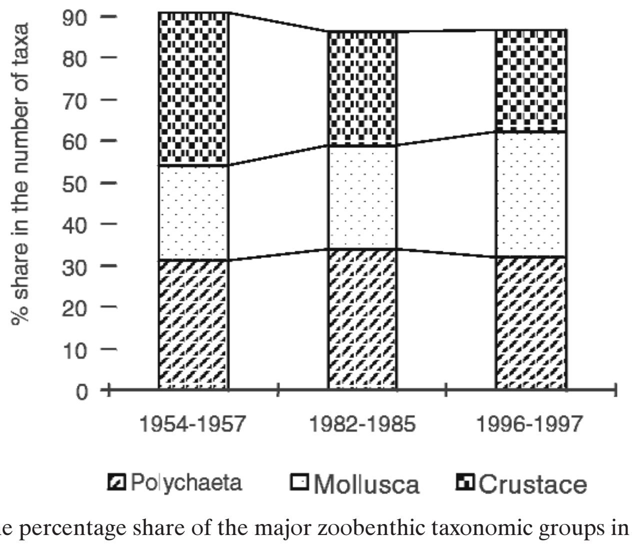


*Fig. 2:* Trend in the percentage share of the major zoobenthic taxonomic groups in the total number of taxa (group "miscellanea" is not included).

**Table 1**
**Species with changed % of occurrence since 1950s.**

| Taxonomic group | Species that became rare | Species with increased occurrence |
|---|---|---|
| *Mollusca* | *Syndesmya alba* | *Cunearca cornea* |
| | *Syndesmya fragilis* | *Mya arenaria* |
| | *Polititapes aurea* | |
| *Crustacea* | *Upogebia pusilla* | |
| *Polychaeta* | | *Polydora ciliata* |

of the molluscs: from 22.7 % in 1954-1957 it increased to 25 % in 1980s and to 30.09 % in 1996-1997.

Further comparison was made between the species with high percentage of occurrence (percentage of stations where a species occurs) in the 1950s and the 1990s. Some of the species that were common in the 1950s displayed also high occurrence in the present study. Among these are the polychaetes *Melinna palmata, Aricidea claudiae, Nephthys hombergii, Heteromastus filiformis,* the molluscs *Cardium edule, Parvicardium exiguum, Chamelea gallina, Mytilus galloprovincialis, Spisula subtruncata* and the crustaceans *Ampelisca diadema, Apseudopsis ostroumovi, Balanus improvisus* and *Iphinoe elisae.* Undoubtedly, these species are the most tolerant both to natural and anthropogenic stresses as it is obvious by their wide spread both in space and in time.

Some noticeable differences in the species composition between the undisturbed period and the recent period are presented in Table 1. Some species common in the past have become rare. The most typical example is the decapod crustacean *Upogebia pusilla.* This species was hypoxia victim during the annual mass mortality of zoobenthos along the Bulgarian Black Sea coast (KONSULOVA *et.al.*, 1991). Vulnerable to hypoxia bivalvia species are *Syndesmya alba, Syndesmya fragilis* and *Polititapes aurea*. These species were not encountered in the present study, though they were very common in the 1950s.

On the other hand new invaders that found favourable trophic conditions in the Black Sea entered the mollusc list. These were *Mya arenaria*, first recorded in 1966 (BESHEVLI & KOLYAGHIN, 1967) and *Cunearca cornea* - found for the first time in the Black Sea in 1982 (MARINOV, 1990). Both species are very tolerant to hypoxia (CVETKOV & MARINOV, 1986, ZAITSEV & MAMAEV, 1997), which is the probable reason for their firm establishment and mass development during the period of the most pronounced anthropogenic eutrophication in the Black Sea.

*Polydora ciliata* was not found in the 1954-57 investigation, while in the present study it was one of the most widely spread species, reaching high abundance at some stations. This small polychaete worm is considered as an indicator of organic pollution (PEARSON & ROSENBERG, 1978).

The average total macrozoobenthic abundance established in the present study was over 5000 ind/m$^2$ with nearly 70 % dominance of the polychaetes. Compared to the pristine period 1954-1957 there is 7-fold increase of the total average abundance and 16-fold increase of the polychaetes abundance.

The percentage share of Polychaeta, Mollusca and Crustacea in the total average abundance for the three compared periods is represented in figure 3. There is a clearly manifested growing trend in the polychaetes contribution from 30 % during the "clean" period (1954-57) to 44 % during the 1980s and to 70 % during the recent period. Currently the polychaetes became the most dominant group in the benthic abundance, while during the pristine period 1954-1957 the most abundant were the molluscs with nearly 61 % of the total abundance.

The crustacean *Apseudopsis ostroumovi* also exhibits increased abundance, which indicates that probably this is an opportunistic species. Its high abundance contributes to the enlargement of the crustaceans' share in the total benthic abundance in figure 3.

The reduced benthic diversity and the degradation of communities to opportunistic species are well documented and predictable responses to the environmental stress (GRAY, 1989). It has been verified that the eutrophication and the recurrent phytoplankton "blooms", the subsequent organic enrichment of the sediments and hypoxia in the near-bottom water layers are major stresses for the macrozoobenthic communities in the north-western part of the Black Sea resulting in mass mortality of benthic invertebrates, extinction of sensitive species and eventually a decreased diversity (GOMOIU, 1992; KONSULOV, 1998; ZAITSEV, 1993).

It is not possible in the present study to assess and relate to eutrophication the total taxonomic diversity decrease because of the different sampling effort during the three compared periods. An alternative indication of the eutrophication impact is the change of the major taxonomic groups' percentage contribution to the total number of species, because of the differences between the molluscs, crustaceans and polychaetes in their tolerance, or their ability to adapt to an altered environment and to the hypoxia in particular. The most vulnerable to hypoxia are the crustaceans - oxygen concentration below 1.5-2 ml/l is lethal for them (ZAITSEV & MAMAEV, 1997). The polychaetes are the most tolerant - they survive concentrations as low as 0.5 ml/l (ZAITSEV & MAMAEV, 1997). Many bivalve species are able to close their shells tightly and use the oxygen reserves retained in their tissues (ZAITSEV & MAMAEV, 1997), which makes them very tolerant to harsh environmental conditions, hypoxia included. Evidently the relative diversity decrease of the crustacean species is a consequence of their weak physiological resistance to low oxygen concentration, while the relative increase in number of molluscan species is due to their hypoxia tolerance. The enrichment in trophic recourses favours those species that are hypoxia tolerant and predetermined the invasion of *Mya arenaria* and *Cunearca cornea*, while many sensitive decapod crustaceans, e.g. *Upogebia pusilla* and *Macropipus holsatus* became very rare (KONSULOVA *et al.,* 1991).

Another evidence of the eutrophication is the burst of the polychaetes' abundance. The polychaetes are both hypoxia tolerant and opportunists in their life-strategy that favours them in an altered environment

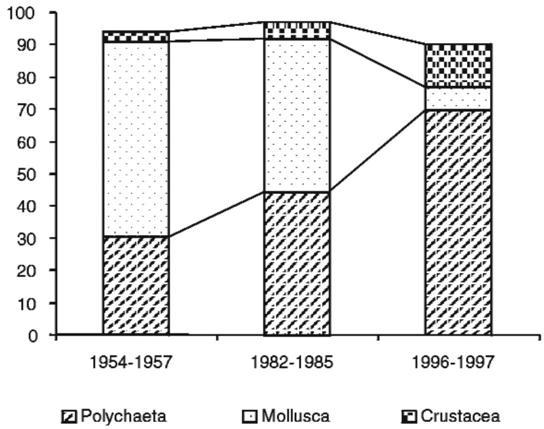


***Fig.3:*** Trend in the percentage share of the major zoobenthic taxonomic groups in the average abundance.

(PEARSON & ROSENBERG, 1978; WARWICK *et al.,* 1987). The predominance of the small rapidly breeding annelids is a response to the superabundance of food available to deposit feeders that is a consequence of the elevated organic load on the bottom resulting both from the organic pollution and the eutrophicaton.

In contrast to the pelagic communities in which signs of recovery have been recognised currently (KONSULOV *et al*., 1998; SHTEREVA *et al*., 1998), the zoobenthic community appears to be even more disturbed in 1996-1997 than in the 1980s. This is evident from figure 2 and figure 3, in which the negative trends in the benthic taxonomic structure and abundance are most distinct in 1996-1997. Clearly, a short period of decreased discharges of nutrients and pollutants is not sufficient for improvement of the benthic ecosystem. If the anthropogenic pressure continues to decrease, restoration of the zoobenthic communities should be expected, but obviously this will take longer time than the recovery of the pelagic communities.

Similarity

The results of the classification analysis is represented on the dendrogram of Figure 4. Three major groups were differentiated. Group 1 includes stations with average similarity 43 %. In group 2 there are differentiated stations with average similarity 49 %. Group 3 includes stations with average similarity 50 %.

The above grouping is also illustrated on the MDS-ordination plot of figure 5. In figure 5a the stations are plotted with their group numbers. The distribution of the stations on the plot reveals a gradual transformation of the community composition: group 1 stations are situated on the left of the plot, group 2 stations are in the middle and group 3 stations - on the right. The ordination plot with superimposed depth

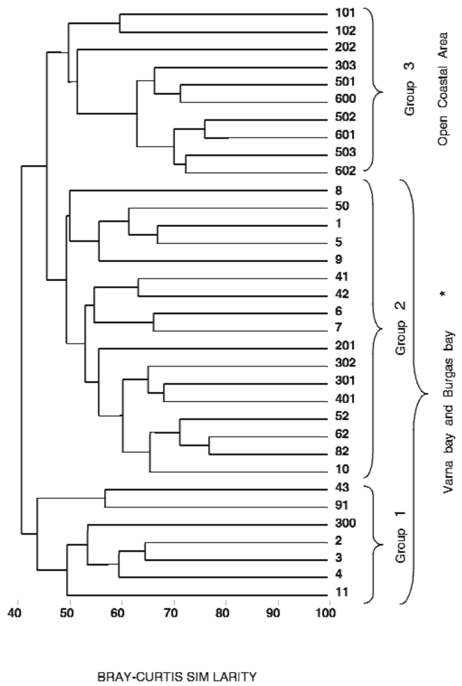


***Fig. 4:*** Dendrogram for hierarchical clustering of stations (group average of Bray-Curtis similarities on log (x+1) transformed abundance).

* Several shallow stations from the open coastal area are also included.

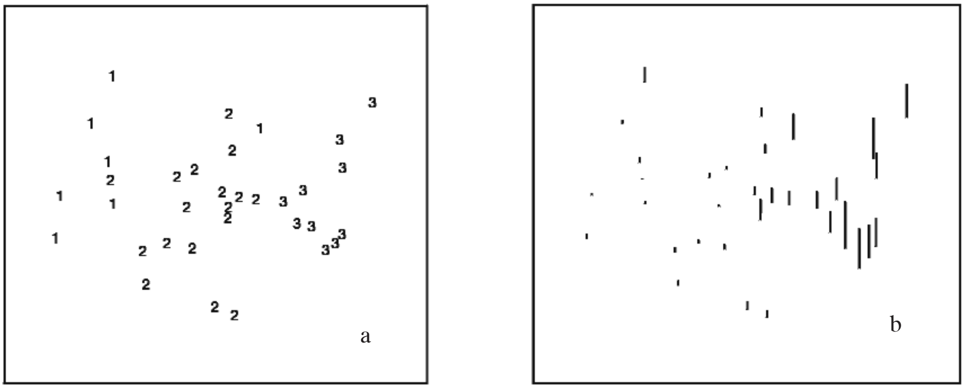


*Fig. 5:* MDS-ordination of stations from Bray-Curtis similarities on log (x+1) transformed abundance a) numbers of groups according to the dendrogram; b) with superimposed depth (lines proportional to the stations depth).

(lines proportional to the depth of the stations) in figure 5b reveals that there is a correlation between the gradation of the benthic community structure and the depth gradient - the shallowest stations are situated on the left of the plot and to the right the depth increases. In our opinion the correlation between community structure and depth is a cause-effect relationship as the vertical gradients of temperature, salinity, oxygen concentration, etc. are especially important in establishing different living regimes for benthic organisms.

Indices

A summary of the four principal univariate statistics, i.e. number of species, abundance, Shannon-Wiener diversity index (H') and Pielou's evenness of distribution (J) for the three groups differentiated by the cluster analysis is presented in Table 2.

The average abundance in the three groups is comparable. In each of the groups, stations with high abundance (over 10 000 ind/$m^2$) were observed. As the abundance is dominated by the deposit-feeding polychaetes this indicates an excess of organic matter in the sediments both near the shore and at a greater distance from the shore.

Group 2 has the lowest average number of species, diversity H' and evenness J. Most of the stations of this group are situated in Varna and Burgas bays. Probably the elevated discharges from land-based sources of contaminants in the industrialised and urbanised territory around the bays are to be blamed for the degradation of the benthic communities. The recent status of the bottom zoocoenoses indicates that Varna and Burgas bays are the most ecologically threatened areas along the Bulgarian Black Sea coast.

The average number of taxa, diversity H' and evenness J of group 3 are higher compared to group 2. The stations are comparatively more distant from the shore. Evidently, the anthropogenic pressure over the benthic communities decreases in the open shelf areas.

Group 1 has the highest average number of species, diversity H' and evenness J. The stations included in that group are situated relatively near the coast but outside the bays. As it is obvious from the map there are areas along the coast with patchy distribution of comparatively undisturbed and very disturbed benthic communities. Probably there are natural environmental factors related to depth, sediment type and hydrology that mitigate the anthropogenic stress at some sites. But on the overall, however, the benthic communities near the coast and

**Table 2**

**Summary of the results from the univariate statistical analysis of the benthic data set. Statistics for number of taxa, number of individuals, Shannon-Wiener diversity (H') and Evenness (J) for each group of similar stations as derived from the classification analysis.**

| | | No of Taxa | Abundance ($ind/m^2$) | H | J |
|---|---|---|---|---|---|
| Group 1 | Mean | 24 | 4355 | 3.17 | 0.70 |
| | Min | 16 | 1240 | 2.44 | 0.61 |
| | Max | 35 | 10610 | 3.72 | 0.77 |
| | Sdev. | 7 | 3241 | 0.44 | 0.06 |
| Group 2 | Mean | 19 | 5236 | 2.26 | 0.54 |
| | Min | 8 | 2250 | 1.41 | 0.37 |
| | Max | 30 | 11410 | 2.91 | 0.64 |
| | Sdev. | 6 | 2057 | 0.45 | 0.07 |
| Group 3 | Mean | 22 | 5384 | 2.68 | 0.60 |
| | Min | 17 | 1700 | 1.80 | 0.38 |
| | Max | 28 | 11450 | 3.18 | 0.76 |
| | Sdev. | 4 | 3622 | 0.40 | 0.10 |
| Overal | Mean | 21 | 5098 | 2.57 | 0.59 |
| | Min | 8 | 1240 | 1.41 | 0.37 |
| | Max | 35 | 11450 | 3.72 | 0.77 |
| | Sdev. | 6 | 2773 | 0.56 | 0.10 |

especially in the bays are more severely disturbed compared to the communities in the open shelf as it is indicated by the indices of the community.

## Conclusions

· The qualitative and quantitative changes in zoobenthic communities that have occurred since late 1950s to the recent time give evidence of the huge eutrophication of the marine environment along the Bulgarian Black Sea coast.

· According to the level of disturbance of the benthic communities Varna and Burgas bays are the most ecologically threatened areas along the Bulgarian Black Sea coast.

· In contrast to the pelagic communities in which signs of recovery have been recognised currently (KONSULOV *et al.*, 1998; SHTEREVA *et.al*., 1998), the zoobenthic community appears to be even more disturbed in 1996-1997 than in the 1980s.

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