

Databases as a tool for studying the dynamics of macro- and meiobenthos on algal communities in the Black Sea

Mazlumyan S.A. and E.A. Kolesnikova

Institute of Biology of the Southern Seas, NASU, Sebastopol, Ukraine

E-mail: mazl@sevpochta.com.ua

Abstract

As an ecosystem component, meiobenthos contributes to the condition and sustainability of the ecosystem. Meiobenthic species are characterised by having a fast response and a short life cycle, they have high energy flow rates and are involved in biochemical processes. Meiobenthic response varies in a wide range, but on the other hand, it is rather predictable, and that makes meiobenthos a useful tool in monitoring. The interannual observations revealed that benthos developed fast responses to unfavourable conditions in 1990 and this makes meio- and macrobenthos a dynamic but vulnerable ecosystem component. The database was created using a seasonal index, determined for the main taxonomic groups of benthos that are associated to algae; comparative analysis was carried out to understand how the index varied during 23 months for identical taxa occurring in three different localities.

Keywords: Black Sea; macro- and meiobenthos; macrophytes; short- and long-term variations.

Introduction

There are huge stocks of data available on coastal algal communities and their associated species, inhabiting the contouring biotopes of our world oceans. In a favorable environment, the fauna occurring on macrophytes is diverse and the density of macro- and meiobenthic species is high.

First qualitative studies of Black Sea meiobenthos go back to the 19th century, quantitative studies to 1955. The creation of a database on taxonomy and the distribution of benthic organisms is essential because the dimension of relevant faunistic information is large. A benthic sample may contain more than ten different taxa and each taxonomic group may count for about 1,000 individuals. According to different methods, samples can be collected in several replications (up to 5 samples). This also adds to the dimension of data. In addition, increasing the geographical and temporal scale of investigation leads to an increasing dimension of the data matrix.

The database has been created using a taxonomic time series (35 years) from a geographically restricted area, more specifically a bay in south-western Crimea. The study focused on the communities found on the algae *Cystoseira crinita* in Kruglaya bay.

Materials and Methods

The three sampling sites with different environmental conditions are located in: the open coastal water (I), at the mouth of the bay (II) and amidst the bay (III). At each sampling site, the samples were collected at 0.7m depth during each month from April 1990 to March 1992. In each sample, the fouling organisms were counted, identified and their numbers determined per 1 kg algal wet weight. Altogether, 190 samples were collected and handled, and ten taxa: Turbellaria, Nematoda, Polychaeta, Acarina, Harpacticoida, Ostracoda, Amphipoda, Bivalvia and Gastropoda were examined.

The database on the taxonomy and distribution of meiobenthos proved to be an efficient tool in addressing some aspects of biodiversity, such as interannual, seasonal and long-term variations. K-dominance analysis was carried out. All the variations were studied in relation to each site.

Results

Seasonal dynamics

Using the database on taxonomy and distribution of meiobenthos in the samples, the trends of seasonal dynamics were obtained for macro- and meiobenthic organisms associated to algae (Fig. 1). Examination of the variations shown in the main taxonomic groups pointed out that for Acarina at locality I and II, the peaks developed concurrently in summer and in winter. In locality III the peaks developed in autumn and in spring; the only peak found in winter concurred with the peak in the 1st locality (Fig. 2). The diversity of peaks for Acarina is due to interspecific variations in reproduction time. Moreover, some species live in soft bottom sediment during almost all year round, while there is much more variation for species depending on short-term algal growths.

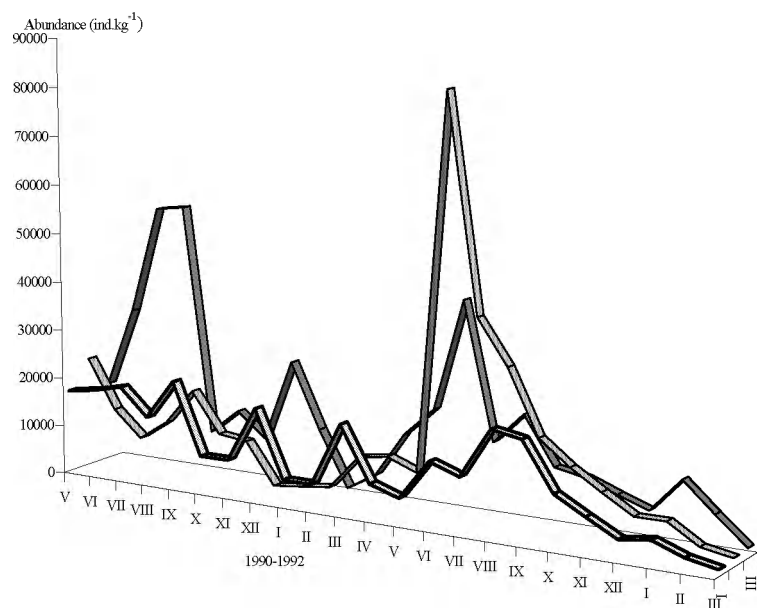
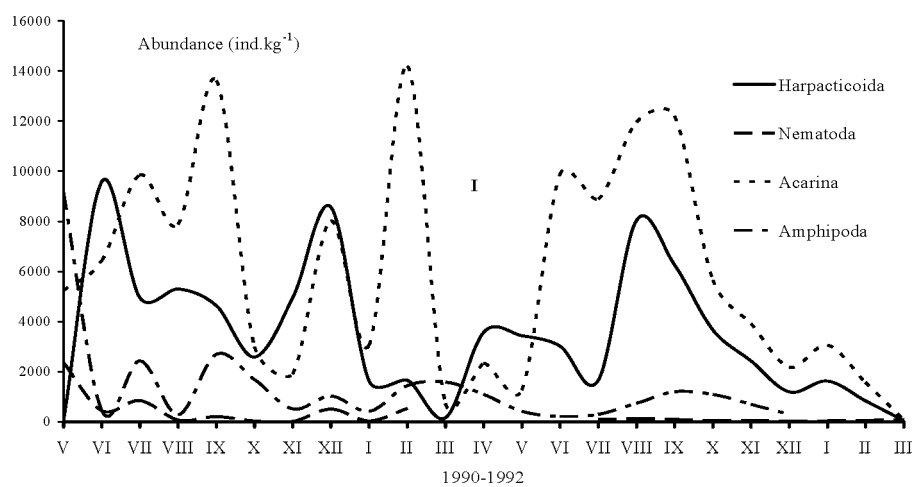


Fig. 1. Seasonal dynamics of the macro- and meiobenthic associated to *Cystoseira crinita*.



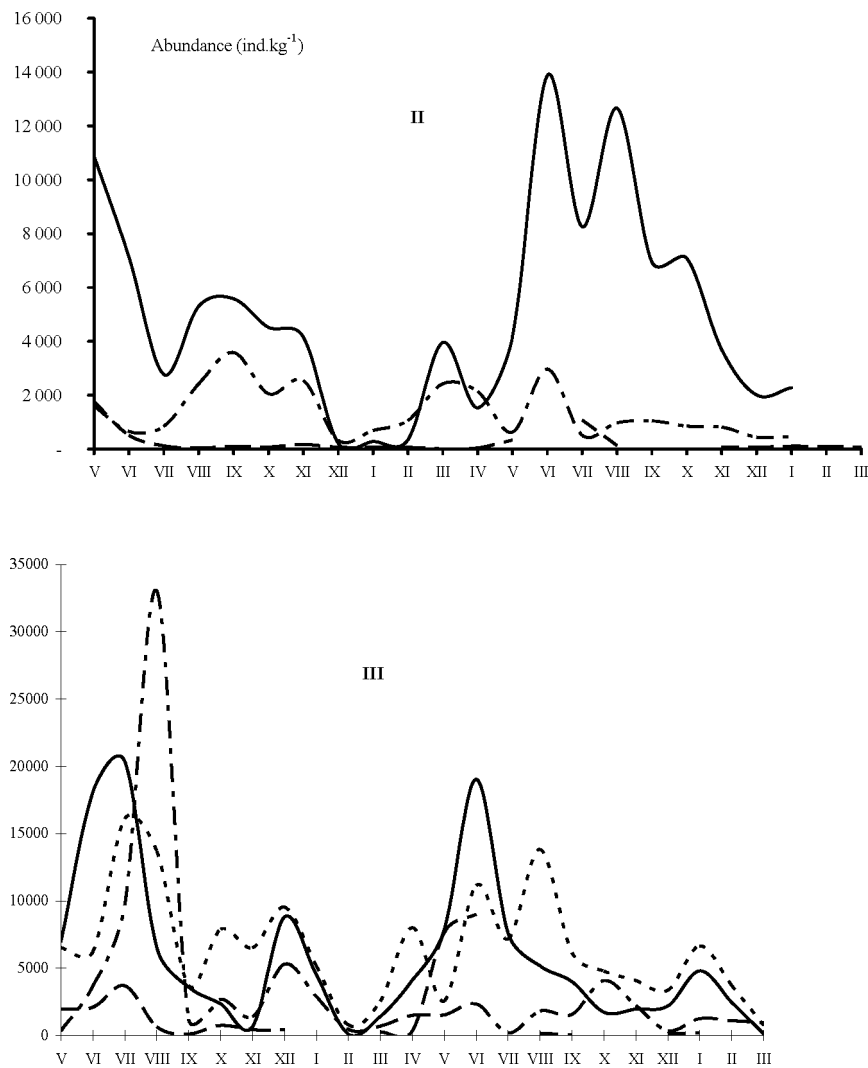


Fig. 2. Seasonal dynamics of meiobenthos taxa in the Kruglaya Bay at points I, II, III.

For Harpacticoida, winter peaks developed concurrently in all the three localities in 1990 and 1992, and summer peaks were present in 1990 and 1991 (Fig. 2). A winter peak was not found in 1991. Seasonal dynamics in abundance of Harpacticoida is related to periodic reproduction. Phytophilous harpacticoids have two reproductive

strategies: perennial and seasonal. Species with an all-year-round reproduction also have seasonal peaks of reproduction during different seasons.

For Amphipoda, summer peaks were simultaneously found in all three localities in 1990; in 1991 autumn peaks concurred for the 1st and the 2nd localities (Fig. 2). During the full period of investigation the 3^d peak was registered in the 1st, 2nd and 3rd localities in winter, summer and autumn. In the biocenosis of *Cystoseira crinita*, the biomass and population density of amphipods have two peaks, one in spring (April) and the other in summer (July-August). These seasonal peaks are directly depending on the biology of amphipods: their biomass reaches a maximum in spring, when many post-winter survivors reproduce. In summer, the peak in population density is related to the reproduction of juvenile individuals of the first generation, while the biomass is considerably lesser than it was in spring.

Interannual variations

Using the taxonomic database, statistical characteristics were calculated for all meiobenthic taxa, associated to algae for each of the three studied localities during 12 months arbitrarily selected between 1990 and 1992. This approach has clarified interannual changes that were typical for the main taxa.

During our study, the marine organisms were unevenly distributed, both quantitatively and qualitatively (Fig. 3, 4).

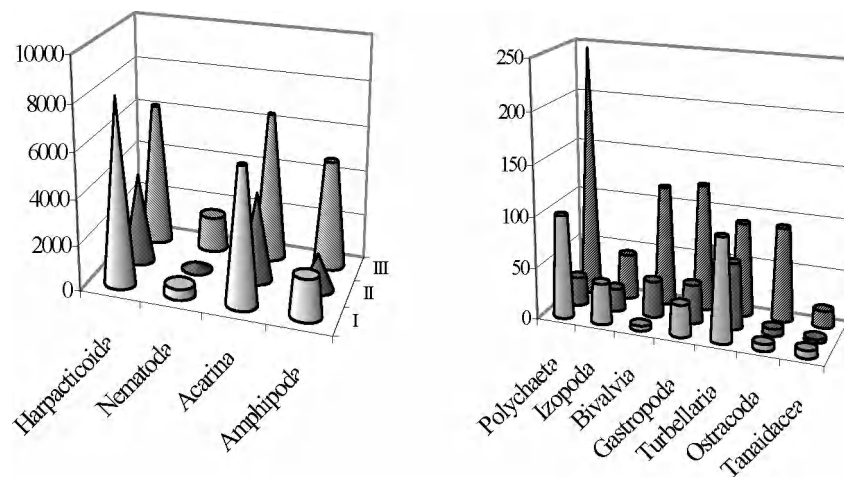


Fig. 3. Average abundance (ind.kg⁻¹ algal wet weight) for the major meiobenthos taxa in the Kruglaya Bay at locality I, II, III (May 1990 - May 1991).

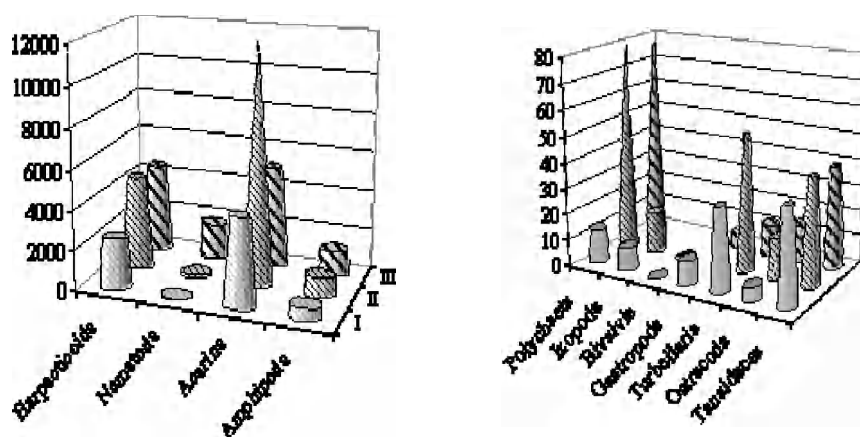


Fig. 4. Average abundance (ind.kg⁻¹ algal wet weight) for the major meiobenthos taxa in the Kruglaya Bay at locality I, II, III (March 1990 - March 1991).

In places where the algae occur and where the activity of waves is relatively low, the population density was higher than in the open sea. Taxa are also distributed unevenly. Nematodes were predominating in the protected area of the bay, the Acarina in the mouth of the bay and harpacticoids were abundant at all localities. Sometimes Amphipods were plentiful in some samples and absent in others, although collected at the same site. Amphipods were numerous in the plankton above the algal growth. Isopods, turbellarians and polychaetes were found all year round but in small numbers, and gastropods and juvenile bivalve molluscs only during spring and summer.

Analysis of the structure of the investigated community pointed out that Acarina and harpacticoids are the prevailing taxa. These organisms can firmly attach themselves to macrophytes and find shelter and food on algal thalli. The third in abundance are amphipods (Fig. 4). They are active migrants which can move from one biotope to the other. Their migration patterns may be seasonal, but also daily. The aggregation of amphipods occasionally found in some places is likely the result of these migrations.

Examination of the interannual average estimates obtained for benthos during 1991-1992 showed low numbers of Gastropoda and a complete absence of Bivalvia on the thalli of macrophytes. There is a direct relationship between the occurrence of larvae in plankton and the recruitment of the benthos in the following year, which is especially evident in the bay.

In 1990, larvae of Gastropoda and Bivalvia were rarely found in Kruglaya bay. In the summer and autumn of 1990, the mortality rate of meroplankton increased with 2-3 times in comparison with spring. This is in accordance with the evidence obtained in

1991 were a negligible numbers of gastropods and no bivalve molluscs on *Cystoseira* were found. Correspondingly, phytophilous benthos rapidly responded to environmental changes in the bay.

Long-term variations

The tendency towards structural changes of the phytophilous benthos in Kruglaya bay is also evident through comparison between our data and those reported by E.B. Mackaveeva (1979). During that time the abundance of the main taxa of phytophilous benthos considerably decreased and the percent ratio between the relevant taxonomic groups changed (Fig. 5).

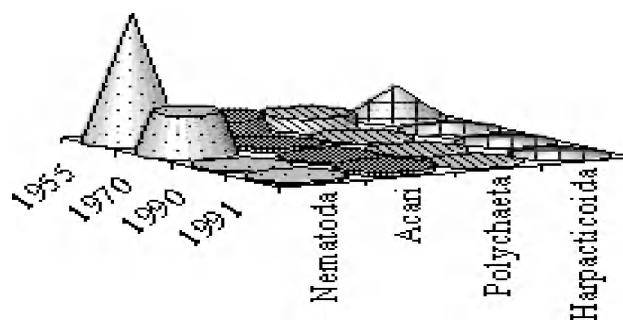


Fig. 5. Long-term variations in abundance (ind.kg⁻¹ algal wet weight) for the major meiobenthos taxa in the Kruglaya Bay.

The database and seasonal index

We propose the seasonal index introduced by Nemchinov (1967) to describe interseasonal dynamics of abundance. The index is calculated based on the method of describing time series using growth rate estimates. If the index is calculated from biomass (abundance) estimates, then chain growth rates, *i.e.* ratio between the biomass (abundance) estimates of the corresponding trophic groups of the community should be determined:

$$\tau_1 = y_2 / y_1; \tau_i = y_{i+1} / y_i; \dots, \tau_{n-1} = y_n / y_{n-1}$$

where $y_1, y_2, \dots, y_i, \dots, y_n$ are the biomass (abundance) estimates of a trophic group of the community for each following time span (month, season, etc.). The first estimate in the studied series, *e.g.* chain ratio between the biomass of seston-eaters in February and

in January, is assumed to be equal to 1. Using the method of chain products, a transformed average is calculated by the formula:

$$\tau_{1\text{ tr.}}=1; \tau_{2\text{ tr.}}=\tau_2*1; \tau_{3\text{ tr.}}=\tau_3*\tau_{2\text{ tr.}}; \dots; \tau_{1\text{ tr.}}; \dots; \tau_{n\text{ tr.}}=\tau_n*\tau_{n-1\text{ tr.}}.$$

where $\tau_1, \tau_2, \dots, \tau_i, \dots, \tau_n$ are the present growth rate, and $\tau_{1\text{ tr.}}, \tau_{2\text{ tr.}}, \dots, \tau_{1\text{ tr.}}, \dots, \tau_{n\text{ tr.}}$ are the transformed growth rate.

Then annual prime average (a. p. a.) is calculated from the sum of the chain transformed estimates:

$$(\tau_{1\text{ tr.}} + \tau_{2\text{ tr.}} + \dots + \tau_{12\text{ tr.}}) / 12 = \tau_{\text{a. p. a. tr.}}$$

Seasonal average is determined as a prime average calculated from the chain average estimates obtained throughout the season. Average for the season (spring) preceding the observation is assumed to be equal to 1. Then averages obtained for the seasons of observation are transformed by the method of chain products.

Seasonal index (J) is determined as the ratio of the transformed (tr.) values to their annual average:

$$J = (\tau_i^{\text{tr.}} * 100) / \tau_{\text{a. p. a. tr.}}$$

When computing the seasonal index of the meiobenthos, annual average abundances of the examined structural components of the community were used as a basis.

The seasonal index computations for the main taxonomic groups of meiobenthos in the algal communities, calculated from the number of estimates obtained in different sites during our monthly monitoring, obtained a variable seasonal index indicating different environmental and ecological conditions of the studied localities. The estimates were arranged within the range from 100 to 1000, which are the precisely determined limits in which the index may vary. Values of the index which vary from 100 to 300 can be regarded as normal seasonal cycles of the four meiobenthic taxa. The range from 300 to 1000 is characteristic for seasonal cycle fluctuations. Factors which induce these fluctuations are natural cycles of reproduction and environmental factors, such as surf force and anthropogenic load. In monitoring studies an important factor is the registered share (%) of fluctuations (seasonal index estimates greater than 300) in the seasonal cycle of taxa under study. For the open coastal sea water this makes up 26%, near the mouth of the bay 22% and inside the bay 48%. These values show how the meiobenthos on algae responds to anthropogenic load inside the bay. Among the studied taxa the percentage of fluctuations is distributed as follows: harpacticoids 32%, Acarina 26%, amphipods 21% and nematods 21%.

Conclusions

The database proved to be a useful tool in the quantitative description of spatial, seasonal, interannual and long-term variability of meiobenthos communities.

The diversity of phytophilous benthos found on the same macrophyte host, *Cystoseira crinita*, differs widely depending on the local conditions.

The analysis of seasonal dynamics of the main taxa, based on the trends in abundance and percentage peak estimates, pointed out that the seasonal modification in the structure of the benthos, associated to *Cystoseira crinita* in the Kruglaya bay, should be regarded as steady, with a constant quantitative ratio between the constituent elements. In the localities under study, the percentage of the main taxa (Acarina, Harpacticoida, Amphipoda) remains invariable.

Abundance estimates obtained for meiobenthos on algae during 1991-1992 showed a tendency of decrease, in particular for Harpacticoida and Acarina from the open coastal sea water, and for Nematoda also in the vicinity of the mouth of the bay, and for Amphipoda at each of the localities. These changes may be the result of environmental changes which took place during 1990-1991; 1990 was especially unfavorable for the ecosystem of Kruglaya bay.

Long-term observation has also shown a substantial decrease in numbers of all main taxa of the phytophilous benthos and revealed changes in the structure of zoobenthos associated to the algae *Cystoseira crinita*.

Anthropogenic pollution of the coastal sea water has provoked replacement of the phytocenosis. In the Black Sea, the communities of brown algae (*Cystoseira*) are replaced by communities of green algae (*Ulvetta*). This phenomenon may also involve changes in the diversity of benthic species associated to algae. The diversity of phytophilous benthos may undergo considerable changes under the replacement of one macrophyte substrate by the other.

In handling the two-year monitoring data, a seasonal index is used to identify changes in the characteristic seasonal cycle, which could identify a response to anthropogenic load in the Kruglaya bay, which is a recreation zone. This approach also allows clarifying which of the taxa occurring in the algal communities are the most vulnerable to an unfavorable environment or, on the contrary, are prosperous: which were harpacticoids and Acarina, respectively. These taxa may be used as indicators in further monitoring investigations including those focused on meiobenthos.

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