# THE PRESENT STATE OF THE EPIBIONTIC POPULATIONS TO THE BIOCENOSIS OF STONE MUSSELS IN THE SHALLOW WATER OFF THE ROMANIAN BLACK SEA COAST

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**Abstract**. This paper presents observations and ecological analyses of benthic community of the hard bottom mussels in the shallow waters. This study is based on the analysis of 21 quantitative biological samples collected by diving at 7 stations in two zones along the Romanian Black Sea Coast – Mamaia and Mangalia in 2003. The study attempts to pinpoint some aspects related to defining and adopting the term of "littoral cell" and to highlight the possible differences between the epibiontic communities developing on the inside and the outside of these coastal artificial structures. These hydrotechnic structures create a specific eco-climate inside the semi-closed aquatic area limited by the protective dams that influence the number and spatial distribution of the epibiontic organisms. The study reveals the occurrence of 76 species of benthic organisms belonging to 13 supraspecific taxa, with an average density of 2 122 523 indvs.m$^{-2}$ and a biomass of 19 437,2 g.m$^{-2}$. Numerically, the dominant species are the crustaceans (~539 224 indvs.m$^{-2}$) and worms (~416 972 indvs.m$^{-2}$) and the weight dominants are molluscs – *Mytilus galloprovincialis* over 96 % and crustaceans (~136 g.m$^{-2}$).

**Keywords**. Black Sea, macro-, meiobenthic communities of the hard bottom, qualitative, quantitative, littoral cell

## INTRODUCTION

Aquatic ecosystems and their biotic and abiotic components in general, but above all marine coastal zones, have been and continue to be both of great scientific interest and also of considerable practical interest. The inherent difficulties in the analysis of the hard bottom have limited the studies of the associated fauna because they are restricted to a very narrow strip in the south of the Romanian littoral and also because of the difficulties in collecting quantitative samples. The first quantitative and qualitative research of the microbenthic and macrobenthic component associated with the natural hard bottom was started by the scientific group led by the great oceanologist M. Băcescu, resulting in a series of valuable papers (Băcescu et al., 1963, 1971). The research of the rocky fauna proper, in a holistic approach to the study of the substrata communities including the associated meio- and macrofauna both qualitatively and quantitatively, began at the same time as the Romanian littoral was transformed by works; these brought about serious changes in the structure of the benthic communities, which are still affected at present. The coastal protection dams, like artificial reefs, have partially compensated for the lack of hard bottom along the Romanian littoral, giving rise after a short time to an epibiontic sessile and vagile fauna very diverse and numerically abundant (Gomoiu, 1986, 1997).

The installation of these hydrotechnical structures in the littoral waters favoured the creation of some more or less closed areas, called littoral cells, where the hydrologic processes and the dynamic of the benthic population present certain differences in comparison with open areas. Consequently, "littoral cells" are coastal marine sectors bordered by permeable or impermeable protective dams, usually built at a right angle to the shore and having variable terminal shapes in T, Y, L, etc. The majority of these structures delimit a semi-closed aquatorium communicating with the sea through one of the sides or through a narrow canal (*e.g*. harbour enclosures). The initial aim of these coastal enclosures was to protect the beaches against erosion and to reduce or break the kinetic energy of the waves. It was later shown that these hydrotechnical structures had and still have both positive and negative ecological implications, and their initial role of coastal protection proved to be insignificant or even sometimes adverse. The closed-in aquatorium has a specific "calm waters" characteristic/encloses a unique "calm-water" area where the eco-climate is different from that of the open sea, and the hydrologic and geo-ecological processes are greatly influenced by this relative isolation.

At the moment, there is little information regarding the dynamic of the ecological variations of the epibionthic populations in the cell, in comparison with those in the open marine sectors. Because of the deficient exchange of water mass from inside the aquatorium with the open sea,/the water mass inside the aquatorium is not influenced by the open sea, these sectors experience important fluctuations in the physical and chemical parameters of the water. During the summer season, these aquatoria can become ecologically high-risk areas because of the explosive growth of some algal, bacterial or fungi populations sometimes followed by the mass mortality of the benthic and nektonic populations.

## MATERIAL AND METHODS

The analysis of the structure of the associations of epibiontic organisms in the two littoral cells is based on 21 quantitative biologic samples collected by diving at 7 stations (5 stations in the Mamaia cell and 2 in the Mangalia cell) in the summer and autumn 2003:

- **Station 1** – the Midia Cape (**CM**) protective dam,
- **Station 2** – the open sea dam in front of the hotel complex «Casino» Mamaia (external area) (**DLC-ex**),
- **Station 3** - the open sea dam in front of the hotel complex «Casino» Mamaia (internal area) (**DLC-pt**),
- **Station 4** – protective dam in front of Pescărie Mamaia (exposed area) (**PM-ex**),
- **Station 5** – protective dam in front of Pescărie Mamaia (protected area) (**PM-pt**),
- **Station 6** – the Mangalia protective dam, in front of "Mangalia" hotel (external area) (**MM-ex**),
- **Station 7** – the Mangalia protective dam, in front of "President" hotel and very close to the Mangalia Harbour (internal area) (**MP-pt**).

They comprise the protected internal and unprotected external areas of the coastal protective dams. A sample was collected from each station at a depth of 3 m, by scraping the epibiosis over a 400 $cm^2$ surface (20 x 20 cm) using a knife with a 20 cm long blade. The blade was also used to measure the scraping area, *i.e.* a square with 20 x 20 cm side/sq.cm. The scraping areas were chosen randomly. The biological material scraped was deposited in a classic mesh (permeable only to water) the end of which was fastened by a string to prevent loss of the material in the water. The sampled material was preserved in formaldehyde neutralized (5 – 6 %) in seawater.

The samples were then processed in the following ways:

- Washing samples using 3 sieves of 1 mm, 0,5 mm and 0,125 mm to separate macro- and meiofauna;
- Identifying the species using either a magnifying glass or a microscope, and, at the same time, counting the number of individuals in each identified species;
- For the macrobenthic forms, the biomass was determined by weighing the organisms using an electronic scales, and for the meiobenthic forms, their weight was determined using standard weight tables;
- Computer processing of the data for ecological parameters.

In order to statistically process the results obtained following separation, the analytical ecological indicators and diversity indicators were used.

## RESULTS AND DISCUSSIONS

### General biological description of communities from the littoral cells

The biological description of the areas investigated is based on the results of laboratory analyses of samples, both from the hard and the mobile bottom, as well as *in situ* observations.

The results of taxonomic determinations and the statistical analysis of the biotic component within the cells, when compared to the data found in specialized literature, indicated that the associated biota is in a relatively good condition, in comparison with that of previous years.

Direct observations in the areas of interest indicate the existence of a greater diversity of biotopes formed as a result of hydrotechnical constructions (dams) and of specific hydrological conditions favouring the migration of pelagic forms (fish – grey mullet, anchovy, atherine) and planktonic forms (coelenterates) in search of food in the shallow waters of the cells.

Planktonic forms include juvenile and adult jelly fish such as *Aurelia aurita* and *Rhizostoma pulmo*, mainly during the second half of July and the ctenophore – *Mnemiopsis leydii* in its adult stage, with much lower densities but with a constant presence in all studied locations. The North-Atlantic ctenofor *Beroe ovata* was found at the end of the summer season, once the water started cooling, in adult populations. Its density however was lower in comparison with previous years, when the species was found in the middle of the summer season, in numbers comparable to those of *Mnemiopsis*. This situation probably shows that a population balance was reached between these two alien species with different feeding regimes – filtration (*Mnemiopsis*) and predator (*Beroe*).

It must be noted that Hyppocampides (sea horses) are present at Pescărie Dam (Mamaia), Casino (Mamaia) and Mangalia but reach impressive densities at the Casino. In both these stations we discovered during the second collecting period, an area of approx. 30x30 cm, populated by small seagrass (*Zostera sp.*), on a sandy-silty texture substratum in the proximity of the dam. Numerous galleries and organisms of *Upogebia pusilla* were also found on the sedimentary bottoms surrounding the inner dam.

As for plankton life forms, around September, it must be emphasized that virtually every adult specimen of *Rhizostoma pulmo* was located near mackerel juvenils (*Trachurus mediterraneus ponticus*), numbering between 3 and 15.

The re-apparition of the perennial brown alga Cystoseira barbata in the southern extremity of the littoral is of a great importance for the littoral hard bottom biocenosis. This situation has resulted in the diversification of habitats and favours the apparition of species closely related to this very endangered species, which has a very sparse distribution.

Hydrological conditions underwent considerable variations during the two sampling periods – the first half of June and the second half of July respectively. In July the hydrological conditions were typical, as far as temperature and salinity were concerned, of the early spring cold water period with temperatures as low as 11°C (*ex*. Midia Cape Dam). This phenomenon was due to a large extent to the dominance partly of southerly winds and partly of winds blowing from a northern direction parallel to the shore combined with a noticeable upwelling of coastal waters. These conditions persisted for approximately two weeks and also influenced the biotic component of benthic biocenosis, favouring species that prefer low temperature waters. Thus, hard surfaces were almost completely covered by algal macrophytes such as *Ceramium sp*. (*ex*. Midia Cape). This is a rather typical situation, generally characteristic of the periods from April to May and October – November.

Warm water forms (*Enteromorpha*, *Ulva*, *Cladophora*) established in June were mainly removed by the more or less marked wave activity present at the end of June and the beginning of July, also related to their inability to withstand low temperatures, and they accumulated in deposits at the bottom of the sea in small semi-closed gulfs (in beds of up to 0.5m) or were stranded in impressive numbers on the shore (*ex*. Cape Midia). Algae stranded on the shore or in shallow (0.5m) waters harbour a vagile fauna exclusively dominated by isopods (*Idotea baltica*, *Sphaeroma pulchellum*) and amphipods (*Melita palmata* etc.).

Algal deposits accumulated on the sedimentary bottoms at depths exceeding 1.5m constitute excellent feeding and living areas for a series of vertebrate and invertebrate organisms, such as Syngnathides, which "give birth" to their young and feed in these thickets (firsthand observation *in situ*), whereas hyppocampides and shoals of grey mullet feed at the boundary between these accumulations and the mobile sediments.

In the other sectors macrophites developed jointly, although rhodophites were being gradually replaced by clorophites (*Enteromorpha*, *Cladophora*) where there was a gradual warming of the water column (approx. 18°C), but with a sudden cooling near the bottom (at 0.5m – 1m) reaching temperatures as low as 10 - 11°C. The most significant example of vagile macrofauna shows that adult isopods (*Idotea baltica*, *Sphaeroma pulchellum*, *S. serratum*) reappear when the water gets colder.

The vagile macrofauna of the sandy bottom is dominated in all locations, apart from Midia Cape, by mysidae, amphipods, shrimp (*Crangon crangon*), diogenic crabs (*Diogenes pugilator*), the sand crab (*Liocarcinus holsatus*). As far as molluscs are concerned, *Corbula mediterranea*, *Mya arenaria*, *Cyclope neritea* are the dominant species.

The observations made in the last month of sampling (September), showed the general tendency of the majority of macrobenthic forms (misids, shrimp, hermits crabs, crabs, etc.) to retreat towards the deep. At the edge of the Pescărie dam, at 4-5 m deep, an interesting condensability or grouping phenomenon was noticed in an impressive number of misids belonging to the species *Mesopodopsis slaberi* and *Paramysis kroyeri* concentrated in a water column of 3 x 3 m.

### Characteristics of the benthic populations associated with the shallow hard bottom in the Mamaia and Mangalia littoral cells

Following the analysis of the biological material sampled, 95 types of benthic organisms associated with the hard bottoms were identified, belonging to 13 taxonomic supra-specific groups. Excluding the organisms identified at group level (Foraminifera, Nematoda, Oligochaeta, Harpacticoida, Insecta) and the varia inside the groups (Hydrozoa, Turbellaria, Nemertini, Polychaeta, Bryozoa, Halacarida, Larvae), the total number of taxa identified according to species/type is 76. Out of a total of 95 identified taxa, 57 (60%) are to be found in both analyzed locations. The number of taxa found only in the Mamaia cell was 20 (21%) and 18 (19%), respectively in the Mangalia cell. Of these, worms are the most numerous as species in the Mamaia area (10 taxa) in comparison with the Mangalia area where only 4 species of polychaeta were found out of a total of 18 taxa identified in this cell alone. In the case of crustaceans, the situation is reversed, so that in Mamaia the total number of species identified in this area alone is 7, compared with 9 in Mangalia (Fig.1).

The ratio between the macrobenthic taxa identified in both locations and of those taxa peculiar to only one location is quite balanced. Only 54% (41) of the identified taxa are common to both locations. Thus, with regard to the macrobenthic associated with the shallow hard bottom, the mixture of conditions in each cell encourages the growth of certain taxa with specific preferences for that biotope (APPENDIX I, Fig. 2). The differences regarding the presence or absence of taxa in a cell were generally noted in the case of polychaeta and superior crustaceans, because of their specific demands in relation to the biotope.

The lowest specificity is noticed in the associated meiofauna, where 83% (15 taxa) of taxa are common for both locations, and the contribution of the characteristic forms is negligible (APPENDIX II, Fig. 3).

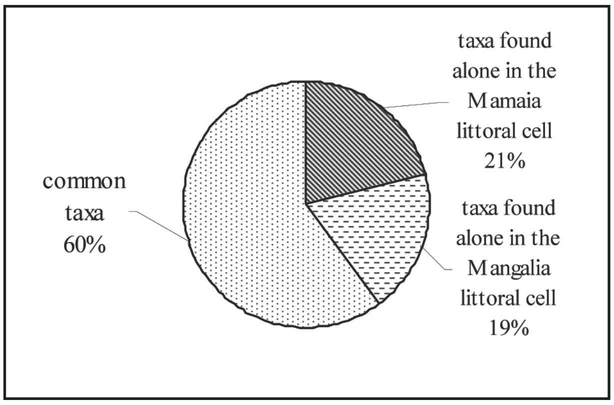


**Fig. 1** The percentage of specific and common macrobenthic and meiobenthic taxa identified in Mamaia and Mangalia cells

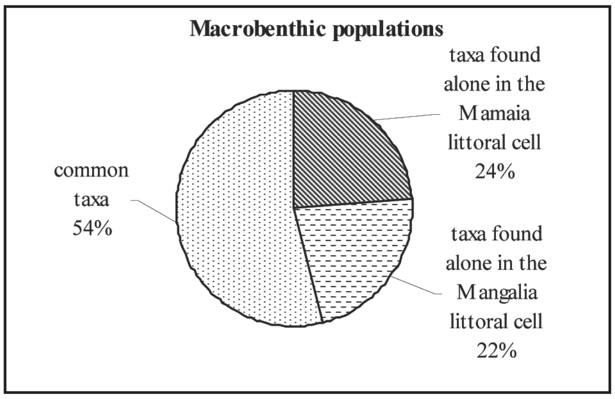


**Fig. 2** The percentage of specific and common macrobenthic taxa identified in Mamaia and Mangalia cells

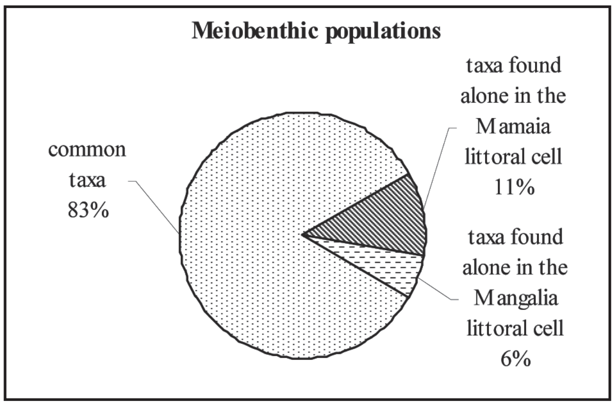


**Fig. 3** The percentage of specific and common meiobenthic taxa identified in Mamaia and Mangalia cells

These percentage estimations show the capacity of the epibiontic system to form and of the associated fauna to constantly evolve, with respect to the diversification of the association and the reconfiguration of the habitat in relation with the abiotic conditions in the specific aquatorium. A high percentage of macrobenthic in association ensure an extraordinary complication of the primary biotope (denuded hard rock) that provides shelter for an amazingly abundant microcosm. The interrelations established between various cocenotes are vital for the maintenance of a dynamic equilibrium inside the system.

The real seasonal diversity, according to the number of identified species, is higher in the Mangalia cell. This can be explained by the same level of physical and chemical parameters of the water, vital for the selection of a population with a low ecologic plasticity and a high heterogeneity of habitats (artificial hard bottom, natural hard bottom, vast algal fields, bottom of rough ground sand mixed with biogenic sediment, enclaves of sand in the hard bottom) (Fig. 4).

The seasonal changes in the structure of the qualitative composition of the benthos in the Mamaia and Mangalia cells are not significant. They have to be considered not changes, but a result of the random distribution of some benthic species, of the heterogeneity of the bottom and of some inherent limits of the sampling.

The most significant taxa occuring in the highest density and frequency parameters : harpactycides, nematodes, veliger larval forms *Mytilus galloprovincialis*, *Microdeutopus gryllotalpa*, *Polydora ciliata*, *Balanus improvisus*, *Melita palmata*, *Rhombognathus sp.*, nectocheta larvae, *Polydora antennata*; and a series of species with reduced frequency, but with numerous populations in certain periods or locations, such as: turbelariates *Stylochus tauricus* and *Leptoplana tremellaris*, polychaeta *Neanthes succinea*, *Fabricia sabella*, *Nerilla antennata*, *Platynereis dumerilii*, *Sphaerosyllis bulbosa*, chitons *Middendorfia caprearum*, leading bivalve in the biocenosis of the shallow hard bottom *Mytilus galloprovincialis*, the ostracodes represented especially by *Xestoleberis decipiens and X. aurantia acutipenis*, the amphipodes *Sthenothoe monoculoides*, *Amphithoe vaillanti*, *Jassa ocia*, *Erichthonius difformis*, the isopode *Idotea baltica*, the crustacean cypris larvae and chironomide larvae. Of these, the nematodes and harpactycides lead in numbers, in 90 % of the total mean densities.

The biomasses are dominated in over 99,09 % cases by only one species, a large form of bivalve *Mytilus galloprovincialis*. With the exception of bivalves, the following species are predominant: cirripedia *Balanus improvisus*, the decapodes *Pilumnus hirtellus* and *Rhithropanopeus harrisii tridentatus,* the amphipodes *Melita palmata*, *Microdeutopus gryllotalpa*, *Amphithoe vaillanti*, polychaeta *Neanthes succinea*, the coelenterate *Actinia equina* and the turbelariate *Stylochus tauricus*.

The ecological parameters typical of the benthic populations indicate a homogenous distribution in the area in terms of both species and abundance of density and biomass. The most important major groups of benthic invertebrates, numerically dominant are the crustaceans – 54 % of the total mean density of the associated fauna, and – 69 %, respectively, of the total mean biomass, and the worms – 38 % of the total mean density and 19 % of the total mean biomass (Fig. 5).

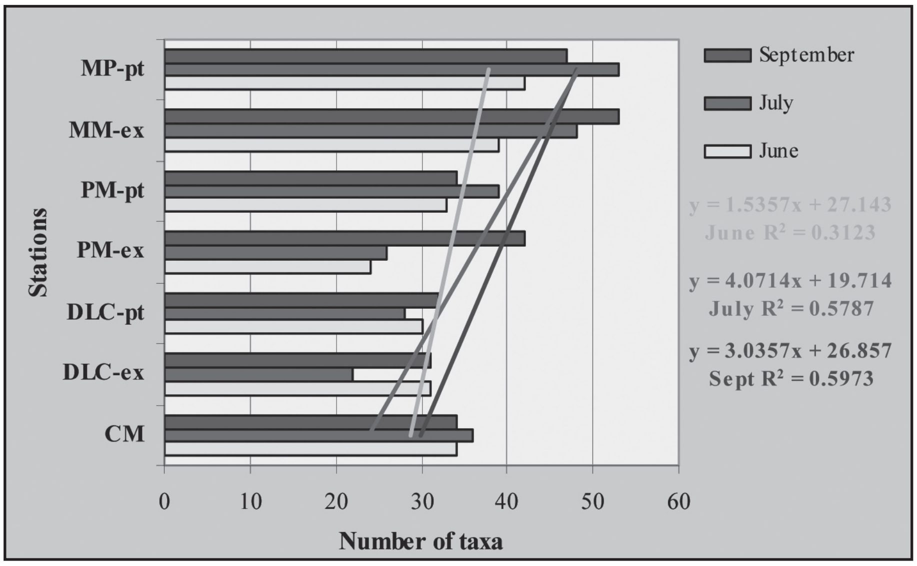


**Fig. 4** Seasonal variation of the total number of epibiontic species identified along the Romanian littoral in 2003

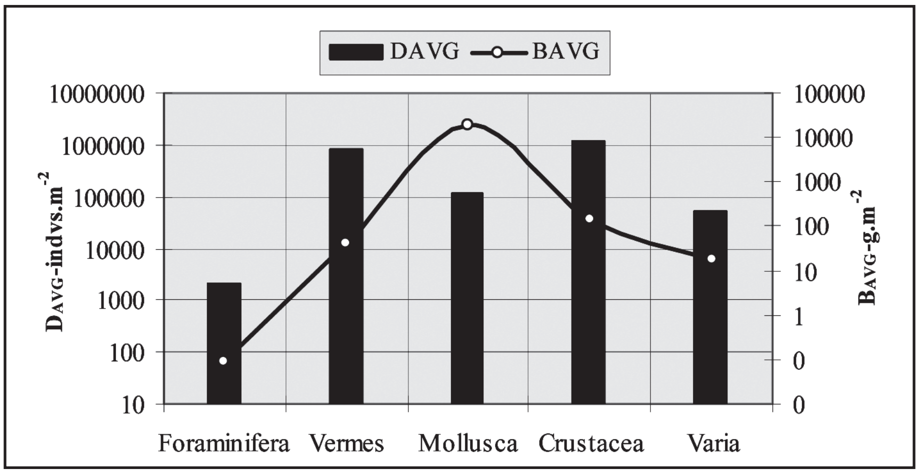


**Fig. 5** Variation of average density ($D_{AVG}$) and biomass ($B_{AVG}$) of the main groups of epibiontic organisms in the Mamaia and Mangalia littoral cells

The scale of the density variations in the Mamaia cell is between 866 922 indvs.m$^{-2}$ and 3 853 500 indvs.m$^{-2}$, and the biomasses between 15 937 g.m$^{-2}$ and 27 927 g.m$^{-2}$. In the Mangalia cell, they are between 1 417 923 indvs.m$^{-2}$ and 3 070 000indvs.m$^{-2}$ with biomasses of 14 090 g.m$^{-2}$ and 20 602 g.m$^{-2}$. In general, the mass values of the epibiontic organisms are almost equal or slightly higher in the interior regions of the Mamaia and Mangalia cells, compared to the external regions. There are no great differences in the biotic composition of the two locations, from a quantitative point of view. The difference in the structure of the epibiosis appears when the macro- and meiobenthic fauna segment in each cell is analysed. Namely, some quantitative differences between littoral cells exist but only in the case of macro-fauna. This can be easily explained by the nature, conditions and variations of biotopes (natural rocky, sand enclaves, algae fields, etc.) of the Southern sector, in comparison with the Northern one, which sustains a more qualitatively diversified epibiosis, with a greater number of macrobenthic organisms. In the Northern sector, *i.e.* the Mamaia cell, the reduced density of macrobenthic organisms is compensated for by the abundance of the meiofauna with affinity for both the hard and the mobile-sandy bottom dominating the distribution in the shallow areas in the Northern sector (Fig. 6, 7). The ratio between the macro- and meiofauna associated for the Mamaia cell is 1 : 9.35 and for the Mangalia cell is 1 : 5.01. The bigger difference in the Mamaia cell is due to the eutrophic character of the aquatorium; this situation permits the development of a very abundant meiobenthic segment, constantly enriched by organisms migrating from the sandy bottom.

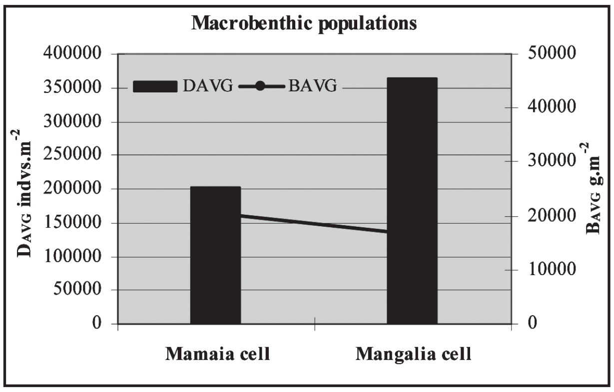


**Fig. 6** Variation of average density ($D_{AVG}$) and biomass ($B_{AVG}$) of the macrobental epibiontic organisms in the Mamaia and Mangalia littoral cells

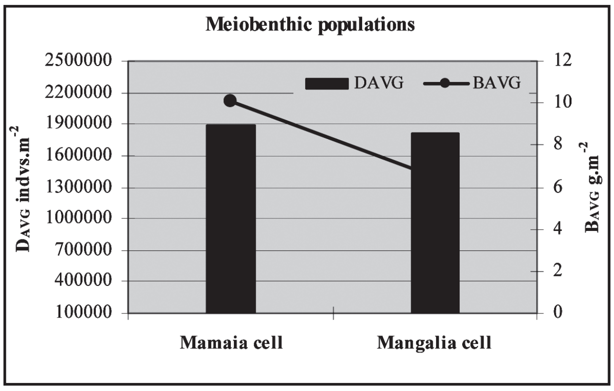


**Fig. 7** Variation of average density ($D_{AVG}$) and biomass ($B_{AVG}$) of the meiobental epibiontic organisms in the Mamaia and Mangalia littoral cells

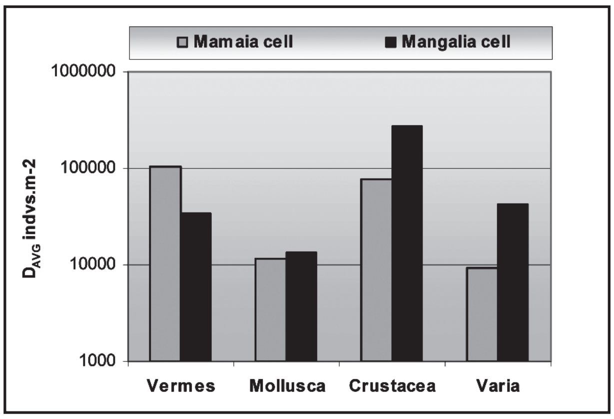


**Fig. 8** Diagram of the weight of the main macrobental epibiontic groups in the Mamaia and Mangalia littoral cells, 2003

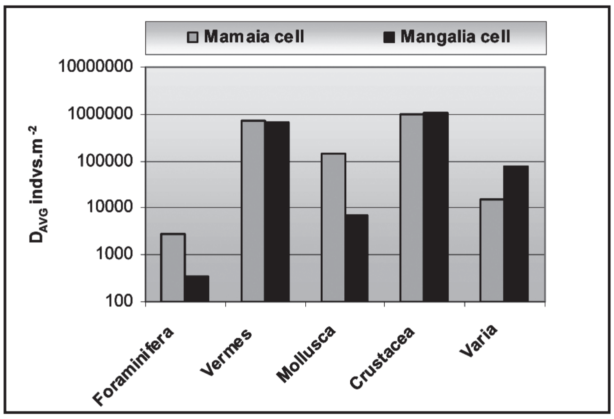


**Fig. 9** Diagram of the weight of the main meiobental epibiontic groups in the Mamaia and Mangalia littoral cells, 2003

The comparative analysis of the epibiontic macro- and meiofauna by taxonomic groups shows that the main groups that create the difference between cells are the Crustacean and Varia in the case of the macrofauna and the Foraminifera, Molluscs and Varia in the case of the meiofauna (Fig. 8, 9). Out of a total of 26 superior macrobenthic crustacean species, only 12 are common to both locations. Thus, in the Mamaia cells 6 species were identified that are not found in the Southern area, such as: *Gammarus olivii*, *Sphaeroma pulchellum*, *Paramysis kroyeri*, *Palaemon adspersus*, *Palaemon elegans*, *Athanas nitescens*. This does not suggest the absence of those species in the epibiotic structure of the Mangalia cell, and is due to some typical limitations of the sampling method (the swimming decapods that represent half of the missing species, because of their active locomotion capabilities, swim away when the biological material is scraped and cannot be captured later). Based on direct visual observations made during diving, *Palaemon elegans* and *Athanas nitescens* are common species for the biocenosis of the rock mussels in the shallow areas along the littoral. For the Mangalia cell, the number of crustacean species identified in this location alone is 8, as follows: *Apherusa bispinosa*, *Hyale pontica*, *Jassa ocia*, *Erichthonius difformis*, *Caprella acanthifera ferox*, *Naesa bidentata*, *Cumella limicola*, *Siriella jaltensis jaltensis*. Most of these species present a degree of specificity with regard to the environment conditions (except for *Apherusa bispinosa*, *Hyale pontica and Cumella limicola*), being found only in the Southern regions. Nevertheless, some of them, such as *Jassa ocia* and *Naesa bidentata,* can be found in some Northern locations as well, but in smaller numbers.

The orientation of the substrata in the direction of/relative to the water masses represents an important ecological factor in selecting and determining the settlement of the epibiontic associations. The calcareous or sessiles species are the dominant fauna segment; they can withstand dislocation caused by the high hydrodynamics of shallow waters. Of the two mollusc species dominating the epibiontic system, *Mytilaster lineatus* and *Mytilus galloprovincialis*, only the young of the mussel and the adult specimens of *Mytilaster* accompanied by/and *Balanus improvisus* shape the epibiontic system in the shallow area of 0 – 1m. Of these, *Mytilaster lineatus* is the dominant species of the system, because of the robust shape of its valves and its protruding/bulky carcass that "breaks" the waves. In the direction of the water masses, the molluscs never form more than 1-2 superposed levels, which prevents the settlement and diversification of the vagile fauna segment; they form a tube using the detritus as a building material or the detritus feeding. The detritus which abounds at the bottom of a coastal protection dam, is mainly made up of the pseudofecales of molluscs from upper levels and is virtually inexistent in the 0m horizon, being permanently washed away by water. The few vagile forms associated with/ found in the shallow areas are therefore either passive or active filtrating species.

The quantitative analysis of the macro- and meiobenthic segments related to the orientation of the substrata, *i.e.* the internal protected and the external unprotected areas of the cell, shows certain quantitative and qualitative differences. Generally speaking, the epibiontic communities on the internal side of the protective dams are more abundant and complex than those on the external side. There are nonetheless cases when the quantitative and qualitative differences are greatly reduced, where there is more communication with the open sea or a large shallow area surrounding the cell. Shallow depths/areas, especially inside the cell – as in the case of the Mamaia cell – favour the movement of the associated fauna on the mobile seabed in periods of high hydrodynamism or when there is strong upwelling, supplementing both qualitatively and quantitatively the epibiontic system on the hard bottom. In this situation, the external area sometimes seems more diversified than the internal one, as in the case of the macrofauna in the Mamaia cell (Fig. 10). Among the sandy macrobenthic invertebrates identified in the epibiosis of the Mamaia cell in the external area, and not present in the samples collected in the internal protected areas, were the polychaeta with a number of 4 species typically sandy worms: *Laonice cirrata*, *Namanereis pontica*, *Pygospio elegans*, *Spio filicornis*. Certainly, in the case of annelids, which prefer a mobile substratum, their presence in the epibiontic system is due to the clogging of the epibiosis with sedimentary material in sufficient quantities for these species to be able to perform vital activities. It must be stressed that the presence of sandy species is characteristic for depths under 1.5 – 2 m (generally) on the external unprotected areas of protective dams, because the sedimentary material that usually clogs the entire side of the dam (vertically) is easily removed from the shallow area. The epibiosis in this area is therefore completely free of mineral or organic suspensions and does not encourage the development of a species needing a mobile substratum.

Consequently, the differences in number and weght are very slight in the Mamaia cell, because of its vast area. The epibiontic associations are nevertheless slightly more abundant in the internal area compared to the external area where they are subject to the moving action of the water masses (Fig. 11).

Because of the limited surface area and semi-closed character of the Mangalia cell, the differences in the numeric abundance of each fauna segment or in relation to the orientation of the substrata seem greater. In any case, the epibiontic associations on the internal side of the dam are qualitatively and quantitatively more abundant. The structure of the bottom around the cell (natural hard calcareous bottom) eliminates the possibility of the epibiontic system being "contaminated" with sandy forms. Thus, most of the identified species are typical of rocky surfaces and some have a very strong stenobiotic character, *e.g. Siriella jaltensis jaltensis*. Still, in the areas where communication with the open sea is limited, the protected nature of this aquatorium tends to trap excess organic material. This leads to the clogging of the epibiontic system and encourages the evolution of opportunistic species with high

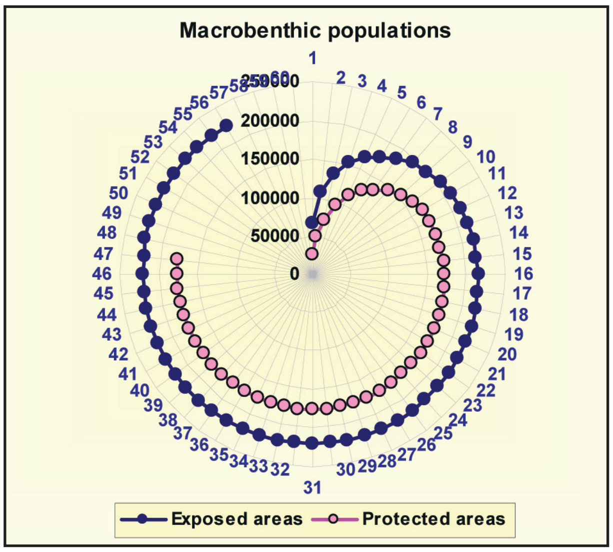


**Fig. 10** Diagram representation of the macrobental populations in the protected and exposed areas of Mamaia cell, in 2003

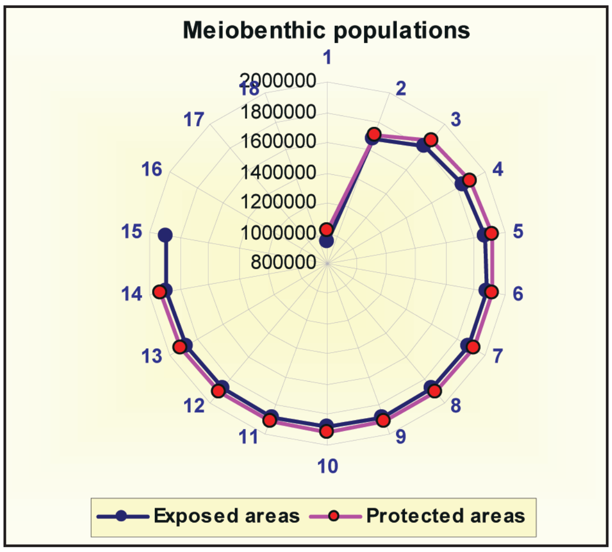


**Fig. 11** Diagram representation of the meiobental populations in the protected and exposed areas of Mamaia cell, in 2003

resistance to this type of biotopes. Such species include the tubular and detritofagous species (ex. *Polydora ciliata*, *Capitella capitata*, oligochetes) (Fig. 12, 13).

The structure of the benthic fauna associated with rocky bottoms (artificial-natural) in the two locations was analysed and compared with the information regarding the epibiontic populations of the last 2-3 decades; no significant qualitative variations in the dominant species in the epibiontic system was evident. The most significant differences were noted between the observations made in the 1960s (Băcescu *et al.*, 1963; Băcescu *et al.,* 1971), 1970s (Ţigănuş, 1979), 1980s (Gomoiu, 1981, `86, `89) and 1990s (Ţigănuş, 1992 in Petranu, 1997; Gomoiu, 1992) concerning the qualitative structure of upper crustacean macrofauna (swimming and crawling decapods). Yet, the most significant differences were probably in the quantitative parameters for both the meio- and the macrobenthic epibiontic forms. Thus, the mean densities of shallow water sessile and vagile epibiontic populations at the end of the 1970s and 1980s-1990s, a period considered to be of the greatest ecological instability for coastal ecosystems in the North-West of the Black Sea were between 163 352 indvs. $m^{-2}$ on the hydrotechnic constructions in Mamaia (Gomoiu, 1989) and 255 697 indvs.$m^{-2}$ in the Agigea area (Ţigănuş, 1979). Compared with the data of 2003, when the total mean density of the zoobenthos associated with the hard bottom was 2122,52x$10^3$ indvs.$m^{-2}$ these mean values are at least 10 times lower. These numeric differences are due to the extremely abundant meiobenthic segment in the epibiontic associations, like the nematodes and the harpactides, forming densities generally higher than 600 000 – 800 000 indvs. $m^{-2}$. The values of the mean abundances obtained in 2003 are only comparable with those noted in 1961 in Agigea (Băcescu *et al*., 1963) and with those in the structure of the fouling on ships' keels where similar values of 500 000 – 1 500 000 indvs.$m^{-2}$ were noted for the vagile meiobenthic forms such as nematodes and copepods (Gomoiu, Ţigănuş, 1974, 1976).

Consequently, the number of epibiontic organisms on both artificial hydrotechnic structures and on natural hard bottom has greatly increased in recent decades compared to the ecological crisis in the 1980s-1990s (Fig. 14). The increase in populations was noticed in all the major invertebrate groups in association of rocky mussels.

The least significant variations were noted for the mean biomasses : 20540,11 g.$m^{-2}$ in the Mamaia cell and 16679,76 g.$m^{-2}$ in the Mangalia cell, together with the malacological component compared to values mentioned in scientific papers. Excluding the molluscs, the mean values for the other epibiontic groups present certain small differences between the two locations. Thus, the mean values registered in Mamaia in 2003 and 1988-1989 were 198,46 g.$m^{-2}$ and 171,75 g.$m^{-2}$ respectively, and quantitative differences were only noted in the groups of worms and crustaceans. For the Mangalia cell, the mean biomass is similar to that in the Mamaia cell, namely 197,80 g.$m^{-2}$. Generally, these mean values are greatly affected by the numeric abundance of cirripedia obscuring the contribution of other zoobenthic groups without calcareous structures to the total biomass per surface unit. The contribution of cirripedia in terms of biomass compared to the rest of the crustacean species was 62,92 g.$m^{-2}$ in 2003 and 226,678 g.$m^{-2}$ in 1977. This was approximately 45 % of the total crustacean biomass in 2003 (total crustacean biomass 143,43 g.$m^{-2}$) and 89 % in 1977 (total crustacean biomass 253,466 g.$m^{-2}$) (Fig. 15).

The most important crustacean species (except the cirripedia) causing higher mean values per surface unit are the decapods represented by *Pilumnus hirtellus, Rhithropanopeus harrisi tridentatus* and the amphipods *Melita palmata*, *Microdeutopus gryllotalpa*, *Amphithoe vaillanti.*

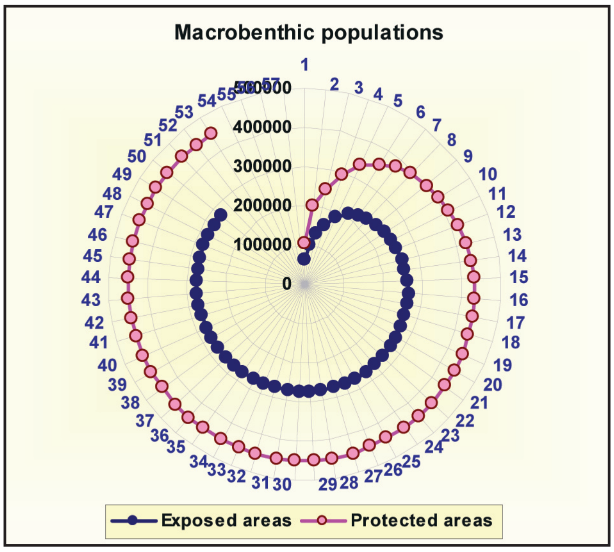


**Fig. 12** Diagram representation of the macrobental populations in the protected and exposed areas of Mangalia cell, in 2003

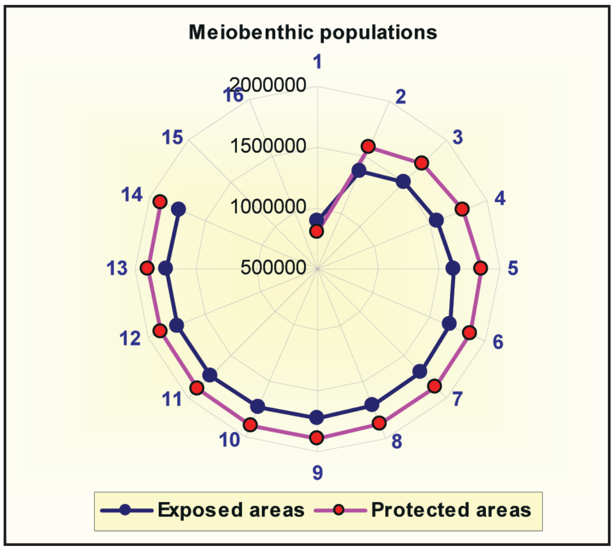


**Fig. 13** Diagram representation of the meiobental populations in the protected and exposed areas of Mangalia cell, in 2003

The greatest quantitative changes in the shallow water epibiontic associations were noted for worms, molluscs and crustaceans. The 1980s-1990s represent the most unbalanced period in the coastal aquatic ecosystems, with serious negative consequences in the structure of the epibiosis due to exclusive dominance of the meiobenthic worms (Nematoda) and of the opportunistic annelids (polichaeta species: *Polydora ciliata*, *Capitella capitata* and oligochaeta species) with high ecological plasticity, capable of enduring the eutrophication of the marine environment during that period. Crustacean and mollusc populations diminished dramatically in terms of abundance and number of species (Fig. 16). Still, both before and after the changes caused by eutrophication, the numerically dominant groups/species among the crustaceans have been and still are: Harpacticoida, *Microdeutopus gryllotalpa*, *Balanus improvisus*, *Melita palmata*.

Surprisingly, the total number of crustacean species identified in 2003 in the Mamaia and Mangaia cells is, in terms of quality, at least 10 taxa higher than in the period of reference around 1977 (as shown by the analysis of the epibiosis in the Agigea area). Thus, 20 taxa and 18 crustacean species were identified in 1977 in the epibiotic associations. The total number of species identified in 2003 is 32 and 33 taxa, respectively. There is an evident contrast between this qualitative abundance and the state of the crustacean epibiontic populations in the 1960s on the natural rocky bottom of Agigea.

The same situation is found in the case of worms (Turbellaria, Nemertini, Nematoda, Annelida) where the total number of taxa identified in 2003 is 39 and 34 species, respectively.

Thus, the yearly comparative analysis shows a deep imbalance in the population equilibrium of the benthic invertebrates, characterized at the end of the 1980s by the exclusive dominance of worms in contrast to other groups. More recently, the situation of the benthos associated with the hard bottom is between the normal limits of evolution for the epibiontic communities, especially through the quantitative and qualitative enrichment of the vagile segment which exhibiting the eco-functional maturity of any natural aquatic system (Fig. 16).

The holistic comparative analysis of the shallow water epibiontic associations for each littoral cell has brought to light important aspects of the distribution and abundance of the epibiontic system. This encourages the study of the evolution of littoral biocenosis relative to changes in the Romanian coastal area. The rich biodiversity in the researched locations can be compared (in the case of some extraspecific groups) with the situation of the benthic populations in the period of ecological stability in the 1960s-1970s.

## CONCLUSIONS

The results of the ecological comparative study of the epibiontic shallow benthic populations of the Mamaia and Mangalia littoral cells in 2003 lead to the following conclusions:

- the qualitative structure of the associated meio- and macrofauna in the two locations is represented by 95 types of benthic organisms belonging to 13 taxonomic extraspecific groups, and the total number of taxa identified according to species/type level is 76;
- as regards quality, in 2003, the total number of crustacean species observed in Mamaia and Mangalia cells was at least 10 taxa higher than in the reference period in 1977, when only 18 species were identified; in 2003, the total number of species identified was 32;
- the quantitative analysis of the macro- and meiobental segment relative to the sub-layer orientation, namely the internal – protected – area and the external – unprotect-

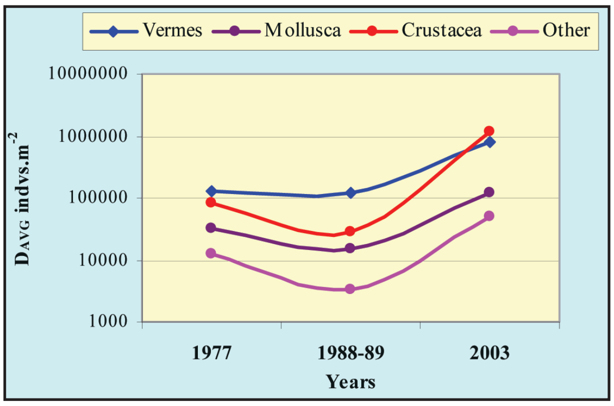


**Fig. 14** Variation of the average density of the main groups of epibiontic invertebrates in the 1977 – 2003 interval along the Romanian Black Sea littoral

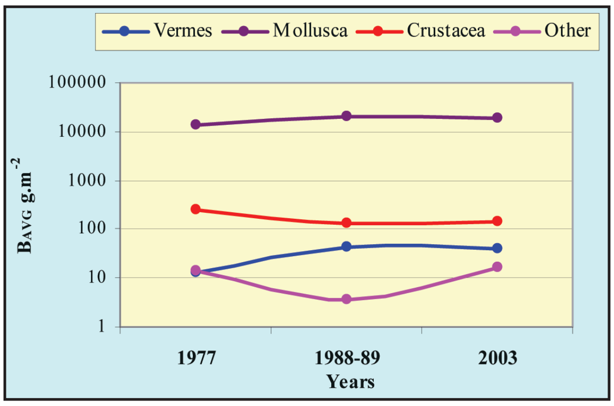


**Fig. 15** Variation of the average biomass of the main groups of epibiontic invertebrates in the 1977 – 2003 interval along the Romanian Black Sea littoral

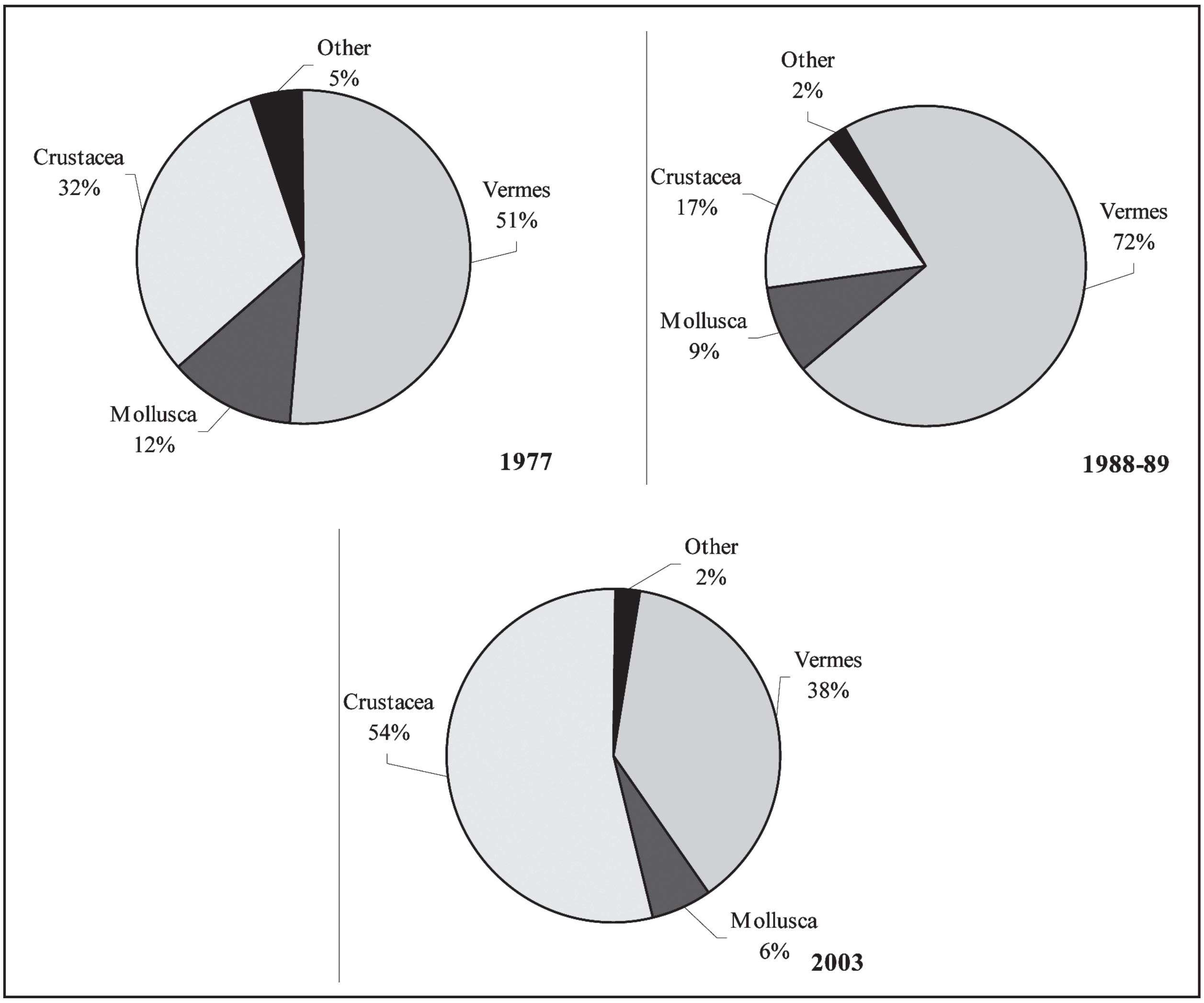


**Fig. 16** The percentage weight of the epibiontic organisms populations in the associations of the shallow hard bottom along the Romanian Black Sea littoral in the 1977 – 2003 time interval

ed – area records some differences in both quality and quantity. They are generally more abundant and more complex on the internal side of the protective dams than on the external side that is subject to the disturbing and continuous action of the water mass;

- due to the large surface area, the numeric and weight differences are very reduced for the Mamaia cell; the qualitative uniformity of the epibiontic associations noted in the interior/exterior of the Mamaia cell is due to the large surface area and extensive communication with the open sea, considerably reducing more significant qualitative differences;
- the reduced surface and semi-enclosed nature of the Mangalia cell, have resulted in greater differences in numerical abundance of each fauna segment according to the sub-layer orientation; in all cases, the epibiontic associations on the internal side of the protection dam are more abundant both in quality and quantity;
- comparing the structure of the benthic fauna associated to/on the rocky floors (artificial-natural) of the two locations examined with information about epibiontic populations in the last two-three decades no important variation is evident in the quality of the dominant species in the epibiontic system. The most important differences recorded were quantitative parameters, for both the epibiontic meio- and macrobenthos; the average values of the epibiontic populations' abundance in 2003 show they were at least 10 times higher than those obtained in the years `60-70.

*APPENDIX I*

## GENERAL CHARACTERISTICS OF THE MACROBENTHIC POPULATIONS RECORDED IN 2003 IN THE MAMAIA AND MANGALIA AREA OF INTEREST

| No. | Taxa | Mamaia cell | | | | | | | Mangalia cell | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | F% | $D_{AVG}$ | $D_D\%$ | $R_{kD}$ | $B_{AVG}$ | $D_B\%$ | $R_{kB}$ | F% | $D_{AVG}$ | $D_D\%$ | $R_{kD}$ | $B_{AVG}$ | $D_B\%$ | $R_{kB}$ |
| 1 | *Halichondria panicea* | | | | | | | | 50.00 | 41.67 | 0.01 | 44 | 37.50 | 0.22 | 5 |
| 2 | Hydrozoa | | | | | | | | 16.67 | 33.33 | 0.01 | 48 | 0.27 | 0.00 | 44 |
| 3 | *Actinia equina* | 60.00 | 150.00 | 0.07 | 27 | 4.01 | 0.02 | 9 | 66.67 | 45.83 | 0.01 | 38 | 6.14 | 0.04 | 13 |
| 4 | *Leptoplana tremellaris* | 60.00 | 4026.33 | 1.99 | 11 | 1.11 | 0.01 | 17 | 83.33 | 954.17 | 0.26 | 23 | 0.40 | 0.00 | 31 |
| 5 | *Stylochus tauricus* | 80.00 | 10452.27 | 5.16 | 8 | 2.95 | 0.01 | 10 | 66.67 | 363.17 | 0.10 | 28 | 0.59 | 0.00 | 28 |
| 6 | *Emplectonema gracile* | 6.67 | 1.67 | 0.00 | 57 | 0.01 | 0.00 | 53 | 66.67 | 45.83 | 0.01 | 39 | 0.82 | 0.00 | 21 |
| 7 | *Tetrastemma sp.* | 80.00 | 323.33 | 0.16 | 21 | 0.61 | 0.00 | 20 | 100.00 | 247.17 | 0.07 | 27 | 0.65 | 0.00 | 19 |
| 8 | Nemertini varia | 66.67 | 278.33 | 0.14 | 23 | 0.55 | 0.00 | 24 | 33.33 | 16.67 | 0.00 | 49 | 0.03 | 0.00 | 50 |
| 9 | *Brania clavata* | 60.00 | 1250.00 | 0.62 | 13 | 0.38 | 0.00 | 26 | 100.00 | 1845.83 | 0.51 | 17 | 0.53 | 0.00 | 22 |
| 10 | *Capitomastus minimus* | | | | | | | | 33.33 | 541.67 | 0.15 | 30 | 0.32 | 0.00 | 40 |
| 11 | *Eteone picta* | 26.67 | 13.33 | 0.01 | 48 | 0.04 | 0.00 | 39 | 50.00 | 45.83 | 0.01 | 43 | 0.15 | 0.00 | 41 |
| 12 | *Eulalia limbata* | 26.67 | 46.67 | 0.02 | 40 | 0.04 | 0.00 | 40 | 16.67 | 4.17 | 0.00 | 56 | 0.00 | 0.00 | 57 |
| 13 | *Fabricia sabella* | | | | | | | | 100.00 | 5262.50 | 1.45 | 13 | 0.31 | 0.00 | 33 |
| 14 | *Grubea limbata* | 20.00 | 111.67 | 0.06 | 39 | 0.03 | 0.00 | 44 | 16.67 | 16.67 | 0.00 | 51 | 0.01 | 0.00 | 56 |
| 15 | *Grubea tenuicirrata* | 40.00 | 133.33 | 0.07 | 30 | 0.04 | 0.00 | 34 | 33.33 | 20.83 | 0.01 | 46 | 0.01 | 0.00 | 53 |
| 16 | *Harmothoe imbricata* | 66.67 | 35.00 | 0.02 | 38 | 0.61 | 0.00 | 21 | 50.00 | 33.33 | 0.01 | 45 | 0.73 | 0.00 | 29 |
| 17 | *Harmothoe reticulata* | 80.00 | 125.00 | 0.06 | 26 | 1.51 | 0.01 | 14 | 83.33 | 33.33 | 0.01 | 41 | 0.77 | 0.00 | 20 |
| 18 | *Janua pagenstecheri* | | | | | | | | 66.67 | 3192.67 | 0.88 | 16 | 0.54 | 0.00 | 30 |
| 19 | *Laonice cirrata* | 6.67 | 1.67 | 0.00 | 58 | 0.00 | 0.00 | 58 | | | | | | | |
| 20 | *Namanereis pontica* | 13.33 | 58.33 | 0.03 | 44 | 0.04 | 0.00 | 45 | | | | | | | |
| 21 | *Neanthes succinea* | 100.00 | 14778.33 | 7.29 | 6 | 26.52 | 0.13 | 5 | 100.00 | 6377.50 | 1.76 | 10 | 14.23 | 0.09 | 7 |
| 22 | *Nereis pelagica* | | | | | | | | 16.67 | 16.67 | 0.00 | 52 | 0.17 | 0.00 | 45 |
| 23 | *Nereis rava* | 100.00 | 628.67 | 0.31 | 14 | 1.65 | 0.01 | 12 | 66.67 | 70.83 | 0.02 | 35 | 0.27 | 0.00 | 39 |
| 24 | *Nerilla antennata* | 13.33 | 1493.33 | 0.74 | 22 | 0.15 | 0.00 | 33 | | | | | | | |
| 25 | *Nerine cirratulus* | 20.00 | 878.33 | 0.43 | 24 | 0.18 | 0.00 | 31 | 16.67 | 4.17 | 0.00 | 57 | 0.00 | 0.00 | 58 |
| 26 | *Nerine tridentata* | 13.33 | 3.33 | 0.00 | 53 | 0.00 | 0.00 | 57 | | | | | | | |
| 27 | *Perinereis cultrifera* | 73.33 | 378.33 | 0.19 | 20 | 1.72 | 0.01 | 13 | 83.33 | 166.67 | 0.05 | 32 | 0.88 | 0.01 | 18 |
| 28 | *Pholoe synophthalmica* | 6.67 | 5.00 | 0.00 | 54 | 0.00 | 0.00 | 55 | | | | | | | |
| 29 | *Phylodoce lineata* | | | | | | | | 16.67 | 4.17 | 0.00 | 58 | 0.01 | 0.00 | 52 |
| 30 | *Platynereis dumerilii* | 60.00 | 941.87 | 0.46 | 16 | 1.61 | 0.01 | 16 | 100.00 | 390.00 | 0.11 | 26 | 3.42 | 0.02 | 14 |
| 31 | *Polydora antennata* | 86.67 | 18796.67 | 9.27 | 4 | 0.44 | 0.00 | 23 | 83.33 | 5629.17 | 1.55 | 14 | 0.50 | 0.00 | 25 |
| 32 | *Polynoe scolopendrina* | 33.33 | 78.33 | 0.04 | 35 | 0.05 | 0.00 | 35 | 16.67 | 12.50 | 0.00 | 55 | 0.01 | 0.00 | 54 |
| 33 | *Poydora ciliata* | 93.33 | 42601.00 | 21.02 | 1 | 1.21 | 0.01 | 15 | 100.00 | 5548.33 | 1.53 | 12 | 0.42 | 0.00 | 26 |
| 34 | *Prionospio cirrifera* | 6.67 | 3.33 | 0.00 | 55 | 0.02 | 0.00 | 48 | | | | | | | |
| 35 | *Pygospio elegans* | 6.67 | 3.33 | 0.00 | 56 | 0.00 | 0.00 | 59 | | | | | | | |
| 36 | *Sphaerosyllis bulbosa* | 86.67 | 5495.80 | 2.71 | 9 | 0.68 | 0.00 | 19 | 100.00 | 995.00 | 0.27 | 20 | 0.19 | 0.00 | 38 |
| 37 | *Spio filicornis* | 6.67 | 60.00 | 0.03 | 47 | 0.02 | 0.00 | 50 | | | | | | | |
| 38 | *Syllis gracilis* | 6.67 | 640.00 | 0.32 | 32 | 0.06 | 0.00 | 46 | 50.00 | 58.33 | 0.02 | 40 | 0.02 | 0.00 | 49 |
| 39 | Oligochaeta | 46.67 | 129.87 | 0.06 | 29 | 0.03 | 0.00 | 38 | 83.33 | 1816.67 | 0.50 | 18 | 0.36 | 0.00 | 34 |
| 40 | *Doridela obscura* | 13.33 | 15.00 | 0.01 | 50 | 0.11 | 0.00 | 36 | | | | | | | |
| 41 | *Tergipes tergipes* | 13.33 | 48.00 | 0.02 | 45 | 0.01 | 0.00 | 51 | | | | | | | |
| 42 | *Middendorfia caprearum* | | | | | | | | 100.00 | 6395.00 | 1.76 | 9 | 10.40 | 0.06 | 9 |

| No. | Taxa | Mamaia cell | | | | | | | Mangalia cell | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | F% | $D_{AVG}$ | $D_D$% | $R_{kD}$ | $B_{AVG}$ | $D_B$% | $R_{kB}$ | F% | $D_{AVG}$ | $D_D$% | $R_{kD}$ | $B_{AVG}$ | $D_B$% | $R_{kB}$ |
| 43 | *Setia valvatoides* | | | | | | | | 16.67 | 25.00 | 0.01 | 50 | 0.05 | 0.00 | 51 |
| 44 | *Mytilaster lineatus* | 100.00 | 2975.07 | 1.47 | 10 | 566.61 | 2.76 | 2 | 100.00 | 1462.00 | 0.40 | 19 | 273.87 | 1.64 | 2 |
| 45 | *Mytilus galloprovincialis* | 100.00 | 8721.80 | 4.30 | 7 | 19767.62 | 96.29 | 1 | 100.00 | 5726.33 | 1.58 | 11 | 16191.50 | 97.11 | 1 |
| 46 | *Bowerbankia gracilis* | 6.67 | 9066.67 | 4.47 | 15 | 0.00 | 0.00 | 56 | | | | | | | |
| 47 | Bryozoa varia | 73.33 | 33.33 | 0.02 | 37 | 0.03 | 0.00 | 32 | 50.00 | 50.00 | 0.01 | 42 | 0.05 | 0.00 | 46 |
| 48 | *Balanus improvisus* | 100.00 | 35129.33 | 17.33 | 2 | 71.59 | 0.35 | 3 | 100.00 | 16559.00 | 4.56 | 7 | 41.23 | 0.25 | 3 |
| 49 | *Amphithoe vaillanti* | 100.00 | 483.00 | 0.24 | 17 | 1.83 | 0.01 | 11 | 100.00 | 17174.17 | 4.73 | 6 | 8.44 | 0.05 | 10 |
| 50 | *Apherusa bispinosa* | | | | | | | | 66.67 | 675.00 | 0.19 | 25 | 0.44 | 0.00 | 35 |
| 51 | *Caprella acanthifera ferox* | | | | | | | | 66.67 | 245.83 | 0.07 | 31 | 0.30 | 0.00 | 37 |
| 52 | *Corophium bonelli* | 40.00 | 193.33 | 0.10 | 28 | 0.03 | 0.00 | 41 | 100.00 | 2704.17 | 0.74 | 15 | 0.28 | 0.00 | 36 |
| 53 | *Dexamine spinosa* | 33.33 | 140.00 | 0.07 | 31 | 0.12 | 0.00 | 30 | 66.67 | 141.67 | 0.04 | 33 | 0.09 | 0.00 | 42 |
| 54 | *Erichthonius difformis* | | | | | | | | 83.33 | 14939.17 | 4.11 | 8 | 3.10 | 0.02 | 15 |
| 55 | *Gammarus olivii* | 40.00 | 64.33 | 0.03 | 36 | 0.26 | 0.00 | 28 | | | | | | | |
| 56 | *Hyale perieri* | 20.00 | 57.33 | 0.03 | 41 | 0.06 | 0.00 | 37 | 16.67 | 16.67 | 0.00 | 53 | 0.01 | 0.00 | 55 |
| 57 | *Hyale pontica* | | | | | | | | 100.00 | 590.83 | 0.16 | 24 | 0.51 | 0.00 | 24 |
| 58 | *Jassa ocia* | | | | | | | | 100.00 | 62400.83 | 17.18 | 2 | 6.45 | 0.04 | 11 |
| 59 | *Melita palmata* | 100.00 | 15854.33 | 7.82 | 5 | 17.10 | 0.08 | 6 | 100.00 | 34780.00 | 9.58 | 5 | 20.17 | 0.12 | 4 |
| 60 | *Microdeutopus gryllotalpa* | 100.00 | 22479.13 | 11.09 | 3 | 7.51 | 0.04 | 8 | 100.00 | 84070.83 | 23.15 | 1 | 11.20 | 0.07 | 8 |
| 61 | *Nototropis guttatus* | 20.00 | 8.33 | 0.00 | 51 | 0.02 | 0.00 | 47 | 66.67 | 283.33 | 0.08 | 29 | 0.50 | 0.00 | 32 |
| 62 | *Stenothoe monoculoides* | 46.67 | 66.67 | 0.03 | 33 | 0.00 | 0.00 | 49 | 100.00 | 35570.83 | 9.80 | 4 | 0.41 | 0.00 | 27 |
| 63 | *Naesa bidentata* | | | | | | | | 100.00 | 940.83 | 0.26 | 21 | 2.43 | 0.01 | 17 |
| 64 | *Sphaeroma pulchellum* | 13.33 | 82.60 | 0.04 | 42 | 1.19 | 0.01 | 27 | | | | | | | |
| 65 | *Idotea baltica basteri* | 66.67 | 1925.00 | 0.95 | 12 | 0.34 | 0.00 | 25 | 50.00 | 83.33 | 0.02 | 37 | 0.03 | 0.00 | 48 |
| 66 | *Cumella limicola* | | | | | | | | 83.33 | 1120.83 | 0.31 | 22 | 0.64 | 0.00 | 23 |
| 67 | *Paramysis kroyeri* | 6.67 | 1.67 | 0.00 | 59 | 0.01 | 0.00 | 52 | | | | | | | |
| 68 | *Siriella jaltensis jaltensis* | | | | | | | | 16.67 | 16.67 | 0.00 | 54 | 0.13 | 0.00 | 47 |
| 69 | *Palaemon adspersus* | 13.33 | 6.67 | 0.00 | 52 | 0.06 | 0.00 | 42 | | | | | | | |
| 70 | *Palaemon elegans* | 40.00 | 15.00 | 0.01 | 46 | 0.18 | 0.00 | 29 | | | | | | | |
| 71 | *Athanas nitescens* | 46.67 | 65.00 | 0.03 | 34 | 0.83 | 0.00 | 22 | | | | | | | |
| 72 | *Pisidia longicornis* | 46.67 | 370.33 | 0.18 | 25 | 1.37 | 0.01 | 18 | 33.33 | 20.83 | 0.01 | 47 | 0.14 | 0.00 | 43 |
| 73 | *Pilumnus hirtellus* | 100.00 | 463.33 | 0.23 | 18 | 35.04 | 0.17 | 4 | 66.67 | 70.83 | 0.02 | 36 | 22.18 | 0.13 | 6 |
| 74 | *Rhithropanopeus harrisi tridentatus* | 86.67 | 421.13 | 0.21 | 19 | 11.72 | 0.06 | 7 | 66.67 | 83.33 | 0.02 | 34 | 3.85 | 0.02 | 16 |
| 75 | Larvae megalope | 20.00 | 48.33 | 0.02 | 43 | 0.04 | 0.00 | 43 | | | | | | | |
| | Chironomida | 6.67 | 46.67 | 0.02 | 49 | 0.00 | 0.00 | 54 | 100.00 | 43150.00 | 11.88 | 3 | 4.59 | 0.03 | 12 |
| **No.** | **Taxa** | **Mamaia cell** | | | | | | | **Mangalia cell** | | | | | | |
| | | | $D_{AVG}$ | $D_D$% | | $B_{AVG}$ | $D_B$% | | | $D_{AVG}$ | $D_D$% | | $B_{AVG}$ | $D_B$% | |
| | Vermes | | 103772.47 | 51.19 | | 42.29 | 0.21 | | | 33713.83 | 9.28 | | 26.34 | 0.16 | |
| | Mollusca | | 11759.87 | 5.80 | | 20334.35 | 99.05 | | | 13608.33 | 3.75 | | 16475.82 | 98.82 | |
| | Crustacea | | 77874.87 | 38.42 | | 149.31 | 0.73 | | | 272489.00 | 75.04 | | 122.54 | 0.73 | |
| | Varia | | 9296.67 | 4.59 | | 4.05 | 0.02 | | | 43320.83 | 11.93 | | 48.55 | 0.29 | |
| | **Total** | | **202703.87** | **100** | | **20530.00** | **100** | | | **363132.00** | **100** | | **16673.24** | **100** | |

*APPENDIX II*

## GENERAL CHARACTERISTICS OF THE MEIOOBENTHIC POPULATIONS RECORDED IN 2003 IN THE MAMAIA AND MANGALIA AREA OF INTEREST

| No. | Taxa | Mamaia cell | | | | | | | Mangalia cell | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | F% | $D_{AVG}$ | $D_D$% | $R_{kD}$ | $B_{AVG}$ | $D_B$% | $R_{kB}$ | F% | $D_{AVG}$ | $D_D$% | $R_{kD}$ | $B_{AVG}$ | $D_B$% | $R_{kB}$ |
| 1 | Foraminifera | 73.33 | 2703.33 | 0.14 | 7 | 0.12 | 1.20 | 4 | 33.33 | 354.17 | 0.02 | 13 | 0.02 | 0.24 | 13 |
| 2 | Turbellaria varia | 20.00 | 563.33 | 0.03 | 11 | 0.06 | 0.56 | 8 | 50.00 | 1133.33 | 0.06 | 12 | 0.12 | 1.86 | 10 |
| 3 | Nematoda | 100.00 | 705187.13 | 37.20 | 2 | 1.06 | 10.45 | 3 | 100.00 | 632882.33 | 34.79 | 2 | 1.00 | 15.32 | 1 |
| 4 | *Nereidae larve* | 13.33 | 576.67 | 0.03 | 12 | 0.02 | 0.23 | 10 | | | | | | | |
| 5 | *Polydora sp. - juvenili* | 13.33 | 83.33 | 0.00 | 14 | 0.01 | 0.07 | 13 | 33.33 | 83.33 | 0.00 | 16 | 0.01 | 0.11 | 14 |
| 6 | *Spionidae larve* | 6.67 | 86.67 | 0.00 | 16 | 0.01 | 0.05 | 15 | | | | | | | |
| 7 | Syllidae juv. | 20.00 | 2213.33 | 0.12 | 8 | 0.05 | 0.52 | 9 | 33.33 | 4800.00 | 0.26 | 10 | 0.10 | 1.47 | 11 |
| 8 | Polychaeta varia | 66.67 | 21461.93 | 1.13 | 4 | 0.08 | 0.78 | 7 | 100.00 | 34941.67 | 1.92 | 6 | 0.17 | 2.57 | 7 |
| 9 | Veliconcha *Mytilus* | 66.67 | 147733.33 | 7.79 | 3 | 7.30 | 72.25 | 1 | 33.33 | 6866.67 | 0.38 | 9 | 1.52 | 23.24 | 6 |
| 10 | *Rhombognathus sp.* | 60.00 | 12837.47 | 0.68 | 5 | 0.09 | 0.87 | 6 | 100.00 | 64053.00 | 3.52 | 5 | 0.55 | 8.48 | 5 |
| 11 | Halacarida varia | 13.33 | 1849.00 | 0.10 | 10 | 0.02 | 0.15 | 11 | 100.00 | 12082.83 | 0.66 | 8 | 0.09 | 1.31 | 9 |
| 12 | *Cyprideis littoralis* | 6.67 | 26.67 | 0.00 | 17 | 0.00 | 0.00 | 17 | 16.67 | 533.33 | 0.03 | 15 | 0.00 | 0.05 | 16 |
| 13 | *Paradoxostoma intermedium* | 6.67 | 960.00 | 0.05 | 13 | 0.01 | 0.06 | 14 | 66.67 | 19096.67 | 1.05 | 7 | 0.24 | 3.72 | 8 |
| 14 | *Xestoleberis decipiens* | 6.67 | 106.67 | 0.01 | 15 | 0.00 | 0.01 | 16 | 100.00 | 93634.17 | 5.15 | 4 | 0.96 | 14.65 | 2 |
| 15 | *Xestoleberis acutipenis* | 13.33 | 2026.67 | 0.11 | 9 | 0.01 | 0.13 | 12 | 100.00 | 97334.17 | 5.35 | 3 | 0.84 | 12.82 | 4 |
| 16 | *Loxochoncha pontica* | | | | | | | | 33.33 | 305.00 | 0.02 | 14 | 0.00 | 0.06 | 15 |
| 17 | Harpacticoida | 100.00 | 977576.33 | 51.56 | 1 | 1.08 | 10.71 | 2 | 100.00 | 846966.67 | 46.56 | 1 | 0.88 | 13.43 | 3 |
| 18 | Larvae cypris | 33.33 | 19876.80 | 1.05 | 6 | 0.20 | 1.97 | 5 | 16.67 | 4200.00 | 0.23 | 11 | 0.04 | 0.64 | 12 |
| No. | Taxa | Mamaia cell | | | | | | | Mangalia cell | | | | | | |
| | | | $D_{AVG}$ | $D_D$% | | $B_{AVG}$ | $D_B$% | | | $D_{AVG}$ | $D_D$% | | $B_{AVG}$ | $D_B$% | |
| | Foraminifera | | 2703.33 | 0.14 | | 0.12 | 1.20 | | | 354.17 | 0.02 | | 0.02 | 0.24 | |
| | Vermes | | 730172.40 | 38.51 | | 1.28 | 12.66 | | | 673840.67 | 37.04 | | 1.39 | 21.34 | |
| | Mollusca | | 147733.33 | 7.79 | | 7.30 | 72.25 | | | 6866.67 | 0.38 | | 1.52 | 23.24 | |
| | Crustacea | | 1000573.13 | 52.78 | | 1.30 | 12.87 | | | 1062070.00 | 58.38 | | 2.96 | 45.37 | |
| | Varia | | 14686.47 | 0.77 | | 0.10 | 1.02 | | | 76135.83 | 4.18 | | 0.64 | 9.80 | |

## REFERENCES


Băcescu, M., Dumitrescu, E., Marcus, A., Paladian, G., Mayer, R., 1963 – Donnees quantitatives sur la faune petricole de la Mer Noire a Agigea (secteur roumain) dans les conditions speciales de l'annee 1961, Trav. Mus. Hist. Nat. "Gr. Antipa", Bucureşti, 4: 131-155

Băcescu, M., Müller, G.I., Gomoiu, M.-T., 1971 – Cercetări de ecologie bentală în Marea Neagră (analiza cantitativă, calitativă şi comparată a faunei bentale pontice), Ecologie marină, Ed. Acad., Bucureşti, 4: 357

Gomoiu, M.-T., Ţigănuş, V., 1974 – Contributions to the knowledge of the fouling on the Romanian maritime ships, Cercetări marine, IRCM Constanţa, 7: 83-112

Gomoiu, M.-T., Ţigănuş, V., 1976 – Cercetări privind compoziţia foulingului de pe navele maritime româneşti, Al VI-lea Simpoz. Biodeter. Climat., Constanţa, 1: 84-91

Gomoiu, M.-T., Ţigănuş, V., Bondar, C., 1978 – Date privind formarea foulingului în apele de larg ale Mării Negre, Al VIII-lea Simpoz. Biodeter. Climat., Braşov: 375-380

Gomoiu, M.-T., Ţigănuş, V., 1981 – Structure qualitative et quantitative des salissures formees dans les eaux du large de la Mer Noire, Rapp. Comm. Int. Mer Medit., CIESM., Monaco, 27, 2: 185-184

Gomoiu, M.-T., 1986 – Donnees preliminaires sur la structure et le role d'une communaute epibionte formee sur le substrat artificiel, Rapp. Comm. Int. Mer Medit., CIESM., Monaco, 30,2: 17

Gomoiu, M-T., 1989 – Potential role and ecological effects of artificial reefs constructed on the coastal sandy bottoms of the Black Sea (Romania), Trav. Mus. Hist. Nat. "Gr. Antipa", Bucureşti, 30: 291-306

Gomoiu, M.-T., 1997 – Recifi artificiali la litoralul românesc. An. Univ. „Ovidius" Constanţa, Seria Biologie-Ecologie, I (1): 159-174

Petranu, A., (compiler), 1997 – Black Sea Biological Biodiversity – Romania. Black Sea Env. Series, 4, United Nations Publ. New York: 314

Ţigănuş, V., 1979 – Observations sur la structure qualitative et quantitative de la biocenose des moules de rocher du littoral roumain de la Mer Noire, Rapp. Comm. Int. Mer Medit., CIESM., Monaco, 25(26):159–160