

## Current Status of Zoobenthic Communities Associated with Deep Circalittoral Habitats from the Romanian Continental Shelf

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**Abstract.** *The European environmental policies related to marine water management require periodic environmental status assessments. Particularly, the Marine Strategy Framework Directive 2008/56/EC, clearly specifies that assessment must take into consideration benthic habitat types, including their associated biological communities. The aim of this study is to present the results from the ecological analysis of macrobenthic fauna from deep circalittoral habitats with mixed and mud sediments dominated by *Modiolula phaseolina* and *Terebellides stroemii* and to provide new information on the current structure and distribution of communities. The analyzed data covers the period 2021-2022 based on the processing of 56 samples on depths ranging between 60 m to 130 m. A total of 70 macrozoobenthic species were found in the assemblages, of which Polychaeta group had the highest number of species and individuals, mostly *T. stroemii* and *Aonides paucibranchiata*. For data interpretation, a synecological analysis was performed allowing the identification of the species with the most significant contribution to the ecosystem in terms of function, energy exchanges with the environment, the species characteristic of a biotope or those that have an accidental presence in the studied area. Also, the present ecological status of deep circalittoral habitats was assessed using the M-AMBI\*(n) index, which was proposed as one of the indicators for assessing the good environmental status of marine habitats in Romanian marine waters.*

**Keywords:** MSFD, good environmental status, deep circalittoral habitats, *Modiolula phaseolina*, *Terebellides stroemii* communities

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### Introduction

In accordance with the requirements of the Marine Strategy Framework Directive 2008/56/EC through Decision 848/2017, in the Romanian marine waters, broad habitat types were evaluated, among them, deep circalittoral habitats with mixed and mud sediments.[9].

The zoobenthic community associated with deep circalittoral habitats dominated by *Modiolula phaseolina* is one of the most important and characteristic benthic communities of the Black Sea. In the north-western part of the Black Sea, this community has a particular importance, both through its expansion (only on the Romanian coast it occupies 40% of the surface of the continental shelf) and its ecological role [2][4]. Periodic surveillance of the state of zoobenthic communities involves an ecological control carried out through research that can highlight the qualitative and quantitative status of the associated benthic invertebrates, but also the changes produced at their level, as well as the tendency to rebalance or restore the populations.

The present paper aims to provide updated information on the structure and distribution of benthic communities characteristic of deep circalittoral habitats and assess their populations through analytical and synthetic ecological indices.

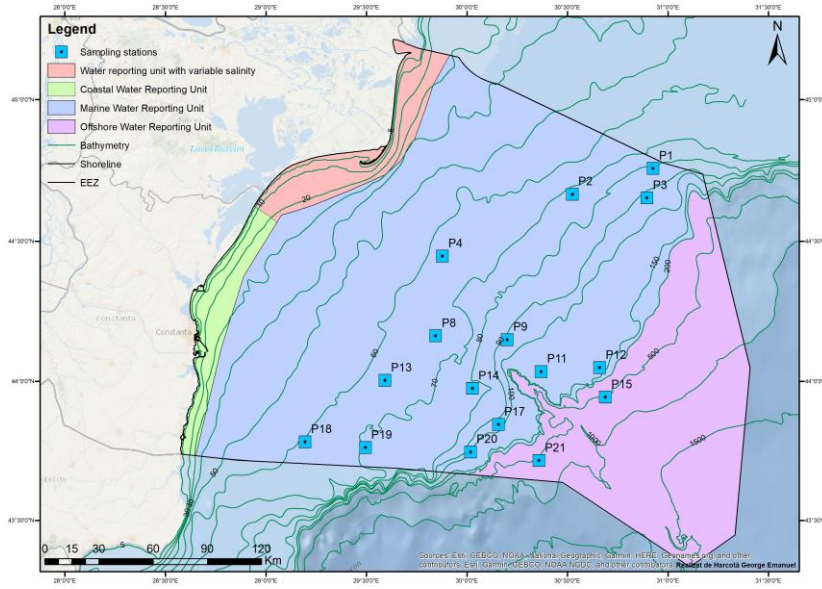
### **Material and Methods**

The analysed data covers the period 2021-2022 based on the processing of 56 samples being collected on depths ranging between 60 m to 130 m (see Map, Figure1). In most of cases, three replicate samples were taken at each sampling point. According to the methodology agreed upon at the Black Sea region, samples were collected using a Van Veen grab with an area of 0.1 m<sup>2</sup>, stored in plastic buckets and buffered with formaldehyde 40%. In the laboratory, macrozoobenthos samples were washed using a set of stainless-steel gauze sieves with a mesh size of 1.0 × 1.0 mm and 0.5 × 0.5 mm [7]. After the organisms were identified and determined under the stereomicroscope, quantitative parameters were calculated. All taxa were identified to the lowest possible taxonomic level (e.g., species) using specific identification keys and all species names were updated according to the World Register of Marine Species (WoRMS) ([www.marinespecies.org](http://www.marinespecies.org)).

To reach the purpose of this study, a synecological analysis was carried out. As analytical ecological indices were used the dominance D% (relative abundance) and constancy (C%) as well as the ecological significance index (*W, Dzuba index*) which expresses the relation between the structural indicator (constancy) and that of productivity (dominance) and which reflects the position of the species into biocoenosis [5].

Also, the present ecological status of the deep circalittoral habitats was assessed using the M-AMBI\*(n) index. This indicator is obtained by integrating the biotic index AMBI based on the proportion of sensitive and tolerant species to pollution, Diversity Index (H') and species richness (S), which makes it compatible with both the WFD and MSFD [1][6]. For this purpose, the AZTI AMBI software (<http://ambi.azti.es>) was used [3].

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**Fig. 1.** Map of sampling site in the Romanian continental shelf

### Results and Discussion

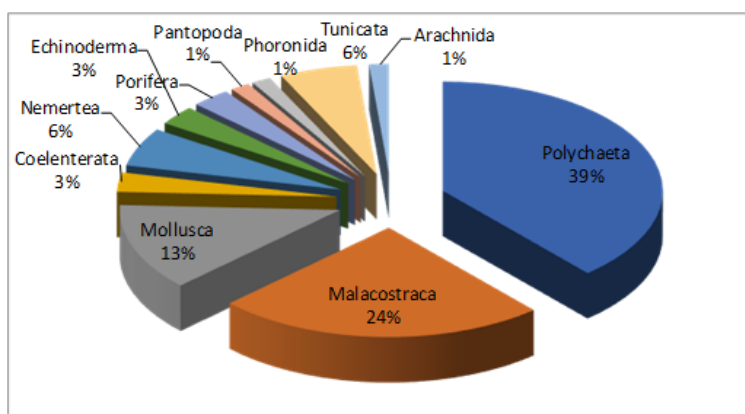
Following the sample processing, 70 macrozoobenthic species were identified in the entire studied area, belonging to the following groups: Polychaeta (37%), Malacostraca (34%), Mollusca (13%), and “Other groups” (24%), represented by Phoronids, Echinoderms, Tunicates, Sponges, Pantopods, Arachnida (see Table 1; Figure 2). According to the population structure, the benthic community which dominates these depths is the one with the small bivalve species *Modiolula phaseolina*, which prefers bottoms with a constant salinity and relatively low oxygen content. Also, the Polychaeta group had the highest number of species and individuals, among them *Terebellides stroemii* and *Aonides paucibranchiata* appearing as permanent accompanying species to *Modiolula*. Besides the dominant species, the macrofauna was characterized by the constant presence of species such as *Phyllodoce maculata*, *Dipolydora quadrilobata*, *Carinina heterosoma*, *Micrura fasciolata*, *Amphiura stepanovi*, *Molgula appendiculata*. Other species of deep circalittoral benthic communities that can also be found frequently at other depths as well, due to their large ecological plasticity were polychaetes *Nephtys hombergii*, *Harmothoe reticulata*, *Exogone naidina* and amphipods *Ampelisca sp.*, *Microdeutopus damnoniensis*.

**Table 1.** List of macrozoobenthic taxa identified in mixed and mud sediments in deep circalittoral zone during 2021 - 2022 period

Crt. no.	Taxa
1	<i>Cylista undata</i> (Müller, 1778)
2	<i>Sycon ciliatum</i> Fabricius, 1780
3	<i>Suberites carnosus</i> Johnston, 1842
4	<i>Amphiporus bioculatus</i> McIntosh, 1874
5	<i>Carinina heterosoma</i> Müller, 1965
6	<i>Micrura fasciolata</i> Ehrenberg, 1828
7	<i>Tetrastemma</i> sp.
8	<i>Amphicorina armandi</i> (Claparède, 1864)
9	<i>Aonides paucibranchiata</i> Southern, 1914
10	<i>Aricidea</i> sp.
11	<i>Capitella capitata</i> (Fabricius, 1780)
12	<i>Dipolydora quadrilobata</i> (Jacobi, 1883)
13	<i>Exogone naidina</i> Oersted, 1845
14	<i>Eulalia viridis</i> (Linnaeus, 1767)
15	<i>Genetyllis tuberculata</i> (Bobretzky, 1868)
16	<i>Harmothoe reticulata</i> (Claparède, 1870)
17	<i>Heteromastus filiformis</i> (Claparède, 1864)
18	<i>Janua heterostropha</i> (Montagu, 1803)
19	<i>Lagis koreni</i> Malmgren, 1866
20	<i>Leiochone leiopygos</i> (Grube, 1860)
21	<i>Melinna palmata</i> Grube, 1870
22	<i>Micronephthys longicornis</i> (Perejaslvtseva, 1891)
23	<i>Nephtys cirrosa</i> Ehlers, 1868
24	<i>Nephtys hombergii</i> Savigny, 1818
25	<i>Nereis zonata</i> Malmgren, 1867
26	<i>Notomastus profundus</i> Eising, 1887
27	<i>Phyllodoce maculata</i> (Linnaeus, 1767)
28	<i>Polydora cornuta</i> Bosc, 1802
29	<i>Prionospio maciolekae</i> Dagli & Çinar, 2011
30	<i>Prionospio</i> c.f. <i>multibranchiata</i> Berkeley, 1927
31	<i>Sphaerosyllis bulbosa</i> Southern, 1914
32	<i>Spirobranchus triqueter</i> (Linnaeus, 1758)
33	<i>Terebellides stroemii</i> M. Sars, 1835
34	<i>Phoronis euxinicola</i> Selys-Longchamps, 1907
35	<i>Abra alba</i> (W. Wood, 1802)
36	<i>Acanthocardia paucicostata</i> (G. B. Sowerby II, 1834)
37	<i>Balcis incurva</i> Monterosato, 1884
38	<i>Mytilus galloprovincialis</i> Lamarck, 1819
39	<i>Monophorus perversus</i> Linnaeus, 1758
40	<i>Modiolula phaseolina</i> Philippi, 1844
41	<i>Parvicardium simile</i> (Milaschewitsch, 1909)
42	<i>Pitar rudis</i> (Poli, 1795)
43	<i>Retusa truncatula</i> (Bruguière, 1792)

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Crt. no.	Taxa
44	<i>Callipallene sagamiensis</i> (Nakamura & Child, 1983 )
45	<i>Ampelisca</i> sp.
46	<i>Apherusa bispinosa</i> (Spence Bate, 1857)
47	<i>Apeudopsis ostroumovi</i> Bacescu & Carausu, 1947
48	<i>Deflexilodes gibbosus</i> (Chevreux, 1888)
49	<i>Dexamine spinosa</i> Montagu, 1813
50	<i>Eudorella truncatula</i> Bate, 1856
51	<i>Iphinoe elisae</i> Băcescu, 1950
52	<i>Iphinoe tenella</i> Sowinskyi, 1893
53	<i>Medicorophium runcicorne</i> (Della Valle, 1893)
54	<i>Microdeutopus damnoniensis</i> (Bate, 1856)
55	<i>Microdeutopus versiculatus</i> (Bate, 1856)
56	<i>Nototropis guttatus</i> Costa, 1853
57	<i>Orchomene humilis</i> Costa, 1853
58	<i>Perioculodes longimanus longimanus</i> (Bate & Westwood, 1868)
59	<i>Phtisica marina</i> Slabber, 1749
60	<i>Synchelidium maculatum</i> Stebbing, 1906
61	<i>Stenosoma capito</i> Rathke, 1836
62	<i>Thalassarachna basteri</i> , Johnston, 1836
63	<i>Leptosynapta inhaerens</i> (O.F. Müller, 1776)
64	<i>Lindrilus flavocapitatus</i> Uljanina, 1877
65	<i>Amphiura stepanovi</i> Chernyavskii, 1861
66	<i>Ascidiella aspersa</i> (Müller, 1776)
67	<i>Ciona intestinalis</i> , Linnaeus, 1767
68	<i>Eugyra adriatica</i> Drasche, 1884
69	<i>Molgula appendiculata</i> Heller, 1877
70	<i>Pachycerianthus solitarius</i> Rapp, 1829



**Fig. 2.** The distribution of benthic invertebrate groups identified in the deep circalittoral habitats (mixed and mud sediments)

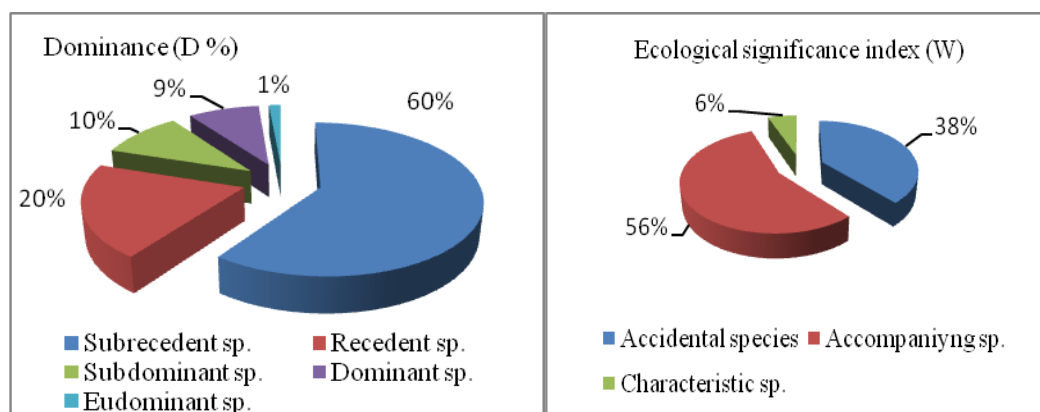
Regarding the quantitative structure of the zoobenthic communities which inhabit the deep circalittoral habitats, the analysis of the results obtained from the calculation of the quantitative allowed us to make a few observations.

Numerically, the group of polychaetes (4,585 ind/m<sup>2</sup>) and molluscs (2,964 ind/m<sup>2</sup>) achieves 60 % of the total average abundance, while the crustaceans and “other groups” had balanced densities, 20% each of them. Among the polychaetes, only four species had a higher abundance from the whole densities of the group, *Terebellides stroemii* (26.12%), *Aonides paucibranchiata* (15.96%), *Nephtys hombergii* (10.22%) and *Phyllodoce maculata* (8,87%). The molluscs are well represented by *Modiolula phaseolina* which recorded 91% of the group abundance. The crustaceans, *Apseudopsis ostroumovi*, *Ampelisca sp.* and *Phtisica marina* dominated with 63% of the total identified species group. Beginning with 70 m depths to 111 m the presence of tunicate *Molgula appendiculata* was observed and recorded at an average density of 429 ind/m<sup>2</sup>.

In terms of biomass, the same tunicate *M. appendiculata* had a significant contribution to the increasing of biomass values, forming compact colonies, mostly at depths over 80 m, recording an average value of 431.63 g/m<sup>2</sup>. Given the small size of the dominant bivalve *Modiolula*, its biomass values were reduced (133.59 g/m<sup>2</sup>).

To determine the species with the most significant contribution in the ecosystem, the characteristic species of a biotope or those that have accidentally arrived in the studied area, analytical ecological indices were used.

The synecological analysis performed based on the average densities of the identified species indicated as dominant species, the bivalve *Modiolula phaseolina* (see Figure 3, a). The ecological significance index (W) indicated the presence of 27 accidental species, 39 accompanying species and 4 characteristic species of the community (see Figure 3, b).



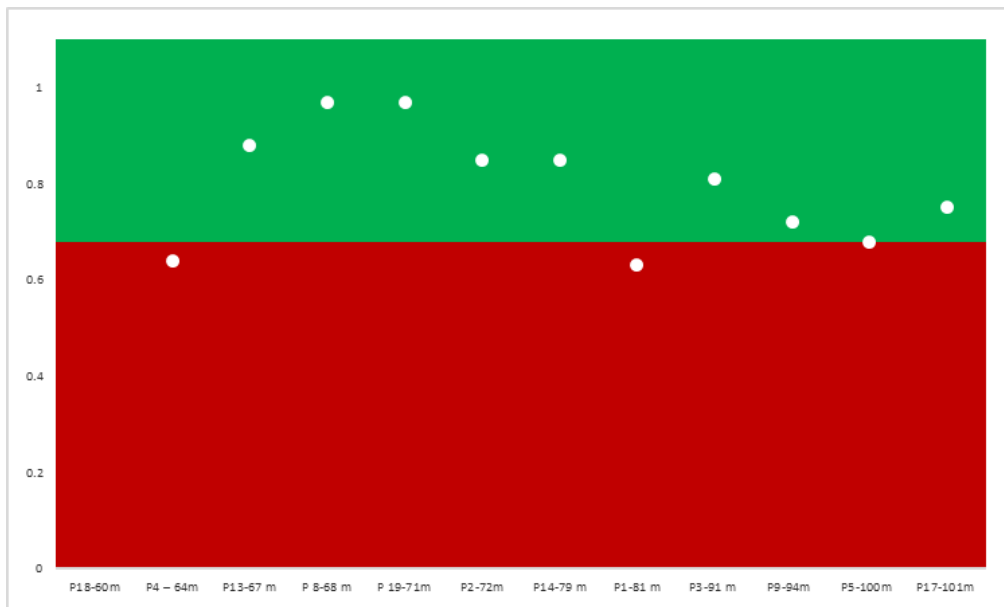
a – Dominance (D%)

b – Ecological significance index (W)

**Fig. 3 (a,b)** - Species distribution based on the analyzed indicators

Also, the qualitative and quantitative data using univariate and multivariate statistical methods were analysed. Using AMBI v.5 program [3], the percentage of the main ecological groups of organisms was calculated. The distribution of macrozoobenthic species by ecological groups, in assessed habitats, showed the dominance of sensitive species to organic matter concentrations in sediments (51%). Besides these sensitive species, both tolerant species to the content of organic matter (35%) and tolerant to high concentrations of organic matter in sediments (10%) were present in high number, as well. The proportion of opportunistic species was greatly reduced with increasing depth.

The ecological status of macrozoobenthos was assessed by applying the M-AMBI\*(n) index. [1] [6] [8]. The results of the M-AMBI\*(n) index highlighted that 83% of the stations (10 stations) are in good ecological condition with the mention that two stations from 111m and 130 m depths were excluded from the analysis, the community being different, formed mainly by meiobenthic organisms (see Figure 4). Therefore, in the analysed depth interval, the value of the M-AMBI\*(n) index exceeded the threshold value in all cases (M-AMBI\*(n)  $\geq 0,64$ ).



**Fig. 4.** The ecological status of benthic communities of deep circalittoral with *Modiolula* on the Romanian Black Sea shelf using M-AMBI\*(n) index values during 2021-2022 period.

## Conclusions

- (1) The study area comprised deep circalittoral habitats with mixed and muddy sediments dominated by *Modiolula phaseolina* and *Terebellides stroemii*.
- (2) 70 taxa including 27 polychaetes, 17 crustaceans, 9 molluscs and, 17 species representing other groups were identified.
- (3) The most dominant benthic group were polychaetes, which represented 37.14 % of the faunal diversity.
- (4) The polychaetes and molluscs groups achieved 60 % of the total average abundance, being well represented by *Terebellides stroemii*, *Aonides paucibranchiata*, *Nephtys hombergii*, *Phyllodoce maculata* and *Modiolula phaseolina* species.
- (5) For biomass, the tunicate *M. appendiculata* had significant contribution to the increasing of biomass values, forming compact colonies, recording an average value of 431.63 g/m<sup>2</sup>. Given the small size of the dominant bivalve *Modiolula*, its biomass values were reduced, not exceeding 133.59 g/m<sup>2</sup>.
- (6) Synecological analysis indicated the bivalve *Modiolula phaseolina*, as one eudominant species, six dominant species, *T. stroemii*, *A. paucibranchiata*, *Ampelisca sp.*, *Apseudopsis ostroumovi*, *Phtisica marina*, *Carinina heterosoma* and the other ones as subdominant, recedent and, in a large proportion subrecedent species (60%) The ecological significance index indicated the occurrence of 4 characteristic species of the community.
- (7) The macrozoobenthic species were predominantly represented by sensitive species to organic matter concentrations in sediments (51%) followed by the tolerant (35%) and indifferent ones (10%).
- (8) According to of M-AMBI\*(n) index, the habitats analysed and the associated communities are in good ecological condition.

## Acknowledgment

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