

MARINE BENTHIC HABITATS WITHIN A PHYSICAL DISTURBED SITE FROM THE ROMANIAN COAST OF THE BLACK SEA

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Abstract. The present study was carried out in the NW Romanian shelf in an area highly affected by dredging and trawling activities performed in scope of sand extraction and *Rapana* whelk harvesting. The aim was to assess the magnitude of impact and the post-dredging evolution of the circalittoral benthic habitats and their populations. On this purpose, 23 samples of macrobenthos were collected during the survey conducted in 2018. The results were compared with data collected in 2016, three months after dredging events. The physical disturbance of habitats was revealed by side scan sonar and multibeam bathymetry scanning. The sand extracting area and the trawled one extend on 2.7 km² (2500 m length and 700 m width) and 33.6 km² of seabottom, respectively, totalising more than 70% of the study area. Moreover, a changing in benthic community in terms of diversity and abundance as well as of functional groups dominance was detected.

Keywords: Romanian Black Sea shelf, dredging and trawling activities, broadscale circalittoral benthic habitats, physical disturbance, macrobenthic ecological response.

AIMS AND BACKGROUND

Beam trawling is regarded as one of the most disturbing activities becoming a regularly activity in the last years at the Romanian littoral. In addition, dredging and related activities such as dredge material placement occasionally performed may affect the fragile marine ecosystem through released sediments into the water column, physical disturbance of habitats, species replacement or disappearing, enrichment of sediments with organic matter, pollutants recycling. Large scale sand extraction has been carried out for the first time within the framework of the project ‘Protection and rehabilitation of the Southern part of the Black Sea Romanian littoral in front of Constanta and Eforie Nord’, aiming among others to protect the beaches against accelerated erosion by artificial nourishment. Since 2016, permissions for using beam trawling were issued by the national authority for fishing and aquaculture, annual quota for harvesting being set at the national level.

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Gutperlet¹ used benthic organisms as efficient indicators of physical disturbance such as dredging, which affects the sediment structure and composition². Recurring dredging activities often lead to substantial reduction in benthic standing crop and species diversity^{3,4}. Studies on the impact of dredging activities on the benthic fauna is widely researched worldwide⁵ being mostly focused on its distribution and diversity but the impact of dredging have not been addressed comprehensively till date. The impact of drag-nets (beam and bottom trawl) for rapa catch, mainly (82%) on the benthic habitat operating for a long period (since 1980s) has been assessed along the southern Black Sea. The by-catch species was estimated at 29.7%, represented by Mollusca (25.7% – of the total catch), Crustaceans (3.5%), fishes (mostly juveniles) (0.2%) and Tunicates (0.3%) (Ref. 6).

In this context, the present study will evaluate whether and how the dredging/trawling activities carried out affected some of the major circalittoral habitats from the Romanian littoral, bringing new data about the structure and distribution of macrozoobenthos. Studies of ecological quality of circalittoral broad benthic habitats and macrozoobenthos previously performed at the Romanian littoral showed GES for the circalittoral biogenic reefs, but no further details were given for the smaller scale habitats within and the economic pressures⁷. Another relevant study analysed the assessment of quality status of benthic communities within the transitional waters, showing the link between the impact of anthropogenic pressure (contaminants) and benthic population state⁸.

EXPERIMENTAL

The study area was located in front of Constanta town. In July 2018, 23 stations were sampled onboard the R/V 'Mare Nigrum' (Fig. 1). Macrozoobenthos samples were collected with a Van Veen grab of 0.135 m² area and then washed through a 0.5 mm mesh sieve according to the methodology agreed at the Black Sea level⁹. The density and biomass per sample are given at square meter. Bivalves were weighed with shells. The free software AZTI Marine Biotic Index, M-AMBI was used to determine the state of soft-bottom macroinvertebrate communities.

For the spatial distribution of species the freeware program OceanDataView was used¹⁰. Benthic broad habitat types are classified according to the Commission Decision (EU) 2017/848, using the classification system of the European nature information system (EUNIS). The nomenclature of species was checked following the World Register of Marine Species (www.marinespecies.org).

For the bathymetric study, the Elak Nautik SeaBeam Multibeam Echo Sounder Systems 1050D at 50 kHz frequency was used. For the acoustic measurements the Klein L3900 Side Scan sonar was used at a frequency of 455 kHz. 39 profiles with lateral sonar and 78 profiles with the multibeam system were performed in the study perimeter.

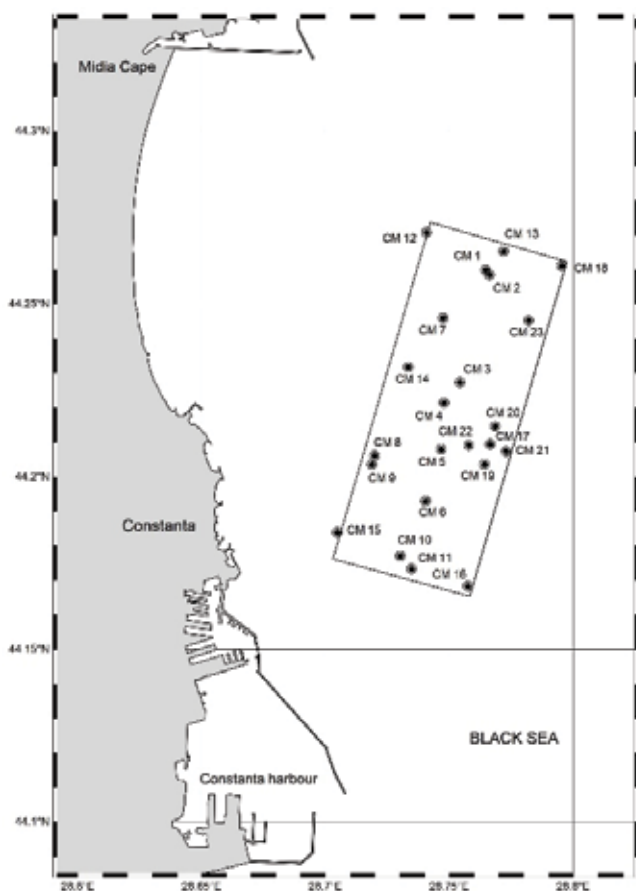


Fig. 1. Map of the study area with locations of sampling stations

RESULTS AND DISCUSSION

There were 62 macrozoobenthic taxa identified in the area. The highest diversity was shown by the groups – Annelida, Crustacea and Mollusca. Species number per station varied between 10 to 31, with the lowest one in the station CM 05 and the highest in the station CM 23, while the average abundances and biomass reached almost 3304.86 ind. m⁻² and 121.3 g m⁻², respectively (Fig. 2).

Four broadscale habitats have been identified within the study area (51.433 km²: 11.2 km length, 4.5 km width) belonging to circalittoral floor: circalittoral mud (33.42 km²), circalittoral mixed sediments (12.784 km²), circalittoral sand: 3.08 km² (present also within the dredged polygon), circalittoral coarse (shell debris) sediments: 3.43 km² (Fig. 3).

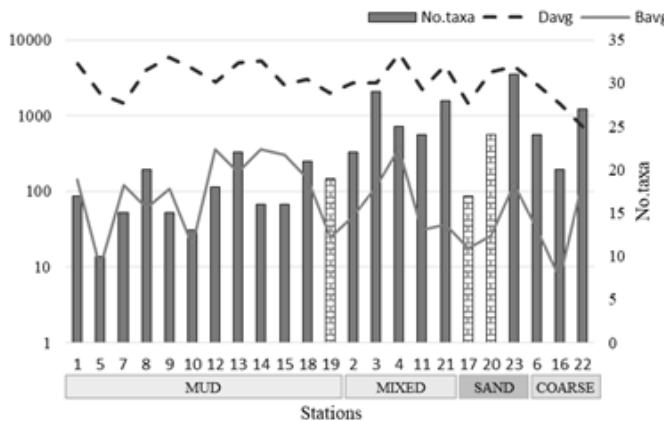


Fig. 2. Distribution of species richness, density and biomass of macrobenthic populations in the study area (impacted stations by sand dredging displayed with red column)

The trawling activity for *Rapana venosa* harvesting affected more than 65% of the entire area, being mostly carried out within the circalittoral mud with communities of *Spisula*, *Abra*, *Pitar* and *Acanthocardia*. In the period 2012–2015, the whelck captures increased three times from about 1500 to almost 4000 t. The dredging activity carried out in the winter – spring of 2016 impacted 5% (2.582 km²) of the area, causing a partial destruction of the habitat of *Upogebia pusilla*, a protected species at the regional level (according to data from 2016 collected short time after dredging activity). The depth within the study area varied between 22 and 27 m (Fig. 3).

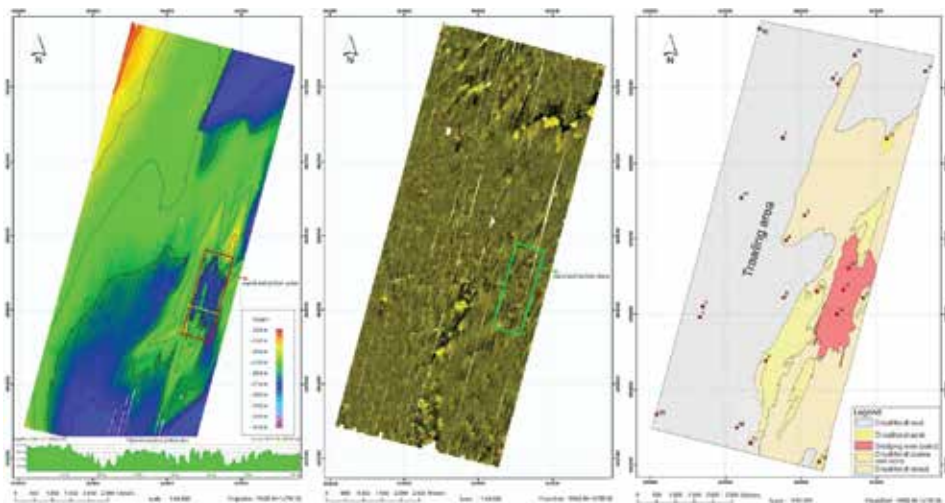


Fig. 3. Bathymetric, side scan and broadscale habitats map of the study perimeter

Circalittoral mud habitat was characterised by a species richness of 46 taxa, among which, besides opportunistic oligochaets and polychaets species (68% of total density; 4% of total biomass): *Melinna palmata*, *Nephtys hombergii*, *Heteromastus filiformis*, typical molluscs association of this habitat dominated: *Abra nitida* (6231 ind. m⁻²), *Spisula subtruncata* (991.6 ind. m⁻²) and *Acanthocardia paucicostata* (481 ind. m⁻²). The molluscs wet biomass represented 92% of the total. Pretty numerous but with limited distribution within this habitat were found the crustacean *Ampelisca sarsi* (414.4 ind. m⁻²) and the phoronid *Phoronis euxinicola* (873.2 ind. m⁻²), forming with *M. palmata* a distinct community/enclave present in the stations CM 1 and 13 (Fig. 4).

Circalittoral mixed habitat accounted for a diversity of 45 taxa, distinguished from the mud habitat through the dominance of small deposit feeders spionid polychaetes *Prionospio multibranchiata* (2,568 ind.m⁻²) and *Pygospio elegans* (1354 ind. m⁻²) though almost overwhelmed in abundance by *M. palmata* (1420 ind. m⁻²), the predators *Nephtys hombergi* (725 ind. m⁻²) and *Micronephthys stammeri* (1495 ind. m⁻²). *A. nitida*, *S. subtruncata* and *Pitar rudis* constituted the greatest bulk of the mollusks association, being predominantly found in the station CM 4 located at about 1.5 km off the impacted dredging area. In terms of biomass, mollusks made up 76% of the total.

Circalittoral sand with only 3.08 km² summed up to 35 taxa, a distinct differentiation being seen in their distribution within and outside the impacted area by dredging. Hence, whereas a richness of 31 taxa was noted in the station 23, only 17 and 24 taxa, respectively were found within the stations 17 and 20 (Fig. 4).

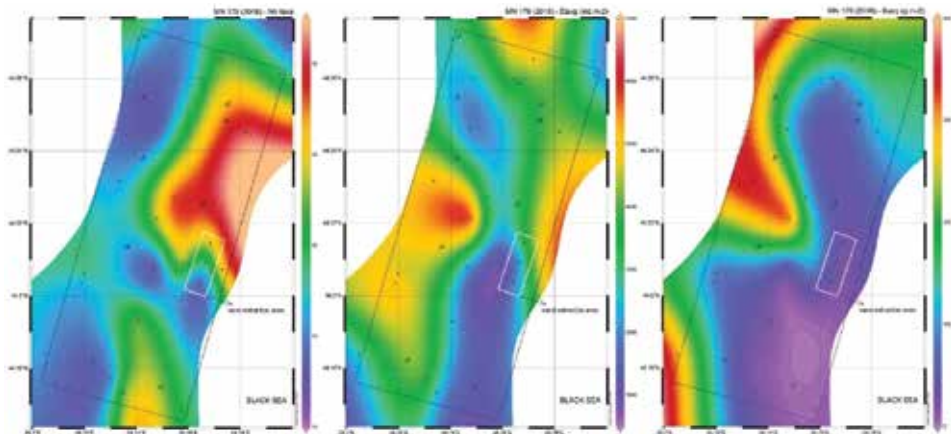


Fig. 4. Distribution of number of species, average density and biomass of the macrobenthic populations

As two to threefold increase of abundance and two to six fold of biomass as distance increases from the stations 17 to 23 was recorded. A shift in species dominance was also found. Hence, from an almost exclusively domination of *M. palmata* (58%) in the station 17 to a more equitable community structure constituted of a mixture of spionids (4 species), nephtyiids (2 species), capitellids (1 species), nemerteans (2 species), phoronids (1 species) in the station 20 and to a community where molluscs (6 species; 7% after density; 77% as biomass) and crustaceans (5 species; 4% after density) mainly featured the habitat structure in the station 23 give a full prove on the changes occurred over time in this habitat due to dredging activities.

Circalittoral coarse sediments represent the ancient littoral bars of dead shells accumulated at this level after sea level transgression 27 000–35 000 years ago in Würmian interstadial Arcy Stillfried (Surojsk) period¹¹. It is seen on the side-scan sonar image as an alternance of dunes of about 0.5 m in height (see further Fig. 7). The habitat is particular, the faunistic composition being diverse (41 taxa) but poor (1559 ind. m⁻² in average). *Microphthalmus szcelkowiei* is rarely found elsewhere, inhabiting almost exclusively coarse sediments found here. *Prionospio multibranchiata* (454 ind. m⁻²; 1.81 g m⁻²) was dominant, while *Polydora cornuta* (451.4 ind. m⁻²; 0.24 g m⁻²), *Alitta succinea*, mostly as juveniles and subadults (222 ind. m⁻²; 0.38 g m⁻²), were subdominant in the same association. Overall, the density was the lowest (710.4 ind. m⁻²) in the station 22, located in the very vicinity of the impacted area.

The Bray – Curtis dendrogram based on biomass highlighted the differentiation of coarse habitat, on one hand, and a high similarity between mixed and sand habitats, on the other hand. 14 species most contributed at similarity between habitats.

The medium-term evolution of macrozoobenthos structure and diversity as well as the physical disturbance of habitats within the impacted sites by dredging were revealed through comparison of changes occurred in the period 2016–2018 (Fig. 5). The sidescan sonar and bathymetry images taken in 2016 show clearly the deep marks (of about 2 m) left by the dredge, which still can be seen in 2018, in spite of steepness attenuation. However, the sediment characteristics changed significantly in that time interval.

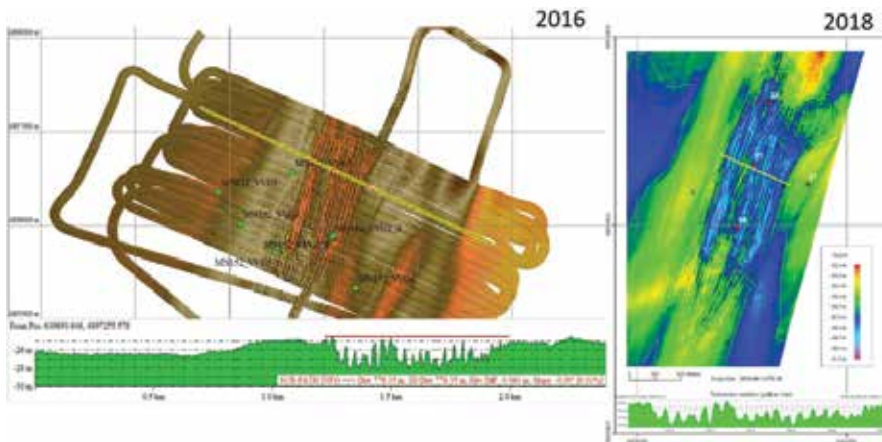


Fig. 5. Dredged area for sand extraction in 2016 (side scan image) and 2018 (multibeam image) along with crosssections through site to evinced the evolution of traces in time interval

Yet, three years after the cessation of sand extraction, macrozoobenthic community is not completely recovered. Comparing the results of analysis of sandy habitats and of fauna obtained in 2016 at three months after extraction with the ones from 2018 in the same stations, it is noted that characteristic species that used to inhabit the sandy substrate in the area are still absent. In 2016, the total taxa number was 40.28 in the dredged area and 32 in the reference (adjacent) area comparing with 2018, when 43 taxa were noted in the area, 28 in the dredged area and 39 in the reference one. A rapid recovery of opportunistic species followed the dredging period. Thus, *M. palmata* and *N. hombergii* replaced in most of the area *P. multibranchiata*, while the number and diversity of nemertean species drastically reduced (*Carinina heterosoma*, *Cephalothrix* sp.). We assume that the process of siltation contributed the most at the changes observed. *M. palmata* and *N. hombergii* are highly tolerant species to organic enrichment comparative with the other polychaetes species or nemerteans. Despite of evident impact, the overall ecological condition of the dredged area seems to be high/good. This could be explained by the structure of fauna itself, which is mainly formed of species with different biological and ecological mechanisms for rapid recovery of their population. The changes of the substrate type in dredged area were the driver factor in fauna shift from typical sandy species (e.g. *Prionospio*) to muddy one (*Melinna*).

According to M-AMBI, both the impacted areas by dredging and trawling underwent a recovery process. In 2018, most part of the mud habitat was in poor state, the second opportunistic species representing more than 50% of the taxa number, while the mixed, sand and coarse habitats were in good and high state, disturbance – tolerant species being predominantly met in stations within these habitats (Fig. 6).

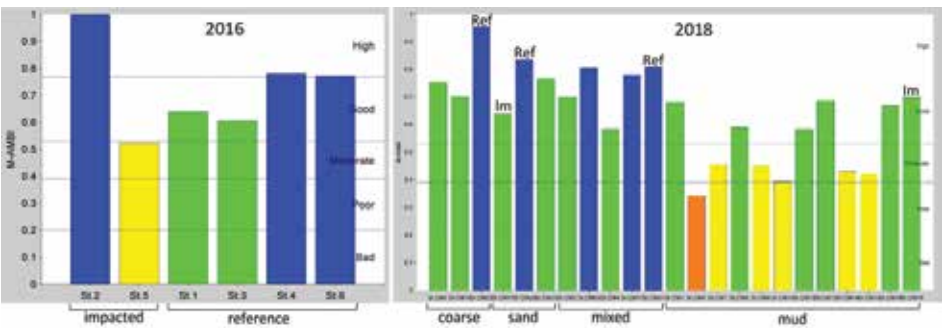


Fig. 6. Ecological quality status (according to M-AMBI index) of the habitats within dredged and reference (not-impacted nearby benthic habitats) areas in 2016 and within the entire study area in 2018 (Im – impacted dredged area; Ref – reference)

The entire muddy area, as revealed by geophysical investigations, is crossed by beam trawl traces (Fig. 7). Our assessment showed an increased number of small detritivore species. Taken into consideration that the mud habitat covers 65% of the area, we believe that the strong siltation produced by the trawl operation affected mainly the epibenthic and subsurface organisms, the molluscs community such as *S. subtruncata*, and the crustaceans (e.g. *Iphinoe elisae*, *Paramysis pontica*, *Diogenes pugilator*). The collateral damage of trawling for rapa is reflected by the by-catch organisms and the unsustainable practice that hinder the recovery of slow-growing species like: *Spisula*, *Pitar*. Still, the poor status of the benthic fauna in trawled area does not permit the detection of significant effects on macrofaunal community structure.

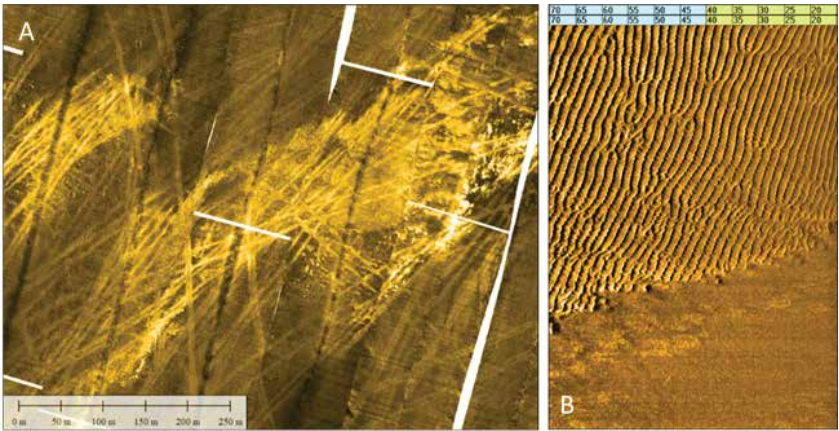


Fig. 7. Beam trawl traces left on the seabottom after rapa harvesting (A) and particular coarse biogenic habitats representing the ancient littoral bars accumulations (B).

CONCLUSIONS

The sand extracting area and the trawled one extend on 2.7 km² and 33.6 km² of seabottom, respectively, representing more than 70% of 51.433 km² total study area. The most affected by the anthropogenic activities (dredging and trawling) habitats out of the four identified were the circalittoral mud (33.42 km²) and circalittoral sand (3.08 km²). A shift in macrozoobenthos diversity and abundance, with a clear tendency of rapid colonisation by *Melinna* of muddy sediments that replaced the sand was noted in the dredging area. In the trawling area, the most striking changes were related to increased number of small detritivore species at molluscs expense. This could be explained by high siltation process that mainly affected the filtering and sessile species. The collateral damage of trawling for rapa is reflected by the by-catch organisms and the unsustainable practice that hinder the recovery of slow-growing species like: *Spisula*, *Pitar*. Assessment of ecological quality status of the overall area by using M-AMBI index showed that most part of the mud habitat is in poor state, the second opportunistic species representing more than 50% of the taxa number. Comparatively, the mixed, sand and coarse habitats are in good and high state, disturbance – tolerant species being predominantly met in stations within these habitats.

The results show that economic activities need a better environmental planning and management in order to get advantage as much as possible of resources exploitation in long term. The unsustainable practices lead to ecological losses (e.g. biological productivity decreasing (e.g. low molluscs stocks) and hence, low economic efficiency and incomes.

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REFERENCES

1. R. GUTPERLET, R. M. CAPPERUCCI, A. BARTHOLOMÄ, I. KRÖNCKE: Benthic Biodiversity Changes in Response to Dredging Activities during the Construction of a Deep-Water Port. *Mar Biodivers*, **45** (4), 819 (2015).
2. T. TAUPP, M. A. WETZEL: Relocation of Dredged Material in Estuaries under the Aspect of the Water Framework Directive – a Comparison of Benthic Quality Indicators at Dumping Areas in the Elbe Estuary. *Ecol Indic*, **34**, 323 (2013).
3. M. DESPREZ: Physical and Biological Impact of Marine Aggregate Extraction along the French Coast of the Eastern English Channel: Short- and Long-term Post-dredging Restoration. *ICES J Mar Sci*, **57**, 1428 (2000).

4. J. M. GUERRA-GARCIA, J. CORZO, J. C. GARCIA-GOMEZ: Short-term Benthic Re-colonisation after Dredging in the Harbour of Ceuta, North Africa. *P.S.Z.N.: Mar Ecol*, **24** (3), 217 (2003).
5. R. F. van DOLAH, P. H. WENDT, N. NICHOLSON: Effects of a Research Trawl on a Hard-bottom Assemblage of Sponges and Corals. *Fish Res*, **5** (1), 39 (1987).
6. R. NIELSEN et al.: Report on Assessing Trawling Impact in Regional Seas. Benthic Ecosystem Fisheries Impact Study (BENTHIS Project). 2014. 183 p.
7. V. ABAZA, C. DUMITRACHE, A. FILIMON, A. OROS, L. LAZAR, V. COATU, D. TIGANUS: Ecological Assessment of Benthic Invertebrate Fauna from the Romanian Marine Transitional Waters. *J Environ Prot Ecol*, **17** (3), 932 (2016).
8. V. ABAZA, C. DUMITRACHE, A.-D. SPINU, A. FILIMON: Ecological Quality Assessment of Circalittoral Broad Habitats Using M-AMBI*(n) Index. *J Environ Prot Ecol*, **19** (2), 564 (2018).
9. V. TODOROVA, Ts. KONSULOVA: Manual for Quantitative Sampling and Sample Treatment of Marine Soft-bottom Macrozoobenthos. www.blacksea-commission.org. 2005. 38 p.
10. R. SCHLITZER: Ocean Data View. <https://odv.awi.de>, 2018.
11. G. CARAIVAN: The Sedimentological Study of the Beach and Inner Shelf Deposits of Romanian Black Sea between Portița and Tuzla. *Ex-Ponto* ed., 2010. 171 p.

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