”OVIDIUS“ UNIVERSITY OF CONSTANȚA
DOCTORAL SCHOOL OF APPLIED SCIENCES
FUNDAMENTAL AREA: BIOLOGY

SUMMARY OF THE PhD THESIS

RESEARCH ON THE CURRENT STATE AND LONG-TERM CHANGES IN THE STRUCTURE OF ZOOBENTHIC COMMUNITIES ALONG THE ROMANIAN BLACK SEA COAST

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CONTENTS

AIM AND OBJECTIVES

Global climate changes, extreme weather events and eutrophication that peaked in the 1980s have undoubtedly led to changes in the Black Sea biodiversity.

In this context, the **AIM** of this PhD thesis is to analyze the benthic communities in the Romanian Black Sea waters in order to determine the long-term changes that have occurred.

The thesis targets several **MAJOR OBJECTIVES**, as follows:

- ***Establishing the current state of macro- and meiobenthic communities along the Romanian Black Sea coast*** (time coverage 2006-2015);
- ***Determining the evolution of keystone species of the main biocoenoses on mobile substrate***;
- ***Determining the influence of environmental and anthropogenic factors on benthic organisms at the Romanian coast*** (structure and distribution of macro- and meiobenthic communities in relation to depth, physical-chemical factors and substrate nature; the influence of heavy metals in sediments on the distribution of macrozoobenthic organisms);
- ***Determining the changes occurring in the past four decades in the structure of benthic communities. Case study for the 30-100 m isolines*** (changes in the structure of communities in the habitat with *Mytilus galloprovincialis* and *Melinna palmata* (30-60 m) and the habitat with *Modiolula phaseolina* (60-100 m); evolution of macrobenthic species contribution and changes in the structure of meiobenthic communities.

THE NOVELTY AND ORIGINALITY of this thesis stem from the holistic and integrative approach of benthic communities along the Romanian coast, whose evolution is strongly connected to external factors (either environmental parameters or anthropogenic influences - eutrophication, contamination etc.).

It has been taken into account that benthic fauna comprises species which respond differently to external fluctuations. The reactions of the benthos are representative for the general state of marine ecosystems, as the biological processes in the water column strongly depend on them. As such, species sensitive to pollutants undergo mass mortalities when the marine environment is in a bad ecological status, while opportunistic species record exponential increases of densities. The changes in the structure of marine fauna caused by climate changes are a hot discussion topic, but no studies aimed at pointing out the nature and extent of these changes have been undertaken at the Romanian Black Sea coast. Consequently, I have dedicated the last chapter of the thesis to research on the changes occurring in the past four decades in the structure of benthic communities of two of the most important biocoenoses of the Romanian coast. The analyses performed have produced new data on the nature and extent of the changes, as well as the determining environmental factors. In the end of the thesis I have provided an updated definition of the investigated habitats in relation to the species with the highest contribution (share) within the biocoenosis.

It was possible to obtain these novel results due to using state of the art tools for the study of the marine environment worldwide (Primer, ODV, Statistica, M-AMBI) and the analyses thereof (SIMPER, MDS etc.).

PART I. STATE OF THE ART

I.1. INTRODUCTION

I.1.1. Importance of benthic communities studies

The benthic environment is the most widespread on Earth and is represented by a huge biodiversity, encompassing a high variety of organisms belonging to numerous phyla. Benthic communities are usually much more diverse compared to pelagic communities (zooplankton and phytoplankton) in terms of number of species.

Benthos is an essential component of the marine environment, as it supports the main ecosystem services. No marine ecosystem can function normally without a healthy benthic community. Benthic organisms regulate the physical-chemical and biological processes of the ecosystem by feeding and building shelter burrows/tubes in the substrate. Benthic filter-feeders pass large amounts of water through their bodies to feed, but, at the same time, this process also helps in cleansing water, by removing sediments and organic matter. The organic matter not used in the water column is then deposited on the seabed. In the Black Sea, mollusks generaly play the role of biofilters. Among mollusks, mussel agglomerations (both on the rocky substrate, and deep water mussels, filter huge amounts of water daily (Tofan, 2014)**.**

The benthic fauna of the Black Sea comprises more than 2,000 species belonging to 22 phyla (Zaitsev, 2008), and is very different compared to the Mediterranean both by the low number of species and the low diversity of Ocean species, such as sponges, nemertines etc. (Shiganova și Ozturk, 2009). Low salinity, on the one hand, and the anoxic layer, on the other hand, are responsible for the occurrence of these peculiarities of the Black Sea fauna compared to other seas.

Nevertheless, the number of benthic invertebrates is several times higher than zooplankton species. Polychaetes only are represented by approximately 312 species.

The Black Sea is also inhabited by approximately 100 bivalve mollusks, most of them psamobiontic. Only few of the bivalve species live on hard substrate, such as *Mytilus galloprovincialis* and *Mytilaster lineatus*, highly abundant on te rocky mid-littoral and infralittoral. Approximately 115 gastropod species are also encountered in the Black Sea.

Among crustaceans, there are 40 species of isopodes, 45 species of decapods and 135 species of amphipods (the most often encountered orders).

Regarding eumeiobenthic organisms, in the Black Sea there are 85 species of Foraminifera, 6 species of Turbellaria, 165 species of Nematoda, 42 species of Nemertea, 5 species of Cirripedia, 91 species of Ostracoda, 61 species of Harpacticoida, 26 species of Missida and 21 species of Cumacea (www.misisproject.eu).

I.1.2. Climate change - effects on Black Sea biodiversity

Global warming, which was reported ever since late in the 19th century, has not been caused exclusively by natural changes, but mostly by the impact of anthropogenic activities on the environment, translated into the "greenhouse effect". According to IPPC (2007), air temperature has raised during the past century by a mean value of 0.7ºC, and, during the last half of century, this value doubled (+ 0.13 ºC in 10 years) (CIESM, 2010).

Some of the most significant processes of the Ocean - Air system, which influence climate fluctuations in Eurasia, are the Atlantic Multidecadal Oscillation (AMO) of sea surface temperature, with durations of 50 to 100 years, and the North Atlantic Oscillation (NAO), which describes the way pressure varies in the Northern Atlantic, strongly influencing the weather on the two continents - Europe and North America (Polonsky, 2008).

Climate variability and its effects in the Black Sea region

Based on the long term observations collected from stations located along the northern and eastern coasts of the Black Sea, the trends and long-term oscillations reveal annual, seasonal and monthly trends of air temperature (AT). Most long-term trends of the AT annual mean in the studied regions of the Black Sea are positive, in accordance with the global air temperature increase 0.4-0.8°C/100 years) (Ilyuin & Repetin, 2006). At decade level, the long-term trend is interrupted by severe slips, of 1-3ºC, corresponding to the oscillations and variations recorded by sea-surface temperature - SST, as well as the sub-surface temperature. Decadal fluctuations are correlated with AMO and NAO values (CIESM, 2010).

All these climate changes have gradually contributed to the occurrence of changes in the structure of benthic communities of Romanian Black Sea waters.

I.2. EVOLUTION OF BIOLOGICAL AND ECOLOGICAL RESEARCH ON BENTHIC COMMUNITIES

I.2.1. Worldwide research

Writings containing observations on benthic organisms have arisen since the time of the Greek philosophers. Of note is Aristotle, who, besides observing the existence of these communities of organisms, did quite interesting research on them. Then, until the time of the Renaissance, which lasted during the 14th-16th centuries, very few researches were carried out, because for a long time the false idea prevailed that Aristotle discovered, described and studied everything. Then there were several main stages in the study of the benthic fauna: the faunistic stage, the faunistic-quantitative stage and the faunistic-ecological stage.

I.2.2. Research at the Romanian Black Sea coast

As with worldwide benthic fauna research, the research at the Romanian coast has seen several evolutionary stages.

In order to clearly emphasize these evolutionary stages of benthic research, we made an arbitrary division into three periods (1900-1960: the stage of faunistic studies, 1961-1980: the stage of faunistic and quantitative studies, 1981 - present: the stage in which qualitative and quantitative studies have been carried out, but a large number of ecological studies have also been added), stating that these stages do not have a precise temporal delimitation. This imprecision is due to the fact that the transition from one stage to another did not mean losing interest in the studies undertaken in the previous stage. We can say that the research has only undergone improvements in the working techniques and, together with them, the quality of the obtained results.

Within the present PhD thesis, the benthic communities were studied qualitatively, quantitatively and ecologically, using a state of the art approach, specific to the last period in the evolution of research in the field.

PART II. OWN CONTRIBUTIONS

II.1. MATERIALS AND METHODS

II.1.1. Sampling area

The Romanian Black Sea coast, with a length of about 250 km, extends from Sulina (on the border with Ukraine) to Vama Veche (the border with Bulgaria). To be fully studied, since the 1980s, the investigations of the National Institute for Marine Research and Development have focused mainly on a network of approximately 45 stations (over time varied), with 12 profiles. These 12 profiles were arranged in such a way as to cover all the areas of interest of the Romanian waters.

Given that the final goal of the PhD thesis is to highlight the long-term changes in the benthic communities, benthos samples were taken from this network of 45 stations between Sulina and Vama Veche (Table II.1.1.1). The studied depths ranged from 5 to 100 m, covering all the main habitats and biocoenoses on the sedimentary substrate. Thus, the current data were integrated into a common database with historical data to achieve the proposed goal.

The dataset used covers a period of approximately four decades: 1980 (1986 and 1987), 1990 (1990, 1991, 1992, 1997, 1998 and 1999), 2000 (2000, 2001, 2002, 2007, 2008, 2009, 2010) and decade 2 of the 21st century (2011, 2012, 2013, 2014, 2015 and 2016). These data are part of the database of the National Institute for Marine Research and Development "Grigore Antipa", a database I have personally contributed to from 2011 until now, by sampling and analysis of the results obtained during this period. Only during the period 2011-2016 I have participated in 12 expeditions, totaling over 70 days at sea, during which I collected and processed 373 zoobenthos samples.

Separately from the dataset above, for the study of the meiofauna microdistribution, data obtained by sampling from three locations (Năvodari, Mamaia and Mangalia) in August 2014 were also used (Table II. 1.1.1).

Table II.1.1.1. Sampling stations for the study of vertical meiobenthos microdistribution.

Stations	Geographic coordinates	Depth
Năvodari (Nv)	**44.336368˚N 28.688018˚E**	**4 m**
Mamaia (Mm)	**44.231635˚N 28.634235˚E**	**4 m**
Mangalia (Mg)	**43.804231˚N 28.591586˚E**	**4 m**

II.1.2. Zoobenthos sample collection

Depending on the purpose, different sampling methods were used. Macrozoobenthos samples were collected with a Van Veen bodengreifer, 0.1 m^2 in size, and sub-samples were taken from the bodengreifer for meiobenthos analysis.

Regarding the vertical distribution, samples were taken using a corer (metal tube) 4.6 cm in diameter and 15 cm high. The sedimentary column was pushed from the corer by means of a plunger and cut into slices of 1 cm thick to a depth of 5 cm, the last slice remaining 5 cm (0-1, 1-2, 2-3, 3-4 , 4-5 and 5-10 cm).

II.1.3. Sample preservation

Samples were preserved with 5% formaldehyde directly in the field. In the laboratory, the samples were washed through sieves with mesh size 1, 0.5 for macrozoobenthos and 0.5 and 0.063 mm for meiobenthos. The fractions remaining in each sieve were then analyzed under the binocular microscope. For the identification and determination of organisms, the Zeis STEMI 2000-C stereomicroscope was used, with a magnification range between 1.95x and 100.0x. This stereomicroscope is provided with a digital camera system and Axiovision system for image processing on the computer. The species names have been updated according to the World Register of Marine Species (http://www.marinespecies.org).

II.1.4. Data analysis and processing

The data obtained were arranged in triage sheets and reported per square meter for quantitative analysis. The biomass of organisms was obtained by weighing the large organisms or using standard tables. For this reason, the emphasis in the analysis is more on densities, the density data having a much higher accuracy compared to biomass.

Some specialized softwares, such as PRIMER v.6, Statistics 10, AMBI - M-AMBI, have been used for data processing, very popular amongst specialists in the field.

The Primer Program has provided me with the possibility of performing univariate analyzes, such as diversity analysis, as well as some multivariate analyzes. Multivariate analyzes compare several samples based on the similarity of abundance of species present in them.

II.1.5. Need of using unitary methods to reduce errors

For the collection of benthos samples, countless qualitative and quantitative methods and tools have been described over time, in the desire to reduce errors as much as possible and to get a picture as close as possible to the real one. However, no matter how much effort is made in this respect, it is almost impossible to eliminate 100% errors. Generally accepted by scientists almost unanimously, the size of the Van Veen bodengreifer, one of the most widely used macrobenthos sampling tools, should be about 1,000 cm^2. Even so, samples taken with the same instrument, from the same place, will produce results with some difference between them.

The differences between the results of the evidence and the real situation do not only arise from the sampling equipment, but a number of factors also contribute, namely: human errors during sorting and identification, the heterogeneity of the benthic communities, the drift, etc. In addition, some organisms, such as, for example, some polychaetes, live in groups (grouped distribution), not evenly distributed on the surface of the seabed. Thus, a sample may have a high density of a polychaete species, and another, a few centimeters away, sampled with the same equipment, may be very poor or the species may be completely absent. And the fact that some organisms have densities of hundreds or even thousands of individuals per m^2, while others have extremely small densities (E.g. *A. stepanovi* - 1 ind./20 m^2) may lead to differences between samples.

II.2. RESULTS AND DISCUSSIONS

II.2.1. STRUCTURE AND DISTRIBUTION OF BENTHIC COMMUNITIES ALONG THE ROMANIAN BLACK SEA COAST IN RELATION TO DEPTH, PHYSICAL-CHEMICAL FACTORS AND SUBSTRATE NATURE

Environmental conditions have a direct effect on the condition of benthic communities (Abaza et al., 2016). The rapid ecological changes that have occurred in recent years at the Black Sea level have brought many changes in the structure of the benthic communities (Boicenco et al., 2014).

Within this chapter analyses were made on the structure of the meio- and macrobenthic communities, as well as analyses regarding the influence of some environmental factors on them.

II.2.1.1. General facts about meio- and macrobenthic communities along the Romanian Black Sea coast

Structure and general distribution of macrobenthic communities along the Romanian coast

Between 2006 and 2015, a total of 93 macrobenthic species were identified, out of which 26 (28%) belonged to the group Polychaeta, 27 (29%) to Mollusca, 27 (29%) to Crustacea and 13 (14%) were assigned to the generic group "other groups".

The research showed that the macrozoobenthic fauna in the sedimentary substrate areas analyzed in this paper is much poorer qualitatively and quantitatively compared to the fauna associated with macrophyte algae in the areas with rocky substrates (Dumitrache et al., 2013; Filimon et al., 2016).

Structure and general distribution of meiobenthic communities along the Romanian coast

In a first phase of meiobenthos research, we verified the vertical distribution of meiobenthic organisms (Filimon and Abaza, 2015).

The analysis of the **vertical distribution pattern** of the meiobenthos showed that the maximum density was limited to the surface layer of the sediment and decreased with the penetration into the depth of the sediment. The percentage of meiofauna concentration in the layers 0-1; 1-2; 2-3; 3-4; 4-5 and 5-10 cm was 53%; 35%; 9%; 2%; 1%; 0% in the Nv station, 73%; 23%; 3%; 0%; 1%; 0% in Mm station and 71%; 18; 6%; 2%; 2%; 1% in the Mg station. Population density fell sharply below 2 cm depth. It is clear that over 90% of the meiofauna was concentrated in the first two layers of sediment (Fig. II.2.1.1.1).

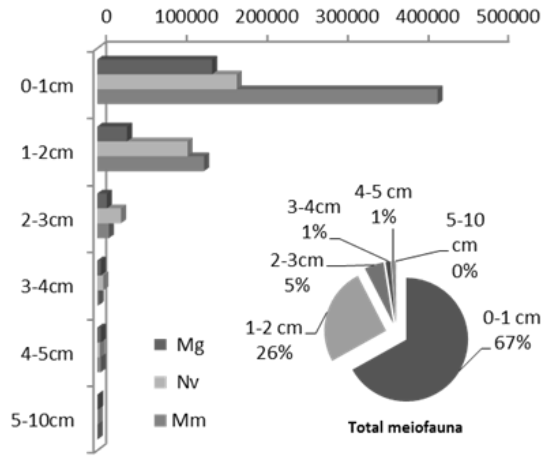

Fig. II.2.1.1.1. Vertical distribution of meiofauna in the three sampling stations and mean percentage amount per each layer.

In the study of the **horizontal distribution**, 14 meiobenthic, 7 eumeiobenthic and 7 pseudomeiobenthic groups were identified. The distribution of diversity in the 32 stations was relatively uniform. Observations on the share of eumeiobenthic and pseudomeiobenthic groups have shown that there is a correlation between the two categories in stations with increased diversity. Where the eumeiobenthos is rich, the pseudomeiobenthos is the same.

The main groups encountered in this study are: Nematoda, Harpacticoida, Bivalvia, Oligochaeta, Polychaeta, Turbellaria, Foraminifera, Halacarida, Amphipoda, Nemertini, Ostracoda, Gastropoda, Kinorhyncha and Cumacea, this being the order they were encountered in samples.

II.2.1.2. Structure and distribution of meio- and macrobenthic communities on depth ranges

Structure of macrobenthic communities on the 5 m isoline

At the 5 m depth, between 2006 and 2015, 29 species were identified. The largest variety was recorded by mollusks (12 species) and polychaetes (12 species). The invertebrates were dominated by filter-feeding bivalve species, the most numerous were *Mya arenaria* and *Lentidium mediterraneum*. Here, in the specific biocoenosis of *Lentidium mediterraneum*, it recorded a maximum total density of 40,660 ind./m^2 and a biomass of 793.52 g/m^2 in 2015.

In addition to filtering mollusk species, the bivalve with both filtering and detritus feeding regime *T. tenuis* appeared here, with average densities of only 8 ind./m^2 and a biomass of 0.75 g/m^2. The most numerous species of gastropods were the microphytobenthic species *Ecrobia ventrosa*, with an average density of 38 ind./m^2 and a biomass of 0.128 g/m^2, and the necrophagous *Trititia neritea* (6 ind./m^2 and 7.3625 g/m^2). Among the crustaceans, with the average density of 44 ind./m^2 and the biomass of 0.314 g/m^2, was noted for the filtering cirriped *Amphibalanus improvisus*. A rare occurrence (3 ind./m^2 and 0.0012 g/m^2) was also the nemertean *Amphiporus bioculatus*, a voracious predator, like all other nemertean species. Greater densities have been encountered in case of companion species such as *Ampelisca diadema* (2,322 ind./m^2), *Spio decorata* (272 ind./m^2) and *Pygospio elegans* (121 ind./m^2). On stations, the densities had values ranging from 6,763 ind./m^2 and 43 in./m^2, while the maximum density of 6,763 ind./m^2 was reached at the Constanţa North Station. The biomass of benthic organisms at the 5 m depth had mean values which ranged on stations between 21,963 g/m^2 and 0,024 g/m^2, the maximum biomass being reached at Constanta North, due to the high density of the *Lentidium mediterraneum* bivalve in this station - 16,960 ind./m^2.

Over the last decade, from the analysis of the data for the period 2006-2015, it resulted that the state of the macrobenthos communities has undergone major qualitative and quantitative changes.

Structure of meiobenthos at 5 m depth

At the 5 m isoline were identified 12 meiobentic groups: Foraminifera, Harpacticoida, Ostracoda, Nematoda, Halacarida, Turbellaria, Oligochaeta, Polychaeta, Bivalvia, Gasteropoda, Nemertea, Amphipoda.

Dominant at this depth, in terms of density, were the nematodes, which recorded 72% (730,714 ind./m^2) of the total density of the meiobenthos, followed by bivalves, polychaetes, oligochaets and harpacticides, the other groups having an insignificant contribution (Fig. II.2.1.2.1).

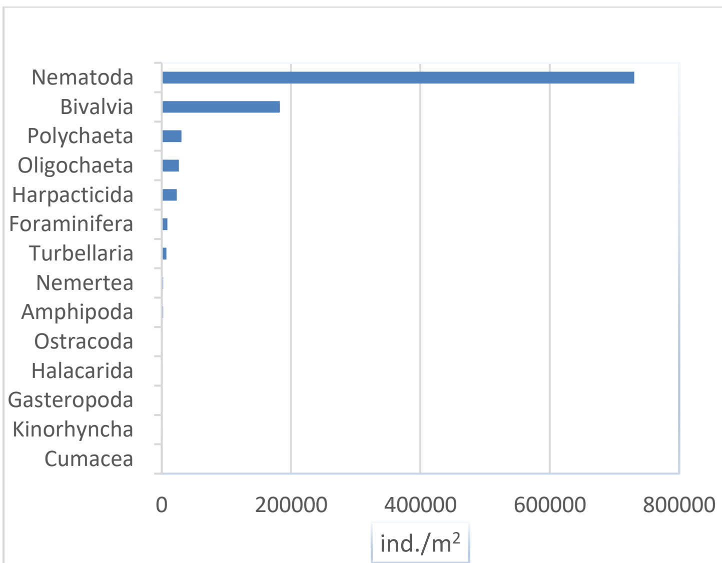

Fig. II.2.1.2.1. Group distribution of meiobenthic organisms as per densities at the 5 m isoline (2015).

Structure of macrobenthic communities on the 20 m isoline

At a depth of 20 meters, between 2006 and 2015, a total of 44 species were identified, as follows: 16 species of mollusks, 15 species of polychaetes, 8 species of crustaceans and 5 species assimilated to the group called "other groups". With the highest average density were found *Alitta succinea* (320 ind./m^2) and *Melinna palmata* (260 ind./m^2), due to the presence of the muddy sediment, especially in the northern part of the coast. Given that there are also sandy sedimentary areas at this depth, other species with high density were the bivalve *Lentidium mediterraneum* (73 ind./m^2) and the polychaete *Pygospio elegans* (59 ind./m^2). The analysis of qualitative and quantitative data over the last ten years has shown a decreasing trend at this isoline. As with the 5 m isoline, the poorest year in terms of quantity was 2012, when the average density was 14 ind./m^2.

Structure of meiobenthos at 20 m depth

According to the classification described in the previous subchapter, at the depth of 20 meters, we are still within the circalittoral. The dominant group at this depth was Nematoda (581,714 ind./m^2), followed by Harpacticoida (375,857 ind./m^2) (Fig. II.2.1.2.2).

At this depth, 13 meiobenthic groups were encountered, the group lacking being Cumacea.

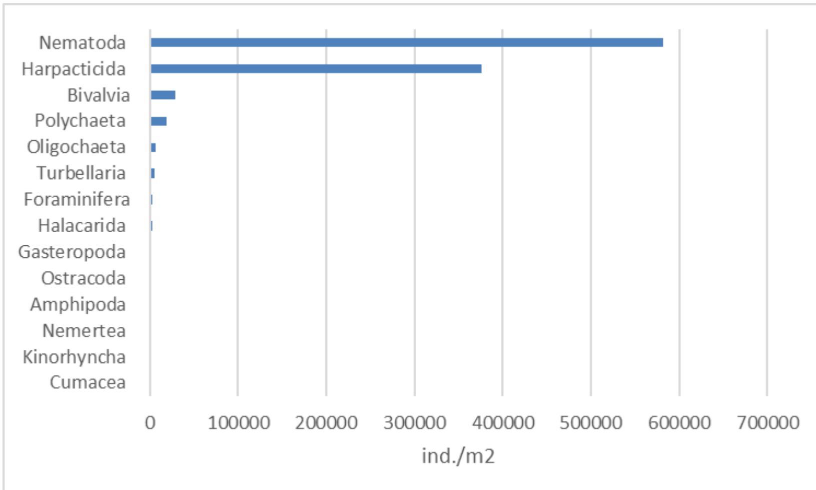

Fig. II.2.1.2.2. Group distribution of meiobenthic organisms as per densities at the 20 m isoline (2015).

Structure of macrobenthic communities at 30-100 m depths

In the circalittoral, between the 30-100 m isolines, two main biocoenoses were revealed. In the bathymetric range 30-60 m, the dominant species is *Mytilus galloprovincialis*, among the mollusks, besides which we encounter a large number of polychaetes, especially *Melinna palmata*. The two biocoenoses intercalate, do not form separate biocoenoses (Fig. II.2.1.2.9). Beyond 60 m, up to 100 m, the biocenosis of *Modiolula phaseolina* muds, which is visibly separated from the other habitat, is encountered. The name of the two biocoenoses was initially given according to literature (Băcescu et al., 1971), and in the last chapter were analyzed the changes that occurred within them.

There have been identified in this area, from 2006 to 2015, a number of 53 macrobenthic species. Compared to the other depths studied, where mollusks dominated as a number of species, the polychaetes (21 species) dominated at depths over 30 meters, followed by crustaceans (13 species), mollusks (11 species) and other groups (9 species). As it is clear from previous analyses, the the richest specific diversity was found here.

Regarding the preferences of the benthic species for certain types of sediment, there were encountered species specific to the sandy sediment, such as *Prionospio cirrifera*, *Pygospio elegans*, *Scolelepis (Scolelepis) squamata,* as well as species typical for the muddy substrate, such as *Melinna palmata*, *Modiolula phaseolina* etc.

In the case of species typical for the muddy areas at these depths, such as *Terebellides stroemii*, there was even an increase in their number after 2010. Here, in 2014 and 2015, was found the non-indigenous polychaete species *Dipolydora quadrilobata*, a species recently reported at the Romanian coast.

Of typical deep-sea mollusks, quantitative changes were observed from year to year in the case of *Acanthocardia paucicostata*, which reached from 70 ind./m^2 in 2006 at 11 ind./m^2 in 2015.

In 2015, for the first time in a long period, species such as *Thalassarachna basteri* and *Lindrilus flavocapitatus* were encountered.

Structure of meiobenthos at 30 - 100 m depths

The dominant group was, at this depth too, Nematoda - 479,065 ind./m^2 (92%), and the other groups had a share of maximum 3% of the total of meiobenthos. Vorobyova and Kulakova (2009), following an international expedition in which samples were taken from the Romanian waters, reported the group Nematoda (Fig. II.2.1.2.3) as a dominant group at depths over 30 m.

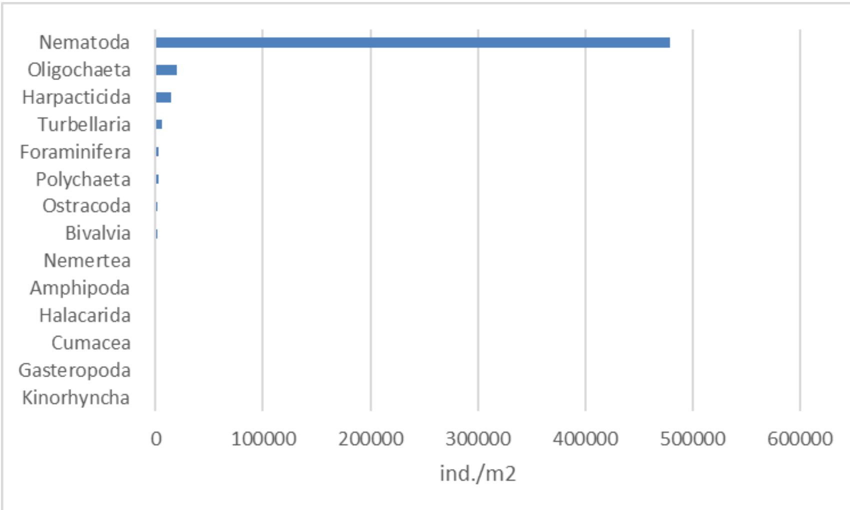

Fig. II.2.1.2.3. Group distribution of meiobenthic organisms as per densities at the ≥ 30 m isoline (2015).

II.2.1.3. Evolution of keystone species of the main biocoenoses on mobile substrate

In this study, samples of the three most important biocoenoses from the sedimentary substrate from the Romanian coast were taken: biocoenosis with *Lentidium mediterraneum*, biocoenosis with *Mytilus galloprovincialis* and biocoenosis with *Modiolula phaseolina.*

Biocoenosis with *Lentidium mediterraneum*

Fine sands with *Lentidium mediterraneum*, a typically psamobiontic bivalve, are one of the most important biocoenoses of the Black Sea, feeding area for many bentophagous fish. It stretches from the mouths of the Danube to Constanţa, occupying a continuous surface of about 600 km^2, and in the south it appears scattered.

The keystone element of the biocoenosis is the psamobiontic suspension-feeding bivalve *Lentidium mediterraneum*, which has a 100% constant occurrence. In 2015, the average density of *Lentidium mediterraneum* was 4,518 ind./m^2 and the biomass 99,19 g/m^2 at a depth of 5 m, and towards the end of the biocoenosis, at 20 m, the average density was 131 ind./m^2 and the biomass 3.68 g/m^2.

A quantitative analysis of *Lentidium mediterraneum* revealed annual average densities of 1,374 ind./m^2 and 4,807 ind./m^2 and a biomass ranging from 18,199 g/m^2 to 105 g/m^2. The maximum values were recorded in 2015 and the minimum values in 2004.

The quantitative analysis over the last 13 years has shown an upward trend of the quantitative parameters recorded by the small bivalve (Fig. II.2.1.3.1).

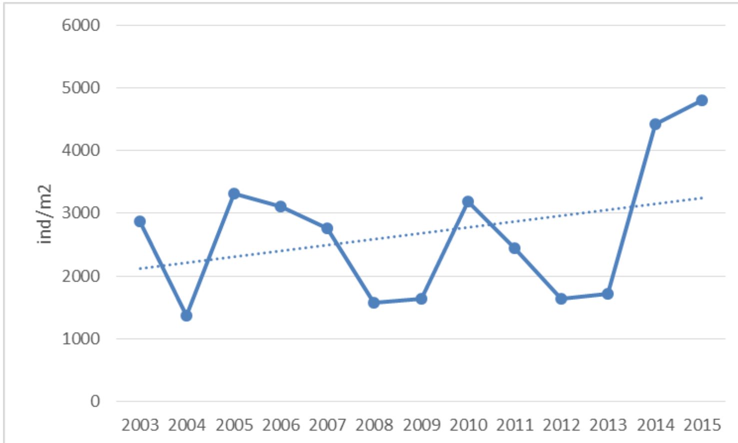

Fig. II.2.1.3.1. Multiannual trend in the density of *Lentidium mediterraneum*.

Deep-water mussels biocoenosis

The total surface area of the *Mytilus galloprovincialis* biocoenosis in front of the Romanian coasts is approximately 7,000 km^2 (Bacescu et al., 1971). The substrate is made of gray muds, with a variable proportion of shelly sands.

It is one of the most characteristic and well-defined biocoenoses on the Romanian coast.

The quantitative analysis of the last seven years of the bivalve showed a downward trend (Fig. II.2.1.3.2). If in 2009 the average annual density was 726 ind./m^2 and the biomass 587,629 g/m^2, in 2015 the density registered 38 ind./m^2 and the biomass 61 ind./m^2. This is probably due to the hypoxic phenomena that have occurred in recent years, the claim being supported by the appearance and smell of the mud, especially from the northern part of the coast, but also by the mussels found in the samples, dead by asphyxiation.

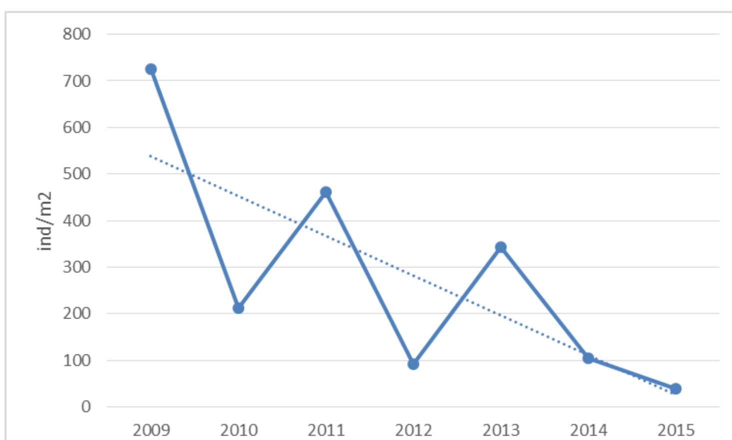

Fig. II.2.1.3.2. Multiannual trend in the biomass of *Mytilus galloprovincialis*.

Biocoenosis of gray muds with *Modiolula phaseolina*

It is a specific Black Sea biocoenosis, it is well individualized and vast, occupying about 10,000 km^2, which is 40% of the surface of the continental shelf at the Romanian coasts (Bacescu et al., 1971). This biocoenosis occurs in its typical appearance between 58 and 90 m deep.

The characteristic species is the small bivalve *Modiolula phaseolina*, which we met in 2015 with average densities of 47 ind./m^2 and a biomass of 2.71 g/m^2. The stations in which this bivalve was found were Portița 70 m and Mangalia 100 m.

These values are much lower compared to 2014, when the density was 210 ind./m^2 and the biomass was 1 g/m^2.

II.2.1.4. Influence of abiotic factors on Romanian Black Sea coast zoobenthos

II.2.1.4.1. Influence of environmental factors on macrobenthic organisms

In this study, samples were taken both from sandy and muddy substrate. Generally, the sandy substrate has been encountered up to 20 meters deep, at greater depths the mud appears. Quantitatively, higher densities have been encountered on the sandy substrate. Differences were statistically significant ($F (1.30) = 4.70$, $p = 0.03$) (Fig II.2.1.4.1.1).

The statistical analysis of the depth influence on the macrobenthic organisms showed a statistically significant negative correlation between the two parameters ($r = -0.38$, $p = 0.02$; $r^2 = 0.15$), meaning that the depth has an important influence on macrobenthos distribution (Fig. II.2.1.4.1.2). With the increase in depth, a decrease in the density of the macrobenthic organisms was observed. Maximum densities were encountered at small depths, in the 5 meter stations.

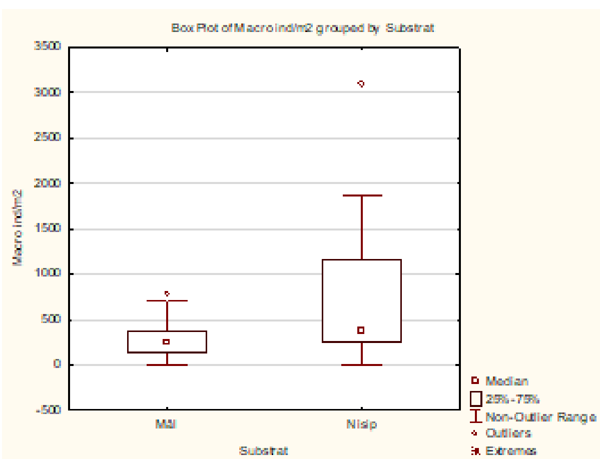

Fig. II.2.1.4.1.1. Distribution of macrozoobenthos total density in relation to substrate.

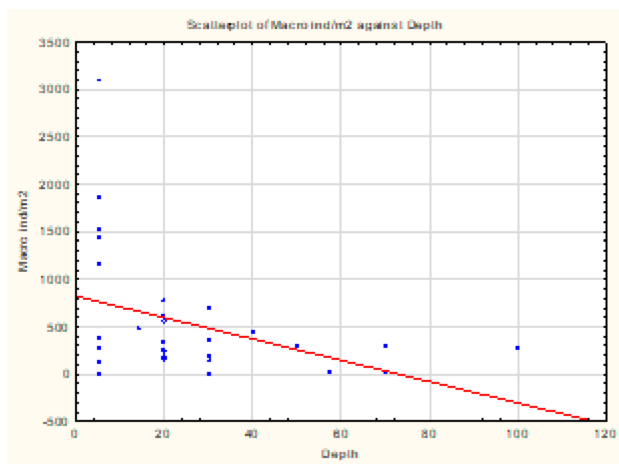

Fig. II.2.1.4.1.2. Distribution of macrozoobenthos in relation to depth.

Macrobenthos - salinity

The analysis of the distribution of macrobenthic organisms by salinity showed a negative correlation between the two parameters, the difference being statistically significant ($r = -0.46$, $p = 0.007$; $r^2 = 0.21$). This indicates that salinity is a major control factor in the distribution of densities of macrobenthic organisms (Fig. II.2.1.4.1.3).

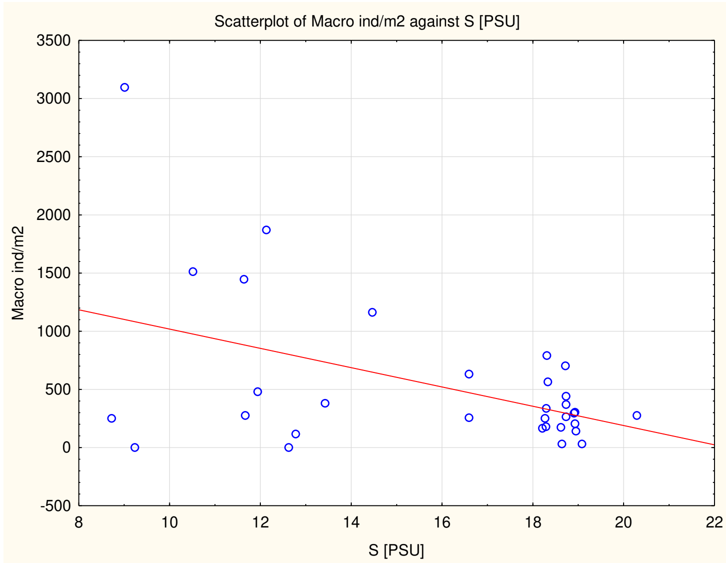

Fig. II.2.1.4.1.3. Influence of salinity of macrozoobenthic organisms.

Macrobenthos - pH

The pH values at the Romanian coast varied between 7.57 (slightly alkaline) and 8.62 (strongly alkaline). The pH variation did not have a statistically significant influence on the distribution of macrobenthic organisms ($r = -0.12$, $p = 0.48$; $r^2 = 0.01$), due to the fact that the variations were within normal limits and no outlier values were recorded (Fig II.2.1.4.1.4)

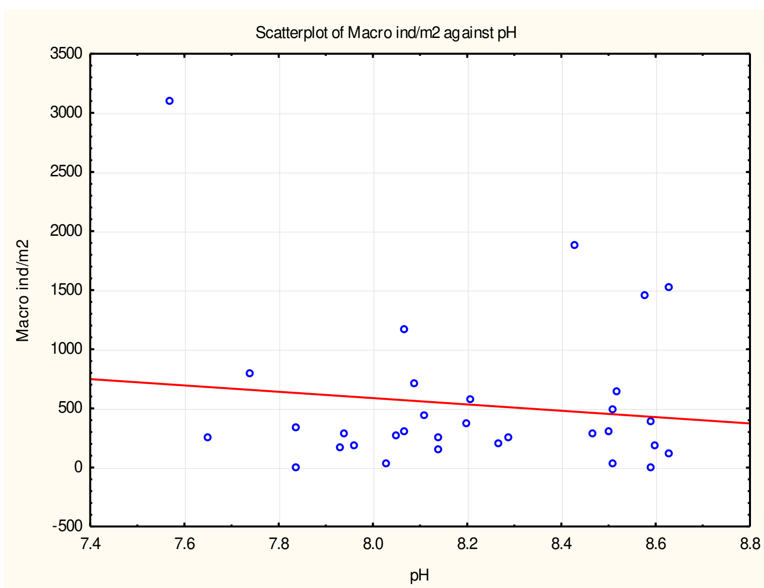

Fig. II.2.1.4.1.4. Influence of pH on macrozoobenthic organisms.

Macrofauna - temperature

Statistically significant positive correlations ($r = 0.41$, $p = 0.01$; $r^2 = 0.16$) were also observed in the case of temperature. The formation of two groups of organisms, one at temperatures between 7 and 12ºC and one formed between 21 and 2ºC, was observed. Higher densities were encountered in the temperature range 21 - 25°C (Fig. II.2.1.4.1.5).

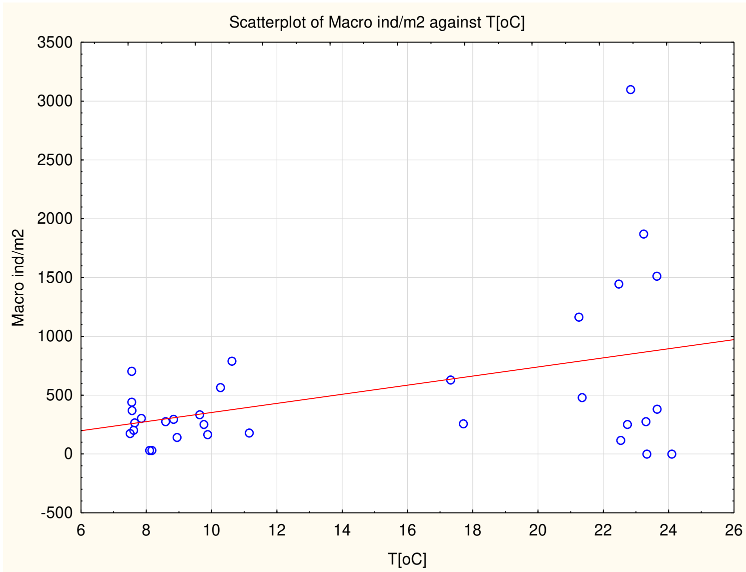

Fig. II.2.1.4.1.5. Influence of temperature on macrozoobenthic organisms.

II.2.1.4.2. Influence of heavy metals in sediments on macrozoobenthic organisms

Heavy metals are of major interest in monitoring aquatic systems because of their toxicity, even at low concentrations.

With the increase in the concentration of heavy metals in the sediment (Cu, Cd, Ni, Cr, Pb), the density of the macrobenthic organisms decreased considerably, the decrease being statistically significant ($r = -0.34$, $p = 0.05$, $r^2 = 0.12$) (Fig. II.2.1.4.2.1).

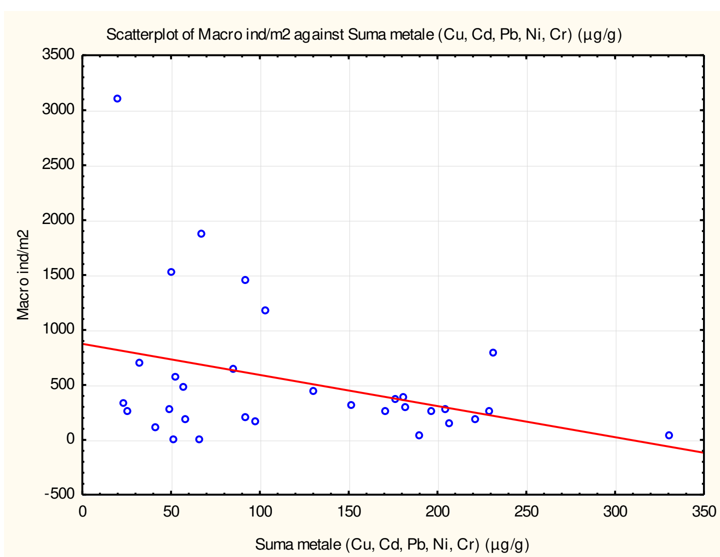

Fig. II.2.1.4.2.1. Correlation between heavy metal concentrations in sediments and macrobenthos density.

II.2.1.4.3. Influence of environmental factors on meiobenthic organisms

None of the environmental factors analyzed had a significant influence on the meiobenthic organisms.

II.2.2. LONG-TERM CHANGES IN THE STRUCTURE OF BENTHIC COMMUNITIES (CASE STUDY FOR THE 30-100 M ISOLINES)

Analyzes of long-term changes in benthic biocoenoses between 30-100 m isolines were based on a dataset covering four decades (269 data).

Firstly, based on the literature and existing raw data, I have delineated the major types of habitats present at these depths. Thus, I have found that at these depths are the habitats where different species dominate. I have called these habitats **Circalittoral biogenic reefs with *Mytilus galloprovincialis***, intertwined with muds, where polychaetes are dominant, mainly *Melinna palmata*, permanent companion species in the bathymetric range of 30-60 m (57 m) in particular, and **Circalittoral deep Pontic muds with *Modiolula phaseolina***, at depths between 60 and 100 m. In the final part of the thesis are presented the updated names of the two habitats, as they resulted from our analyzes.

Analyzing the set of 269 data using the Primer v6 program, we noticed that the biogenic reefs with *Mytilus galloprovincialis* and the muds with *Melinna palmata* overlap, so there is a great similarity between them, and we considered that in the range of 30-60 m, the habitat of the Circalittoral biogenic reefs with *Mytilus galloprovincialis* is dominant.

From the point of view of the similarity of data on a temporal scale, it is observed that, after 2010, the benthic communities have undergone some quantitative changes, which are somewhat different from the other years. In the 1980s, some extreme fluctuations were recorded, which caused the point to appear on a very distant representation of the other points, which means that its similarity to the other samples is extremely low.

II.2.2.1. Changes in the structure of communities within the habitat Circalittoral biogenic reefs with *Mytilus galloprovincialis* (30-60 m)

The similarity dendrogram on years at this depth range, based on square-root transformed densities, indicates the separation of four groups (Fig. II.2.2.1.1). There is clearly a group with almost 60% similarity of samples taken in the 1980s and early 1990s, the samples taken at the end of the 1990s were similar to over 60% with those taken in 2000, and after 2010 the samples had a similarity of almost 70%.

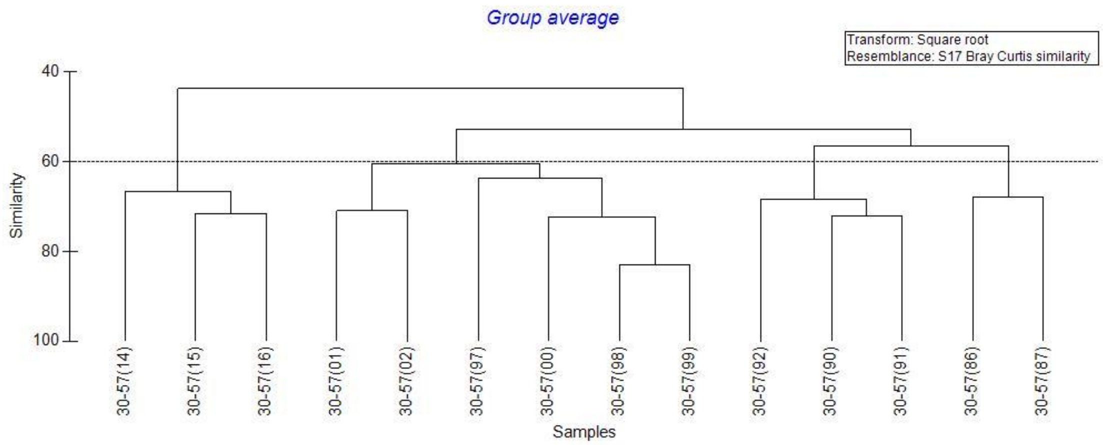

Fig. II.2.2.1.1. Bray-Curtis similarity dendrogram at 30-60 m depths.

For example, the most characteristic species of the habitat, *Mytilus galloprovincialis*, has undergone changes with the passing of the years. The largest densities of *Mytilus galloprovincialis* were found in samples from the 1980s, in immediately following years, the early 1990s, the late 1990s, and after 2010 the bivalve densities were smaller. The average density observed for *Mytilus galloprovincialis* was 26 ind./m^2 in 2014 and 16 ind./m^2 in 2015, compared with 1,013 ind./m^2 in 1987, the maximum density recorded throughout the study period.

At this depth range (30-57 m), the specific diversity reached from 20 species in 1986 to 56 species in 2016, and the number of individuals (abundance) increased from 156 individuals in 1986 to 212 individuals in 2016. The other ecological indices - d, J and H - had a positive trend. The indices' rise was not linear, considerable fluctuations were recorded during the 14 years. For example, the best year in terms of specific diversity was 2016, and in terms of abundance it was 2002.

Based on the analysis of the results from the calculation of the M-AMBI index, a trend towards Good Ecological Status within the habitat was observed. This Good Ecological Status is achieved in 2002 and continued almost constantly until 2016 (Abaza et al., 2018) (Fig. II.2.2.1.2).

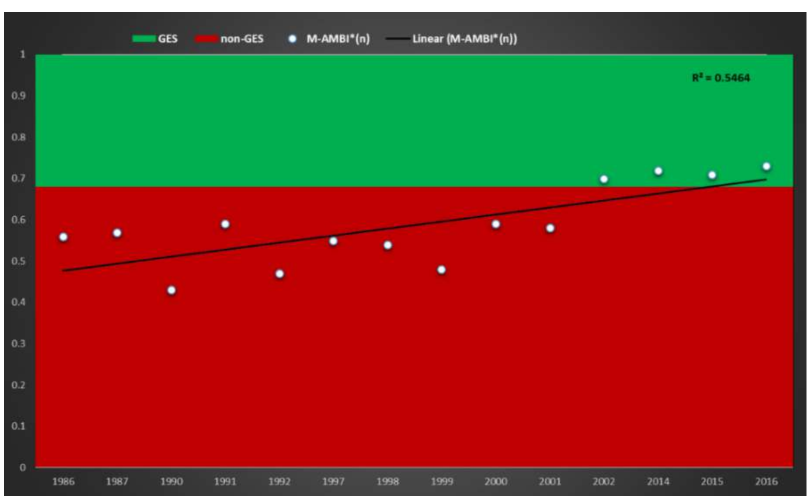

Fig. II.2.2.1.2. Evolution trend of the Good Ecological Status based on the M-AMBI*(n) index (30-60 m) (Abaza et. al., 2018).

With the help of Primer's DistLM analysis, we calculated the statistical significance of the correlation between biological data (densities) and 5 environmental factors: temperature (T), oxygen (O), salinity (S), phosphates PO_4) and dissolved inorganic nitrogen (DIN). Densities correlated statistically significant with T (p = 0.028) and with O (p = 0.036), with a significance threshold of 95% (Table II.2.2.1.1).

Table II.2.2.1.1. MARGINAL TEST results on the correlation between densities and environmental factors (30-57 m).

Variable	SS(trace)	Pseudo-F	P	Prop.
T[oC]	2584.7	2.4692	0.028	0.17065
S[‰]	2413	2.2742	0.036	0.15932
O2[mg/L]	2115.6	1.9484	0.089	0.13969
PO4 [µM]	866.61	0.7282	0.643	0.05721
DIN [µM]	1725.3	1.5427	0.161	0.11391

II.2.2.2. Changes in the structure of communities within the habitat Circalittoral deep Pontic muds with *Modiolula phaseolina* (60 - 100 m)

The similarity dendrogram on years at this depth range, based on a square-root transformation, indicates the separation of a single group with similarity over 60% in the years 2015 and 2016 (Fig. II.2.2.2.1).

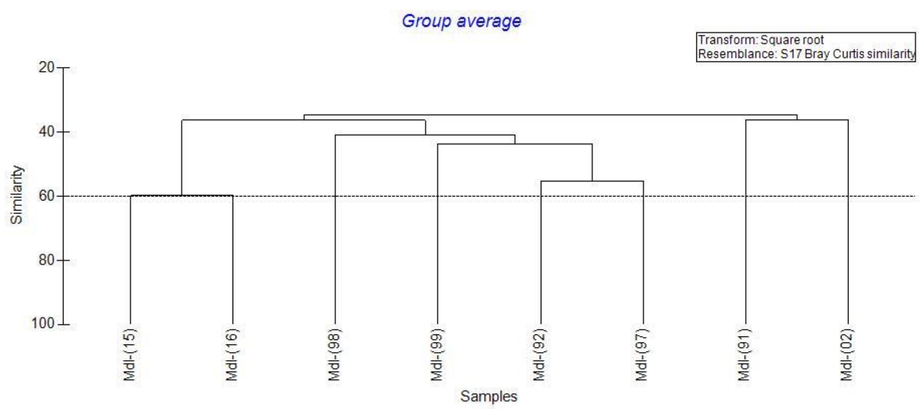

Fig. II.2.2.2.1. Bray-Curtis similarity dendrogram at 60-100 m depths.

The quantitative structure of *Modiolula phaseolina*, a typical species for the 60-100 m habitat, has also undergone changes over the years. The highest density recorded by this species was in 1999 and the smallest in 2002. Changes were not linear, fluctuations were observed, but there was a recovery in the years after 2010 compared to 2000.

A steady evolution was mainly observed in the case of specific diversity (S). It is known that, under good conditions, when ecological status is favorable, specific diversity increases and the abundance of opportunistic species decreases. In our case, the highest specific diversity was recorded in 2016, and this is the case for the other indices, except for the abundance (N).

The habitat analysis over a period of 8 years, calculated on the basis of the M-AMBI index, clearly shows a trend of improvement in recent years, with a Good Ecological Status in 2016 (Fig. II.2.2.2.2).

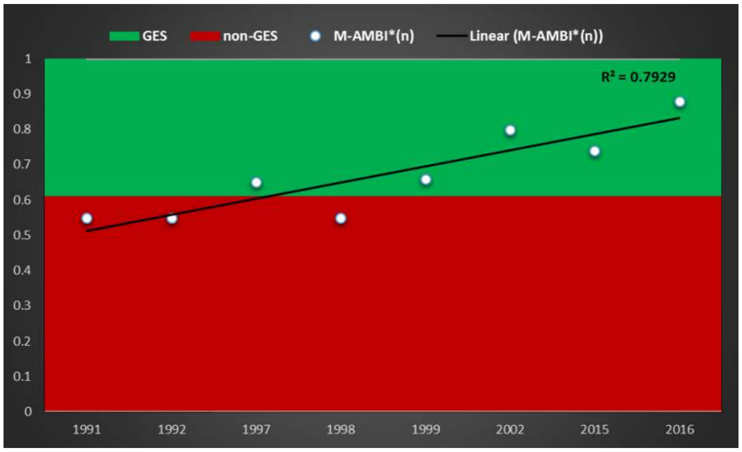

Fig. II.2.2.2.2. Evolution trend of the Good Ecological Status based on the M-AMBI*(n) index (60 - 100 m) (Abaza et. al., 2018).

The density of benthic organisms at 60-100 m depths was statistically correlated only with phosphates (p = 0.015), with a significance threshold of 95% (Table II.2.2.2.1).

Table II.2.2.2.1. MARGINAL TEST results on the correlation of density and environmental factors (60-100 m).

Variabile	SS(trace)	Pseudo-F	P	Prop.
T[oC]	2961.8	1.6509	0.066	0.21578
S[‰]	2385.4	1.2621	0.216	0.17379
O2[mg/L]	2674.5	1.452	0.153	0.19485
PO4 [µM]	3438.5	2.0054	0.015	0.2505
DIN [µM]	2430.6	1.2911	0.222	0.17708

II.2.2.3. Habitat definition in relation to species contribution

Circalittoral biogenic reefs with *Mytilus galloprovincialis* (30-60 m)

In the first phase, the samples were taken in turn and each year was given a code from I to IV, to cover the four decades studied: I - 1980, II - 1990, III - 2000, IV - 2010. After the results of the SIMPER analysis were obtained, the species with a significant contribution were classified according to their sensitivity to the degree of pollution: I - very sensitive species, II - indifferent species, III - tolerant species, IV - V - order one opportunistic.

In the 1980s (Group I), the average similarity within the group was 68.02%. The species with the highest contribution were *Melinna palmata* (25.15%) and *Mytilus galloprovincialis* (24.50%). Another species with a rather large contribution compared to the other species was *Mya arenaria* (10.36%). If we were to make a general classification of the habitat according to the species contribution, in the 1980s this habitat would have been named Circalittoral Pontic muds with *Melinna palmata*, *Mytilus galloprovincialis* and *Mya arenaria*.

After 2010 (Group IV), the similarity within the group was 68.35%. The contribution of species was much more balanced compared to other periods. For a contribution of over 60%, 12 benthic species were needed. The first two contributing species were *Nephtys hombergii* (9.31%) and *Heteromastus filiformis* (8.37%). If we were to define the habitat, it would be called Circalittoral Pontic muds with *Nephtys hombergii* and *Heteromastus filiformis*.

Circalittoral deep Pontic muds with *Modiolula phaseolina* (60-100 m)

Within the group of the first studied period (1990s), the similarity was 39.67%. The species that are conducive to their contribution to the habitat were *Apseudopsis ostroumovi* and the bivalve *Modiolula phaseolina*, known in the 1970s (Băcescu et al., 1970) as the keystone species at these depths. The habitat at the level of the 1990s could be defined Circalittoral deep Pontic muds with with *Apseudopsis ostroumovi* and *Modiolula phaseolina*.

In the years after 2010, the similarity within the group was 59.77%. The highest contribution was recorded by *Terebellides stroemii* (9.92%), *Prionospio cirrifera* (9.71%) and *Modiolula phaseolina* (9.5%). Thus, if we take into account the species with the highest contribution, the habitat would be called Circalittoral deep Pontic muds with with *Terebellides stroemii*, *Prionospio cirrifera* and *Modiolula phaseolina*.

II.2.2.4. Changes in the structure of meiobenthic communities

From the analysis of similarity using the Primer software, resulted a group with a similarity of more than 60% comprising the years 1978, 1979, 1990, a group with a similarity of more than 80% between 1977, 1986, 1987, 1988. The year 2015 recorded a similarity to the two groups of 60%, and 1999 was very different from the rest, having a similarity of up to 30%.

OVERALL CONCLUSIONS

The most comprehensive monograph dedicated to the benthos on the Romanian coast is Marine Ecology IV. Although it was published in the early 1970s, it is still a reference for specialists in the field. Consequently, the results of the assessments made for this PhD thesis have been largely reported to the state described in Marine Ecology IV. In the 1960s-1970s, the zoobenthos status was undoubtedly better than the present situation. The main biocoenoses had as keystone species bivalves (*Lentidium mediterraneum* up to 20 m, *Mytilus galloprovincialis* up to 60 m and *Modiolula phaseolina* up to approximately 120 m), the important role of bivalve mollusks of biofilters in the marine ecosystem being well known, compared to the current situation, when the main role was taken by polychaetes.

In the future, we aim to be able to make a comparative analysis in the case of rocky biocenoses, which were much less studied and their situation is much less known compared to the situation of sedimentary substrate sediment biocoenoses.

The research carried out during the PhD thesis on the current state and the long-term evolution of the macro- and meiobenthic communities on the Romanian Black Sea coast led to the following overall conclusions:

- **Current state of macro- and meiobenthos:**
  - ✓ Between **2006 and 2015**, a total of **93 macrobenthic species** were identified, out of which 26 (28%) belonged to the group Polychaeta, 27 (29%) to Mollusca, 27

(29%) to Crustacea and 13 (14%) to ″other groups″. Regarding **meiobenthos**, for horizontal distribution, 14 meiobenthic groups were identified, 7 eumeiobenthic and 7 pseudomeiobenthic. The distribution of diversity in the 32 stations was relatively uniform. The main groups encountered in this study are: Nematoda, Harpacticoida, Bivalvia, Oligochaeta, Polychaeta, Turbellaria, Foraminifera, Halacarida, Amphipoda, Nemertea, Ostracoda, Gastropoda, Kinorhyncha and Cumacea, this being the order encountered in the samples.

- **Structure and distribution of macro- and meiobenthic communities on depth ranges:**
  - ✓ At **5 m depth**, between 2006 and 2015, a number of 29 macrobenthic species were identified. The largest variety was recorded by mollusks (12 species) and polychaetes (12 species). The invertebrates are dominated by bivalve species, the most numerous being *Mya arenaria* (48 ind./m^2) and *Lentidium mediterraneum*. Over the last decade, from the analysis of the data for the period 2006-2015, the state of the macrobenthos communities has undergone major qualitative and quantitative changes. Also at the 5 m isoline were identified **12 meiobenthos groups**: Foraminifera, Harpacticoida, Cumacea, Ostracoda, Nematoda, Halacarida, Turbellaria, Kinorhyncha, Oligochaeta, Polychaeta, Bivalvia, Gasteropoda, Nemertea and Amphipoda. Dominant at this depth, in terms of density, were the nematodes, which recorded 72% (730,714 ind./m^2) of the total density of the meiobenthos, followed by bivalves, polychaetes, oligochaets and harpacticides, the other groups having an insignificant contribution. In view of the analyses made and given the fact that the shallow area is the spawning ground of many bentophagous fish species, part of them of economic value, we can deduce the importance of the meiobenthic organisms, especially of the nematodes, in the marine ecosystem economy and, last but not least, in the human economy.
  - ✓ At **20 m depth**, between 2006 and 2015, a total of **44 macrobenthic** species were identified, as follows: 16 species of mollusks, 15 species of polychaetes, 8 species of crustaceans and 5 species assimilated to the group generically named ″other groups″. The polychaete *Melinna palmata* recorded the highest densities, due to the presence of the muddy sediment, especially in the northern part of the coast. Bivalve mollusks have made a significant contribution from the qualitative point of view, by the small filter bivalve *Lentidium mediterraneum*. The mollusk *Mytilus galloprovincialis*, a species commonly found at this depth, suffered decreases in density in 2015. In the case of mollusks, it is interesting that in 2015 appeared two species that in the other years were not reported, namely *Ebala pointeli* and *Parthenina interstincta*. Regarding meiobenthos, the dominant group at this depth was Nematoda, 581714 ind./m^2, followed by Harpacticoida 375,857 ind./m^2. Increased biomass values were recorded by harpacticides, followed by bivalves and nematodes.
  - ✓ In the **circalittoral**, between the 30-100 m isolines, were identified in this area, from 2006 to 2015, a number of **54 macrobenthic species**. An overview of the data obtained from this area shows a better situation than the other two areas. In the case of species typical for muddy areas at these depths, such as *Terebellides stroemii*, there was even an increase in numbers after 2010. Here, in 2014 and 2015, the non-indigenous species *Dipolydora quadrilobata*, a species recently found at the seaside Romanian, was reported. Regarding meiobenthos, the dominant group was

Nematoda, 479,065 ind./m^2, and the other groups had a share of no more than 3% of the total of meiobenthos.

- **Evolution of the keystone species of the main biocoenoses on mobile substrate**:
    - ✓ **Fine sands with *Lentidium mediterraneum***, a typically psamobiontic bivalve, are one of the most important biocoenoses of the Black Sea, a foraging ground for many bentophagous fish. It is a qualitatively rich biocenosis, former NIMRD reports naming in these areas over 100 benthic species; however, we have encountered about 30 species, all strictly macrobenthic. The quantitative analysis over the last 13 years has shown an upward trend in the quantitative parameters recorded by the small bivalve.
    - ✓ **The deep-water mussel biocoenosis** is one of the most characteristic and well-defined biocoenoses on the Romanian coast. The quantitative analysis over the last seven years of the bivalve *Mytilus galloprovincialis* showed a decreasing trend. This is probably due to the hypoxic phenomena that have occurred in recent years, the claim being supported by the appearance and smell of mud, especially from the northern side of the coast, but also by the mussels found in the samples, dead by asphyxiation. Until 2016, however, the last year studied, the mussel community at the mouths of the Danube has recovered almost completely.
    - ✓ The biocoenosis of the gray muds with *Modiolula phaseolina*, specific to the Black Sea, is well individualized and extensive. In recent years, the characteristic species has shown a decreasing trend.
- **Influence of environmental factors on the distribution of macrobenthic and meiobenthic organisms:**
    - ✓ The investigation of the influence of environmental factors on the macrobenthos revealed that depth, temperature and salinity had a significant influence on the distribution of macrobenthic organisms. It has been observed, however, that pH has a significant effect only on mollusks, not on other groups.
    - ✓ It was found that at the maximum concentration of heavy metals (330 μg/g), the density of macrobenthos fell close to 0.
    - ✓ However, in the case of meiobenthos, the environmental parameters did not statistically correlate with biological parameters, which suggests that the spatial distribution of meiobenthos at the Romanian coast was controlled by a multitude of factors, not by a single factor on its own.
    - ✓ Another conclusion could be that the normal fluctuations of a single environmental factor do not significantly affect meiobenthic organisms.
- **Long-term changes in the structure of benthic communities (case study on the 30-100 m isolines):**
    - ✓ A set of 269 data, covering four decades, was analyzed.
    - ✓ The qualitative structure of the benthic communities at depths between 30 and 100 m has undergone positive qualitative changes, with only 30 species registered in the 1980s, while after 2010 - 57 species.
    - ✓ Between 30 and 100 m depth, according to literature sources and our raw data, the habitats Circalittoral biogenic reefs with *Mytilus galloprovincialis* and Circalittoral deep Pontic muds with *Modiolula phaseolina* were encountered.

- ✓ For the first habitat were observed four phases in which the benthic fauna underwent changes (1980s - maximum eutrophication, 1990-1992 - industry collapse, 1999-2009 - slight recovery, after 2010 - balance).
- ✓ For the habitat Circalittoral deep Pontic muds with *Modiolula phaseolina*, three different stages were observed where quantitative changes occurred in benthic fauna.
- ✓ The peak abundance was reached in 2002 for the habitat Circalittoral biogenic reefs with *Mytilus galloprovincialis* and in 1999 for the habitat Circalittoral deep Pontic muds with *Modiolula phaseolina.* In the latter habitat, when abundance reached its maximum value, diversity has recorded the minimum value.
- ✓ For the habitat Circalittoral biogenic reefs with *Mytilus galloprovincialis*, in the 1980s and early 1990s, some opportunistic species such as *Mya arenaria*, *Melinna palmata* and even *Mytilus galloprovincialis*, which is also considered tolerant, proliferated.
- ✓ All calculated ecological indices have had a positive trend, showing a good evolution for the benthic communities.
- ✓ The ecological status of the ecosystem, measured on the basis of the M-AMBI indicator, is currently good within the studied habitats, at depths between 30 and 100 m.
- ✓ From one decade to the next, the structure of communities in terms of contribution of benthic species has changed drastically at the level of the two habitats (Circalittoral biogenic reefs with *Mytilus galloprovincialis* and Circalittoral deep Pontic muds with *Modiolula phaseolina*). If we were to define habitats according to the contribution of the species, the name of the habitat would be completely different from one period to another. At depths of 30-60 m, the difference between the 1980s and the post-2010 years was 59.31%, and at depths of 60-100 m the difference between the 1990s and the post-2010 years was even higher (65, 30%). It was only after 2010 that there was a balance in the species contribution, in the sense that the contribution of certain species decreased and other species started to appear (increased diversity).
- ✓ The current name of habitats according to species contribution to biocenosis is the following: Circalittoral Pontic muds with *Nephtys hombergii* and *Heteromastus filiformis* (30-60 m) and Circalittoral deep Pontic muds with *Terebellides stroemii, Prionospio cirrifera* and *Modiolula phaseolina* (60-100 m).
- ✓ Environmental factors, such as temperature, salinity or dissolved inorganic nitrogen, have contributed statistically significant to the occurrence of these changes in benthic communities.

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SCIENTIFIC PUBLICATIONS ACHIEVED DURING THE DOCTORAL PROGRAMME

A. PAPERS PUBLISHED IN ISI-RATED JOURNALS WITH IMPACT FACTOR:

1. **FILIMON ADRIAN**, ABAZA VALERIA (2015), Preliminary Data on the Vertical Distribution of Meiobenthos in the Sediment of the Romanian Black Sea Shallow Waters, Journal of Environmental Protection and Ecology (JEPE) 16, No. 3, pp. 919-925; **Thomson Reuters ISI Web of Knowledge, impact factor 0.734**;
2. **FILIMON ADRIAN**, ABAZA VALERIA, MARIN OANA, DUMITRACHE CAMELIA (2016), Community Structure of Zoobenthos Associated with *Cystoseira barbata* Facies from the Southern

Romanian Black Sea coast, Journal of Environmental Protection and Ecology (JEPE) 17, no. 3, pp. 942-949 **- Thomson Reuters ISI Web of Knowledge, impact factor 0.774**;

3. ABAZA VALERIA, DUMITRACHE CAMELIA, **FILIMON ADRIAN**, OROS ANDRA, LAZĂR LUMINIȚA, COATU VALENTINA, ȚIGĂNUȘ DANIELA (2016), Ecological Assessment of Benthic Invertebrate Fauna from the Romanian Marine Transitional Waters, Journal of Environmental Protection and Ecology (JEPE) 17, no.3, pp. 932-941; **Thomson Reuters ISI Web of Knowledge, impact factor 0.774;**
4. ABAZA VALERIA, DUMITRACHE CAMELIA, SPINU ALINA, **FILIMON ADRIAN** (2018), Ecological Quality Assessement of Circalittoral Major Habitats Using M-Ambi*(N) Index, Journal of Environmental Protection and Ecology (JEPE) 19, no. 2 (in press). **Thomson Reuters ISI Web of Knowledge, impact factor 0.774.**

B. PAPERS PUBLISHED IN ISI-RATED JOURNALS WITH NO IMPACT FACTOR:

1. ROȘIORU DANIELA, ABAZA VALERIA, DUMITRACHE CAMELIA, **FILIMON ADRIAN**, TIMOFTE FLORIN (2014), Ecological and biochemical aspects of *Mytilus galloprovincialis* from the Romanian Black Sea coast, 14th International Multidisciplinary Scientific Geoconference SGEM 2014, Albena, Bulgaria, volume 2, pp. 569-576. **Thomson Reuters ISI Web of Knowledge;**
2. ABAZA VALERIA, MARIN OANA, **FILIMON ADRIAN**, DUMITRACHE CAMELIA, ROSIORU DANIELA (2016), The Status of Benthic Invertebrate fauna from the Romanian Black Sea Ports under Present Ecological Conditions. Proceedings of the International Multidisciplinary Scientific Geoconference SGEM, Albena, Bulgaria, 2016, Vol. 2, p. 901-908; **Thomson Reuters ISI Web of Knowledge;**

C. PAPERS PUBLISHED IN IDB INDEXED JOURNALS:

1. NENCIU MAGDA, OROS ANDRA, ROŞIORU DANIELA, GALAŢCHI MĂDĂLINA, **FILIMON ADRIAN**, ŢIGANOV GEORGE, DANILOV CRISTIAN, ROŞOIU NATALIA (2016), Heavy Metal Bioaccumulation in Marine Organisms from the Romanian Black Sea Coast, in Annals Series on Biological Sciences - Academy of Romanian Scientists, Online Edition ISSN 2285-4177, Volume 5, No. 1, 2016, pp. 38-52 - **B+**;
2. DUMITRACHE CAMELIA, **FILIMON ADRIAN**, ABAZA VALERIA, ZAHARIA TANIA (2013), Recent Data on Benthic Populations from the Sandy Bottom Community in the Marine Zone of the Danube Delta Biosphere Reserve (ROSCI0066), Cercetări Marine, Volume No. 43, Constanta, Romania, pp. 219-231.

D. PUBLISHED BOOKS, MONOGRAPHS:

1. SEZGIN M., ÜRKMEZ D., TEACĂ A., MUREȘAN M., **FILIMON A**. AND G.K. ŞAHIN (2014), Report on the MISIS cruise Intercalibration Exercise: BENTHOS, ISBN: 978-606-598-361-8, 83 pp.;
2. BOICENCO L., SPÂNU A.D., COATU V., BEKEN C., DENCHEVA K., **FILIMON A**., LAZĂR L., MONCHEVA S., MARIN O., OROS A., STHEREVA G., STEFANOVA K., TIMOFTE F., ȚIGĂNUȘ D. (2014), Overview of the marine environmental monitoring in Bulgaria, Romania and Turkey, ISBN: 978-606-598-362-5, 47 pp.;
3. GALAȚCHI MĂDĂLINA, ȚIGANOV GEORGE, NENCIU MAGDA, MARIN OANA, **FILIMON ADRIAN**, NIȚĂ VICTOR (2013), Life in the Black Sea, GWP, Romania, Edit Aureo, Oradea, 63 p.;

4. NICOLAEV SIMION, ZAHARIA TANIA, GALAȚCHI MĂDĂLINA, NENCIU MAGDA, NIȚĂ VICTOR, MARIN OANA, **FILIMON ADRIAN**, ȚIGANOV GEORGE (2014), Life in the Black Sea, V. Sites of Community Importance at the Romanian Black Sea coast, GWP Romania, Ed. Aureo, Oradea, ISBN 978-606-8614-29-8, 98 pp.

E. PAPERS DEFENDED DURING INTERNATIONAL SCIENTIFIC EVENTS AND PUBLISHED AS ABSTRACT:

1. NIȚĂ VICTOR, NENCIU MAGDA, **FILIMON ADRIAN**, CRISTEA MĂDĂLINA, ZAHARIA TANIA, GOLUMBEANU MARIANA (2013), Using Ecological Education and Awareness in Exerting the Management of the Vama Veche - 2 Mai Marine Reserve, in Book of Abstracts of the 1st International U.O.C.-B.EN.A Conference "The Sustainability of Pharmaceutical, Medical and Ecological Education and Research SPHAMEER 2013, 20-23 June 2013, Constanta, Romania", ISBN 978-973-614-784-5, p.158;
2. **FILIMON ADRIAN,** DUMITRACHE CAMELIA, (2013), Data on the Actual State of Benthic Communities in the Romanian Marine Waters, in Book of Abstracts of the 1st International U.O.C.-B.EN.A Conference "The Sustainability of Pharmaceutical, Medical and Ecological Education and Research SPHAMEER 2013, 20-23 June 2013, Constanta, Romania", ISBN 978-973-614-784-5, p.170;
3. NIȚĂ VICTOR, NENCIU MAGDA, **FILIMON ADRIAN**, ZAHARIA TANIA, GOLUMBEANU MARIANA (2013), Ecological Education - Management Tool for the Vama Veche - 2 Mai Marine Reserve, in Book of Abstracts of the 4th Black Sea Scientific Conference - Black Sea, Challenges towards Good Environmental Status, 28-31 October 2013, Constanta, Romania, ISBN 978-606-8066-46-2, p. 232;
4. **FILIMON ADRIAN,** ABAZA VALERIA (2015), Preliminary Data on Vertical Distribution of Meiobenthos in the Sediment of the Romanian Black Sea Shallow Waters, in Book of Abstracts of the International U.A.B. - B.EN.A. Conference Environmental Engineering and Sustainable Development, Alba Iulia, Romania, May 28-30th, 2015, ISSN 245702829, p. 77;
5. NENCIU MAGDA, OROS ANDRA, ROȘIORU DANIELA, GALAȚCHI MĂDĂLINA, ȚIGANOV GEORGE, DANILOV CRISTIAN-SORIN, **FILIMON ADRIAN**, ROȘOIU NATALIA (2015), Bioacumularea metalelor grele la specii din familia Syngnathidae de la litoralul românesc al Mării Negre, în Volumul de Rezumate al Sesiunii Ştiinţifice de Toamnă 2015 a Academiei Oamenilor de Știință din România, 24-26 septembrie 2015, Iași, România, p. 53-54;
6. **FILIMON ADRIAN**, ABAZA VALERIA, DUMITRACHE CAMELIA, MARIN OANA, NENCIU MAGDA, ȚIGANOV GEORGE, TIMOFTE FLORIN (2015), Fauna asociată câmpurilor de *Cystoseira barbata* din sudul litoralului românesc al Mării Negre, în Volumul de Rezumate al Sesiunii Științifice de Toamnă 2015 a Academiei Oamenilor de Știință din România, 24-26 septembrie 2015, Iași, România, p. 102;
7. **FILIMON ADRIAN**, ABAZA VALERIA, DUMITRACHE CAMELIA, NIȚĂ VICTOR, NENCIU MAGDA, ȚIGANOV GEORGE (2015), Impact of Dike Construction on Marine Habitats and Benthic Populations, in in Proceedings Book of the 1st International Conference on Ecology and Protection of Marine and Freshwater Environments - ECOPROWATER 2015, Viterbo, Italy, 1-3 October 2015, ISBN: 9788890755361, p. 55;
8. **FILIMON ADRIAN**, ABAZA VALERIA, DUMITRACHE CAMELIA, MARIN OANA, NENCIU MAGDA, ȚIGANOV GEORGE, TIMOFTE FLORIN (2015), Benthic Invertebrates Associated with *Cystoseira barbata* from the Romanian Black Sea Coast, in Book of abstracts of the International Symposium Protection of the Black Sea ecosystem and sustainable management of maritime activities: PROMARE 2015, 96 p., ISBN 978-606-8066-52-3: p. 55;
9. ȚIGANOV GEORGE, **FILIMON ADRIAN**, NENCIU MAGDA IOANA, ANTON EUGEN (2015), Assessment of Dolphin Population Abundance at the Romanian Black Sea Coast in 2013, in Book of Abstracts of the International Symposium Protection of the Black Sea ecosystem and

sustainable management of maritime activities: PROMARE 2015, 96 p., ISBN 978-606-8066-52-3: p. 78;

10. **FILIMON ADRIAN,** ABAZA VALERIA (2016), Current State of Meiobenthos Communities from the Romanian Black Sea under Environmental Changes, Book of Abstracts of the Green Development, Infrastructure and Technology - GREDIT 2016"International Conference, Skopje, FYR Macedonia, 31.03-01.04.2016, editor in chief Dame Dimitrovski, 322 p., ISBN 978-608-4624-21-9: p. 150;
11. NENCIU MAGDA, OROS ANDRA, ROŞIORU DANIELA, GALAŢCHI MĂDĂLINA, **FILIMON ADRIAN**, ŢIGANOV GEORGE, DANILOV CRISTIAN, ROŞOIU NATALIA (2016), Heavy Metal Bioaccumulation in Marine Organisms from the Romanian Black Sea Coast, in Book of Abstracts of the Romanian Scientist Academy/Spring Session, 27-28 May 2016, Bucharest-Mioveni, Romania, p. 64;
12. NENCIU MAGDA IOANA, MICU DRAGOŞ, **FILIMON ADRIAN**, NIŢĂ VICTOR (2016), The Romanian Natura 2000 MPA Network as a Tool for Connectivity and Resilience of the Marine Ecosystem, in Book of Abstracts of the International Workshop Water Added Value to Health and Life, 17-19 June 2016, Eforie Nord, Romania, editors F.K. Vosniakos & M. Golumbeanu, Printing House of Alexander TEI of Thessaloniki, Greece, ISBN 978-960-287-151-5, p. 26;
13. NENCIU MAGDA, GOLUMBEANU MARIANA, NIŢĂ VICTOR, **FILIMON ADRIAN**, STOICA ELENA, ANTON EUGEN (2016), Marine litter surveys along the Romanian Black Sea coast, in Abstracts Book of the BLACK SEA FROM SPACE Workshop, 28-30 September 2016, Flora Hotel, Mamaia, Romania, p. 36;
14. NENCIU MAGDA IOANA, MICU DRAGOŞ, **FILIMON ADRIAN**, NIŢĂ VICTOR, GOLUMBEANU MARIANA (2016), Romanian Marine Protected Areas Supporting the Connectivity and Resilience of the Ecosystem, in Book of Abstracts of the 6th International Conference Protection of Natural Resources and Environmental Management: The Main Tools for Sustainability - PRONASEM 2016, ISBN 978-606-8066-53-0, Boldas Printing, Constanta, 2016, p. 49-50;
15. **FILIMON ADRIAN**, ABAZA VALERIA, MARIN OANA, DUMITRACHE CAMELIA (2016), Associated Fauna of the *Cystoseira barbata* Facies from the Southern Romanian Black Sea Coast, in Book of Abstracts of the 6th International Conference Protection of Natural Resources and Environmental Management: The Main Tools for Sustainability - PRONASEM 2016, ISBN 978-606-8066-53-0, Boldas Printing, Constanta, 2016, p. 99.

F. PARTICIPATION IN INTERNATIONAL SCIENTIFIC CONFERENCES

1. U.O.C.-B.EN.A Conference The Sustainability of Pharmaceutical, Medical and Ecological Education and Research - SPHAMEER 2013, Constanța, România, 20-23 iunie 2013 - poster;
2. 1st International Conference on Ecology and Protection of Marine and Freshwater Environments - ECOPROWATER 2015, Viterbo, Italia, 1-3 octombrie 2015 - poster;
3. Simpozionul Internațional PROTECTION OF THE BLACK SEA ECOSYSTEM AND SUSTAINABLE MANAGEMENT OF MARITIME ACTIVITIES - PROMARE 2015, 7th Edition, Constanța, România, 29-31 octombrie 2015 - oral presentation;
4. 6st International Conference PROTECTION OF NATURAL RESOURCES AND ENVIRONMENTAL MANAGEMENT: THE MAIN TOOLS FOR SUSTAINABILITY - PRONASEM 2016, București, România, 11-13 noiembrie 2016 - poster;
5. International Conference GREDIT 2016, Skopje, 31.03 - 01.04.2016 - poster;
6. International Conference Maritime Spatial Planning in the Black Sea, Constanta, Romania, 3-4 May 2017 - poster
7. UAB-B.EN.A Conference "ENVIRONMENTAL ENGENEERING AND SUSTAINABILITY DEVELOPMENT", 25-27 mai 2017, Alba Iulia, România - poster;

8. International Symposium ”PROTECTION OF THE BLACK SEA ECOSYSTEM AND SUSTAINABLE MANAGEMENT OF MARITIME ACTIVITIES”, PROMARE 2017, 8th Edition, Constanța, România, 7-9 SEPTEMBER 2017 - poster.

G. AWARDS

1. **Best poster award** at the 6st International Conference PROTECTION OF NATURAL RESOURCES AND ENVIRONMENTAL MANAGEMENT: THE MAIN TOOLS FOR SUSTAINABILITY - PRONASEM 2016, Bucharest, Romania, 11-13 November 2016 with paper: Associated fauna of the *Cystoseira barbata* facies from the Southern Romanian Black Sea Coast - **A. FILIMON**, V. ABAZA, O. MARIN, C. DUMITRACHE
2. **3rd prize for best poster** at the International Symposium PROTECTION OF THE BLACK SEA ECOSYSTEM AND SUSTAINABLE MANAGEMENT OF MARITIME ACTIVITIES, PROMARE 2017, 8th Edition, Constanța, Romania, 7-9 SEPTEMBER 2017 with the paper - Life History of the Black Sea Long-Snouted Sea Horse (*Hyppocampus guttulatus*) Colonization Pattern and Genetic Differences - E. TAFLAN, M. NENCIU, D. HOLOȘTENCO, M. CIORPAC, **A. FILIMON**, C. DANILOV.
3. **2nd prize for the best oral presentation** at the International Symposium PROTECTION OF THE BLACK SEA ECOSYSTEM AND SUSTAINABLE MANAGEMENT OF MARITIME ACTIVITIES, PROMARE 2017, 8th Edition, Constanța, România, 7-9 SEPTEMBRIE 2017 with the paper Ecological Quality Assessment of circalittoral major habitats using M-AMBI *(N) index - V. ABAZA, C. DUMITRACHE, **A. FILIMON**

H. PARTICIPATION IN RESEARCH CONTRACTS

1. EASME/EMFF/2014/1.2.1.5/2/SI2.707672MSP LOT 1 Black Sea - MARSPLAN BS - member of the team, covering zoobenthos and invasive species;
2. FP7 COCONET - towards COast to COast NETworks of marine protected areas (from the shore to the high and deep sea), coupled with sea-based wind energy potential (CoCoNET) - field work and scientific diving;
3. MSFD (Marine Strategy Framework Directive) GUIDING IMPROVEMENT IN THE BLACK SEA INTEGRATED MONITORING SYSTEM (MISIS) - member in the team for zoobenthos. I participated in an international survey during which an intercalibration exercise with other zoobenthos experts was performed;
4. FP7 Policy-oriented marine Environmental Research for the Southern European Seas (PERSEUS) - member in the team for zoobenthos;
5. Characterizing benthic and plankton communities of the Romanian continental shelf (PN09320202) - member in the team for zoobenthos;
6. Integrated approach of the marine protected areas/Natura 2000 marine sites in Romania on the connectivity and structural and functional resilience at Black Sea ecosystem level (PN16230204) - member in the team for zoobenthos;
7. Study for the elaboration of the Red List of vulnerable marine species, aimed at drawing-up a regulatory act for their protection, according to the requirements of the Bucharest Convention - biodiversity expert (zoobenthos);
8. Framework contract for service related to coordination between the different marine regions in implementing the ecosystem approach (MILLIEU Ltd.) - biodiversity, benthic habitats expert;
9. Study for developing the operational indicators set to measure progress aimed at reaching the Good Ecological Status of the marine environment in compliance with the requirements of the Marine Strategy Framework Directive - benthic habitats and zoobenthos expert;

10. Service provision for obtaining the Environmental Permit and Water Management Permit ROVOCON12-016 of 19.06.2012, beneficiary ExxonMobil Exploration and Production Romania Limited Nassau (Bahamas) - biodiversity expert;
11. Providing training and obtaining environmental permits for oil and gas drilling well Ioana, in block XV Midia - biodiversity expert;
12. Marine environment monitoring report before/during/after offshore drillig and exploration acitivities - 1 Domino well opening, on the Romanian Black Sea continental shelf EXXON - ROVOCON - 11-023 - field sampling and zoobenthos expert;
13. Creating a methodology for using dispersants in the Black Sea, as the background for a legal framework for dispersants use in the Black Sea (contract no. ROVOCON13-011/28.02.2013) - responsible for experiments on the effects of dispersants on the species *P. elegans*. The data obtained where then use for elaborating the methodology.