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STATE OF THE ENVIRONMENT OF THE STRANDZHA – IGNEADA MPA

MSFD Guiding Improvements in the Black Sea
Integrated Monitoring System

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LIST OF ABBREVIATIONS

ACCOBAMS	Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and contiguous Atlantic Area, http://www.accobams.org/
BG	Bulgaria
BS	Black Sea
BSC	Black Sea Commission (Commission on the Protection of the Black Sea Against Pollution), www.blacksea-commission.org
EC	European Commission, http://ec.europa.eu/
ECBSea	Environmental Collaboration for the Black Sea (Project of EC DG Devco), http://81.8.63.74/ecbsea/en/documents/relevant/index.htm
EU	European Union
EUNIS	EU Nature Information System
HD	Habitat Directive
GeoEcoMar	National Research and Development Institute for Marine Geology and Geoecology, Bucharest-Constanta, Romania
GES	Good Environment Status
IO-BAS	Institute of Oceanology, Varna, Bulgaria
IUCN	International Union for Conservation of Nature
MPA	Marine Protected Area
NGO	Non-governmental organization
NIMRD	National Institute for Marine Research and Development, Constanta, Romania
SAC	Special Area of Conservation (EU)

SCI	Sites of Community Interest (EU)
SPA	Special Protected Area (EU Wild Bird Directive); Specially Protected Area (Barcelona Convention)
RAC/SPA	Regional Activity Centre for Specially Protected Areas (Barcelona Convention)
RO	Romania
TBPA	Transboundary Protected Areas
TR	Turkey
TUBITAK	The Scientific and Technological Research Council of Turkey, www.tubitak.gov.tr/
UNEP-WCMC	UNEP-World Conservation Monitoring Centre
WCPA	World Commission on Protected Areas
WFD	Water Framework Directive

EXECUTIVE SUMMARY

The MISIS project has proposed among others to deal with the challenge required by the process of establishment of the Transboundary Protected Areas Strandzha – Igneada situated at the border between Bulgaria and Turkey.

By the time this study begun the protected area BG0001007 Strandzha had already the status of Natura 2000 SCI under the Habitats Directive. During the MISIS project time, as a result of implementation of the project "Extension of the marine Natura 2000 in the Bulgarian Black Sea" carried out in 2011-2012 and an official proposal to the MOEW the marine range of SCI Strandzha has been extended to the current area of 37, 612.52 ha and 75 m depth, which comprises 15 % of the overall national coverage of marine protected areas within Natura 2000 ecological network in Bulgaria.

On the other hand, the Iğneada marine area had no status of protection, except that it indirectly benefited from its location in the very close vicinity of Longoz forest National Park (designated in 2007). Therefore during project lifespan, the accent has been put on deeply investigation of its present biological and ecological status for future designation of the marine part of Iğneada region as Marine Protected area under Habitat Directive.

The report contains the results of the desk and field studies carried out in Strandzha and Iğneada areas in purpose of getting knowledge regarding the ecological value and its present status from biological, ecological and socio-economic point of view.

The scope of the study was in first place to reveal the reasons why the areas are perfect candidates to be declared as transnational/transborder marine protected areas.

In the first chapter there are presented elements which describe in general terms the geographical location and main physical features of Strandzha and Iğneada areas, as well as the actual status of protection of each site. In order to harmonize the process required by the designation of protected areas according to NATURA 2000, the scientific criteria for selection of Special Areas of Conservation (SACs) and Special Protection Areas (SPAs) under Natura 2000 have been used to assess the approppriatness of designation of Strandzha - Iğneada as a Transboundary Marine Protected Area. There were envinced the biodiversity elements in each site which make them not only unique, representative or of high importance for preserving species and habitats mentioned by either Habitats and Birds Directives or

International Conventions (Berna, Bonn Conventions), but also there was underlined the character of ecological corridor between the sites for some of the protected species.

The second chapter proceeds with description of general oceanographic features (physical and geomorphological) of the Strandzha-Iğneada area. The physico-chemical ecological status of water body of Strandzha has been asessed based on results of studies performed in the area in the period 2012 - 2013 during national monitoring and surveys carried out within the MISIS framework. A first assessment of water physico- chemical status in the Iğneada area has been performed by the researchers from SINOP University.

The third chapter integrates the results of the biological surveys carried out in the summer and fall of 2012 and 2013, within the areas. Based on ecological assessment of phyto - and macrozoobenthos, on one hand, and phyto - and zooplankton communities, on the other hand, there were revealed the diversity, abundance and trends in evolution of specific biodiversity components, but also their quality status and implicit of the environment.

The study concluded that the ecological complexity of the marine environment represented by Strandzha - Igneada area could only be maintained by implementing common conservation measures, which would enhance the long - term existence and evolution in benefice of nature and human. The premises for designation of Transboundary Marine Protected Area Strandzha - Iğneada are fully achieved from the ecological point of view, the connectivity between the two countries being demonstrated by the existence of species and habitats of conservation importance in both areas which depend of each other spatially and functional. The breeding and migration corridors passing through the areas are essential for surviving of fish, crustaceans, mammals and birds inhabiting here.

INTRODUCTION

One of the main objectives of the MISIS (**M**SFD GUIDING **I**MPROVEMENTS IN THE BLACK **S**EA **I**NTEGRATED MONITORING **S**YSTEM) Project is *the increase in number and size of protected areas in the Black Sea as well as the increase in their degree of protection.*

In the frames of the project there have been raised an idea for a Black Sea Transboundary Protected Area to be proposed for designation in between Bulgaria and Turkey. It would include the Strandzha protected area from the Bulgarian side and on the Turkish side the area is named İğneada. From Bulgarian side the area is included in the NATURA 2000 network. It is generally far from direct influence of large land based sources of pollution coming from the Bulgarian side and is still supposed to have preserved communities in good ecological status. The area is characterized by high biodiversity of fishes, mammals, invertebrates, birds and plants. Many different habitats can be found there with high importance for the Black Sea health. The area is of scientific importance, it can be also used as a reference zone as almost undisturbed conditions are still observed. Besides, environmentally-friendly tourism, non-commercial/sports fishing, underwater sports, scuba-diving, photography and others can be of interest for the people if the area is kept in its pristine state.

Thus, the preservation of the beautiful and unique landscapes in the area is of high priority. This is the reason why we would like to propose enlargement of the BG Nature 2000 site into the south direction, to Turkish waters along the Igneada coast, and advocate for the need in designating this region as a Transboundary Protected Area. The area proposed in Turkish waters was not sufficiently investigated before and there are no protected areas in coastal or marine waters here previously designated or proposed.

In the frame of the MISIS project the process for establishment of a Transboundary Protected Areas Strandzha – Igneada started with an initial assessment of habitats and species existed in the areas. In the process, ecological criteria were used to verify the eligibility of the area for designation as a Transboundary Protected Area and the type of protection to be proposed.

The aim of the initial assessment was to obtain data about the biodiversity of the region and the quality status of the communities in the area. The investigations focused on the macrozoobenthos and macroalgae quality status. In addition, samples for zooplankton, phytoplankton, and nutrients in the water column were also collected to better identify the general environmental status of the area.

CHAPTER 1. DESCRIPTION OF THE STRANDZHA - IGNEADA AREA

1.1. Regional setting for Strandzha - Igneada

STRANDZHA PROTECTED SITE

The protected area BG0001007 Strandzha was designated under the Habitats Directive (transposed in the Bulgarian Biodiversity Act) as a Natura 2000 SCI with the Decision of the Council of Ministers N 122 of 2nd March 2007 (State Newsletter N 21/2007). The marine extent of the site covered 2296.35 ha limited to the 20 m isobaths at that time.

In 2010, at the Black Sea Biogeographical Seminar in Brindisi organised by the European Commission, ETC/BD concluded insuficency of the current SCI network in the Bulgarian Black Sea in terms of the marine natural habitat types 1110 and 1170 and the habitats of the species 4125 - *Alosa immaculata* 1349 - *Tursiops truncatus* and 1350 - *Phocoena phocoena*. Therefore, the Bulgarian MOEW was requested to extend the network of marine SCIs under NATURA 2000.

As a result of the Brindisi Biogeographic Seminar decisions, an initiative was undertaken by the MOEW for implementation of the project "Extension of the marine Natura 2000 in the Bulgarian Black Sea" that was carried out in 2011-2012 under the coordination of the Institute of Oceanology – BAS. The required scientific information and legal documentation were compiled in the project and proposal was put foreward to extend the marine network of SCIs in the Bulgarian Black Sea. Consequently, a Decision of the Council of Ministers N 660 of 1st November 2013 (State Newsletter N 97/2013) extended significantly the marine range of SCI Strandzha to the current 37 612.52 ha and 75 m depth, which comprises 15 % of the overall national coverage of marine protected areas within Natura 2000 ecological network in Bulgaria (Fig. 1).

Curently Strandzha SCI has a total area of 153541.2 ha of which 24.5 % represents marine area. It is located in the South-eastern part of Bulgaria having the Turkish border and Rezovo River in the south. The marine boundaries (42°09' N - 41°54' S and 28°15' E - 27°33' W) stretch between the Bulgarian coastline to the West (from Rezovo river to south of Tsarevo City), the Bulgarian-Turkish marine boundary to the South and the 75 m isobath to the East.

Figure 1. Marine NATURA 2000 sites in Bulgarian waters

The area covers part of Burgas region (part of the territory of Malko Tarnovo and Tsarevo municipalities). The coastal settlemens include 1 town-Ahtopol and 3 villages - Varvara, Sinemoretz and Rezovo. Within Strandzha's territory the town of Malko Tarnovo and a number of villages are situated, nevertheless urbanization is low on the overall. The shortest connection of the protected site with regional administrative centre Burgas town is 41km – road Burgas-Malko Tarnovo. Another main road in coastal area is Burgas-Rezovo.

The special location of Strandzha Mountain on the route between Europe and Asia makes it unique in cultural, historical and biodiversity aspects. Due to that a number of protected areas have been designated at the national level under the Bulgarian Protected Areas Act, including Nature Park Strandzha, 5 strict nature reserves, numerous protected sites and natural monuments. One internationally protected site is designated as well – the Ramsar site Uzunbodzhak.

SPA Strandzha BG0002040 is designated under the Birds Directive, the boundaries partially overlapping the Habitats directive SCI BG0001007 Strandzha (Fig.2).

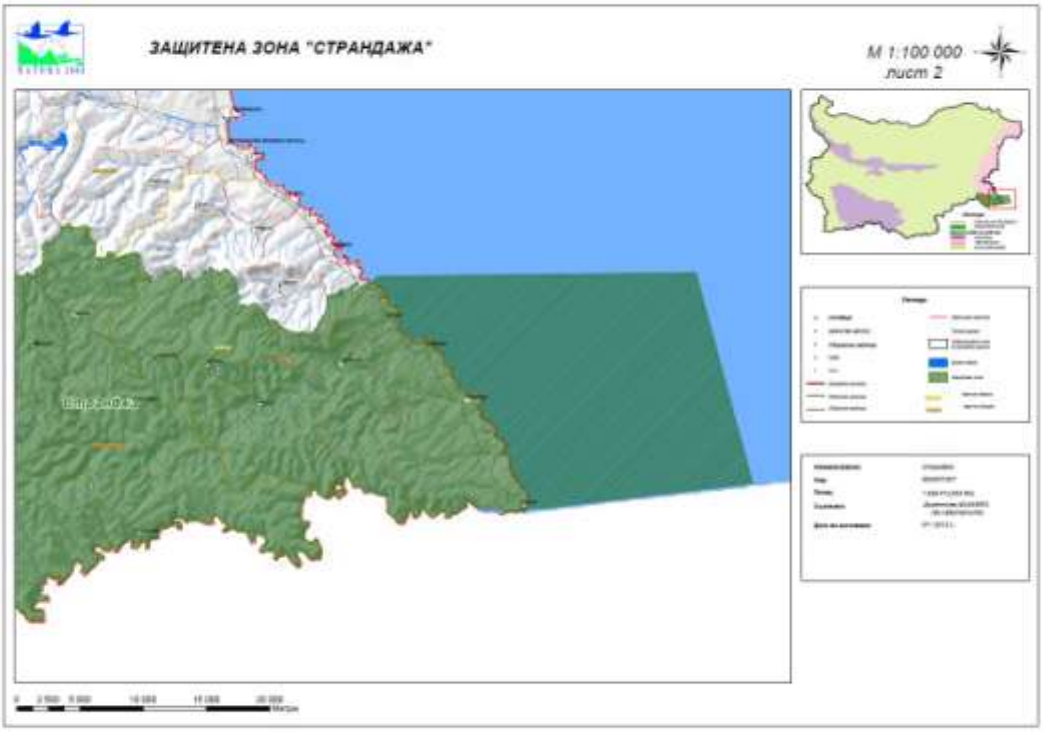

Figure 2. Map of Strandzha protected area. Source: Project "Extension of the marine Natura 2000 in the Bulgarian Black Sea", Contract № 7976/04.04.2011 between EMEPA and IO-BAS.

IGNEADA AREA

Iğneada is located in the north-western part of Turkey, being a small town within the district of Demirköy in Turkey's Kirklareli Province. It lies on the Black Sea coast and it is approximately 5 km south of the Rezovo River, which forms the border with Bulgaria. Southern and western parts of İğneada lies at the lower slopes of the Istranca (Yıldız) Mountains with its highest point at 1035 m. İğneada is only 74 km far from the city Kırklareli and the district Lüleburgaz (Fig. 3).

İğneada and its vicinity have the Black Sea type climate characters. Although temperature and precipitation features reveal changes depending on height, summer is rainy and winter is cool and rainy. Annual mean precipitation in the area is 800-1000 mm and 70% of it falls during autumn and winter. This amount drops to 10% during summer.

Marine boundaries

The area which is recommended as a marine protected area is the 50 m contour line of İğnaeada coasts. The borders (Fig. 4) and coordinates of the area are given (Table 1).

Figure 3. Map of İğneada area

Table 1. Coordinates of the proposed MPA Igneada

Points	Coordinates	Points	Coordinates
1	41°56'8253 N	2	41°56'8494 N
	28°04'8633 E		28°05'7972 E
3	41°55'2967 N	4	41°50'4707 N
	28°06'8409 E		28°06'8409 E
5	41°48'6696 N	6	41°46'8267 N
	28°06'6760 E		28°04'0943 E

7	41°45’6796 N	8	41°43’5072 N
	28°03’5450 E		28°05’7422 E

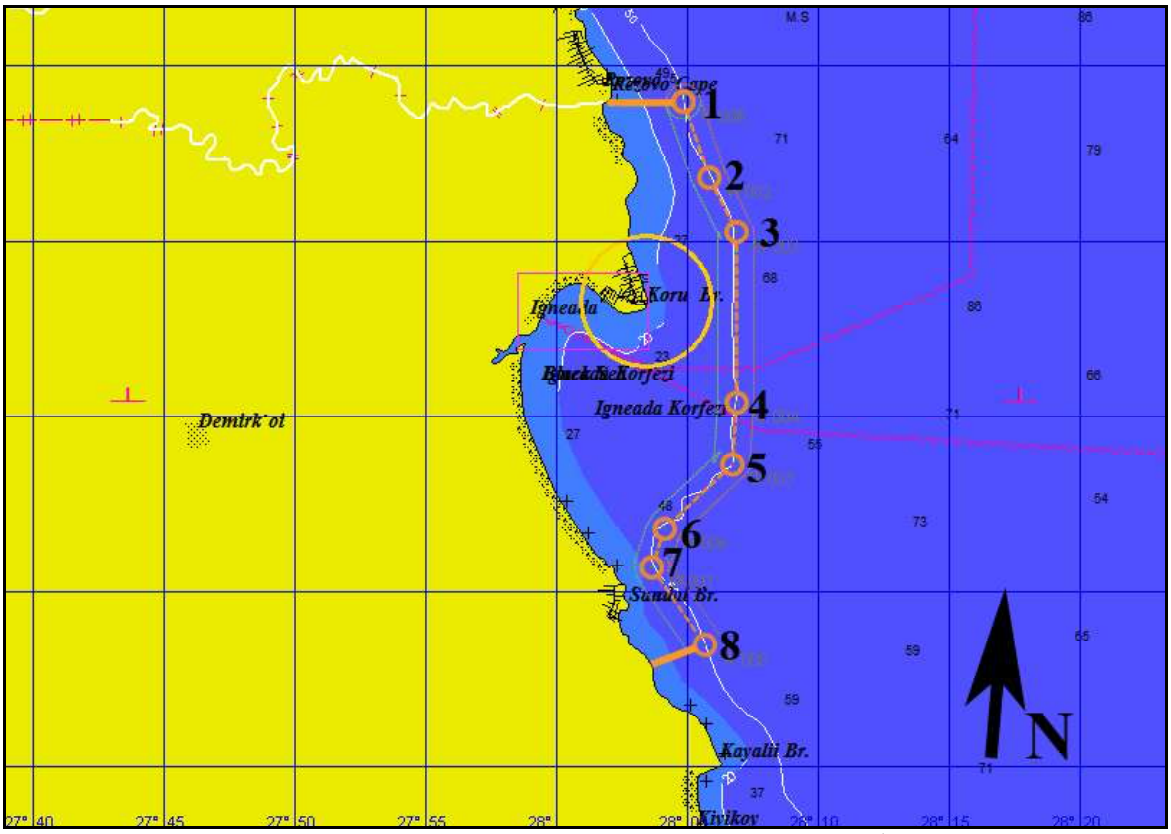

Figure 4. Boundaries of proposed marine protected area in İgneada region

1.2. Conservation values of the Strandzha and Igneada areas

STRANDZHA AREA

Located in the South East of Bulgaria the SCI Strandzha encompasses the Strandzha Mountains ridges and foot reaching to the Black Sea coast and the adjacent marine area to the 75 m depth. The area is unique in Europe for its endemic and diverse flora and fauna. The special nature is a result of Strandzha‘s geolological past, climate and geographical location. The plant communities in Strandzha developed before Europe was separated from Asia by the formation of the Bosphorus strait that now connects the Black Sea and the Mediterranean Sea. Land-ice never reached Strandzha during the ice-ages of the Pleistocene and the Holocene. This lack of glaciations has created a unique window to the past. Plants that were once widespread on the European continent during the Tertiary period are now only preserved in Strandzha. It is a living museum.

Character and use of adjacent areas

Large part of Strandzha Mountain was designated as Nature Park in 1995 with the objective to conserve in the long-term the unique nature within the watersheds of Veleka and Resovska rivers, as well as to ensure the sustainable socio-ecological development in the region (Strandzha Nature Park Management Plan - http://www.biodiversity.bg/files/File/STRANDJA_ManagPlan.pdf).

The area has been designated as one of the five top priority sites for protection in Central and Eastern Europe, and the whole Nature Park has been included in the Natura 2000 ecological network.

On the territory of the two protected areas under the Habitats Directive (SCI) (Strandzha BG00001007) and the Birds Directive (SPA) (Strandzha BG0002040) and Nature Park there have been designated 5 strict nature reserves (Vitanovo, Sredoka, Uzunbodzhak, Silikosia, Tisovitsa), 19 protected sites (ncluding the complex of the Rezovo River mouth, Veleka River mouth and Silistar River mouth protected sites) and 17 natural monuments. The nationally protected areas aim mainly at conserving the unique forest ecosystem of Standzha Mountain characterised by endemic flora and high faunal diversity of fish, reptiles, amphibian, birds, mammals and plants. The area is important for birds: the second largest in Europe birds’ migration route crosses Strandzha, while the bays and estuaries along the coast are important wintering grounds for a number of water birds. The mouth of Veleka River is designated to conserve the coastal landscape, cliffs, fjords and specific xerothermic flora. In the frames of the project CORINE Biotopes, Strandzha region (terrestrial and marine part) is defined as a priority in the ecological network of the country and one of the most important territories for conservation in Europe.

Naturalness, rarity, biodiversity, aesthetic values, and the degree of habitat representativeness

Territories with high conservation values

These are territories with high floristic and/or habitats biodiversity and the priority habitats and species. Dunes, reefs, sandbanks which are slightly covered by seawater all the time, inlets, estuaries of international importance as habitats for priority species of plants and animals are present within the protected area. The marine coastal area of the park hosts 20 species (3 species of mammals, 13 bird species, 3 species of reptiles, 1 of amphibian). In coastal area could be met 200 vertebrate animals. In marine coastal habitats breed 10 priority vertebrate animal species, 120 invertebrate species of conservation importance and 7 priority plant species. For plants of special importance the dune habitats and cliffs are considered of high conservation value. Cliffs are the habitat of some bat species, otter and seal. *Cystoseira* meadows and oyster reefs are also of high conservation value.

Biodiversity in the park is represented by 120 habitat units from which 13 are found in Strandzha.

Terrestrial habitats of conservation importance

The complete list and assessment of the habitats of European conservation importance present at the site is provided on the web based information system of the Bulgarian Ministry of Environment and Water available at: http://natura2000.moew.government.bg/Home/ProtectedSite/?code=BG0001007

The main terrestrial part (80 %) of SCI Strandzha is occupied by well conserved beech and oak forests. This site is identified as the most important for the conservation of the natural habitat type of priority importance:

91S0 * - Western Pontic beech forests

Other representative forest habitats include:

91M0 - Pannonian - Balkanic turkey oak - sessile oak forests

91F0 - Riparian mixed forests of *Quercus robur*, *Ulmus laevis* and *Ulmus minor, Fraxinus excelsior* or *Fraxinus angustifolia*, along the great rivers (*Ulmenion minoris*)

91E0 * - Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (Alno- Padion, Alnion incanae, Salicion albae)

The representative freshwater habitats comprise:

3150 - Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition* - type vegetation

3260 - Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation

The largest river in the site is Veleka (147 km legth).

Coastal habitats of conservation importance

Typical of the site are dune habitats occurring mainly nearby river estuaries. The site is important for the geographic coherence of the white and grey dunes including the habitats of European importance:

2110 - Embryonic shifting dunes

2120 - Shifting dunes along the shoreline with *Ammophila arenaria* ("white dunes")

2130 * - Fixed coastal dunes with herbaceous vegetation ("grey dunes")

The majority of the coastline is occupied by well conserved cliff habitat of the type:

1240 Vegetated sea cliffs of the Mediterranean coasts with endemic *Limonium* spp.

Among the most important habitats representative of Stranszha site are the estuaries (habitat type **1130**) of Veleka (Fig. 5), Butamiata, Silistar and Rezovska rivers. The estuaries support high biodiversity and provide shelter for endangered species such as *Emys orbicularis* (Fig. 6) and *Mauremys caspica*.

Figure 5. Veleka river estuary and sandbar. Source: project "The development of an indicative ecologically coherent network of sub-tidal Marine Protected Areas (MPAs) in Bulgaria and Romania"

Figure 6. *Emys orbicularis* in Veleka estuary. Source: project "The development of an indicative ecologically coherent network of sub-tidal Marine Protected Areas (MPAs) in Bulgaria and Romania"

Marine habitats of conservation importance

The marine habitats are highly varied. The most representative among them encompass:

1110 Sandbanks which are slightly covered by sea water all the time.

This habitat is represented by clean coarse to fine sand and shell rubble inhabited by psamophilic clams *Donax trunculus, Chamelea gallina, Gastrana* fragilis*, Lentidium mediterraneum, Lucinella divaricata*. The habitat area is estimated at 2835.81 ha, comprising 7.6 % of the national habitat coverage.

1140 Mudflats and sandflats not covered by seawater at low tide.

The coarse sands in the mediolittoral zone, well flushed by the wave action, are inhabited by dense populations of the small wedgeclam *Donacilla cornea*. The habitat area is estimated at 7.56 ha.

1170 Reefs. The rocky seabed is luxuriously covered by the brown alga *Cystoseira barbata* (Fig. 7) and the blue mussels *Mytilus galloprovincialis* and *Mytilaster lineatus*. The unique Black Sea habitat of *Ostrea edulis* biogenic reefs occurs as well. The area of the rocky bottom within Stranzdha SCI is estimated at 1384.46 ha. Another habitat interpreted as type 1170 is the mussel beds of *Mytilus galloprovincilis* on sediments with area estimated at 33624.59 ha. Overall the habitat type 1170 in SCI Strandzha comprises 8.3 % of the national habitat coverage.

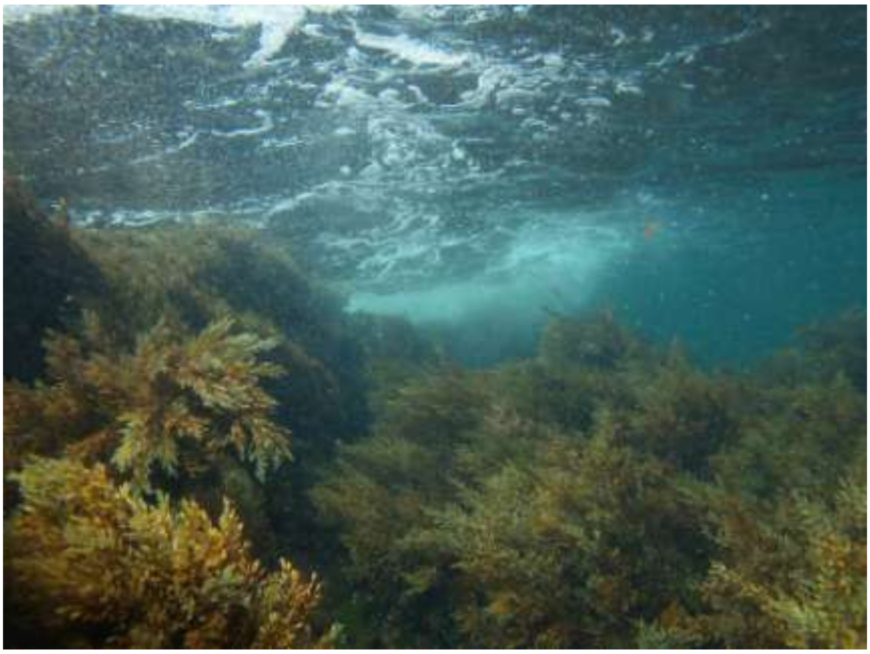

Figure 7. *Cystoseira barbata* over rocky bottom along Strandzha coast. Source: project "The development of an indicative ecologically coherent network of sub-tidal Marine Protected Areas (MPAs) in Bulgaria and Romania".

On the biogenic reefs and marvelous rocks many sponges, sciaphylic algae *Zanardinia typus, Apoglossum ruscifolium, Phillophora crispa*, crusts (*Peisonellia rubra, Hildenbrandia rubra, Phimatholiton lernormandii*) crabs (*Eriphia verrucosa*), blennies, gobbies, scorpion fishes (*Scorpaena porcus*), wrasses and mullets could be seen. The *Cystoseira* meadows are the habitat for fish species such as *Syngnathus typhle, Symphodus ocellatus*, *Salaria pavo, Atherina boyeri, Hypocampus gutulatus, Pomatomus saltator, Blenius tentacularis*, *Mulus barbatus*, *Aidablenius sphinxs,* also decapods *Polybius navigator*, *Macropodia sp, Eriphia verrucosa*, *Palaemon elegans.* High diversity of gastropods has been observed - *Tricolia pullus, Rissoa splendida, and Bittium reticulatum*. *Actinia equina* was also present on hard substrate. The blue sponge *Dysidea fragilis* is frequently seen here at almost all depths. The fish *Belone belone* was also registered in the area. *Pomatomus saltator* and *Belone belone* are listed in the Bucharest Convention Protocol, but are not included in Standard data form of Strandzha protected area. *Scomber scombrus* also is not listed, but it is critically endangered species. Turbot *Pseta maxima* is recognized as being an endangered species in Bulgarian Red Data Book and mentioned in the "Aims of conservation of species and habitats" of Strandzha protected area.

In the frame of the project "Extension of ecological network of NATURA 2000 in Bulgarian Black Sea sector to overcome deficiency of marine habitats 1100 and 1170 and species 4125 - *Alosa* *immaculata* 1349 - *Tursiops truncatus* and 1350 - *Phocoena phocoena*", there was estimated besides *Cystoseira* species and Phyllophora's biomass also the distribution of the latter along the Bulgarian Black Sea coast. Based on this study, *Cystoseira* spp. and *Phyllophora* sp. were for the first time mentioned in the Natura 2000 Standard Data Form of new Strandzha protected area. *Cystoseira* spp. has the highest biomass in the south part of Bulgarian Black Sea coast, namely Sinemoretz, Varvara, Maslen nos (Fig. 8).

Seagrasses and macroalgae compose the biological quality element "benthic vegetation" used by both the WFD and the MSFD. These species are included in Red Data Book of Black Sea as vulnerable and their habitats are defined as endangered in Bulgarian Red Data Book (http://e-ecodb.bas.bg/rdb/bg/). The sea's shallow areas, including coastal lagoons, shallow sandbanks, and both coastal and offshore reefs, serve as important spawning and nursery areas for fish as well as important feeding and wintering areas for large number of sea birds. Meadows and kelp forests are extremely valuable ecosystems because they provide many ecological services to coastal zone. They are highly productive, influence the structural complexity of habitats, enhance biodiversity, play important roles in global carbon and nutrient cycling, stabilize water flow and promote sedimentation, thereby reducing particle loads in the water as well as coastal erosion. In fact, has been estimated that *Cystoseira* meadows such as kelp forests and sea grasses meadows deliver the highest value, in terms of ecosystem services, of all natural ecosystems. Policies aiming at improving coastal waters' and ecosystem's quality are a priority in European countries as well as in other countries and regions on the Globe (e.g. USA: Clean Water Act (CWA, 2002/P.L. 107–303/USA), National Estuary Program (www.epa.gov/nep).

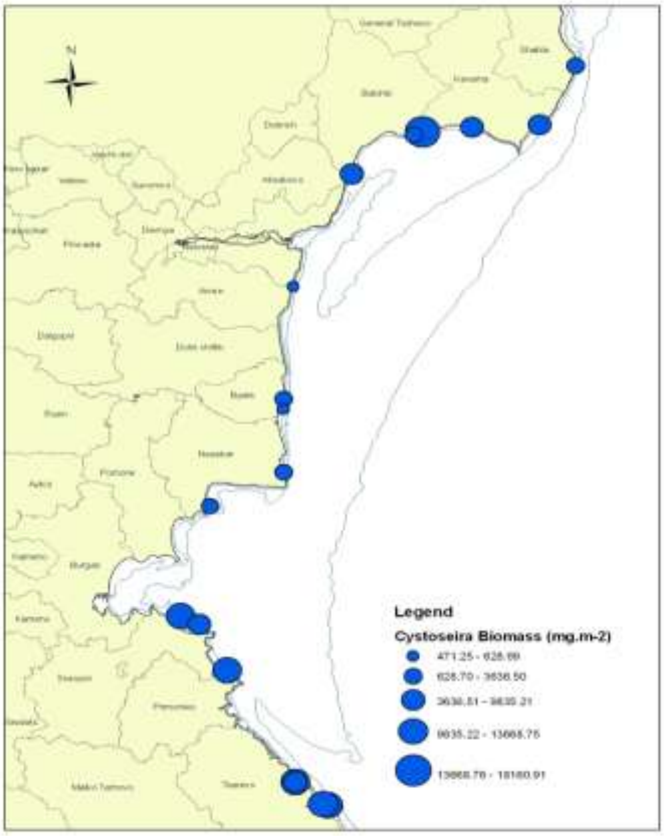

Figure 8. Distribution of *Cystoseira* spp. total biomass (g.m^{-2}) along Bulgarian Black Sea coast

Species diversity and conservation importance

Nature Park Strandzha is the richest Bulgarian protected area in terms if the invertebrate fauna with 404 species encountered in the area.

The fish diversity at the protected area ranks among the highest in Europe with 41 freshwater and 70 marine species (http://www.biodiversity.bg/files/File/STRANDJA_ManagPlan.pdf).

In Strandzha Nature Park are established half of the nesting birds in the country and 28% from the nesting birds in Europe. Through the protected area passes the second largest in Europe birds migration route "Via Pontica". The globally endangered birds *Aquila heliaca*, *Aythya niroca*, *Pelecanus crispus*, *Circus macrourus* have been observed to migrate over the Park. Strandzha coast is an important wintering ground for a number of water birds.

At the national level the highest biodiversity of marine macrophytes - 102 species was established in that region (Dimitrova, 1981).

The species listed in Annex II of the Habitats Directive found in Strandzha SCI comprise 13 invertevrates, 7 fish, 2 amphibians, 5 reptiles and 42 mammals. Among them there are 5 marine species:

1103 *Alosa fallax* (Twaite shad)

4125 Alosa immaculata (Pontic shad)

4127 *Alosa tanaica* (Azov shad)

1349 *Tursiops truncatus* (Bottlenose dolfin)

1351 *Phocoena phocoena* (Harbour porpoise)

Other marine species of national or Black Sea conservation importance listed for the site include:

Algae: *Cystoseira barbata, Cystoseira crinite, Phyllophora crispa*.

Benthic invertebrates: *Chamelea gallina, Donacilla cornea, Donax trunculus, Lentidium mediterraneum Ostrea edulis, Mytilus galloprovincialis, Eriphia verrucosa, Pachygrapsus marmoratus, Xantho poressa*.

Fishes: *Acipenser gueldenstaedtii, Acipenser stellatus, Aidablennius sphynx, Anguilla anguilla, Atherina boyeri, Coryphoblennius galerita, Dasyatis pastinaca, Hippocampus guttulatus, Huso huso, Liza ramada, Pegusa lascaris, Mesogobiusbatrachocephalus, Neogobius melanostomus, Pomatoschistus microps, Raja clavata, Salaria pavo, Sarda sarda, Syngnathus typhle, Trachinus draco, Uranoscopus scaber*.

With its number of fish species, the protected area occupies one of the first positions among the other protected areas in the country, all of them situated along the Black Sea coast (Management plan for Strandzha Nature Park http://www.biodiversity.bg/files/File/STRANDJA_ManagPlan.pdf). Fish populations represent an important value for fisheries and also for genetic analyses and scientific investigations (Apostolou, et al., 2007; Tsekov et al., 2008; Dobrovolov et al., 2012; Kotlik et al. 2008; Atanasov et al., 2011; Panayotova, 2012).

Species from *Alosa* genus are considered endangered and sensitive to anthropogenic influence. Studies about distribution and population structure of *Alosa spp.* in Bulgarian Black Sea coast were performed in the frame of the project ”Extension of ecological network of NATURA 2000 in Bulgarian Black Sea sector to overcome deficiency of marine habitats 1100 and 1170 and species 4125 - *Alosa immaculata* 1349 - *Tursiops truncatus* and 1350 - *Phocoena phocoena*“.

The sea is also the home of 3 species of dolphins and of otter *Lutra lutra,* species listed in the Bern Convention http://conventions.coe.int/Treaty/en/Treaties/Html/104.htm. Models of distribution of cetaceans in the Bulgarian Black Sea are based on data obtained from accidental observations. Data for genetic structure were also collected. Recent data collected in the period 2006-2010 concerning the distribution of the three species of cetaceans were published by Raykov & Panayotova (2012). The investigations cover the area comprised between 20-100 m depth (shelf zone). The total number of dolphins observed was of 933 exemplars out of which *Tursiops truncatus* – 486, *Delphinus delphis* - 288 and *Phocoena phocoena* - 159 (Fig. 9).

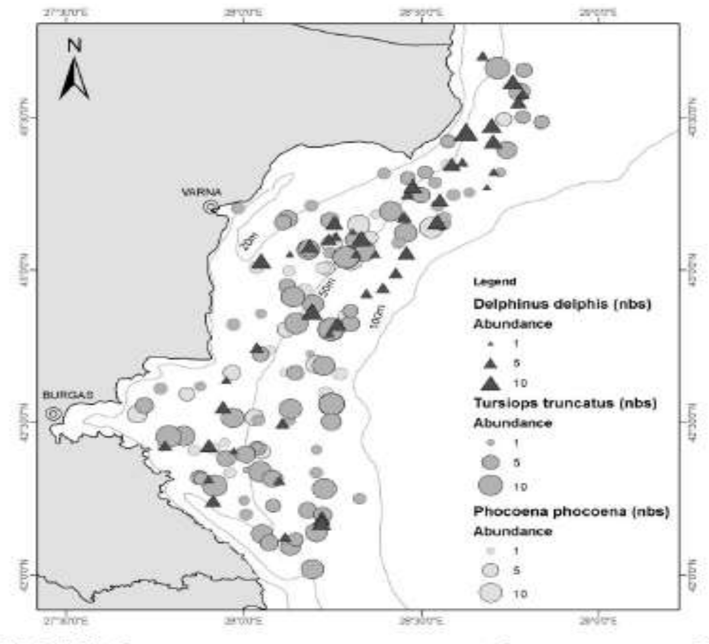

Figure 9. Observations on marine cetaceans in the period 2006-2010 (after Raykov, Panayotova, 2012)

In spite of insufficient studies, the three species are subject to special protection in the Bulgarian part of the Black Sea. The acts under which they are protected are: Biodiversity Act, Fisheries and Aquaculture Act, Protection of Environment Act and others. These species are subject of many international agreements and conventions: Agreement for Protection of Cetaceans in the Black Sea, Mediterranean and Atlantic Ocean (ACCOBAMS), Convention on the protection of Black Sea against polution (Bucharest Convention), UN Convention of Wetlands with International Importance (RAMSAR), Bern Convention, Bonn Convention on the conservation of migratory species of wild animals, European Habitats Directive, Marine Strategy Framework Directive and others. The three species are included in Bulgarian Red Data Book and in the Red list of endangered species of IUCN.

Strandzha coast might still be visited occasionally by the monk-seal (*Monachus monachus*), a world threatened species included in Annex II of the Bern Convention. This is probably the last secure and tranquil area of the Bulgarian coast where exists the possibility for restoration of the monk-seal population.

In addition to the diversity of habitats and species of conservation importance at European, regional and national level other features considered as conservation values deserving the designation of Strandzha as a protected site is the uniqueness, rarity and preserved naturalness of the biota and habitats, as well as the cultural values of the area.

Uniquesness and rarity

Strandzha possesses autochthonous flora and fauna formed of species descended from different biogeographical regions (Central Europe, Mediterranean, Anatolia, Caucasus, and Balkan Peninsula) with characteristic presence in the region. Wild flora and fauna is typical for the area and at the same time, unique for Europe, which requires special measures for preservation of this characteristic.

Strandzha offers the rare chance to observe centuries - old *Fagus orientalis* and *Quercus polycarpa* forests of moderate climate, typical for the Tertiary (before 2 million years) (Strandzha Nature Park website - http://www.strandja.bg/). Unique feature of Strandzha forests is the evergreen undergrowth of relic shrubs.

The indented by fiords cliff coast represents an open museum of paleovolcanic activity of great scenic value.

Ostrea edulis biogenic reefs must be mentioned among the unique habitats of the Black Sea (Todorova et al., 2009).

Natural rivers as Veleka and Rezovska are rare phenomenon in Europe.

With reference to the unique flora 7 relic species occur only in Strandzha at the European level: *Rhododendron ponticum*, *Daphne pontica*, *Vaccinium arctostaphylo*, *Quercus hartwissiana*, *Ilex colchica*, *Hypericum calycinum* and *Hypericum androsaemum.* Two local endemics *Veronica turrilliana* and *Anthemis jordanovii* are unique of Strandzha area. Another 6 Bulgarian endemics and 40 Balkan endemics occur in the protected site.

Rare marine algae are: *Padina pavonia*, *Cladostephus sp*., *Nemalion sp., Ceramium ciliatum, Laurencia sp*.

Endemic Black Sea fish fauna in SCI Strandzha is represented by 7 species: *Rutilus frisii, Syngnathus abaster,* gobbies *Ponticola cephalargoides*, *Neogobius gymnotrachelus, N. fluviatilis*, *N. melanostomus,* and *Mesogobius batrachocephalus. Proterorchinus marmoratus* and *Stizostedion marinus are endemic for the Black Sea and the Caspian Sea.*

Naturalness

Overall the terrestrial and coastal habitats are characterised by preserved naturalness and vast wild areas with relatively low fragmentation due to limited urbanization, roads and other infrastructure in the site. The marine habitats of underwater sandbanks and reefs have also preserved their natural character due to relative lack of human-induced disturbance or degradation.

Typicalness

Strandzha possesses autochthonous flora and fauna formed of species and groups of species, descended from different biogeographical regions (Central Europe, Mediterranean, Anatolia, Caucasus, and Balkan Peninsula) with characteristic presence in the region. Wild flora and fauna is typical for the area and at the same time, unique for Europe, which requires special measures for preservation of this characteristic.

Cultural values

In addition to the nature conservation values, due to being a bridge between Europe and Asia Strandzha Mountain area has a very rich culture and history, ancient folklore customs and traditions.

Diversity of monuments of culture from all the historical epochs, supplements the specific spirit of the territory. Here complement each other almost all culture layers from Eneolit and bronze epoch, Thracian megalith culture, antiquity, Middle Ages, Bulgarian renaissance up to new history, in concentration, rarely seen in Europe. Unique phenomenon is the sunken towns in the Bulgarian part of the Black Sea. Objects established in inlets of Varvara, Ahtopol, Sinemoretz, Silistar, north of Rezovska estuary are evidence for developed Thracian culture with active navigation, shipbuilding, economic and commercial connections far away from Greece civilization. Some of the villages with their original architecture complement the uniqueness of nature in the park.

Natural vulnerability of habitats and species

Species

Vulnerable are considered those sensitive biological and ecological species, which once that their habitats change or undergo anthropogenic pressure, the risk of their disappearance increases. Most important characteristics of these species are: adherence to substrate and/or trophic specialization, low reproductive success, late maturity, weak demographic structure of their population, predators' competition. All endangered and rare species are considered also as vulnerable ones.

Hunting and fishing. Destruction and collecting of wild plants and animals, destruction of habitats

Object of commercial fishing are some species of mussels, crabs, fishes. Object of illegal hunting are European otter (*Lutra lutra*), the monk seal *(Monachus monachus)* (information referring to poaching date back to 1980). The Mediterranean monk seal (*Monachus monachus*) is one of the most endangered mammals in the world.

Recreational fishing affected the fish stocks that have been decreased dramatically in the last years. The invertebrates that are subject to exploitation are: snails, crustaceans, mussels. The flora diversity is also threatened because of illegal collection, the coastal sand species being the most affected, among which endemic and rare species.

In conclusion, the threat of use and illegal destroy of wild flora and fauna could have tremendous effect on hundreds of species, especially if their populations are small or their usage is considerable.

Alignment of dunes and extracting of sand for building almost destroyed one of the rarest habitats in Europe – "Westpontian white dunes". Building of hydro - constructions and corrections of rivers course and coastal area changed their natural habitat character. Damage or changing of riverbanks destination for building and agricultural needs also disturbed these habitats. Coastal zone is exposed to intensive construction and urbanization as result of development of tourism (http://www.natura.bsnn.org/pdf/Protected_Natura_3.pdf). This led to worsening and even destruction of coastal habitats. There is a risk of local pollution from waste water sewerage input into the sea. Especially dangerous for migratory birds are plans for construction of wind generator parks. Construction of mussel farms also leads to deterioration of water quality and disturbance of natural habitats.

Climatic changes are another factor which makes species and habitats vulnerable. Mussels are vulnerable to high temperatures, also fish, marine benthic organisms and algae. In result of hypoxia and anoxia, caused by warming, marine organisms could die. This leads to additional pollution, which is negatively reflected on biota.

İĞNEADA AREA

The İğneada region is well- known for the national park (3155 ha) designated in 2007 and the lakes situated within its borders (Fig. 10). There are 7 lakes in total, the most important ones being Mert Lake, Hamam Lake, Erikli Lake and Saka Lake.

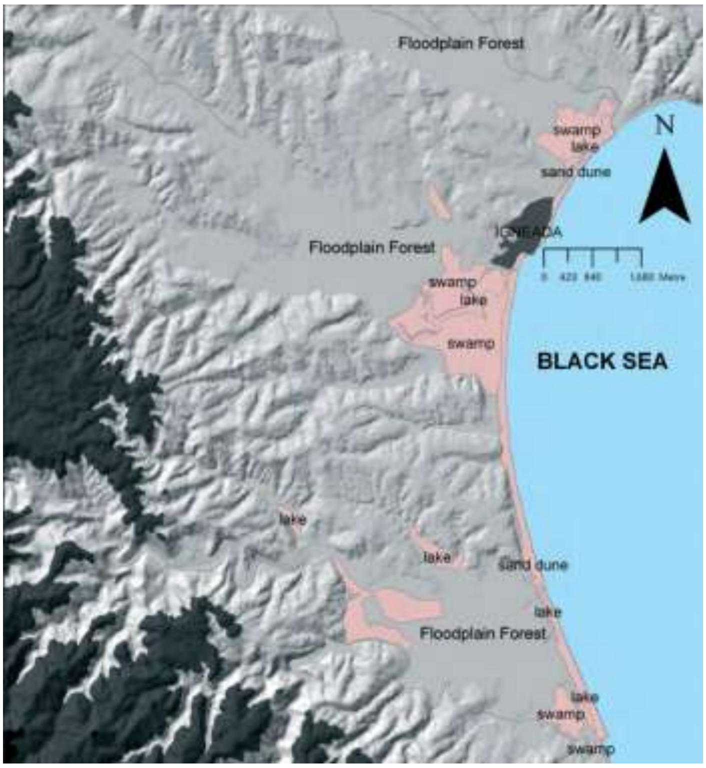

Figure 10. The general relief features in Iğneada area

Mert Lake is located about 12 Km far from the Bulgarian border. In the lagoons, the lakes, and the wetlands of İğneada there are 30 different species of fish. There are 8 species of fish "in need of protection" included in the **Bern Convention**. These are *Chalcalburnus chalcoides, Syngnathus abaster, Neogobius fluviatilis, Aspius aspius, Alburnoides bipunctatus, Rhodeus amarus*, *Cobitis taenia,* and *Chondrostoma nasus*.

Hamam Lake is located 20 Km south of İğneada, surrounded by forestland, and at 2 Km distance of the Black Sea and 20 meters elevation from the sea level. It has 19 hectares and 2.6 meters in its deepest point. The lake supplied by numerous streams from the surrounding forest transfers a part of the input into Bulanık Stream through a channel in the southeastern part. Perch and crayfish occupy an important place in the fauna of the lake.

Saka Lake Longoz is situated in the south of İğneada and was formed through the filling of Bulanık Stream. The lake has nearly 5 hectares of land with reed fields. This land is submerged in spring and autumn due to the increase in water level forming a longos rarely found in Turkey and even in Europe. In the longoz there are alders, witch elms, European ashes, oaks, hornbeams, common beeches, black poplars, willow trees, limes and walnut trees. It was declared as a protected area in 1988.

Pedina Lake: This Lake is situated 25 Km south of İğneada and 5 Km west of Hamam Lake, being like the Hamam Lake fully covered by forest. It has 10 ha area, and 2.10 meters in the deepest point. The lake which is supplied by numerous streams from inside the forest and also by Pedina Stream transfers the excess water into Bulanık Stream through a channel. İğneada region has a rich biological diversity and natural balance in the region has not been disturbed. Approxtimately 670 plants exist in the region. Mammals such as deer, roe-deer, wild boar, wolf, fox, jackal, wildcat, weasel, mustelid, bat, otter and 194 bird species such as pygmy, cormorant, white-tailed eagle, lesser kestrel, grey-headed woodpecker, lizard, green lizard, copper skink, snake, turtle and insects such as butterfly and fish such as anchovy, monkey goby, wolfish, spirlin, narroe-snouted pipefish, bitterling, painted comber live in İğneada Longoz forest region (Fig. 11).

Hamam and Pedina Lakes can also be defined as an accommodation point for birds, wild ducks and swans coming from Bulgaria, Russia and from the Danube River. The Longoz forests which are completely covered with water during winter and spring have a floristic composition of mixed forest trees of 8-15 meters tall. The mixed forests consist of trees named "dişbudak, kayın, saplı meşe, sapsız meşe, ova akaçaağacı, çınar yapraklı akçaağaç, üvez, ıhlamur, kızılağaç, mürver, kızılcık, karaağaç, gürgen". Since the alluvial soils have more intensive micro-organism activities, the forests and the other plants in this region start vegetation earlier than the other plants. The protection of the habitat of these forests has crucial importance. These forests are not only a rare natural value for Turkey but also for Europe (www. greencorridors.com).

Figure 11. İgneada Longoz Forests (http://www.milliparklar.gov.tr)

Igneada relatively lacks human-induced disturbance or degradation. But the constructions of summer houses and touristic facilities threaten the ecosytem. The area includes different ecosystems and a wide range of biodiversity, making it one of the Turkey's most important areas.

İğneada flooded forest is a unique assemblage created by various diverse ecosystems through thousands of years and it is a part of Istranca humid forest which is an independently natural richness. Lagoons, freshwater and salty lakes, coastal sand dunes, aluvial flooded forests, seasonal marshes, reedbeds and meadows generate a wild nature around İğneada which has an enviable and valuable beauty. It is an extremely diverse nature in terms of living species. Although not investigated completely, scientists have identified 180 bird, 33 mamalian, 6 amphibian, 94 tree and bush and 500 grassy plant species living in this small geographical area. It is obvious that these numbers cannot be encountered in another natural place with a similar coverage area.

Igneada hosts many threatened or endangered species and habitats.

The region is used traditionally for fisheries, forestry, tourism and recreation, so it is needed to maintain these activities in this area as a way to promote the environmentally friendly activities. There is also a significant potential in İğneada for eco-tourism. Honey, mushrooms, fruits, marine products, handcrafts, dairy products and organic fruits are the most common products of the town.

The area can be used in the educational process, first of all by children, but not only, because the entire community can learn about the marine ecosystems and how these can change under human pressure.

Naturalness, rarity, aesthetic values, and the degree of habitat representativeness

In Iğneada, forest and sea are side by side. The cave of Dupnisa which is close to İğneada is a unique cave for the people interested in cave tourism. Dupnisa cave, which is one of the best-known caves in Turkey, has continued its construction for almost four million years. Its total length is 2720 meters. It is quite interesting that it consists of three opposite caves. It has been a tourist site since 2003.

Territories with high floristic importance

İğneada and its vicinity are among the rare places in the country functioning as an ecosystem chain ecologically connected with each other. The forest contains different vegetation types composed of Longoz forests and patching, tall tree species.

Coastal sand dunes with longoz forests comprise the most delicate ecosystem of İğneada. Rich and interesting plant types are found on sand dunes. The vegetation of the coast, front side and stable sand dunes are distinctly at good state. Several types of oak tree are dominant here as the pedunculate oak, which is the primary species in relatively dry regions and the mountain alder and common ash tree, abundant at marshy parts of the ash-oak-alder type forest unique to the southeastern part of Europe. Additionally, climbing plant species are the most distinct feature of the forest. These forest assemblages are rare and important habitats that exist at southwestern coasts of the Black Sea and called as 'longoz'. The dominant plants in the upper layer are common alder, ash tree, common beech and maple tree. As it has a tropic forest character, it is also rich in climbing plants.

Territories with faunistic importance

İğneada and its vicinity has high priority in terms of its faunal diversity. The result of the studies revealed the below species at the area:

Fishes: Trout, Silver Fish, Grey Mullet

Birds: White tailed Eagle, Green Woodpecker, Owl, Grey Heron, Cuckoo, Kingfisher, Black Stork, Hoopoe

Mammals: Wild Cat, Wild Boar, Deer, Hare,Tree marten, Badger, Wolf, Fox, Otter, Yellow necked Wood Moose, Weasel, large eared bat, multicolored skunk

Reptiles: Thracian tortoise, Southern crested newt, European legless lizard, Horned viper, Ring snake.

Typicalness

İğneada possesses autochthonous flora and fauna formed of species and groups of species, descended from different biogeographical regions (Central Europe, Mediterranean, Anatolia, Caucasus, and Balkan Peninsula) with characteristic presence in the region. Wild flora and fauna is typical for the area and at the same time, unique for Europe, which requires special measures for preservation of this characteristic.

Naturalness

Criterion "naturalness" is leading in determining of representative territories in the area. Natural habitats are coastal cliffs, inlets with algae meadows, inhabited by fishes, zoobenthos. Sand banks contain also a rich diversity of zoobenthos. The area includes different ecosystems and a wide range of biodiversity, making it one of the Turkey's most important areas. İgneada has a relative lack of human-induced disturbance or degradation. The human population density in this region is also very low for Turkey (as well as for Bulgaria) hence the anthropogenic stress is very limited on this coastal ecosystem. But the constructions of summer houses and touristic facilities threatens the ecosytem.

Diversity of species and habitats

Species

The area includes different ecosystems and a wide range of biodiversity, making it one of the Turkey's most important areas. The most important marine fish species are turbot, red mullet, whiting, bonito, blue fish and anchovy. Significant decreases particularly in stocks of turbot and bonito are recorded at the coasts of Kırklareli where the prominent impacts of fishing pressure are observed. Statistics revealed that 30 thousand tones of bonito were caught at Western Black Sea coasts in 2005, however the amount dramatically declined to 500 tones in 2007. Kırklareli coasts, ignored in terms of research on marine fish species, should be investigated extensively, the biology of economical species should be studied in detail to obtain data for sustainable fisheries, and the status of endangered species has to be urgently identified. As a result of the studies on freshwater fish species, no threatening risks have been found since heavy industry and intensive human population are absent at the area.

Habitats

If we take into consideration high degree of their naturalness coastal and marine cliffs, clean sand habitats, estuaries, longos forests as well as other habitats are of national and European importance.

Natural vulnerability of habitats and species

Species

In terms of natural conservancy, the high biologic and ecologic diversity of İğneada region is very important. It is possible to see floodplain forests, high forestry lakes, swamps, sand dune, shrub communities and sea in a very narrow belt in İğneada. All of them have their special biological and ecological properties. Although the proportion of endemism is low in İğneada region, it has high species diversity and many species distrubute on only specific habitats. This probably indicates high habitat diversity in the region (Kavgacı et al., 2007).

Vulnerable are considered those sensitive biological and ecological species, which once that their habitats change or undergo anthropogenic pressure, the risk of their disappearance increases. Most important characteristics of species are: close adherence to habitat and specialization to nutrition base; low reproduction success; late maturity; restricting social structure of population; predators' competition. All endangered and rare species are vulnerable.

Climate change is another factor which makes species and habitats vulnerable. Mussels and other fish, marine benthic organisms and algae are vulnerable to high temperature. In case of hypoxia and anoxia phenomena caused by warming, marine organisms are very sensitive and could die. This will increase the pollution risks, which in turn will be reflected negatively on biota. Natural vulnerability is one of the criteria based on which the priority measures for conservation species and habitats will be taken.

Eco-tourism

Marine Tourism

Iğneada has a beach of 40-50 m width and 10 km lenght. In recent years, the tourist facilities, training camps and resorts founded by both public bodies and private enterprises are modern elements of forest and marine integrity. İğneada has entered into the process of being a Nature City with this structuring (Karaçam, 1995). İğneada beach has an interesting feature. Years ago MTA conducted a research at the area and found gold granules among sand grains. İğneada, among the most beautiful coasts of the Black Sea, has ideal water and sand to go swimming during June-July-August.

Cave Tourism

Dupnisa Cave located near İğneada is a golden natural wonder for adventurers and nature lovers. It is composed of two floors and three caves different in evolutional properties. Dupnisa cave is at 5 km south of Sarpdere Village, Demirköy district 50 km northeastern of Kırklareli. Total length of Dupnisa Cave System is 2720 m and it is a natural wonder flooded by visitors. Therefore in recent years, day trips are organized from nearby cities, mainly from İstanbul especially at weekends. Tent camping is developing owing to cave visits.

Botanic Tourism (Longoz Forests)

Longoz Forests of İğneada is 39th national park of Turkey and it is one of a few sites in Turkey and Europe. Longoz forests are seen at three places in the world and one of these is İğneada. Longoz forests, still harboring wild life, are protected by a project called GEF 2.

Bird Watching

İğneada is on ornithologically significant migration path of Paleoarctic. Three bird species existing at İğneada and its vicinity are listed among (probable) endangered species according to European Red List criteria. Approximately half (194) of Turkish bird diversity (454 species) are observed in İğneada Longoz Forests within a year. The area is the passage way during autumn migration for many water birds and hunting birds but particularly for storks. Nine bird species occurring in the area are accepted to be the species indicating whether the İğneada ecosystem is healthy or not. İğneada and its vicinity is a significant potential natural tourism opportunity for bird watching due to the aforementioned features. Nature tourism continues during all seasons since different bird species visit the area at different time intervals.

Cultural Values

İğneada took the name Thynias, meaning the place where Thyn people live, from the tribe of Trak. Migration wave has a great impact on the area. Cultural pressure of ancient Greek has never been absent particularly from the south. İğneada was invaded by Bulgaria during Balkan War before republican period and left to Bulgaria with the determination of Midye-Enez line. As a result of the assaults and agreements after the lost of Edirne, today's Thracia border was drawn and İğneada was kept in our domain. The name of the commander who conducted the conquest of İğneada was İne Bey. The area was named after him as "İneada" and it turned into İğneada in time (http://www.milliparklar.gov.tr/).

Shipwrecks in the region

It has been known that many shipwrecks lie in İğneada Bay from modern age and also dating back to prehistoric ages. Research on these shipwrecks revealed al lot of amphoras, tobacco pipes and ceramics. There are also shipwrecks from the period of First World War.

CHAPTER 2. GENERAL OCEANOGRAPHIC FEATURES DESCRIPTION OF THE STRANDZHA-IGNEADA AREA

2.1. Survey sites

The study area was the Western Black Sea, including the Bulgarian and Turkey waters. The primary scope of expeditions carried out in 2012 and 2013 in Strandzha and Igneada areas was to collect data for assessing the ecological quality status of habitats and species and identification of further conservation and protection needs in order to increase the management measurements effectiveness of both areas by designing the Transboundary Marine Protected Area Strandzha-Igneada. All information about survey is available in the Tehnical Report on Joint Survey in Rezovo - İgneada Region.

The objectives of this activity foreseen:

- to help at designing Igneada as protected area under Habitats and Birds Directive and to include it in NATURA 2000 network and connecting it with Strandzha NATURA 2000 protected area;
- to highlight the biological, ecological and socio-cultural features standing at the base of IUCN scientific criteria of designation of NATURA 2000 protected areas, which to be used in the process of Igneada designation as protected area;
- to scientifically argument the reasons for including both areas in an extended protection regime under joint countries management by identifying the species and habitats representative for both areas which are protected under European Directives (Habitats and Birds Directive) and Black Sea Conventions and Protocols;
- to determine the status of conservation of species and habitats of community importance from both areas

2.2. Geological caracterization of Strandzha - Igneada area

2.2.1. Geology: evolution, erosion, accumulation /deposition

STRANDZHA AREA

From geological point of view, the Strandzha -Igneada area is situated in the major tectonic unit of Sredna Gora, and more specifically in the Eastern Sredna Gora structural zone, i.e. the Bourgas basin

(Cheshitev & Kanchev, 1989) (Fig. 12). The Burgas synclinorium is an extremely fractured area (Fig. 13). Its northern and southern borders are represented by deep fractures – the Back Balkan Fault and the North Strandja Flexure. Its western margin is marked by disrupted structures, while the structure is open to the east.

The basement of Sredna Gora zone is represented by Precambrian metamorphic rocks, Paleozoic granite-dominated batholiths and Triassic - Jurassic sediments. On this heterogeneous basement, volcanic successions dominated by andesites accumulated in the Late Cretaceous.

South of Burgas, the Black Sea coastal area exposes dominantly Late Cretaceous volcanic rocks, interbeded with turbidites, the latter increasing in volume to the South, in the Rezovo-Igneada area. Late Cretaceous (Santonian-Coniacian) intrusives (gabbros and granodiorites) occur locally within the volcanic successions, between Burgas and Primorsko and NW of Rezovo. The volcanic successions are overthrust from the west by earlier, Turonian-Cenomanian turbidites and volcanics. The total thickness of the volcanic successions (separated in three distinct formations – Burgas, Michurin and Grudovo groups), estimated at over 3000 m, is increasing to the east. The volcanic complexes interbedded with sediments (mainly turbidites) are considered to have formed in an island-arc geotectonic setting; rocks were subjected to compression, intense folding and thrusting in the Maastrichtian times (Zagorchev, 2001).

Locally, the volcanic deposits are overlain by small patches of Palaeogene continental molasses (coal-bearing clastics) and small basins filled with Neogene terrigenous clastics and Quaternary (alluvial drift and talus drift) sediments.

The Burgas synclinorium is divided into two distinct structural zones: a northern zone, with a blocks and folds pattern. In the northern zone, the volcanic complexes are folded and disrupted. The structure of the southern zone is monoclinal and intensely fractured, as result of Alpine deformations affecting the largest part of the Late Cretaceous successions. Faults with a general NE-SW trend control the zones of volcanic activity and the linear pattern of volcanic structures. The Late-Alpine tectonic deformation produced a block-faulted structural pattern (Fig. 13).

Several aqueous horizons and complexes are hosted in the Bourgas synclinorium, due to its geological-structural and lithological - facial features. They include the Quaternary, Pliocene, Miocene and Paleogene aquifers and the Upper Cretaceous aqueous complex. The latter occupies the largest area as it is practically found in all parts of the synclinorium. The basin contains several major faults, which act as the main drainage system. The most important fault is connected to the hydrothermal fields Poljanovo, Aitos, Sadievo, and probably the Bourgas spas (Georgieva & Vlaskovski, 2000). The Medovo hydrothermal field is connected to a group of shorter fractures.

Geomorphology of the coastal area and natural hazards

The southern part of the Black sea coast (Srednogorie) is divided into three main geomorphological zones: Burgas Depression, Medni Rid and Strandja (Fig. 14).

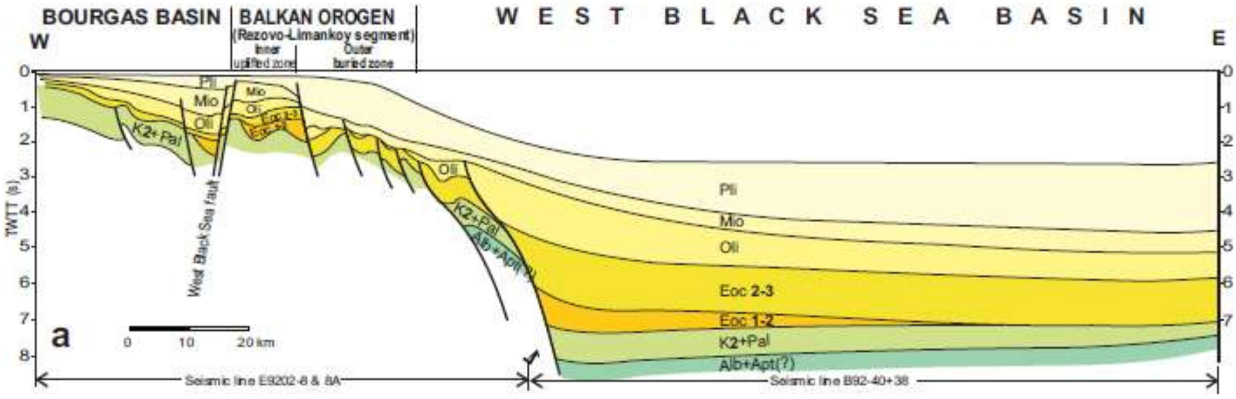

Figure 12. Geological cross-section in the Burgas basin (after Georgiev, 2012) showing the geological succession and structure of the sediments in the Black Sea offshore in Strandzha-Igneada area Abreviations: Alb+Apt – Albian-Aptian; K2+ Pal – Late Cretaceous-Paleogene; Eoc – Eocene; Ol – Oligocene; Mio – Miocene; Pli – Pliocene.

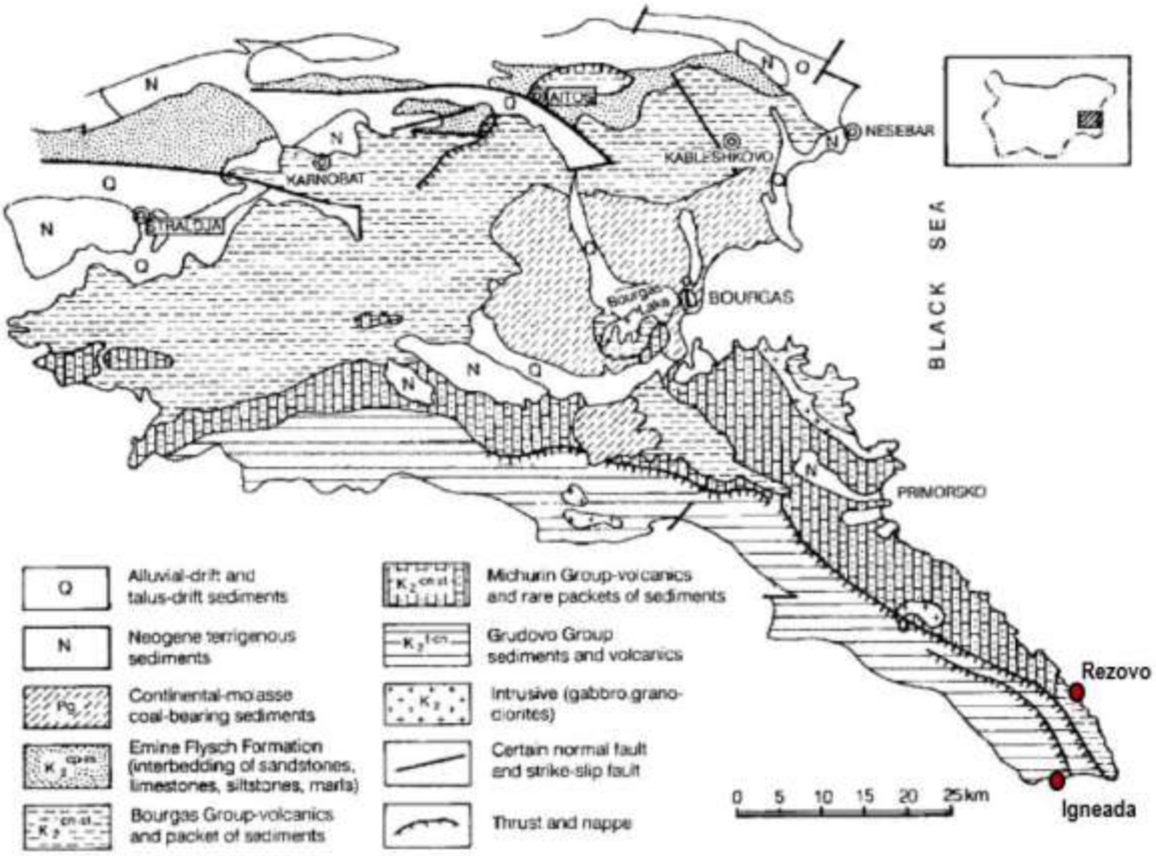

Figure 13. Geological map of the Burgas synclinorium (after Cheshitev and Kanchev, 1989).

Figure 14. Geomorphological regions of the Bulgarian Black sea coast (from MARINEGEOHAZARD project, unpublished report 2011): A - Dobrudja-Frangya Plateau: A1 – Durankulak-Shabla; A2 – Kaliakra, A3 – Balchik-Frangya; B - Lower Kamchia Depression and ForeBalkan: B1 – Varna; B2 – Avren; B3 – Kamchia-Fandakliiski; C – Balkanides: C1 – Byala-Obzor; C2 – Emine; C3 – Nesebar; D – Srednogorie: D1 – Burgas Depression; D2 – Medni Rid; D3 – Strandzha.

Development of coastal cliffs within the Bulgarian coast is the action of a complex of the natural factors. From the eight types of cliffs along the Bulgarian littoral, in the southern part of the Burgas basin there are three types of cliffs (unpublished report, 2011, project MARINEGEOHAZARD):

- cliffs composed by sedimentary and low metamorphosed rocks with weaker links, intrusive and effusive rocks prevalent on the Strandja coast and on the Medni Rid coast;
- cliffs containing a more solid rock; The sliding of the cliff takes place without significant changes of the rock packages and without any mixing of materials; it can be found near the villages Tyulenovo and Kamen Bryag, near the town of Tzarevo and south of Ahtopol town.
- cliffs characteristic mostly for the southern Bulgarian coast; the pocket beaches are fed with sediments eroded from the rocks composing the cliffs; such beaches are formed at the bottom of the small bays in Tsarevo area, Varvara area and Ahtopol area.

Sand-beach strips represent one of the most widespread accumulative forms along the Southern Black Sea coast (Popov & Mishev, 1974). Their formation is related to the energy of the blacklash of waves and of coastal currents. Trough their composition, the beach-strips are closely related with the lithological structure of the coastal area, as well as with their morphological structure, the wind and wave dynamic of the shelf water. The beach-strips of the Burgas Bay and Medni Rid coastal areas consist mainly of pyroxene-magnetite sands and heavy minerals, as well as of also younger Sarmatian, Pliocene and Pleistocene sediments. The sand-strip along the Strandja Mountain coast consists of carbonates, quartz and heavy minerals.

The abrasion-accumulative morphosystem is characterized by the following processes: accumulation and movement of sediments, underwater landslides and rockfalling, movement of suspension processes occurring under the influence of exogenous factors. The entire Bulgarian coastal zone is affected by old and recent landslides, which are in various states of slope stability and degrees of activity.

The geological-engineering zonation of Bulgaria placed the entire coastal strip and adjacent areas in the Black Sea Landslide Zone. As the Black Sea coast South of Burgas consists mainly of magmatic rocks, the conditions for development of large landslides are strongly limited. Most landslides in this area are shallow and develop in the cliff strip. Main destabilizing factors are represented by marine abrasion and fluctuations in groundwater levels. Single shallow landslides affect the shoreline up to the Bulgarian-Turkish border, so the Rezovo-Igneada area.

IGNEADA AREA

According to geological data, the base has a structure belonging to neogene period (Fig. 15). Lagoons are formed on this structure with sands brought by rivers and with the accumulation of finer material. İğneada has a remarkable richness due to the diversity of rocks and their sequence characteristics. Alluvions composed of young river deposits, and old alluvial deposits protected by beach sand dunes and terraces exist in the research area. The sandy beaches at İgneada coasts are remarkable. İğneada beaches are composed of coarse and fine sand, mollusc shells and fragments. Longoz forests and the area where other wetland ecosystems occur are under a slight or no influence of water erosion. On the other hand, the area close to the border of Bulgaria may be exposed to wave erosion.

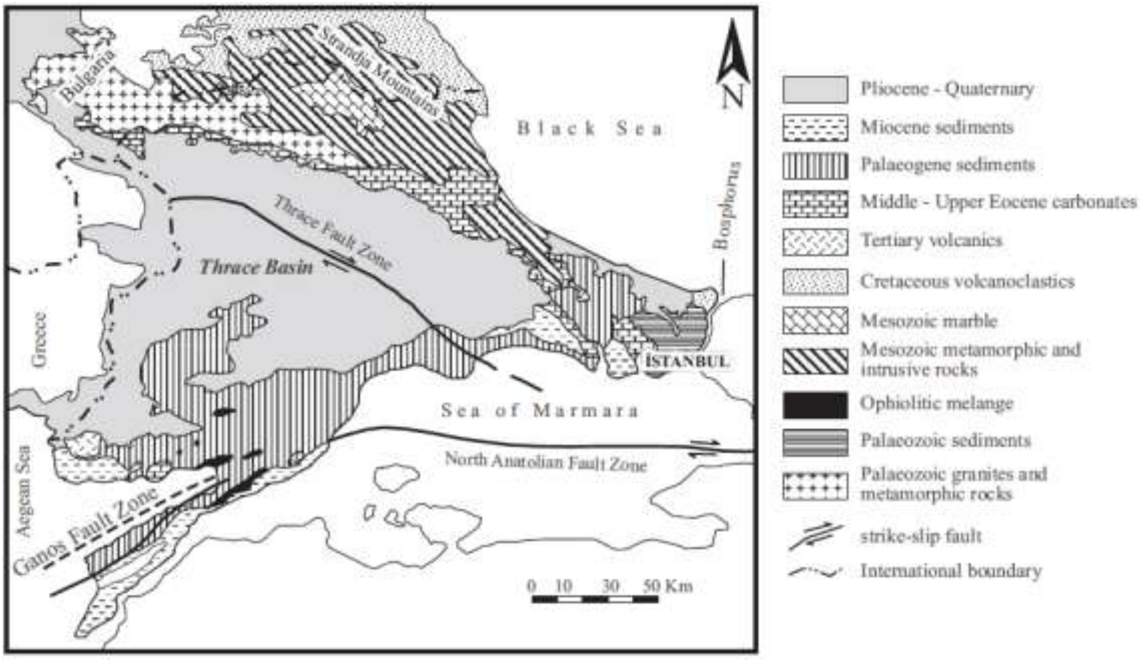

Figure 15. Geological map of Turkish Thrace (Ekmekçi, 2005)

2.2.2. Geomorphology: coastal and marine landscapes, sediment types

STRANDZHA AREA

The Bulgarian coastline is 378 km long with a general eastward aspect. The coastline is composed of rock cliffs along some 60 % of the entire shoreline, sand beaches (about 30%) and dunes or low-laying parts of firths and lagoons together with two large bays (Varna and Burgas). Firths (26) and lagoons (5) are typical of the Bulgarian coastal zone in particular along the south part of coast. Firths are former river valleys that have been drowned by rising sea levels in the Holocene. Today, firth configuration almost repeats the contours of old river valleys drowned during the Holocene (Dachev, 2000). Hard stabilization structures and harbour development cover some 10 % of the coast. The coefficient of coastline crenulations varies from 1.02 at the north to 3.79 on the south (Popov and Mishev, 1974; Peychev, 2004; Keremedchiev and Stancheva, 2006).

The coastline is characterized with various geological types. An erosion coast is prevalent at the northernmost part as the geology includes loess sediments and limestones. In the middle part, the geological properties are sandstones, limestones, marls and clays, aleurolites and argillaceous rocks. Large sand strips are formed here. Volcanic rocks (potassium-alkaline trachytes, latites, psammitic and psephitic tuffs, pyroclastic flysch) and volcanites, andesite-basalts, and basalts outcrop along the coast at the southernmost part between Cape Foros and the Rezovska River. These volcanic rocks are resistant against wave erosion and the average rate of cliff retreat is low (around 0.01 m/y; Peychev and Stancheva, 2009).

Beaches and dunes are widely distributed along the Bulgarian Black Sea coast. There are over 70 sand beaches with a total length of 121 km (Stancheva, 2009). Small beaches, generally less than 3 kilometres in length, have formed in the region extending from Burgas to the border with Turkey, composed of medium- and fine-sized magnetite-titanite sands, with a high content of heavy minerals (up to 75%) due to the volcanic rocks (Sotirov, 2003; Peychev, 2004).

Sand dune systems occur behind the larger beaches or in small inlets, where their development has been favoured by the combined factors of coastline orientation, wind direction and sufficient sediment supply. Extensive dune fields are developed at the northern and middle sections and a number of dune complexes are located along the southern coastline (Stancheva, 2013).

Fourteen Bulgarian rivers enter the Black Sea, but the total coastal discharge rate is less than 2 cubic kilometres per year. River flow is highly variable and dependent on the season: it is highest during the spring snow-melt and autumn rains, whereas in summer flow rates are much lower. In majority, the rivers from the southern part of Burgas Bay to Rezovo area flowing directly into the sea form a sand bar in front of their mouth (e.g., Veleka River: annual rate discharge (km^3/y): 0.24)).

Within the Bulgarian continental shelf parallel to the coast line, there are three main geomorphological areas: Coastal, central and peripheral inner (Fig. 16). Coastal zone is located near the coast line. It covers the underwater coastal slope, submerged relict terraces and coastal depression. The central zone of the shelf occupies the largest area of with depth of about 30 m to 90-95 m. It is divided into three sub-areas - accumulative bars, slightly indented plane and indented plane. Peripheral shelf zone is differentiated into at most seaward part of the shelf as a strip width from 3-4 to 10 km.

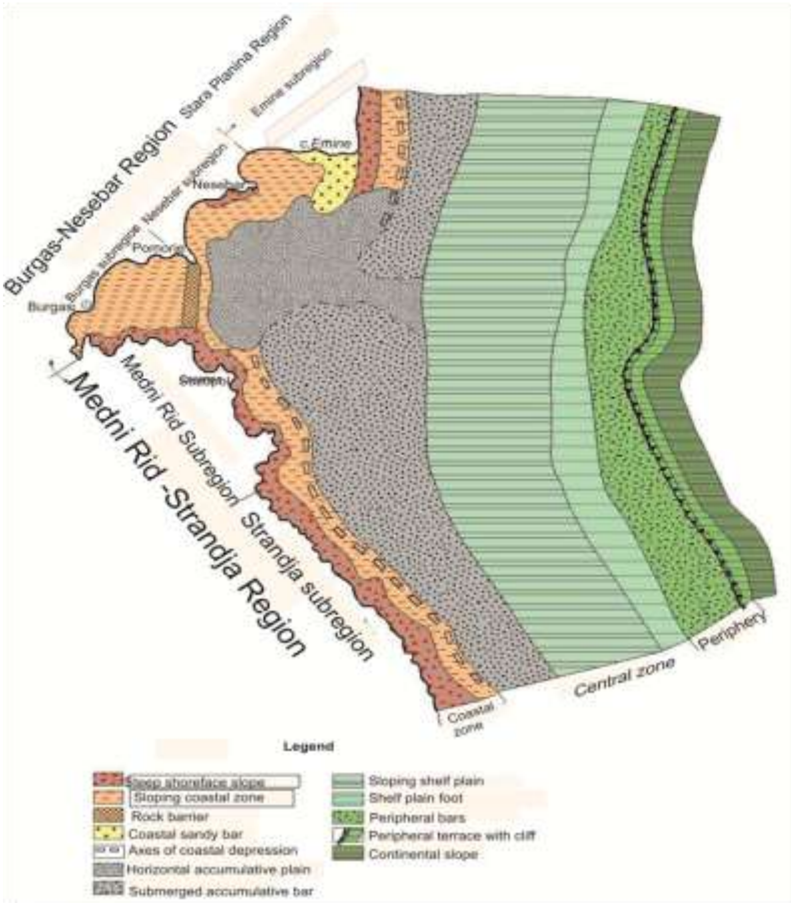

Figure 16. Geomorphological scheme of Southern Bulgarian Black Sea shelf (ESIA Report of Burgas – Alexandroupolis pipeline 2011) (After Ionin et al. 1979, Parlichev et al. 1972)

The coast in Strandja - Medni Rid is erosion. The coastline is straight and underwater coastal slope - steep, reaching considerable depth - 40 m in the north to 70 m in the south. Coastal depression is located along shoreline at distance about 5 km from the coast. It situated between steep underwater coastal slope to the west and accumulative bar in central part of the shelf to the east. The width of accumulative bar is about 6 km, the height - about 18 m and the water depth above its ridge vary between 34 in the northern part to 60 m in the southern. Eastward bar gradually passes into inclined flat surface that reaches the peripheral area. Seaward depths change from 50-60 to 90-105m (ESIA Report, 2011).

For the MSFD purposes Bulgarian shelf was subdivided into 3 parts from north to south (Northern, Central and Southern) and from the coast to the shells break into shallow sublittoral (below 20m depth) and deeper shelf sublittoral (from 20 m to shelf periphery, approximately 90-100m). Additionally, the coastal shallow water zone (midlittoral and shallow sublittoral) is divided into 5 basic regions from north to south. Zoning is done by several key indicators: morphographic (erosion and hydrographic segmentation of coastal landscape and lithostratigraphic characteristics of the bottom sediments, density of river-valley network, average unit runoff and average turbidity and morphometric (coastal exposure, coastal indentation, and slope of the underwater slope morpho-lithostratigraphic structure. The southernmost area is between Sozopol and Rezovo River.

Sozopol and Rezovo River Region is characterized by high erosion and hydrographic segmentation of relief as a result of tectonic block structure forming the beach Kp coefficient of indentation to 3.02 and slopes of the underwater slope to 0.025, as the horizontal segmentation is km/km2 to 22.30 and the vertical to 200 m/km^2. There is a highly developed river-valley network (km/km^2 to 1.55) with constant high annual sediment discharge to 11 l/s/m^2. Northeastern coastal exposure prevails, as the coast is open to the waves from NE and E quarter. Slopes of active hydrodynamic zone range from 0.03 to 0.06 and in less active to 0.02. Biogenic component is a major sediment forming factor, the content of $CaCO_3$ in sandy sediments ranges from 40% to 50% (Todorova et al. 2013).

The areas in Sozopol – Rezovo region in medio-sublittoral rocks and reefs and sands are included in Table 2 and depicted in Fig. 17 (Todorova et al. 2013).

Table 2. Areas in Sozopol – Rezovo region in mid-sublittoral rocks and reefs and sands

Zone	Substrate	Substrate Type	Area	Area % from the zone
Mediolittoral	Rocks		3.649	
Mediolittoral	Sediments		2.1456	
Shallow sublittoral	Rocks		20.79	20.46
Shallow sublittoral	Rocks	Calcareous rocks	0.2805	1.349
Shallow sublittoral	Rocks	Sandstone	7.1289	34.29
Shallow sublittoral	Rocks	Volcanic Rocks	13.3804	64.36
Shallow sublittoral	Sand		36.11	35.56
Shallow sublittoral	Sand	Coarse sand	6.9686	19.3*
Shallow sublittoral	Sand	Medium Sand	19.5897	54.24*
Shallow sublittoral	Sand	Fine sand	9.5563	26.46*
Shelf sublittoral	Rocks and Reefs		31.722	
Shelf sublittoral	Rocks and Reefs	Limestone	1.6792	5.29**
Shelf sublittoral	Rocks and Reefs	Sandstone	17.0553	53.76**
Shelf sublittoral	Rocks and Reefs	Volcanites	12.9875	40.94**
Shelf sublittoral	Sands		61.275	
Shelf sublittoral	Sands	Coarse sand	18.93394	30. 9***
Shelf sublittoral	Sands	Medium sand	22.9127	37.39***

Zone	Substrate	Substrate Type	Area	Area % from the zone
Shelf sublittoral	Sands	Fine sand	7.4569	12.17***
Shelf sublittoral	Sands	Sandy mud	11.9717	19.54***

* percent from sand and sandy mud area

** percent from rocky bottom area

*** percent from mixed sublittoral sediments area

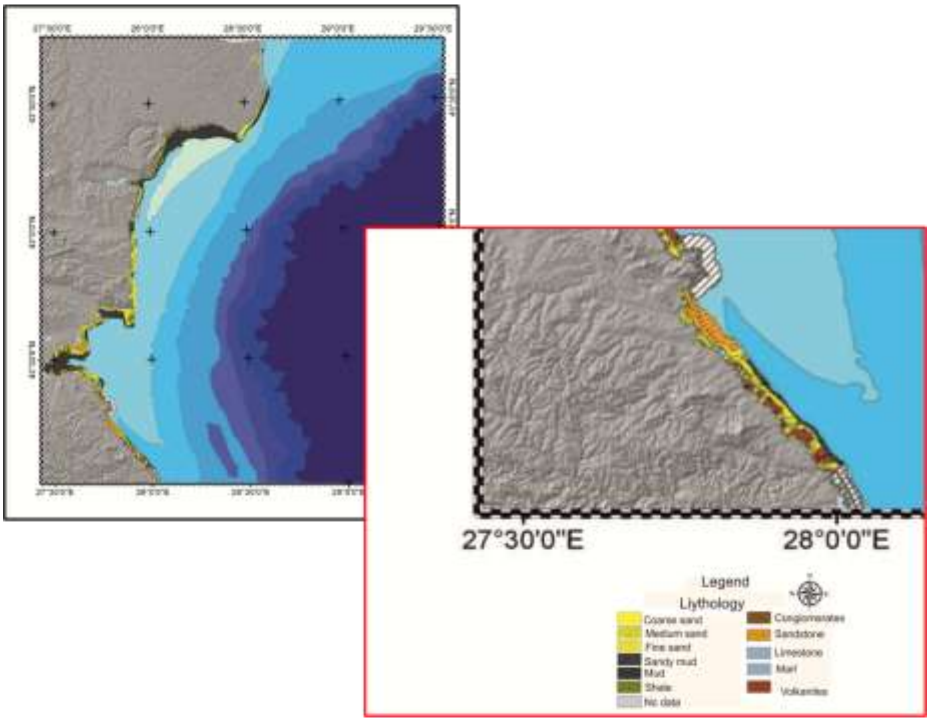

Figure 17. Substrates in shallow (0 - 20m) sublittoral in Region Sozopol – Rezovo River (after Todorova et al. 2013)

Most coarse sediments are distributed patchy in coastal area. They are attached to submarine bars or estuaries and submerged river valleys. Sandy sediments with median diameter 0.50-0.10 mm are present only in the coastal area. Seaward zone with increased values of Md, but not in excess of 0.025 mm coincides with ridge parts of accumulative bars of the central shelf under the influence of the southern current (Fig. 18).

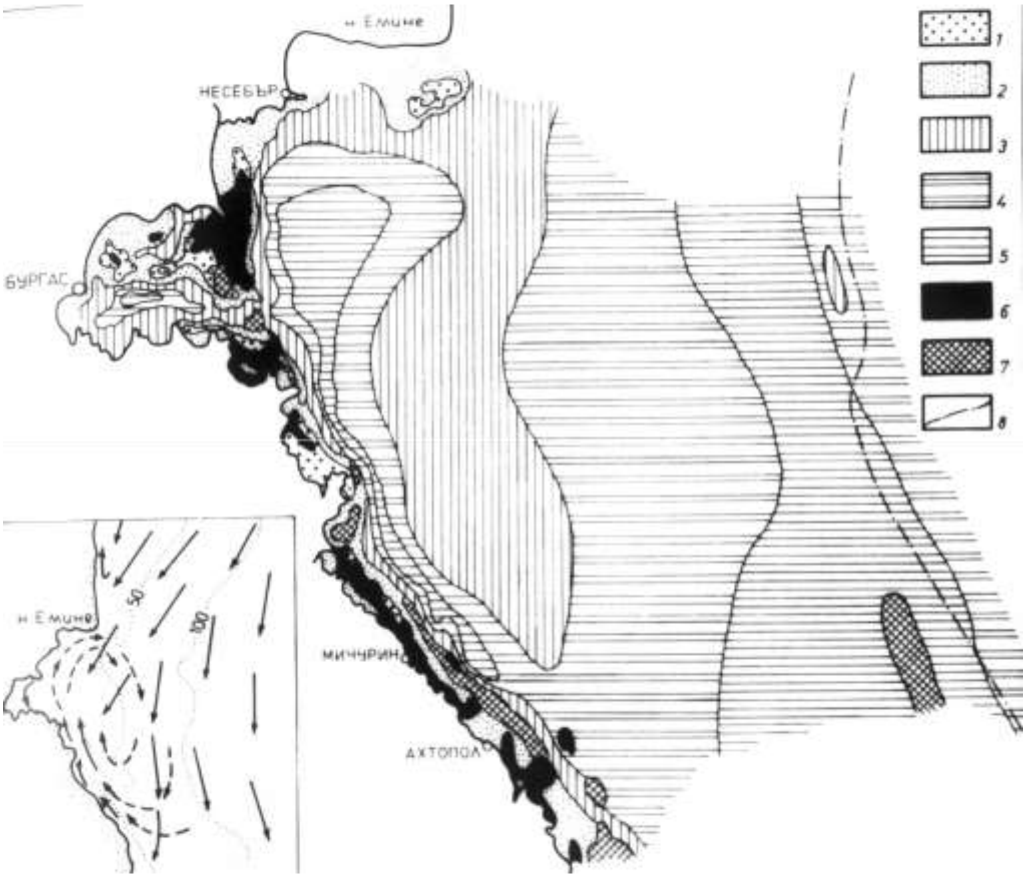

Figure 18. Distribution of the values of the median diameter (Md) in surface sediments Values of Md in mm: 1. - > 0.50; 2. – 0.50 – 0.10; 3. – 0.10 – 0.025; 4. – 0.025 – 0.010; 5. - <0.010; 6. - rocks; 7. – relict sediments; 8. – shelf edge (ESIA Report, 2011)

Distribution of sorting coefficient values in surface sediments largely follows the distribution of median diameters. Two areas with good sorting are formed. One coincides with coastal area where sandy sediments were developed. The second zone with good sorting matches with longitudinal ridge parts of accumulative bars of the central shelf region while in the adjoined accumulative plane sorting is worse (ESIA Report, 2011) (Fig. 19).

The dominating sediments in the deep littoral shelf area are:

Units A, B, C, D - greyish black, gray and greyish green soft plastic terrigenous mud with layers of shelly debris. Low to high gas-saturated

Units K and H - Olive green to greyish green medium plastic terrigenous mud with layers of shelly debris. Low to high gas-saturated (Kojuharov et al, 2008).

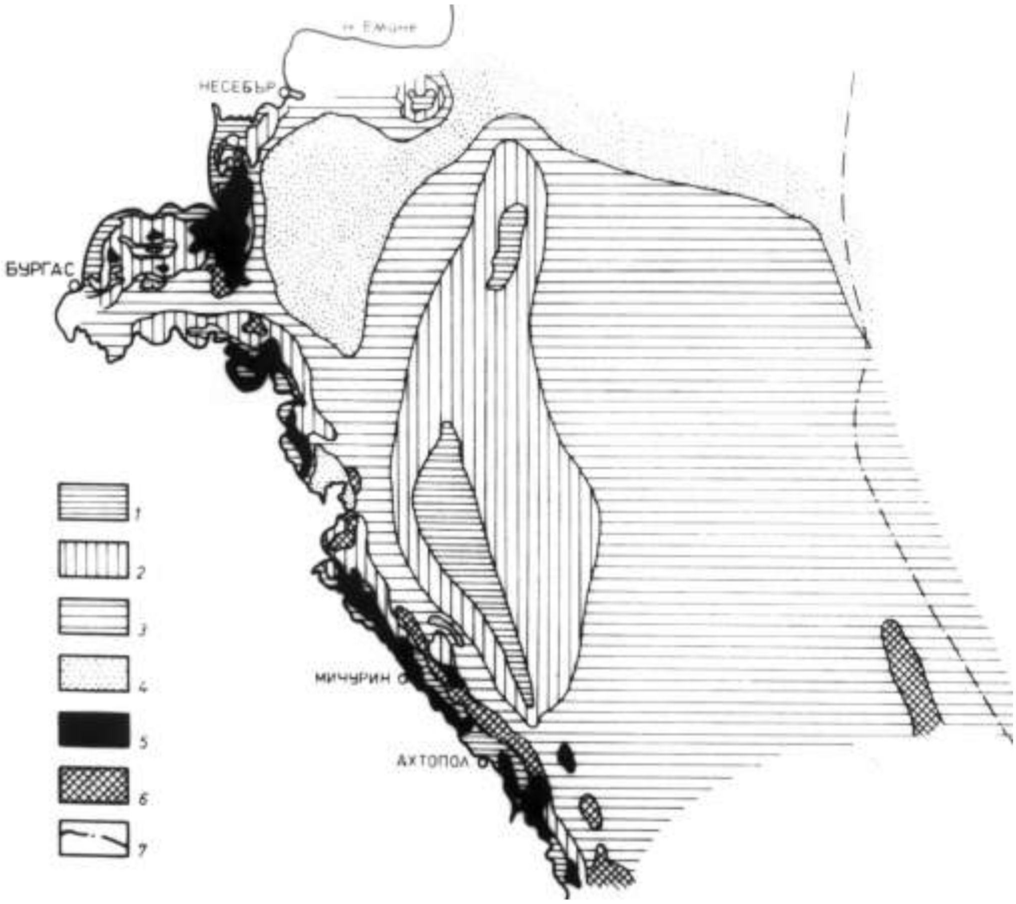

Figure 19. Distribution of sorting coefficient (So) in surface sediments
Values of So: 1. – 1.00 – 1.50; 2. – 1.50 – 2.50; 3. – 2.50 - 5.00; 4. - > 5.00; 5. - rocks; 6. - relics sediments;7. - shelf edge. (ESIA Report, 2011)

IGNEADA AREA

Coastal structures consist of small bays and high lands at the mouth of valleys between Kıyıköy and İğneada in form of capes. The coast is flat from place to place but cliffs are also seen. Strong waves created by northern winds have caused the formation of cliffs by constantly undermining the coast. Main beaches along the coast are located on the bays of Kıyıköy, Panayır İskelesi and Selves. It is possible that the places where Longoz forests exist may have been under the sea in ancient times. It is understood that they are formed by the depostion of material carried thorugh by rivers in the shallow part of the sea. Moreover, beach sand dunes disconnected the rivers and the sea resulting in the formation of lagoons behind the sand dunes. The general bathimetry of the area is presented in the Fig. 20.

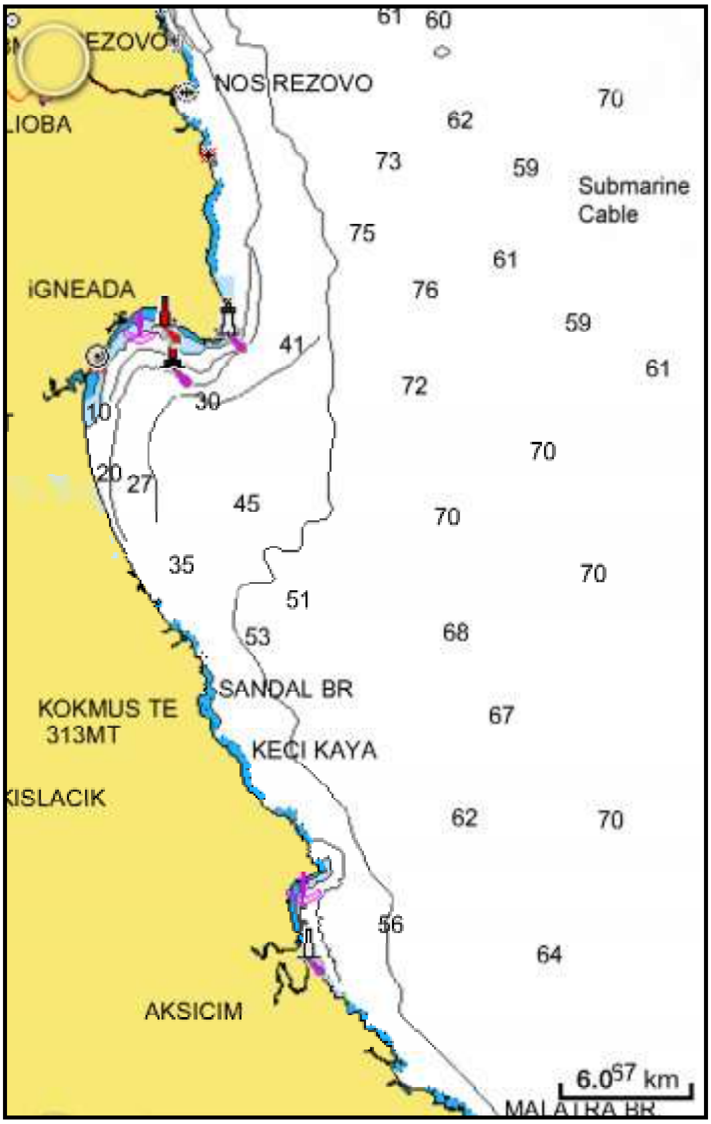

Figure 20. Bathymetric map of the İğneada region

2.3. General physico-chemical characterization

STRANDZHA AREA

Physical - chemical characterization of water body

The Bulgarian coast is predominantly subject to northerly, north-easterly and north-westerly winds throughout the year. Occasional westerly and south-westerly also occur during the cold season (October to March). The wind strengths are lower during the warm season (April to September), when easterlies and more rarely south-easterlies also occur. Southerlies are rare throughout the year. The predominant northerlies and north-westerly of the cold season are generated by depressions over Central Europe.[54] In autumn, the presence of a marked European north-south temperature gradient is responsible for the north-easterlies. Summer daytime easterlies are commonly caused by onshore sea breezes with reciprocal weak westerly at night. The most stable wind flows are in the dominant northerly directions, with an average life of approximately 14-18 hours and speeds of 7- 12 meters per second.

The Rim Current separates the interior of the basin from the narrower coastal zone (out to 200 meter water depths). This zone is dominated by clockwise eddies, resulting in the shoreward drift of water along the Bulgarian coast, which is particularly marked in summer and autumn.

In the immediate vicinity of the coast, out to a depth of about 20 metres, the surface flow is dominated by southerly movement of low salinity water from rivers. In certain areas offshore winds can move surface waters away from the coast allowing the inflow of colder, deeper offshore water to replace it. This process is known as 'upwelling' and can bring fresh nutrients to the surface, thus enhancing the productivity of the coastal waters.

Surface water temperatures range from 18 to 24 ^{o}C in the summer, with the seasonal thermocline extending to depths of 15 to 25 metres. In autumn, the thermocline deepens to around 50 metres and the surface temperature drops to an average value of 11.5 °C. In winter, the surface temperature drops to as low as 6.5°C. The salinity ranges between 16.0 - 18.2 PPS while the oxygen concentrations range from 5 to 9 ml/L, with summer concentrations being 70 to 80% of the winter values. This decrease is due to biological utilisation and increased surface temperatures.

The physico-chemical characterization of water quality status was completed by information obtained in the frame of Bulgarian National monitoring programme.

The investigated area (MPA Strandzha) belongs to the Bulgarian water body WB **BG2BS000C012** located in south part of coastal waters along Bulgarian coast (Fig. 21). The study of Water Quality (WQ) of the body was carried out in 2012 in the frame of National monitoring programme on the base of data for nutrients, salinity, pH and oxygen from two stations (BG2BS00000MS012 - Veleka and BG2BS00000MS013 - Varvara). Further data details and chemical parameters distribution could be found in the Report on the State of Marine Environment in 2012 (IO Report, 2013) of the Institute of Oceanology (IO).

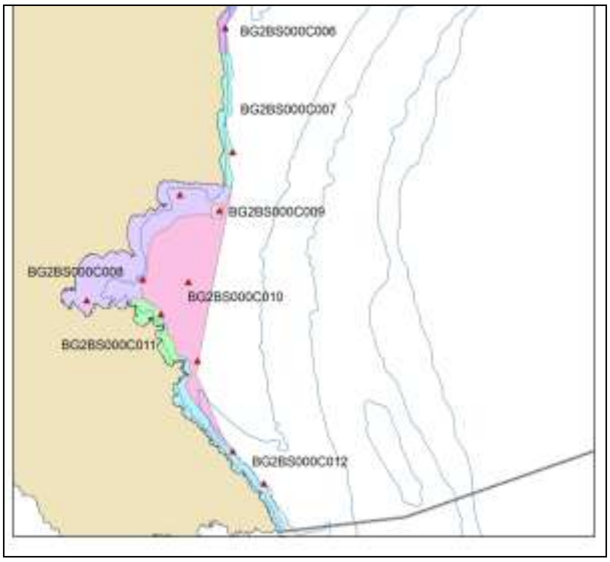

Figure 21. Map of water bodies and sampling stations in Bulgarian Black Sea coastal waters (WFD)

The CTD measurements were done at two stations in the south part **BG2BS000C012** along Bulgarian coast in the frame of the National monitoring programme. The onboard equipment Sea-Bird Electronics CTD SBE with sensors: pressure, temperature, conductivity and fluorescence were used. The devise equipped with a Rosette System with twelve 5l Niskin sampling bottles was used for collection of water samples. Sediments samples from both stations were collected by Van Veen sampler grab from the bottom surface. The samples from bottom waters and from sediments during the autumn MISIS survey campaign and monitoring programe surveys were collected by divers parallel with macrophytobenthos sampling. Thermo-saline structure of the water column was assessed using CTD CC1215002.

Chemical parameters were analyzed by using **standard methods** (Grasshoff, 1999; Manual, 2003) as follows:

- Dissolved oxygen (DO) - by Winkler method

- Phosphorus (PO4-P) - photometric method based on formation of phosphomolibdate complex and using ascorbic acid as redactor; **Total Phosphorus (TP)** – determination of phosphates after oxidation with disulphate

- Ammonia-nitrogen (NH_4-N) - photomeric indophenol (Koroleff) method using Trione; **Nitrite-nitrogen (NO_2-N)** - photometric method with 1-naphtil-ethilenediamine; **Nitrate-nitrogen (NO_3-N)** - determination of nitrites after reduction of nitrates to nitrite with copper-coated cadmium used as reducing agent*;* **Total Nitrogen (TN)** – photometric determination of nitrates after alkaline oxidation (Standard solution EDTA)

Vertical profiles of hydrophysical parameters presented in Fig. 22 showed typical seasonal changes in water column hydrological structure within May – November period. Thermocline formation and low salinity characterized the spring season. The maximum surface water temperature (>26ºC) was measured in summer (July and August). Homogeneity of the upper layer was registered in November (Fig.22f), when the temperature and salinity in the first 34 m recorded 18ºC and 18.05‰, respectively. Transparency (Secchi depth) in 2012 varied from 4 – 8 m in spring to 7 – 10 m in summer-autumn period.

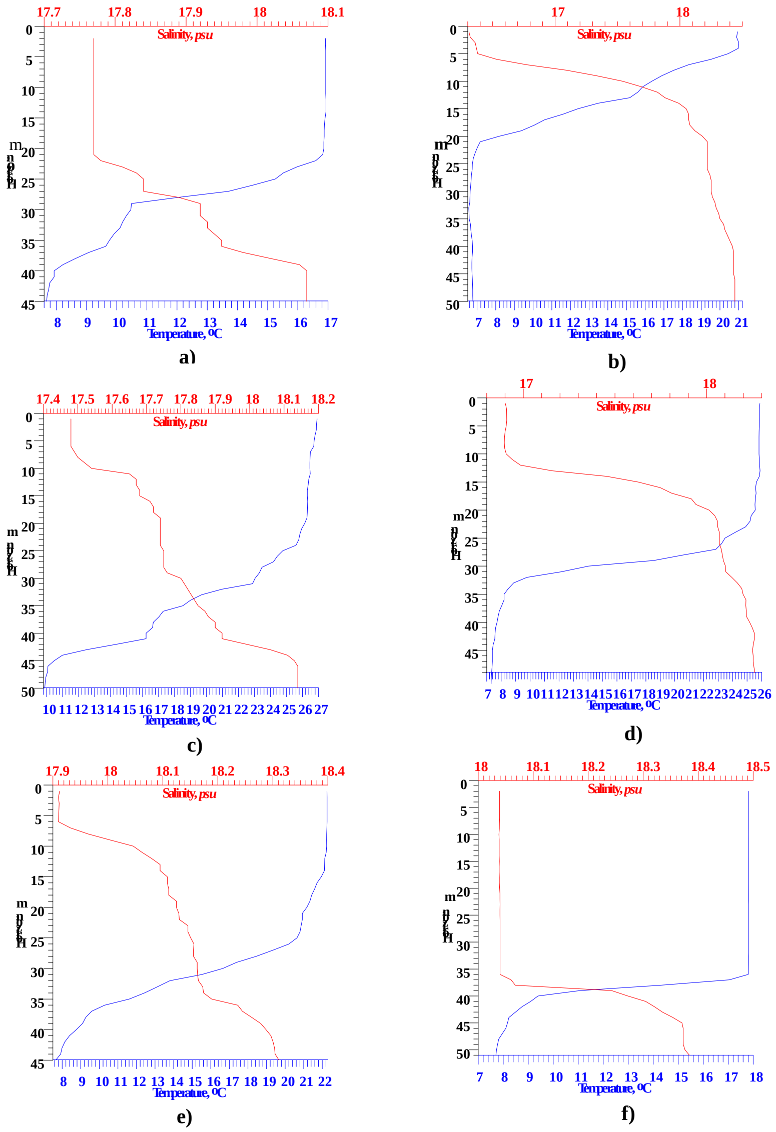

Figure 22. Vertical distribution of TºC and S‰ in May (a), June (b), July (c), August (d), September (e) and November (f).

Nutrients content during different seasons varied in the following ranges: 0 - 0.7µM NH_4-N, 0 - 0.21µM NO_2-N, 0-1.4µM NO_3-N, 0-0.3µM PO_4-P, 0.05-0.96µM TP, 31-40µM TN.

The hydrochemical parameters distribution during the period from May to November 2012 is presented in Fig. 23. Maximum dissolved oxygen content (DO) and saturation (OS) were recorded in May-June period. Oxygen (DO and OS) in bottom layer decreased during summer-autumn period (OS < 80%) due to the summer vertical stratification.

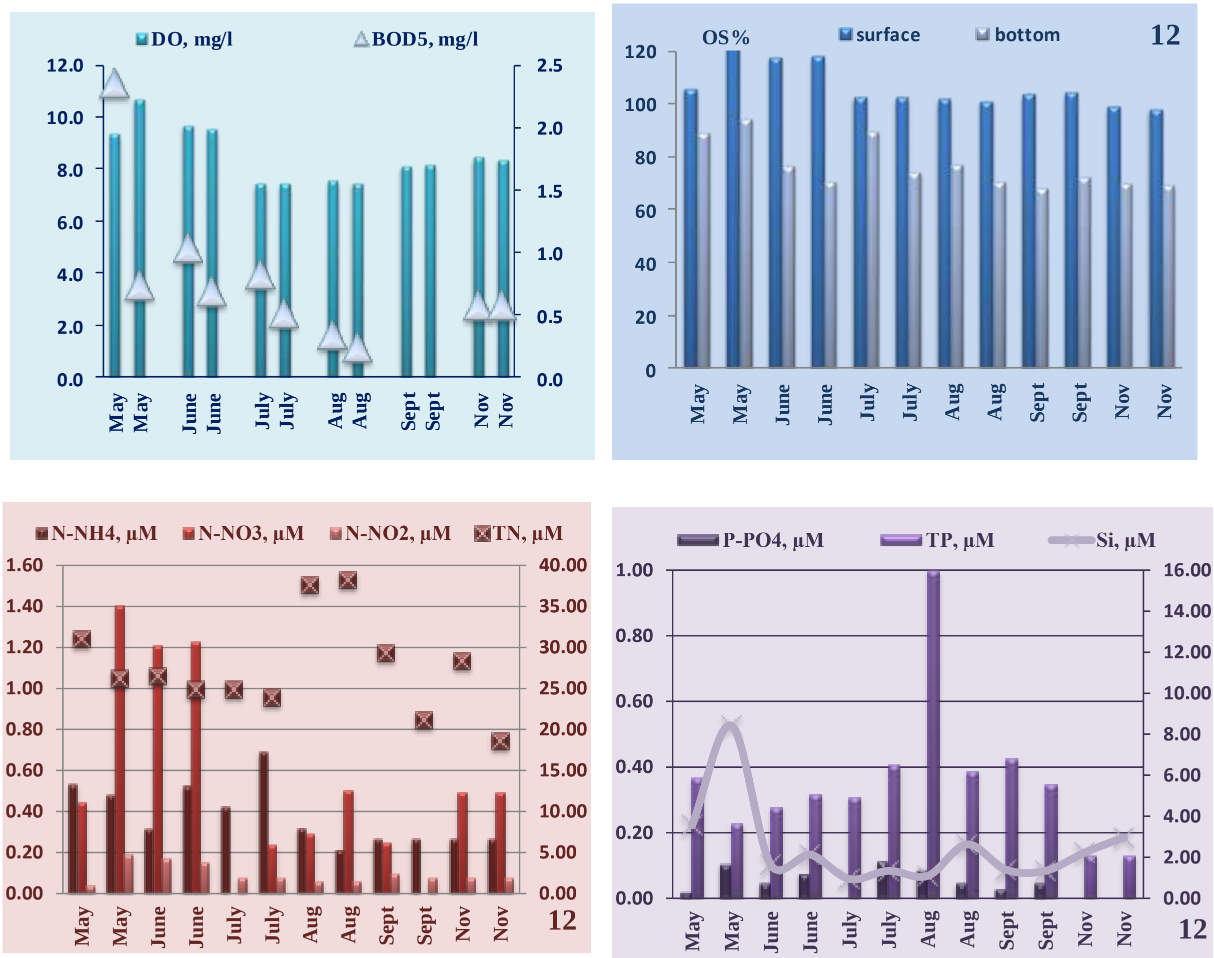

Figure 23. Chemical parameters distribution in May –November period of 2012 in the WB BG2BS000C012

Comparison between both seasons revealed higher nutrients content in July, best expressed for phosphate and ammonia (Fig. 23). OS% in bottom waters is characterized by values >100% in October, while it is lower in July, due to the different depths.

The assessment performed in 2012 revealed a ***Moderate*** status of water body. The status was high for nutrients and moderate for oxygen parameters. The low oxygen concentrations in bottom water during summer - autumn period at both sampling stations of the WB could be explained by high depth (about 50m) in this area.

The sediments study revealed 0.19-0.27% phosphorus (P) content and 0.67-1.33% organic carbon (Corg) (IO Report, 2013).

The physical-chemical parameters measurements (Table 3) carried out within the frame of MISIS Project in the protected area Rezovo in October, 2012 completed the picture about the abiotic condition of the area. Thus, the typical values of temperature of 21^{0}C, salinity ranging from 16.7 to 17 ‰ and a transparency of 15m (Secchi disc depth) were recorded.

Table 3. Phisical-chemical parameters, measured in October, 2012

Station	Horizont, m	O_2, µM	TN µM	NO_3-N µM	NO_2-N µM	NH_4-N µM	TP µM	PO_4-P µM	S‰	TºC
Rezovo1	2	280.9	22.10	1.20	0.08	0.52	0.21	0.13	16.7	21.0
Rezovo2	2	308.6	10.00	0.15	0.04	0.33	0.22	0.11	17.0	21.0

The oxygen content ranged between 281 - 309 µM and had a saturation >105%. While phosphorus content is similar at sampling stations, ammonia N and nitrate N content was higher at St. Rezovo 1 (Fig. 24).

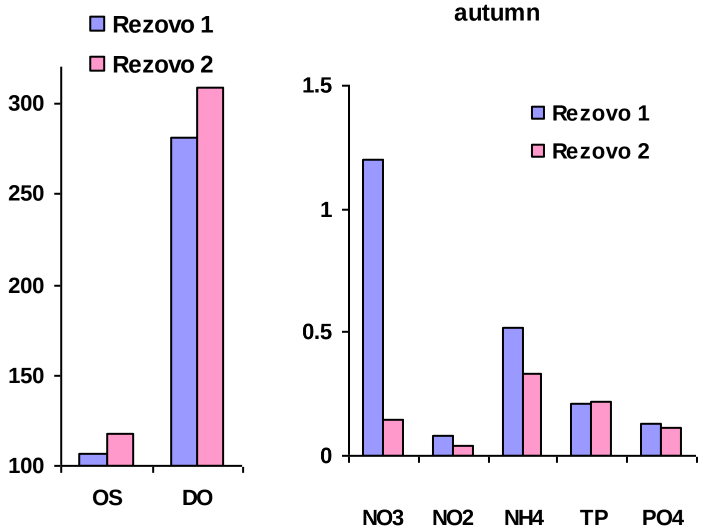

Figure 24. Oxygen and nutrients distribution (µM/l) in Bulgarian MPA Rezovo in autumn 2012

The results from autumn survey (2012) revealed that nutrients and oxygen conditions (OS%) correspond to WQ standards for ***High*** state according to classification in Bulgarian legislation.

Acording to the IO Report, (2013) the state of Rezovo site (polygon for macrophites investigation) in summer 2012 was categorized as ***High*** by nutrients and as *Moderate* by oxygen conditions, due to the low oxygen saturation in bottom waters (IO Report on Assessment of marine environment state in 2012) (Table 4).

Table 4. Ecological status of investigated poligons at 2m depth, based on nutrients and oxygen saturation measurements

Poligons	Summer-nutrients	Summer-OS%
Varvara	High	Moderate
Sinemoretz	High	Moderate
Rezovo	High	Moderate

In July 2013 the main physical parameters of seawater: temperature and salinity varied between 22.5 °C and 26.2 °C and 13.61 and 16.1 PSU, respectively. In the observed area no clear thermocline or halocline existed. The vertical distribution of temperature and salinity at each sampling point is showed in the fig. 25.

Water column in summer is oversaturated with oxygen, but OS corresponds to ***Good* status**. No evidence for hypoxia in bottom waters was established. Veleka station in summer is characterized by higher oxygen and phosphorus content, while poligon Rezovo 2 – by higher nitrate N concentration (Fig. 26). The summer data reveals *High* WQ for oxygenated N forms except station Rezovo2 for NO3-N and *Good* WQ for PO4-P and NH4-N.

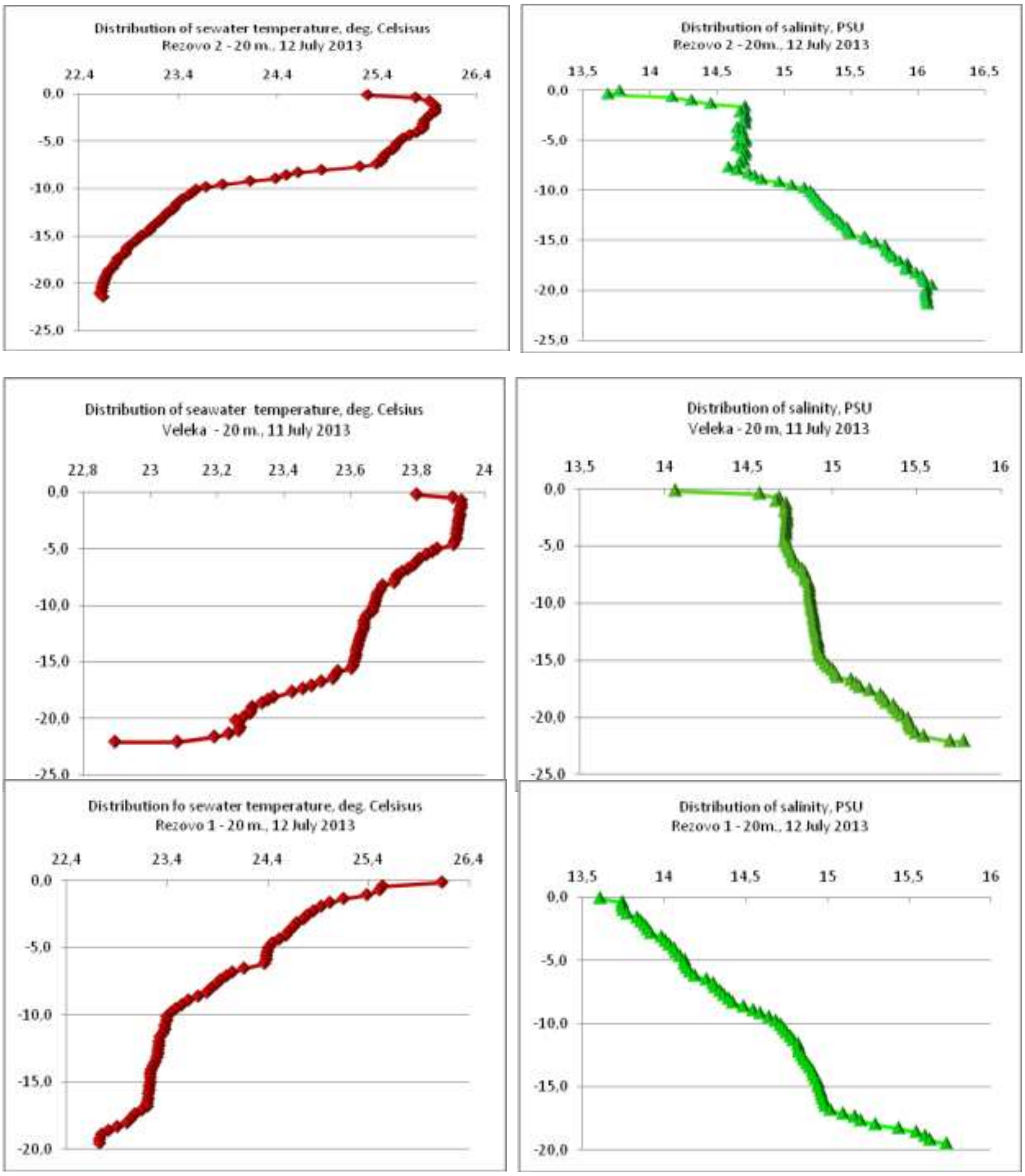

Figure 25. Distribution of temperature and salinity of water column in the study area in July 2013

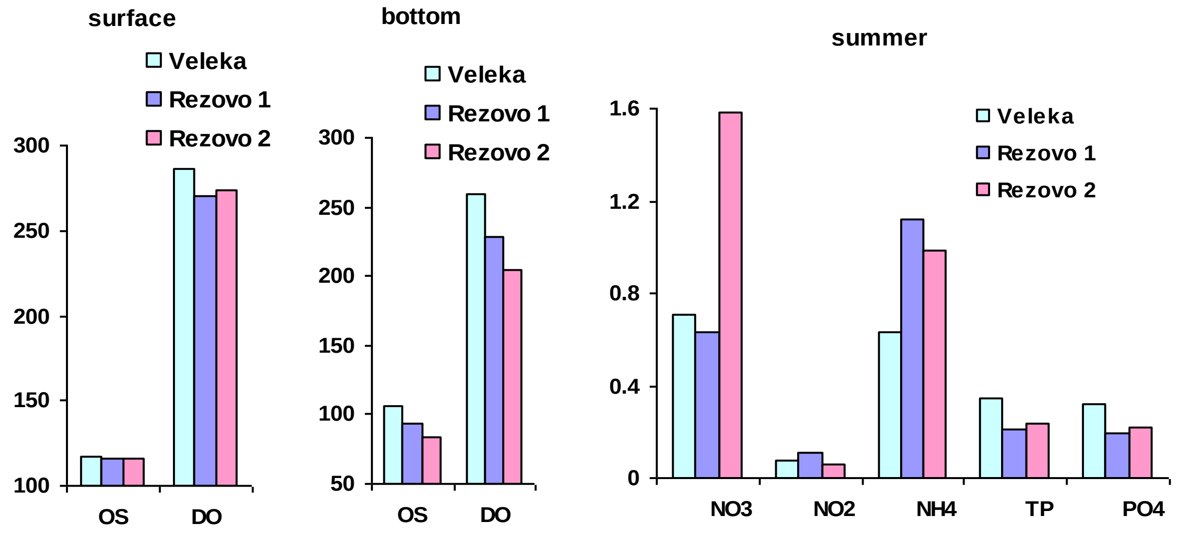

Figure 26. Oxygen and nutrients distribution (μM/l) in Bulgarian MPA Strandzha in summer 2013

In contrast with 2012 (Table 5), NO_3-N and TP content in 2013 are higher in September, while TN and Si content, in November. The oxygen condition in 2012 was better than in 2013. During summer 2013 the oxygen content <200μM/l and OS<60% in bottom waters were measured. In November a minimum for DO and OS was established (179μM/l and 55%). The WQ assessment in 2013 revealed that the water body BG2BS000C012 does not correspond to Good status according to oxygen parameters (DO and OS %) while the nutrients concentrations within WB corresponds to High status (IO Report, 2014).

Table 5. WQ of poligons by seasons

Poligons	Autumn (October2012)	Summer (July2013)
Veleka		Good
Rezovo 1	High	Good
Rezovo 2	High	Good

The information about sea water pollution in the area is poor. Monitoring of pollutants was not carried out in Bulgarian Black Sea area in correspondence to Water Framework Directive (WFD). Some data for pollutants were collected in the frame of scientific projects or contracts supporting the WFD implementation.

The results of the survey in 2011 (Annual report on state of waters in 2011, BSBD) revealed that all pollutants concentrations in water were lower the Detection limit (<DL). Pesticides, PAHs, PCBs and some priority substances were measured at one station and heavy metals at both sampling stations in water

body BG2BS000C012. The DL values for some of the pollutants were higher than values of Quality standards (Regulation, 2010) and it is impossible to assess the chemical state of waters. The sediments in the polygon Rezovo contain 0.4%P and 0.32% Corg, respectively.

The main pressure indicators near the Rezovo site are represented by anthropogenic sources represented by human agglomerations, which led to important N and P inputs via rivers into the coastal water bodies (Fig. 27 and 28). However, it is evident that in the south part, loads are amoung the lowest values compared with the other areas of Bulgarian Black Sea coast.

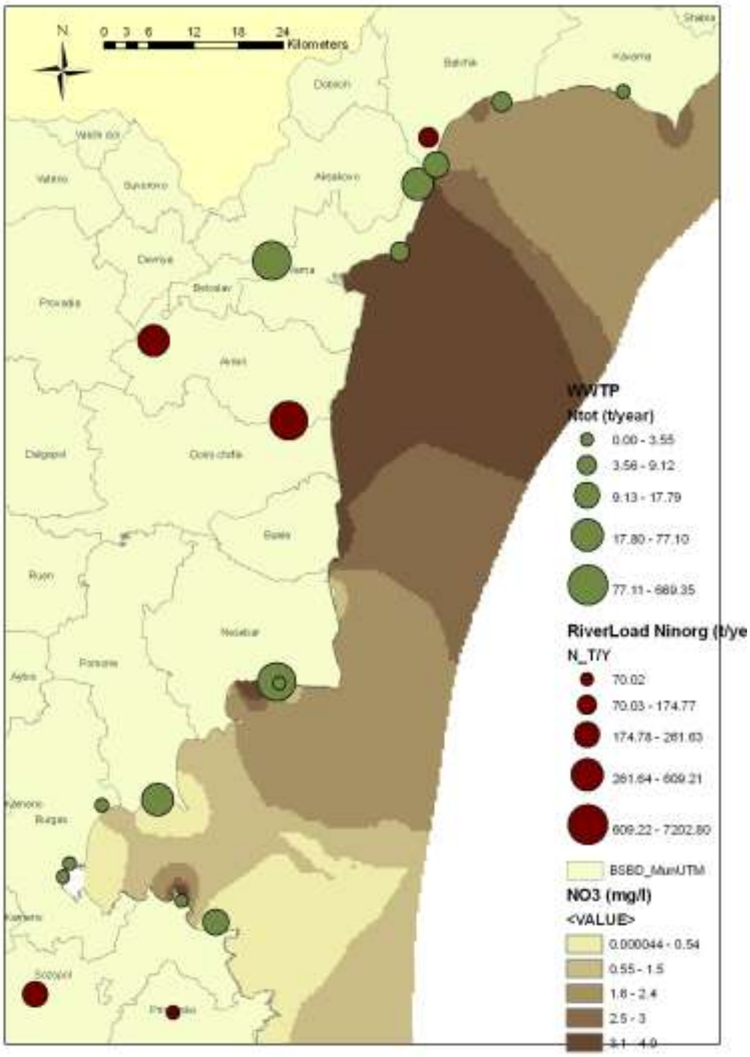

Figure 27. Maps of pressure indicators inorganic nitrogen (mg/l) by sites of investigation from bathing waters data, river load (N) tones per year and Total Nitrogen (N tot- t/year) from waste water treatment plants along Bulgarian coast - in 2007 (Maps made by Valentina Doncheva- Institute of Oceanology, Varna, Bulgaria)

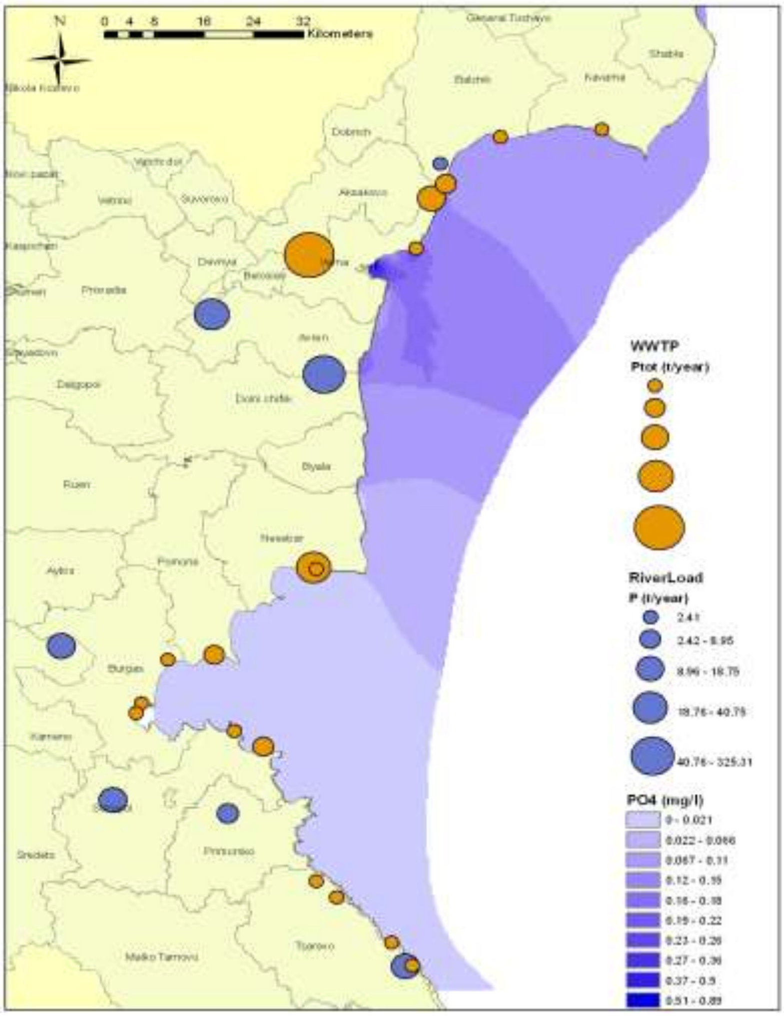

Figure 28. Maps of pressure indicators inorganic nitrogen (mg/l), phosphorus PO4 (mg/l) near by sites of investigation from bathing waters data, river load (P and N) tones per year and Total nitrogen and phosphorous (P, N tot- t/year) from waste water treatment plants along Bulgarian coast – in 2007 (Maps made by Valentina Doncheva-Institute of Oceanology, Varna, Bulgaria).

IGNEADA AREA

A general pollution status of the region with respect to Cf (Contamination factors) and CD (sediment contamination) was considered, coming from the pollution induced by heavy metals.

In the Table 6 there are shown the comparative data regarding the contamination factors (Cf) of metals and degree of sediment contamination (CD) of the Black Sea along Turkish coast. The criteria for Cf and CD are presented in the Table 7 (Hakanson, 1980) and show a moderate degree of contamination according to CD of Igneada region, much lower than the values calculated for the other stations, except Sile, while in case of Cf of different metals, a considerable degree of contamination at Igneada station is given by Hg (mercury), and in less measure by Al (aluminium), however the highest in the series of Cf recorded in the other stations.

Table 6. Comparative data regarding the contamination factors (Cf) of metals and degree of sediment contamination (CD) of the Black Sea along Turkish coast

Stations	C_f						C_D
	Al	Cd	Cu	Pb	Hg	V	
İğneada	1.26	0.27	0.12	0.54	4.55	0.13	6.87
Terkos	0.71	0.63	0.05	1.19	6.13	0.16	8.86
Şile	0.45	0.90	0.11	1.11	3.28	0.16	5.99
Sakarya R	0.44	1.30	0.83	1.20	4.43	1.00	9.19
Ereğli	0.34	1.67	0.23	0.13	4.55	0.08	6.99
Zonguldak	0.32	1.23	0.97	2.15	4.55	1.17	10.39
Bartın	0.36	3.47	1.28	1.28	2.83	0.98	10.19
Cide	0.29	0.63	0.38	1.27	6.23	0.56	9.36
İnebolu	0.52	0.10	1.06	1.33	4.78	0.92	8.69
Sinop-2	0.52	0.67	0.13	1.08	4.93	0.31	7.62
Sinop-1	0.48	0.67	0.39	0.87	5.30	0.57	8.28
Kızılırmak R	0.30	0.93	0.81	0.97	6.03	1.08	10.11
Samsun	0.61	0.93	1.12	1.48	5.83	1.24	11.21

Table 7. Descriptive criteria of the Cf and CD (Hakanson, 1980).

C_f	C_D	Description
$C_f<1$	$C_D<6$	Low degree of contamination
$1\leq C_f<3$	$6\leq C_D<12$	Moderate degree of contamination
$3\leq C_f<6$	$12\leq C_D<24$	Considerable degree of contamination
$C_f\geq 6$	$C_D\geq 24$	Very high degree of contamination

Physical - chemical characterization of water body

The physical parameters such as temperature, salinity, pH and dissolved oxygen (Table 8) have been measured with a multiparameter device (YSI- 6600V).

Table 8. Seasonal physical parameters of water column in the study area

		Temp (°C)	Salinity (ppt)	pH	DO (mg/L)
Nov-2012	Min	14.81	17.82	8.25	8.24
	Max	15.25	18.04	8.31	9.43
	Mean	15.05	17.95	8.29	8.47
May-2013	Min	9.69	15.42	8.39	9.21
	Max	18.04	17.95	8.61	10.51
	Mean	15.72	16.17	8.53	10.01
July-2013	Min	22.97	14.92	6.87	7.39
	Max	24.72	16.17	6.98	8.66
	Mean	23.71	15.76	6.92	8.05
Oct-2013	Min	18.35	18.24	6.85	7.86
	Max	18.65	18.28	6.89	8.2
	Mean	18.54	18.26	6.87	7.96

The lowest temperature value was recorded in May (9.69°C), while the highest in July 2013 (24.72°C) (Table 8). The warming period was generally accompanied by decreasing oxygen concentrations and low pH values, indicating a high input of humic matter of terrigenous origin, caused by flooding phenomenon, which affected the hydrological regime of the area at that period. This situation is confirmed also by low salinities measured in May (16.17‰) and July 2013 (15.76‰). In October 2013, the physical characteristics within the water column have slightly changed comparative with the summer period in terms of salinity (18.26‰) and temperature (18.54°C), while the pH (6.87) and oxygen (7.96 mg/L) parameters have maintaned the same tendency (Fig. 29). According to these parameters, the water quality was high during November 2012 and May 2013 and low in the July and October 2013.

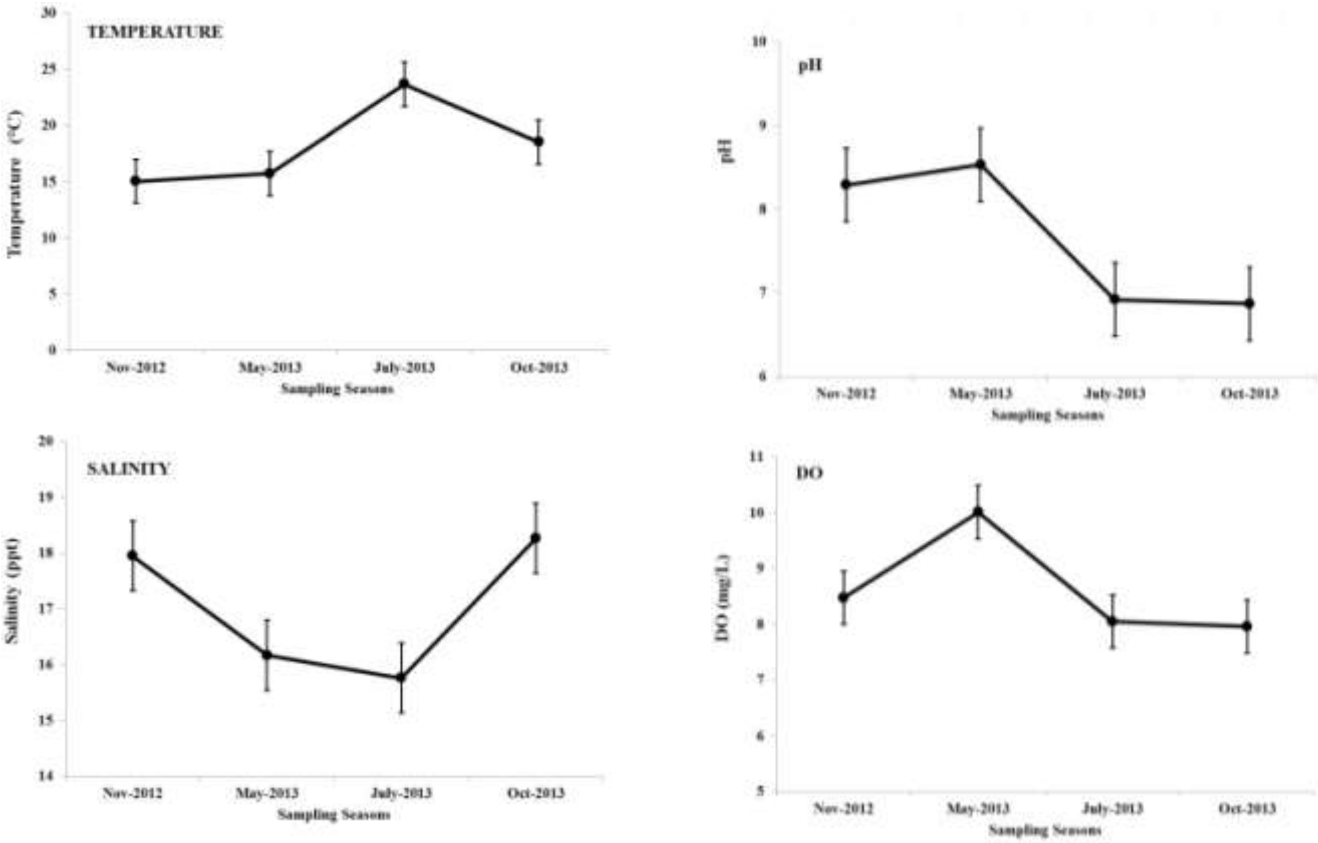

Figure 29. Physical parameters of water column during the sampling months

These observations are supported also by the values of transparency given by the measurements done using Secchi Disc. Thus, the highest SD depth was recorded as 6.5 m in station I-1-3 in November

2012, while the lowest SD depth (2.6 m) was found in station I-2-1 (5 m bottom depth) in October 2013. However, the deeper and further of coast the sample point was the higher the transparency (May 2013). The local wind regime influenced also the water transparency, situation that can be observed in large variation of transparency recorded in autumn months (October and November) (Fig. 30).

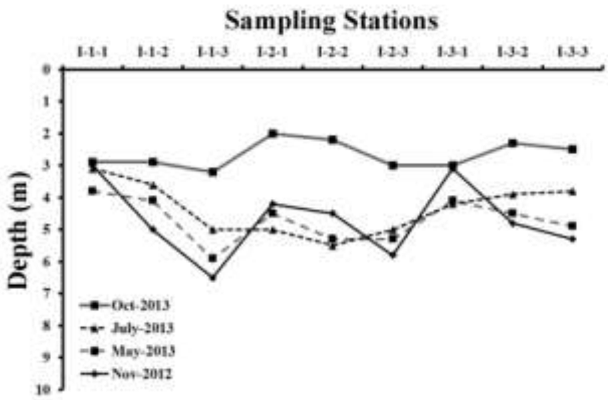

Figure 30. Secchi Disc Depths (m) at the sampling stations in the sampling seasons.

CHAPTER 3. DESCRIPTION OF THE STRANDZHA-IGNEADA BIOLOGICAL FEATURES

3.1. Ecological status of phytoplankton community

STRANDZHA AREA

Investigations of phytoplankton in Bulgarian waters date back to 1954 when four major transects were surveyed. The survey showed a rich variety of 255 species with a dominance of diatoms (Bacillariophyta) and dinoflagellates (Dinophyta) almost all year round. The distribution of abundance and biomass showed seasonal variability, with a general increasing during the spring and summer months when light and temperature promote growth. There is also a clear zonation with distance from the shore. The coastal zone has a higher abundance of phytoplankton compared to offshore waters.

Materials and methods

Phytoplankton characteristics of the area are based on data collected during a special survey conducted between 11-12 July 2013 at 3 stations - Rezovo1, Resovo 2 and Veleka1.

According to WFD defined water bodies along the Bulgarian coast, the area enclosed between Varvara, Veleka and Resovo represents one water body (BG2BS000C012 - exposed and shallow waters with mixed substratum), while Varvara and Veleka are common stations from the national WFD monitoring network. Monitoring data collected during 2010-2013 were also used for the assessment of the ecological status of the area based on phytoplankton as BQE (Moncheva et al., 2010, 2012, 2013). Information on stations coordinates, depths and sampling months is presented in Table 9.

Table 9. Sampling stations coordinates', depth and sampling frequency (2010-2013)

Station code	Station name	Lat	Long	Sampling month/year	Depth, m
BG2BS00000MS112	Varvara	42°09.000'N	27°54.750'E	IX 2010	47
				IX, XI 2011	
				V-IX, X 2012	
				VI , IX, XI 2013	
BG2BS00000MS113	Veleka	42°05.000'N	28°00.000'E	IX 2010	53
				IX, XI 2011	
				V-IX, X 2012	
				VI , IX, XI 2013	
	Veleka 1			VII 2013	20

	Rezovo1			VII 2013	20
	Resovo 2			VII 2013	20

The samples were collected by Niskin bottles attached to CTD from 2 sampling depths (surface and 10m). The water samples of 1 L volume were fixed on board in 4% formaldehyde solution, buffered to pH 8 - 8.2 with disodiumtetraborate and stored in plastic bottles. In the laboratory the samples were concentrated down to 50 cm^3 by slow decantation after storage for at least 20 days in a cool and dark place. An integrated depth sample (0-10m) was used for the analysis to comply with the methodology used in the national monitoring (Moncheva, 2013). Taxonomic identification and cells count were done under inverted microscope (Nikon T300E) connected to a video-interactive image analysis system (L.U.C.I.A, Version 4.8, Laboratory Imaging Ltd, Prague) at 400x magnification by the Uteröhl (1958) method in Sedgwick-Rafter counting chambers. From each sample 400 cells were counted, while rare and large species were checked in the whole counting chamber (Moncheva and Parr, 2005/2010). The individual cell biovolume (V, μm^3) was derived through the approximation of the cell shape of each species to the most similar regular solid, calculated by the respective formulas (Vadrucci et al., 2007), averaged over measurement of ten cells from each species. Cell bio-volume is converted to weight (W, ng) following Hatchinson (1967). Species identification is mainly after Carmelo (1997) and Fukuyo (2000) and the taxonomic nomenclature according to the on-line data-base of World Register of Marine Species (WoRMS) and the Black Sea phytoplankton check-list (http://www.marinespecies.org ; http://phyto.bss.ibss.org.ua)

The QC/QA of the data is performed following the quality control Guidelines for phytoplankton (Moncheva, 2010).

The Bulgarian WFD national classification system was used for the ecological quality assessment of the area, based on quantitative metrics (phytoplankton abundance [cells/l] and biomass [mg/m^3]), taxonomically based metrics (MEC% and DE%, Bac: Din biomass ratio in spring), biodiversity indices (Menhinick, 1964 and Sheldon, 1969) and Integrated Biological Index (IBI) (Ordinance 4/14.09.2012 of the Ministry of Environment and Water and Commission Decision, 20Sept/2013).

For statistical analysis the software Primer 5.2.4 -E Ltd (Clarke and Warwick, 2001) and Excel 12 (Microsoft Office 2007) were employed.

Phytoplankton community taxonomic composition

The phytoplankton assembly in the area in July was represented by a high variety and species richness, a total of 98 species belonging to 12 classes (Fig. 31). Class Dinophycea was the most diverse – 58 species, representing more than 60% of the species pool, followed by Bacillariophycea (14 species) the other classess composed of 1-5 species and a high variety of microflagellates. In 2012-2013 (May-November) in the stations Varvara and Veleka more than 128 species were recorded and the species number per sample varied between 23 - 44 and between 44 - 64 in 2013 with similar pattern of distribution among the different taxonomic classes (Moncheva et al., 2012, 2013). In general the species composition in the Rezovo area was similar to the community composition of the other water bodies along the Bulgarian coast. High diversity and species richness emerged as a recurrent feature of phytoplankton community along the Bulgarian Black Sea coast, in line with the recent trends documented for other areas of the Black Sea (Nesterova et al, 2008).

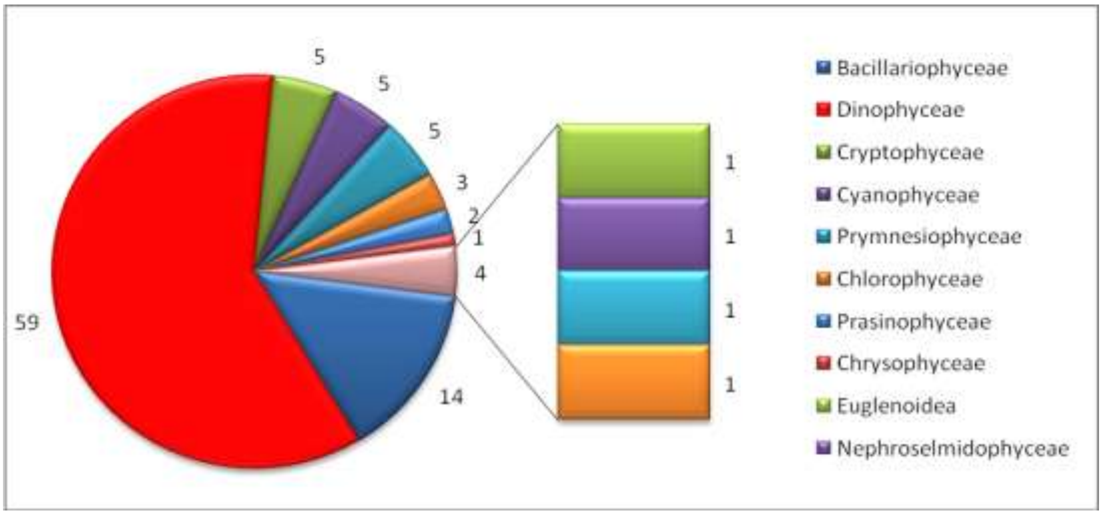

Figure 31. Proportion of phytoplankton species richness by taxonomic classes

Phytoplankton taxonomic structure and dominant species

The taxonomic structure of phytoplankton community, unlike the species diversity, in July 2013 was dominated by diatoms both in the abundance (55%, 39%, 55%) and biomass (64%, 52%, 70%) respectively in Rezovo1, Rezovo 2 and Veleka1, which in this particular case could be related to the intensive mixing during the period of sampling and associated nutrients enrichment of water column, as evident from the almost homogenous vertical distribution of nutrients (Fig 32 and Fig. 33). The coccolithophorid *Emiliania huxley* represented a high proportion in the total abundance (36%, 47% and

33%), which is a common feature of the recent period for the entire Black Sea (Mykaelyan et al, 2011, 2013).

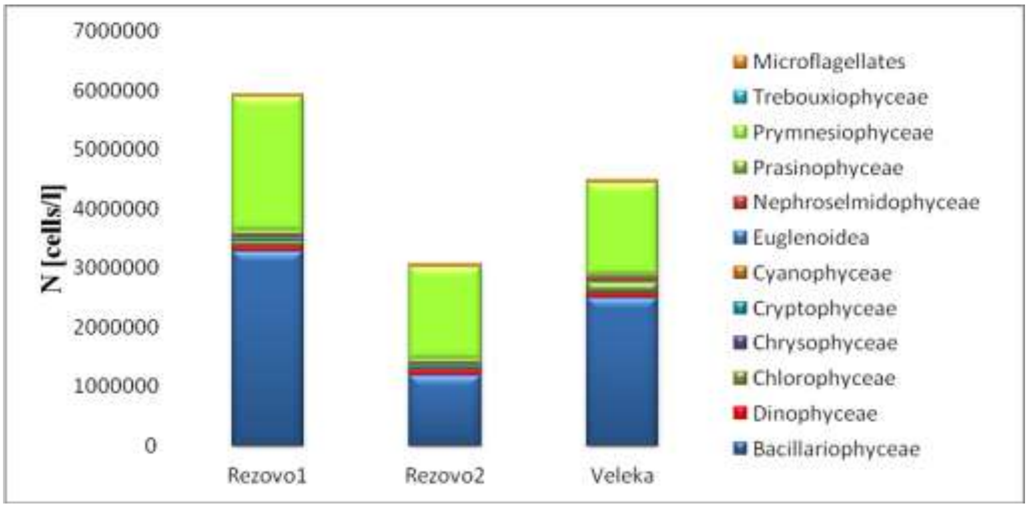

Figure 32. Phytoplankton community taxonomic structure in July 2013: proportion of taxonomic classes in the total abundance [cells/l]

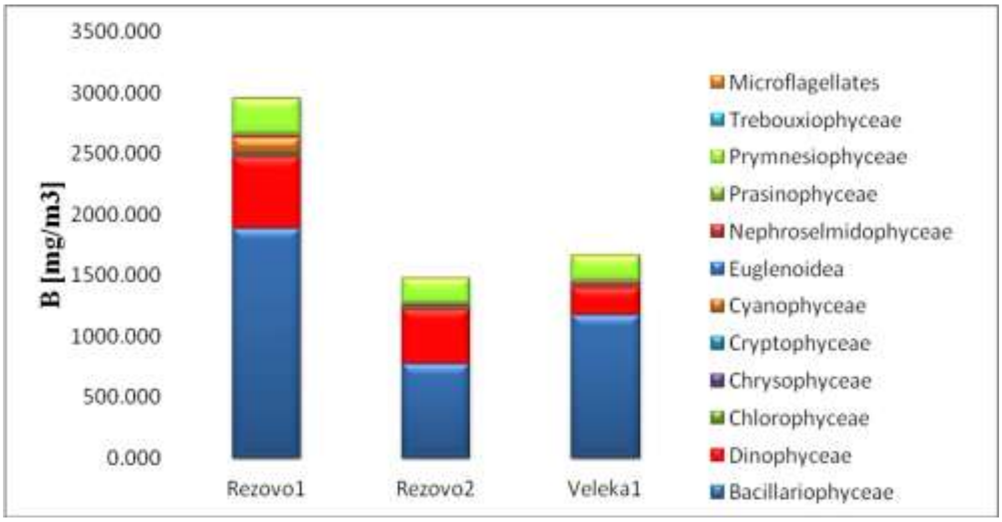

Figure 33. Phytoplankton community taxonomic structure in July 2013: proportion of taxonomic classes in the total biomass (mg/m^3)

Dominant species among diatoms were *Thalassionema nitzschioides* (in Resovo and Veleka in abundance >1x10^6 cells/l), *Pseudo-nitzschia delicatissima, Pseudo-nitzschia seriata, and Emiliania huxleyi* (abundance between 1 and 2x10^6 cells/l). Among dinoflagellates albeit the high diversity the contribution of a single species to the total abundance/biomass was very low even for the most common *Prorocentrum micans, Protoperidinium granii, Scrippsiella trochoidea*, the share of the class in the biomass varying between 13-19%.

The total abundance and biomass were high and varied between 3 - $6x10^6$ cells/l and 1.4 - 2.9 g/m^3 exceeding the summer threshold for good ecological status (800 000 cells/l and 950 mg/m^3] several times. According to the IBI index in July 2013 the area is classified in "poor" ecological status – Table 10.

Table 10. Ecological status assessment based on WFD phytoplankton metrics (colors correspond to the WFD classification color codes)

Station	S	$Nx10^3$ [cells/l]	B [mg/m^3]	Menhinik	Sheldon	MEC%	DE%	IBI
Rezovo1	74	5935	2948.777	0.03	0.09	0.91	80.4	0.28
Rezovo2	67	3077	1473.245	0.04	0.1	1.84	76.5	0.37
Veleka1	57	4484	1659.153	0.03	0.12	1.32	86.1	0.31

In the context of phytoplankton characteristic in spring, summer and autumn 2010-2013, July 2013 is an exception in terms of the high numerical abundance and biomass, which could be related to the intensity of hydrodynamics in the area, mentioned above, and also to the shallower location of the stations than the traditional monitoring stations in the area, where the land-based effects could be stronger. The average seasonal values of phytoplankton abundance and biomass and their variability were lower than the reference for good ecological status over the entire period – Table 11.

Table 11. Average seasonal, stdev and threshold for good ecological status of phytoplankton abundance and biomass (2010-2013)

Parameter	spring	summer	autumn
average N [cells/l]	812606 ± 342136	506462 ± 544126	514152 ± 50765
category good		<800000	
average B[mg/m3]	324 ± 156	317 ± 246	152 ± 131
category good	<3000	<950	<1700

The main features of phytoplankton seasonal taxonomic structure were the disproportion of diatoms in the spring total biomass (almost inverse Bac : Din biomass ratio to the reference), a high contribution of coccolithophorid *E. huxleyi* in spring and autumn, increased diversity and share of small-sized species from "other" classes than diatoms and dinoflagellates along with a high proportion of microflagellates in the total abundance, indicating a misbalance in phytoplankton seasonal succession – Fig. 34 and 35.

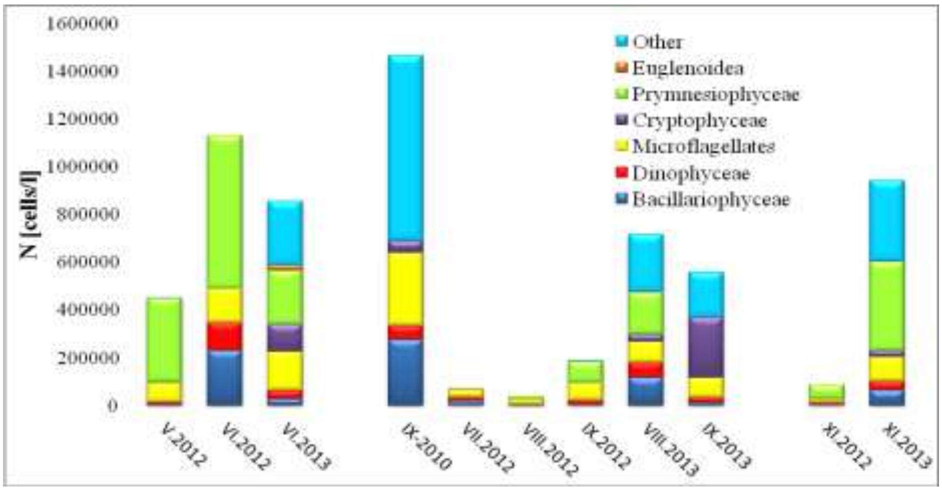

Figure 34. Phytoplankton taxonomic structure by sampling months (2010-2013) and phytoplankton abundance

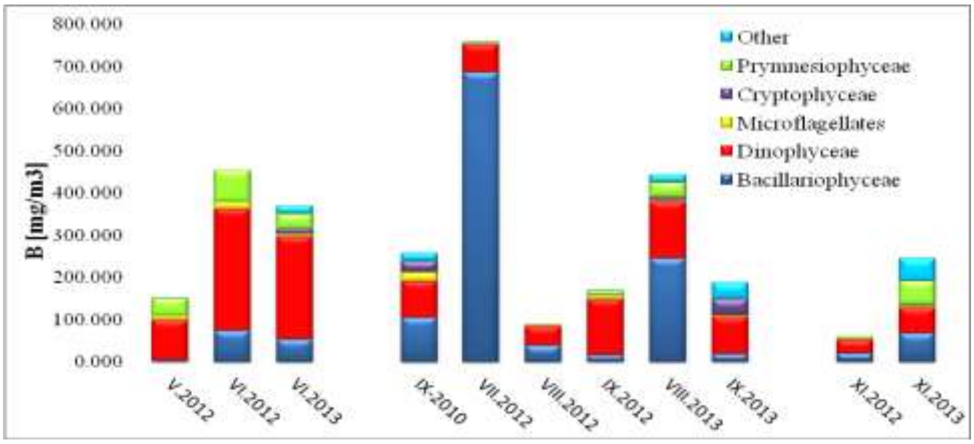

Figure 35. Phytoplankton taxonomic structure by sampling months (2010-2013) and phytoplankton biomass

The dominant species assembly during 2010-2012 was composed of the diatoms *Pseudo-nitzschia delicatissima, Pseudo-nitzschia seriata, Pseudosolenia calcar-avis, Thalassionema nitzschioides*, dinoflagellates *Prorocentrum cordatum, Prorocentrum micans, Scrippsiella trochoidea* and representatives of genus Gymnodinium, the prymnesiophyte *Emiliania huxleyi*, cryptophytes *Hemiselmis sp., Hillea fusiformis*, prasinophyte *Pyramomonas sp.* and a number of microflagellates.

The ecological status of the Rezovo area (WB BG2BS000C012) during 2006-2013 assessed by the **Phytoplankton Integrated Index** varied predominantly between the categories moderate-good with two cases in category "poor" in spring 2012 – Fig. 36.

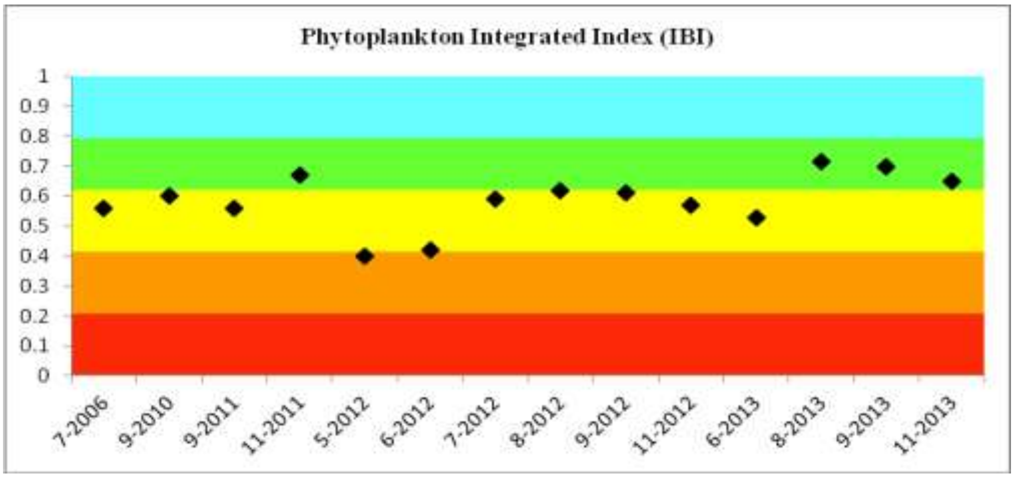

Figure 36. Ecological status assessed based on Phytoplankton Integrated Biological Index in WB BG2BS000C012 (colors correspond to the WFD classification codes)

IGNEADA AREA

Material and Method

In the laboratory the samples were kept for 15 days in 1 L cylinders to settle down. At the end of this period, the supernatant was carefully vacuumed using a cyclone equipped with a plankton net of 20µ at its opening and then transferred to dark bottles of 50 cc. Following sedimentation, the suspensions were reduced to a final volume of 5 ml using the same method.

A Sedwick-Rafter counting chamber was used for the micro-phytoplanktonic species with cells over 15 µm diameter. The samples brought to maximum concentrations specific to each sample, depending on the structure of each suspension, were carefully stirred in order to provide a homogenous distribution. From this suspension, a drop of 1 ml was placed on the counting chamber and left to settle down for a while. Following this procedure, cells (L^{-1}) were counted under Nikon Eclippse E600 at various magnifications. Nanophytoplanktonic species with a cell diameter <15 µm were mounted on glass slides (0.01 ml) and examined under the same microscope at high magnifications such as x20, x40 and x100.

Depending on the density or dimension of the species counting was done either for the entire chamber or for several chosen columns. For the estimation of species densities the volume of columns and the number of species were recorded. A coefficient was calculated for each counting chamber in order to determine the abundance of phytoplankton.

The formula below was used to calculate the coefficient (K):

K= V2 x 1000/ V3 x V1, where:

V1= The initial sample volume (ml), V2= The volume of the retained fraction after sedimentation (ml), V3= The volume of the counting chamber used to count cells (ml)

Following the determination of the coefficient, the abundance of the cell in 1 liter of seawater was assessed by multiplication of this coefficient with the cell counting in each chamber for each cell.

For estimation of biomass, the diameter, length and width of each cell were measured under a microscope equipped with an ocular micrometer. The data were further processed using the software developed by Dr. A. Mikaelyan (P.P.Shirshov Institute of Oceanology, Russia), the biomass of all identified cells being calculated (Kiselev, 1950; Proshnika and Lavienko, 1955; Cupp, 1977; Rampi and Bernhard, 1980; Senichkina, 1986; Hillebrand et al., 1999). Taxonomy of species is organized according to AlgaeBASE.

Abundance data (X) were transformed using Log10(X+1) chosen as result of application of Taylor's Power Law (Taylor 1961). Species abundance among sites was tested using Cluster, MDS and ANOSIM (multivariate analyses) (Clarke and Green, 1988; Clarke and Warwick, 1993). CLUSTER performed hierarchical agglomerative clustering of species/ sample data with group average linkage (Clarke and Warwick 2001). Nonmetric multidimensional scaling MDS was used to evaluate the group separation derived from cluster analysis (Field et al. 1982). ANOSIM (Analysis of Similarities) was used to test for differences among groups of samples based on the (ranked) similarity matrix from the cluster (Bray-Curtis Similarity index, Bray and Curtis 1957).

Phytoplankton community taxonomic composition

Species belonging to 7 classes of algae (Bacillariophyceae, Coscinodiscophyceae, Fragilariophyceae, Dinophyceae, Prymnesiophyceae, Ebriophyceae and Dictyochophyceae) have been recorded. A total of 88 species (Annex 1) was determined out of which Bacillariophyceae was represented by 9 species belonging to 7 genera, Coscinodiscophyceae by 14 genera and 30 species, Fragilariophyceae by 3 genera and 5 species, Dinophycaeae by 17 genera and 39 species, Dictyochophyceae by 3 genera and 3 species, Ebriophyceae by 1 genus and 1 species and Prymnesiophyceae by 1 genus and 1 species (Table 12). Among these classes, Dinophycaeae dominated in terms of number of species. From the total number of species, 44% was represented by Dinophyceae, 34% by Coscinodiscophyceae and the remaining 22% by the other classes (Fig. 37).

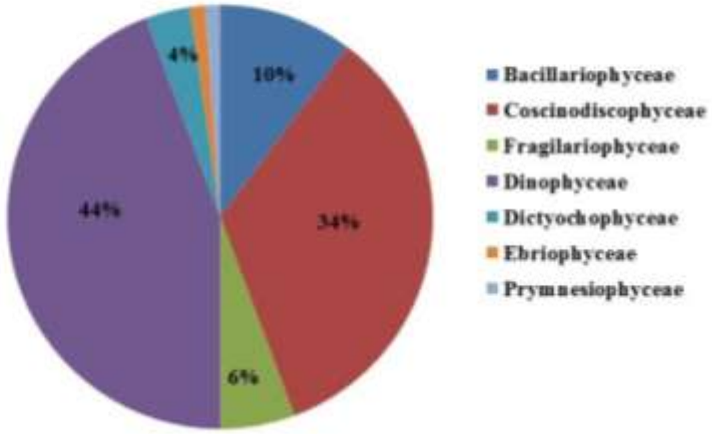

Figure 37. Percentage distribution of phytoplankton classes sampled in 2012 – 2013 period

Table 12. Taxonomic results of phytoplankton classes recorded in 2012 – 2013 period

		SAMPLING PERIODS			
CLASS	**GENUS**	**Nov-12**	**May-13**	**Jul-13**	**Oct-13**
Bacillariophyceae	*Achnanthes*	1	-	-	-
	Cylindrotheca	1	-	-	1
	Gyrosigma	1	-	-	1
	Navicula	1	-	-	-
	Nitzschia	-	-	-	2
	Pleurosigma	1	1	1	1
	Pseudo-nitzschia	1	1	1	2
Coscinodiscophyceae	*Biddulphia*	1	-	-	-
	Cerataulina	-	-	1	1
	Chaetoceros	4	4	4	8
	Coscinodiscus	2	-	1	3
	Dactyliosolen	-	1	1	-
	Ditylum	1	-	-	1
	Hemiaulus	1	-	-	-
	Leptocylindrus	1	1	1	1
	Melosira	-	-	-	2
	Proboscia	1	1	1	1
	Pseudosolenia	1	1	1	1
	Rhizosolenia	-	-	-	2
	Skeletonema	1	-	1	1
	Thalassiosira	1	1	1	2
Fragilariophyceae	*Licmophora*	2	-	2	1
	Striatella	1	-	1	-
	Thalassionema	1	1	1	1

		SAMPLING PERIODS			
CLASS	**GENUS**	**Nov-12**	**May-13**	**Jul-13**	**Oct-13**
Dinophyceae	*Akashiwo*	-	-	1	-
	Alexandrium	-	-	-	1
	Biceratium	1	1	1	1
	Dinophysis	3	-	1	4
	Glenodinium	-	-	-	1
	Gonyaulax	-	-	2	3
	Gymnodinium	-	-	1	1
	Gyrodinium	2	1	1	3
	Lingulodinium	1	1	1	1
	Neoceratium	2	2	2	2
	Phalacroma	1	-	1	1
	Podolampas	1	-	-	-
	Polykrikos	-	-	1	-
	Prorocentrum	2	2	3	3
	Protoceratium	-	-	-	1
	Protoperidinium	10	2	6	9
	Scrippsiella	1	1	1	1
Dictyochophyceae	*Dictyocha*	-	-	-	1
	Distephanus	1	-	-	1
	Octactis	1	-	-	1
Ebriophyceae	*Ebria*	1	-		1
Prymnesiophyceae	*Emiliania*	1	1	1	1
	TOTAL SP NO	**52**	**23**	**41**	**70**

Assessment of phytoplankton qualitative and quantitive composition during sampling periods

November 2012

The highest value after abundance recorded the species from Prymnesiophyceae class, with 99 % of total abundance followed by members of the class Dinophyceae. In terms of biomass, the contribution of coccholiths (recorded as the most abundant phytoplankton group) in the total phytoplankton biomass value reached 48%. Additionally, the class Dinophyceae accounted for 38% and the class Coscinodiscophyceae for 13% of the total biomass value. In terms of spatial distribution the abundance of Prymnesiophyceae had an increased tendency as moving from Igneada transect to north, while the Dinophyceae abundance was higher in deepest stations than in the coastal ones.

According to univariate ecological indexes, both the highest number of species (S) (28) and implicit the highest species richness (d) value – 3.938 - were found in St I-1-1, while the greatest density (N) and the second ranked diversity of species (27 species) were encountered in the St I-2-1. The St I-3-1 was the poorest in terms of number of species and individuals. The highest species evenness (J’) was recorded by populations found in St I-2-2. Because of high abundance of *Emiliania huxleyi* which exceeded few times the abundance of the other groups it was not included in the analyses of diversity index.

In order to reveal the frequency index values of phytoplankton species at the stations, Soyer (1970)'s “Frequency Index” was utilized.

According to the frequency of the species belonging to the class of Dinophyceae, 25% of the species were “rare”, 29% of the species were “frequent”, 25% of the species were “common” and 21% - “constant”.

- 34% of the species in Bacillariophyceae was determined to be rare, 33% to be frequent and 33% to be constant in the community.
- 22% of the species in Coscinodiscophyceae was determined to be rare, 36% to be frequent, 21% to be common and 21% to be constant in the community.
- 75% of the species in Fragilariophyceae was determined to be rare and 25% to be constant in the community.

Pseudosolenia calcar-avis, *Thalassionema nitzschioides*, *Biceratium furca*, *Neoceratium fusus*, *Prorocentrum micans* and *Emiliana huxleyi* species were the constant (F=100) species at sampling stations in November 2012.

May 2013

In May 2013 were registered the lowest abundance values among all the sampling periods. The class Prymnesiophyceae contributed with only 41% at the total abundance followed by Bacillariophyceae with 33% and Coscinodiscophyceae with 25%. Diatoms reached 57% of the total abundance.

In terms of biomass, the large cells of Coscinodiscophyceae members dominated in proportion of 96% the quantitative composition.

According to the frequency of the species belonging to the class of Dinophyceae, 50% of the species were found to be as rare, 40% of the species were found to be as frequent and 10% as common.

50% of the species in Bacillariophyceae were determined to be rare and 50% to be constant in the community.

11% of the species in Coscinodiscophyceae were determined to be rare, 67% to be frequent and 22% to be constant in the community.

Pseudo-nitzschia delicatissima, *Chaetoceros affinis*, *Chaetoceros curvisetum* and *Emiliana huxleyi* species were the constant (F=100) species at sampling stations in May 2013.

July 2013

The class Prymnesiophyceae accounted for 65% of the total abundance in this period and the highest abundance of all sampling periods. Diatoms ranked the second most abundant group with a percentage of 33 .

Concerning the biomass values, diatoms accounted for 54% while dinoflagellates for 34% of the total abundance. In turn, the class Prymnesiophyceae which dominated in total abundance, comprised only 12% of the total biomass.

According to the frequency of the species belonging to the class Dinophyceae, 4% of the species were found to be as rare, 14% of the species were found to be as frequent, 9% of the species was found to be as common and 73% as constant.

50% of the species in Bacillariophyceae were determined to be common and 50% to be constant in the community.

25% of the species in Coscinodiscophyceae were determined to be rare, 25% to be frequent and 50% to be constant in the community.

50% of the species in Fragilariophyceae were determined to be rare, 25% to be frequent and 50% to be constant in the community .

Pseudo-nitzschia delicatissima, *Chaetoceros affinis*, *Chaetoceros curvisetus*, *Proboscia alata*, *Pseudosolenia calcar-avis*, *Thalassionema nitzschioides*, *Akashiwo sanguinea*, *Biceratium furca*, *Gyrodinium fusiforme*, *Lingulodinium polyedra*, *Neoceratium fusus*, *Polykrikos schwartzii*, *Prorocentrum compressum*, *Prorocentrum cordatum*, *Prorocentrum micans*, *Protoperidinium claudicans*, *Scrippsiella trochoidea* and *Emiliana huxleyi* species were the constant (F=100) species at sampling stations in July 2013.

October 2013

During this sampling period, the class Prymnesiophyceae dominated in abundance (99%) and biomass (66%). Although the species diversity was high, all classes except Prymnesiophyceae were represented by low number of infividuals. The most important contribution to the total biomass value besides class Prymnesiophyceae had the Coscinodiscophyceae with 29%.

According to the frequency of the species belonging to the class Dinophyceae, 47% of the species was found to be as rare, 25% of the species were found to be as frequent, 16% of the species were found to be as common and 12% as constant.

28% of the species in Bacillariophyceae were determined to be rare, 29% to be frequent, 14% of the species were found to be as common and 29% to be constant in the community.

35% of the species in Coscinodiscophyceae were determined to be rare, 30% to be frequent, 13% to be common and 22% to be constant in the community.

50% of the species in Fragilariophyceae were determined to be frequent and 50% to be constant in the community.

Pleurosigma elongatum, *Pseudo-nitzschia delicatissima*, *Chaetoceros affinis*, *Pseudosolenia calcar-avis*, *Rhizosolenia setigera*, *Thalassiosira eccentrica*, *Thalassionema nitzschioides*, *Biceratium furca*, *Neoceratium fusus*, *Prorocentrum micans* and *Emiliana huxleyi* species were the constant (F=100) species at sampling stations in October 2013.

Seasonal Analysis of Phytoplankton

According to the frequency of the species belonging to the class of Dinophyceae, 38% of the species were found to be as frequent, 21% of the species were found to be as common and 41% as constant.

56% of the species in Bacillariophyceae were determined to be frequent, 22% to be common and 22% to be constant in the community.

53% of the species in Coscinodiscophyceae were determined to be frequent, 17% to be common and 30% to be constant in the community.

40% of the species in Fragilariophyceae were determined to be frequent, 20% to be common and 40% to be constant in the community (Fig. 38).

Pleurosigma elongatum, *Pseudo-nitzschia delicatissima*, *Chaetoceros affinis*, *Leptocylindrus danicus*, *Proboscia alata*, *Pseudosolenia calcar-avis*, *Thalassiosira eccentrica*, *Thalassionema nitzschioides*, *Biceratium furca*, *Gyrodinium fusiforme*, *Lingulodinium polyedra*, *Neoceratium fusus*, *Prorocentrum compressum*, *Prorocentrum micans*, *Protoperidinium depressum*, *Protoperidinium granii*, *Scrippsiella trochoidea* and *Emiliana huxleyi* species were the constant (F=100) species at sampling stations in the sampling seasons.

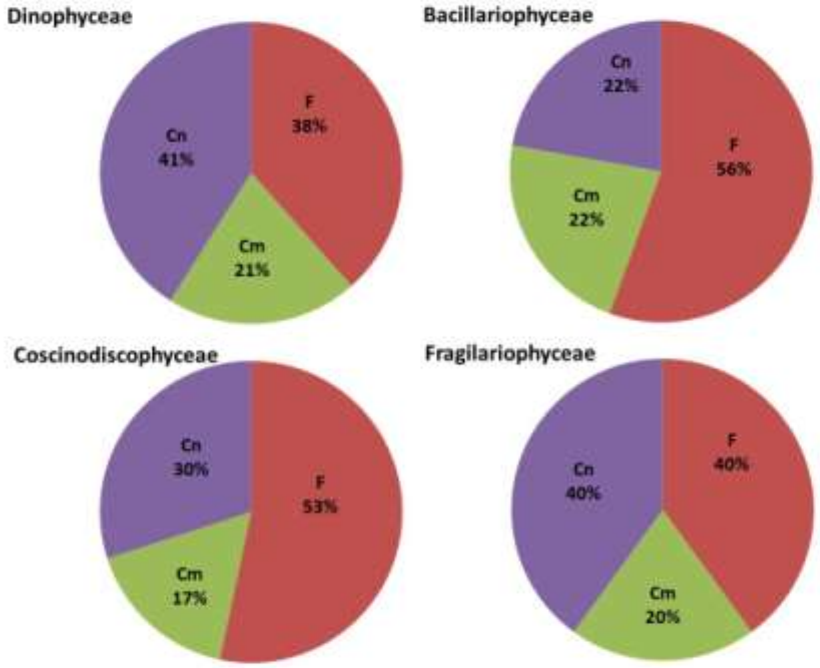

Figure 38. The frequency percentages of the species belonging to the important phytoplankton classes (%) in the sampling seasons.

The results of the cluster analysis performed on a presence-absence matrix of the species found in all sampling season are given in Fig. 39a and the results of MDS analysis performed on qualitative data are given in Fig.39b. As can be seen from the figure, two significant clusters (A and B) are formed among the stations at a similarity level of 0.60 (Fig. 39).

Phytoplankton reached its highest abundance and biomass values in July 2013 followed by October 2013. The lowest abundance and biomass values were calculated for May 2013 throughout the sampling period (Fig. 40). The results of the cluster analysis of the species abundance found in all stations and seasons are given in Fig. 41a and the results of MDS analysis performed on quantitative data are given in Fig. 41b. Discrimination was prominent with a significant stress factor of 0.01. As can be seen from the figure, four significant clusters (A, B, C and D) are formed among the stations at a similarity level of 0.60 (Fig. 41). As a result of this analysis, each season formed its own clusters.

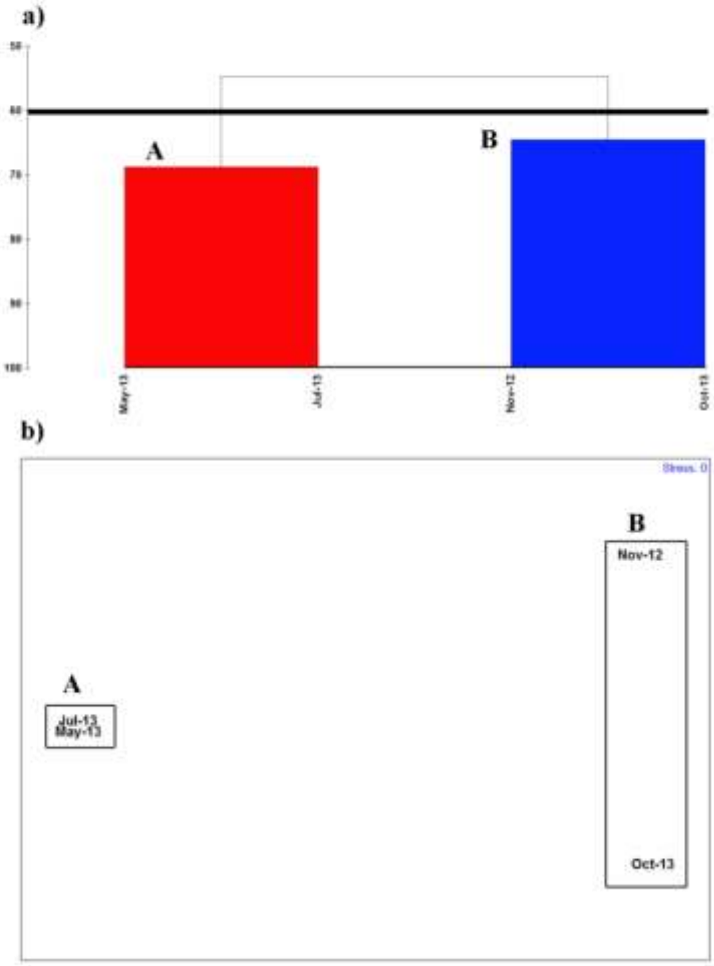

Figure 39. The dendogram (a) and MDS diagram (b) of qualitative clustering analysis of phytoplankton in sampling seasons

In order to support the results of MDS and Cluster analyzes, AnoSIM (Analyses of Similarity) was performed. As a result of this analysis, the phytoplankton community of the area was observed to show a seasonal change. A statistically significant difference was found among seasons. (Sample statistic-Global R: 0.92, Significance level of sample statistic: 0.001). However, no statistically significant difference was found among depths (Sample statistic-Global R: -0.126, Significance level of sample statistic: 0.986).

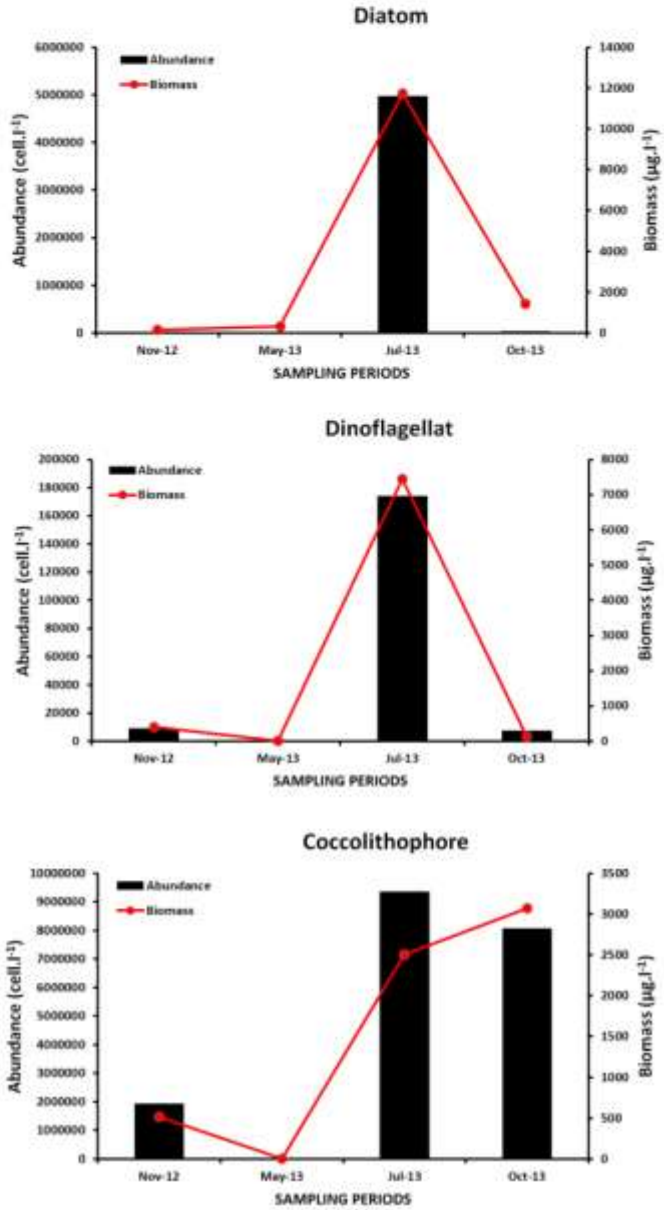

Figure 40. Distribution of abundance (cell.l^{-1}) and biomass (µg.l^{-1}) of the main phytoplankton groups in the sampling season.

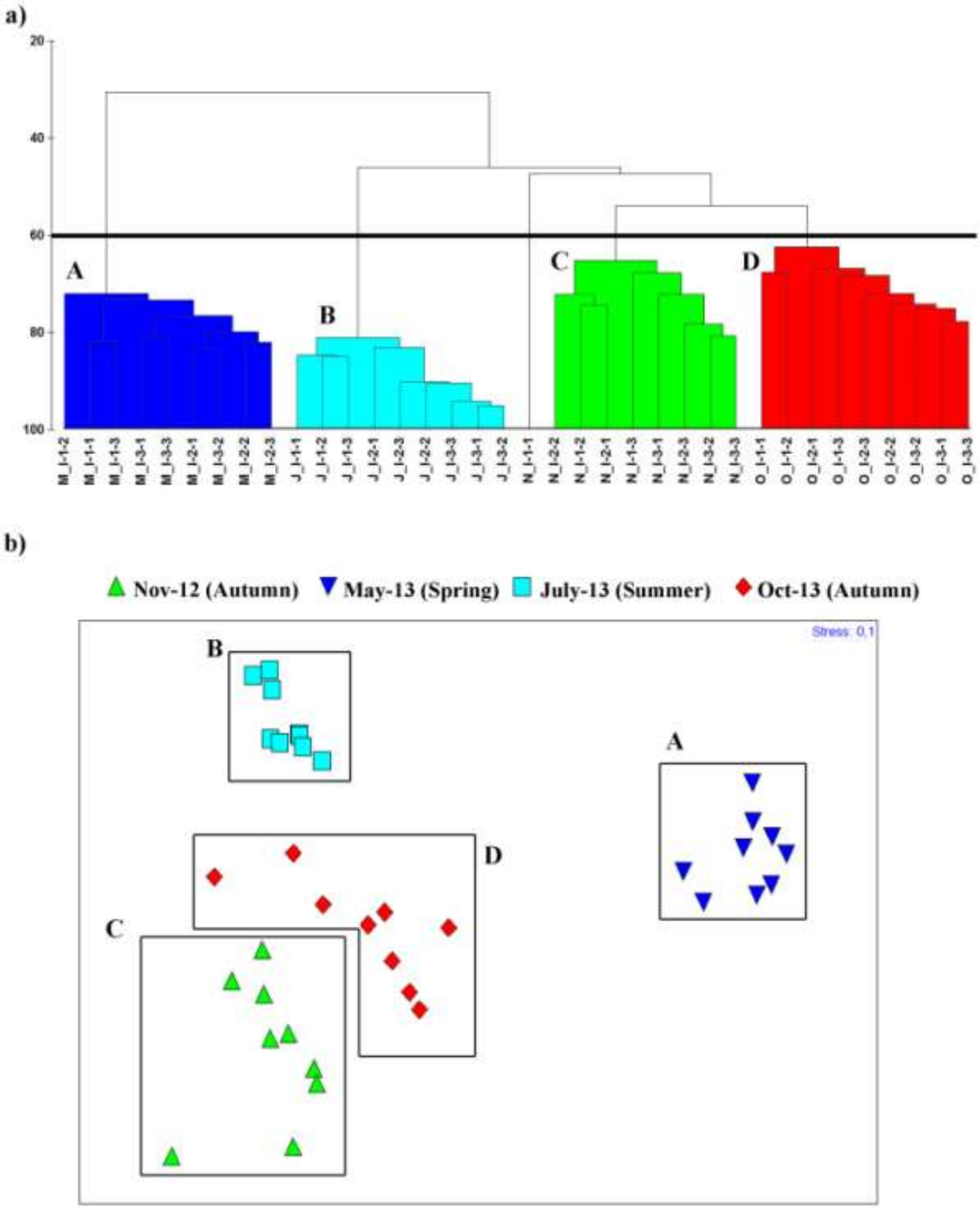

Figure 41. The dendogram (a) and MDS diagram (b) of quantitative clustering analysis of phytoplankton in sampling seasons.

3.2. Ecological status of macrophytobenthos community

STRANDZHA AREA

Material and methods

In laboratory, the samples have been either preserved in a freezer (-20°C), or fixed in formalin (4%). Before identification of species, the samples were well rinsed under running water through a sieve to remove sand, zoobenthos and other possible particles. Then, there were identified to the lowest taxonomic level under the microscope. For species identification were used the guidebooks of Zinova, 1967, Dimitrova – Konaklieva, 2000, Temniskova et al., 1999. Taxonomic nomenclature was standardized in accordance with Algae base: http: //www.algaebase.org//. Each species was dried for a while on a filter paper and then weighted on a scale with precision of two decimals. All species weighting at least 0.5 g. m^{-2} were taken into account. Wet weight (g) was multiplied by coefficient 25 to obtain biomass on square meter (Minicheva, 2003, Orfanidis 2012). Species were divided into Ecological State Groups (ESGI - sensitive and ESGII - tolerant species).

Macrophytes community taxonomic composition in October 2012

During the study period, based on the qualitative analysis, 32 taxa assigned to the following phyla were identified: 7 species of Chlorophyta, 21 species of Rhodophyta, 4 species of Ochrophyta (Table 13). Out of them 13 species were categorized as sensitive (ecological state group – ESGI) and 29 – tolerant (ecological state group - ESGII). In the group ESGI, 3 species were ESGIA, 2 species - ESGIB, 8 - ESGIC and from ESGII, 5 were ESGIIA, 4 - ESGIIB, 3 - ESGIICa, 7- ESGIICb.

Table 13. Species list of macrophytes in sampling seasons and ecological state groups (ESG).

SPECIES LIST	SAMPLING PERIOD			ESG
	August 2012	October 2012	July 2013	
Chlorophyta				
Chaetomorpha linum (O.F.Müller) Kützing	-	-	+	ESGIIA
Cladophora albida (Nees) Kützing	-	+	+	ESGIICb
Cladophora coelothrix Kützing	-	+	-	ESGIIB
Cladophora vagabunda (Linnaeus) Hoek	+	-	-	ESGIICb
Cladophora vadorum (Areschoug) Kützing	+	-	-	ESGIICb
Ulva intestinalis L.	+	+	+	ESGIICb
Ulva rigida C. Agardh	+	+	+	ESGIICa

SPECIES LIST	SAMPLING PERIOD			ESG
	August 2012	October 2012	July 2013	
Ochrophyta				
Cladostephus spongiosus (Hudson) C.Agardh	-	+	+	ESGIC
Cystoseira barbata C. Agardh	+	+	+	ESGIA
Cystoseira crinita Duby	+	+	+	ESGIA
Sphacelaria cirrosa (Roth) C.Agardh	-	+	+	ESGIIB
Zanardinia typus (Nardo) G. Furnari	-	+	+	ESGIC
Rhodophyta				
Acrochaetium virgatulum J. Ag.	+	+	+	ESGIICb
Antithamnion cruciatum (J. Agardh) Nägeli	-	+	+	ESGIICb
Ceramium ciliatum (J.Ellis) Ducluzeau	+	+	+	ESGIIB
Ceramium circinatum J. Agardh	+	+	+	ESGIIB
Ceramium diaphanum (Lightfoot) Roth	+	+	+	ESGIICa
Ceramium virgatum Roth	+	-	-	ESGIICa
Corallina officinallis Linnaeus	+	+	+	ESGIC
Ellisolandia elongata (J.Ellis & Solander) K.R.Hind & G.W.Saunders		+	+	ESGIC
Gelidium crinale (Turner) Lamour.	+	+	+	ESGIIA
Gelidium spinosum (Gmelin) Silva	+	+	+	ESGIC
Hildenbrandia rubra (Sommerfelt) Meneghini	+	+	+	ESGIC
Laurencia coronopus J.Agardh	-	+	+	ESGIB
Palisada thuyoides (Kützing) Cassano, Sentíes, Gil-Rodríguez & M.T.Fujii in Cassano et al	+			ESGIB
Hydrolithon farinosum (J.V.Lamouroux) D.Penrose & Y. M.Chamberlain	+	+	-	ESGIC
Phyllophora crispa *Polysiphonia elongata (Huds.)* Harv. in Hooker	- -	+ +	+ +	ESGIA ESGIIA
Polysiphonia fibrillosa (Dillwyn) Sprengel	-	+	+	ESGIIA
Polysiphonia fucoides (Hudson) Greville	+	-	-	ESGIIA
Polysiphonia subulifera (C. Agardh) Harv.	+	+	+	ESGIIA
Stylonema alsidii (Zanardini) K.M.Drew	+	+	+	ESGIICb
Phymatholiton lenormandii (Areschoug) Adey	+	+	+	ESGIC

In Rezovo near the border and Rezovo 2 at 0-3m depth there were found 9 macrophyte species while on the Before Ahtopol, Varvara and Sinemoretz profiles, there were 11 taxons registered (Fig. 42).

On Rezovo 2 transect there were found 17 species comparative with 18 species on Rezovo 1 and 16 on "Before Ahtopol" transect at 0-15 m depth (Fig. 43).

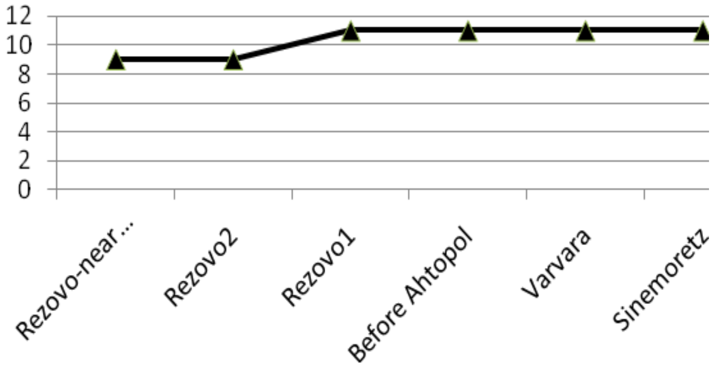

Figure 42. Number of species on each transect between 0 – 3 m depth in October 2012

Figure 43. Number of species registered between 0-15 m depth, in October 2012

Biomass of macrophytobenthic communities (0 -15m)

Cystoseira plays an important role in the diversification of existing habitats, acting as a second substrate for the epibionthic vagile species such as gastropod *Rissoa* splendida, *Bitium reticulatum*, *Tricolia pulus* or cryptic decapode *Macropodia sp.*, shells *Mytilaster lineatus* and *Mytilus galloprovinciallis*, barnacle *Balanus improvisus*, some hydrozoans and bryozoans, fish, crabs, marine sponges, actinias.

On all transects (Rezovo1, Rezovo2 and Before Ahtopol) between 0 and 3m dominated *Cystoseira crinita* community which gave the place to *Cystoseira barbata* community as the depth increased to 5 and 10 m, recording very high biomass at 5 m but low at 10 m. The highest biomass was estimated on Before Ahtopol (7,128.67 g*m^{-2}*)* at 5 m depth and the lowest one (283.39 g*m^{-2}) at 10 m depth. At 15 m *Gelidium spinosum* formed a well developed community. In "Before Ahtopol"at 0-3m depth the next after *Cystoseira crinita* with high biomasses were situated *Cladophora albida, Ceramium diaphanum,* *Laurencia coronopus* (252.56 g*m^{-2}). In Rezovo 1- at 5m depth except *Cystoseira Cladophora albida, Sphacelaria cirrhosa,* and *Gelidium spinosum* were present with high biomasses; in Rezovo 2- *Polysiphonia subulifera, Cladostephus spongiosus*; in Before Ahtopol - *Laurencia coronopus, Ceramium diaphanum, Polysiphonia subulifera*. Besides *Cystoseira* important contributions to biomass at 10m depth had *Sphacelaria cirrhosa* in Rezovo 1, *Gelidium spinosum, Gelidium crinale*. At 15 m depth important contribution had *Gelidium spinosum, Gelidium crinale*.

When compare biomass values at different depths in the studied area, it is evident that highest biomass was found at 5m depth (7917.97 g.m^{-2}) on "Before Ahtopol" transect. Biomasses at 0-3m depth were lower than at 5m depth, followed by biomass values at 10 and 15 m depth. The lowest biomass (309.25 g.m-^{2}) is estimated in Rezovo 1 transect at 15m depth (Fig. 44).

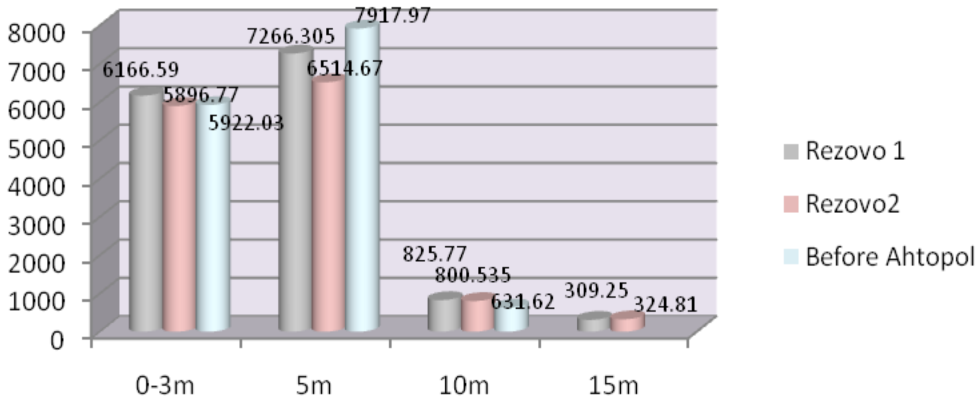

Figure 44. Biomass values of macrophytes at different transects at different depths (2012-2013).

Highest biomass was calculated for Before Ahtopol transect (5060 g.m^{-2} ± 3250.88), followed by that of Rezovo 1(4140.95 g.m^{-2} ± 3289.57) and Rezovo 2 (Fig. 45).

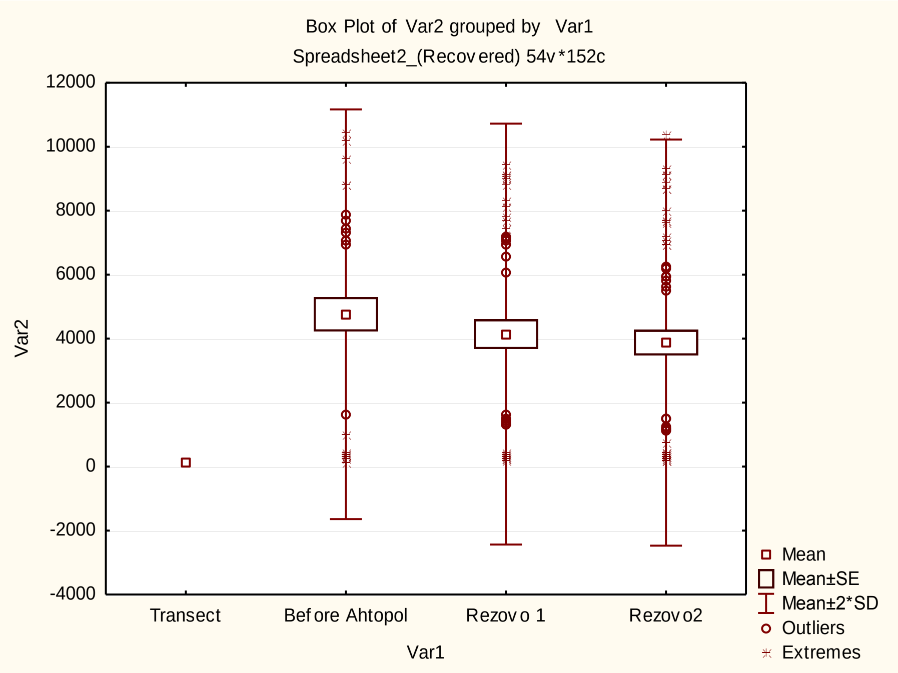

Figure 45. Total biomass of macrophytes from investigated transects (2012-2013).

Highest biomass proportion is that of Ochrophyta phylum and ranges from 89.27 in "Before Ahtopol" to 91.34% in Rezovo2. Chlorophyta and Rhodophyta were represented by low biomasses.

Sensitive species biomass percent is very high ranging from 94.5% to 91.77%, which is in agreement with high condition of marine water. Tolerant species biomass percent varies from 5.5% (Before Ahtopol) to 8.1 % - Rezovo1 (Fig. 46).

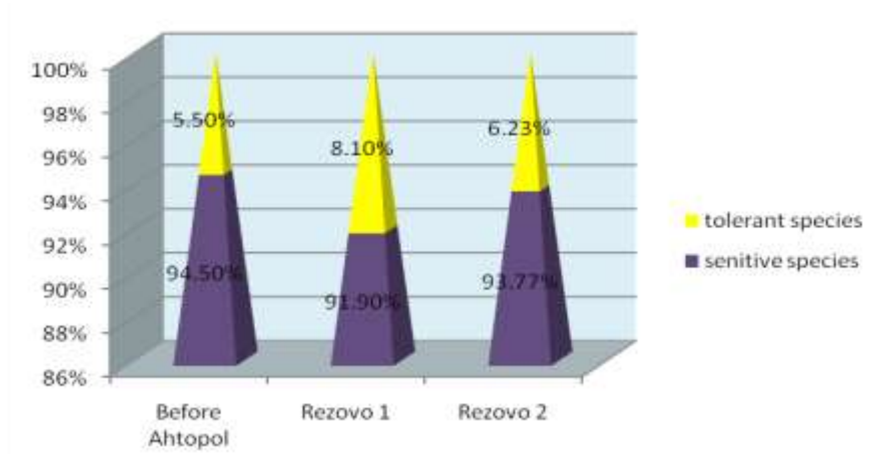

Figure 46. Proportion of sensitive and tolerant species biomass in investigated transects (2012-2013).

Highest diversity index value among the transects is found to be at transect "Before Ahtopol" (H'=1.68), and the lowest at transect "Rezovo 1" (H'=1.45) (Fig. 47)

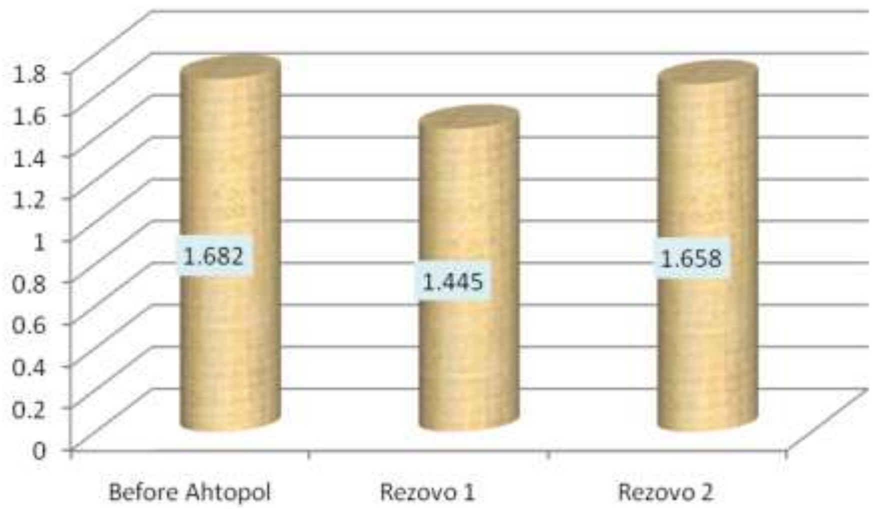

Figure 47. Diversity index values at sampling transects in 2012-2013 years.

Highest diversity index value among the stations was found to be at station I-2-3 (H'=3,30), and the lowest at station I-2-2 (H'=1.92). Evenness index (J') values ranged between 0.41 (Before Ahtopol) and 0.36 (Rezovo 1) (Fig. 48). There have been observed an even distribution of the identified species at sampling stations.

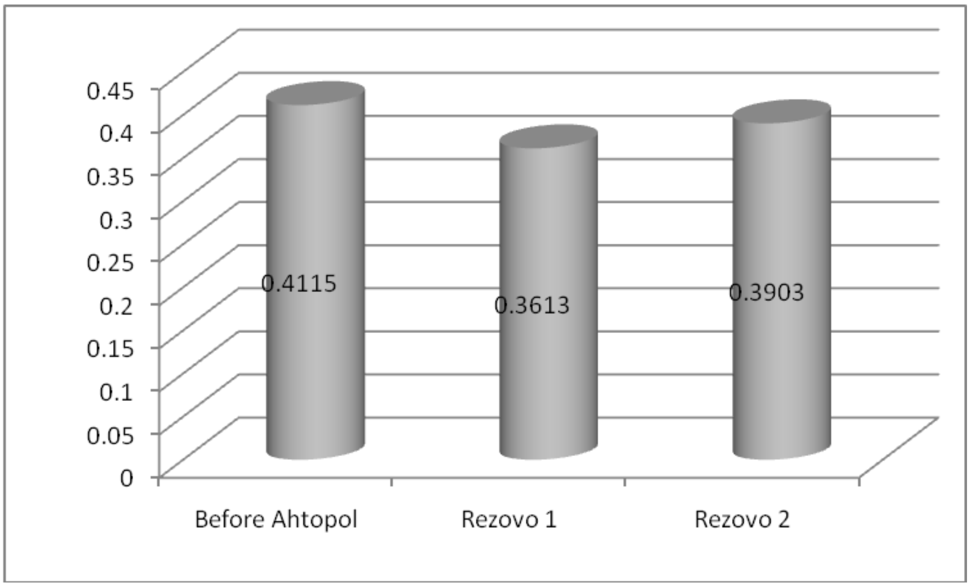

Figure 48. Eveness index (J') values at sampling transects - 2012-2013 years

When the results of Bray-Curtis Similarity Index analyze are taken into consideration, two separate species clusters are observed. The similarity between "Before Ahtopol" transect and Rezovo 1, Rezovo 2 transects was of 85 %. Between Rezovo 1 and Rezovo 2, the similarity was 95 % (Fig. 49).

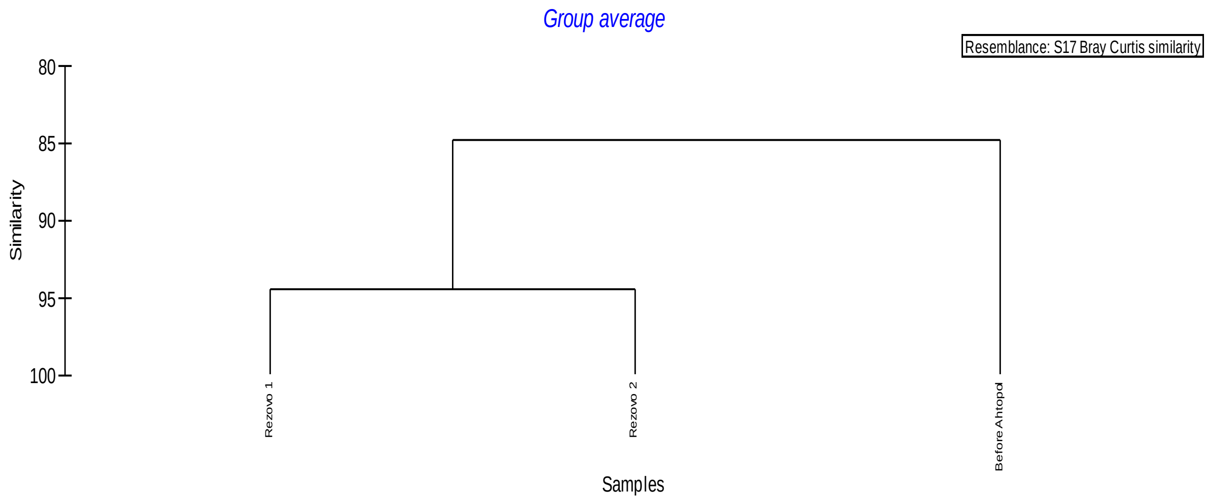

Figure 49. Dendogram graph Bray- Curtis similarity analisys for MISIS monitoring transects

In Table 14 could be seen the average biomass distribution of some invertebrates in meadows of *Cystoseira* community.

Table 14. Biomass distribution of *Cystoseira* foulings *(Mytilus galloprovincialis, Mytilaster lineatus, Tricolia pullus, Rissoa splendida, Bitium reticulatum, Amphibalanus improvisus*) - 0-10m depth.

Transect	Biomass ($g.m^{-2}$)	stdev
Before Ahtopol	208.27	272.85
Rezovo 1	295.43	295.05
Rezovo2	401.77	413.63

Ecological status

The ecological status assessed with ecological index-ecological quality ratio (EI-EQR) from 0 - 5m depth for 2012 (Table 15) and 2013 (Table 16) year is high. The ecological status in all the investigated transects in 2012 at 0-3m depth is high (Fig. 50).

Table 15. Ecological status and ecological quality ratio of ecological index in 2012 year from 0-5m depth

year 2012						
Depth/Transect	Rezovo1	Rezovo2	Before Ahtopol	Rezovo	Sinemoretz	Varvara
0-3m	0.94	0.95	0.97	0.85	0.9	0.93
5m	0.95	0.97	0.93	0.9		

Table 16. Ecological status and ecological quality ratio of ecological index in 2013 year at 5m depth

2013 year		
Rezovo1	Rezovo1	Rezovo2
0-3m		
5m	0.94	0.95

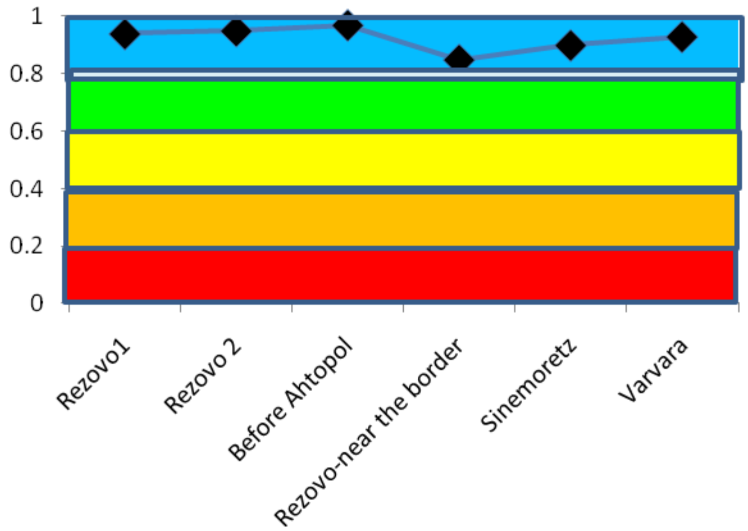

Figure 50. Ecological status of all the investigated transects in 2012 at 0-3m depth (Blue-high status; green-good status; yellow- moderate status; orange-poor status; red-bad status)

In Table 17 is presented ecological status at 0-1m depth, established with ecological index-ecological quality ratio (EI_EQR) for Bulgarian part of protected area and compared with ecological status established for Turkish side (0.2 m) (Table 21). For Bulgarian part ecological status is high and in Turkish side it is good. The good status is due to lower biomass of *Cystoseira* and *Zostera* at 0-2m depth, which is normal for this depth in comparison with 0.5-1m depth.

Table 17. Ecological status, ecological quality ratio of ecological index in Bulgarian part of protected area at 0-1m depth (blue-high ecological status)

depth	Rezovo1	Rezovo 2	Before Ahtopol
0-1m	0.92	0.92	0.92

For comparison is given the ecological status of macrophytobenthic communities in Sinemorets and Varvara which are part of the Strandzha protected area estimated too with Ecological index in 2006-2008 years. For these years, final ecological status in Sinemoretz was high (0.85) and for Varvara it was on the border of high/good (0.8). In 2012 improvement is noticed in ecological status (see Table 18).

Table 18. Ecological index-Ecological Quality Ratio, estimamed for macrophytobenthic communities, 2006 - 2008)

Transect/year	2006	2007	2008	EI-EQR average
Sinemoretz	0.82	0.89	0.85	0.85
Varvara	0.75	0.82	0.81	0.8

IGNEADA AREA

Material and Method

During sampling expeditions carried out in November, 2012, May and July 2013 in Igneada area, 1 macrophyte sample per each station (B1_HB and B2_HB) and season has been collected. All algae comprised within a standard 20x20 cm metal frame were detached (scraped off) carefully from the rocky bottom using a spatula handled by divers.

Species Composition of macrophyta

Based on the qualitative analysis, 13 taxa were identified, assigned to the following phyla: 6 species of Chlorophyta, 5 species of Rhodophyta, 1 species of Heterokontophyta and 1 species of Tracheophyta (marine phanerogams) (Table 19).

Table 19. Species list of the macrophyta in the sampling seasons.

PHYLUM	CLASS	SPECIES
Chlorophyta	Ulvophyceae	*Cladophora laetevirens* (Dillwyn) Kützing, 1843
		Cladophora fracta (O.F. Müller ex Vahl) Kützing, 1843
		Cladophora glomerata (Linnaeus) Kützing, 1843
		Cladophora sericea (Hudson) Kützing, 1843
		Rhizoclonium tortuosum (Dillwyn) Kützing, 1845
		Ulva intestinalis L. 1753
Rhodophyta	Florideophyceae	*Ceramium virgatum* Roth, 1797
		Laurencia obtusa (Hudson) J.V. Lamouroux, 1813
		Lomentaria clavellosa (Lightfoot ex Turner) Gaillon, 1828
		Parviphycus antipai (Celan) B. Santelices, 2004
		Polysiphonia fucoides (Hudson) Greville, 1824
Tracheophyta	Monocots	*Zostera* (Zosterella) *noltei* Hornemann
Heterokontophyta	Phaeophyceae	*Cystoseira crinita* Duby, 1830

Among macrophytes, the perenial algae *Cystoseira crinita* dominated, forming a well delimited belt in the exposed midlittoral and infralittoral at 10 m depth. Other macrophytes species, such as *Cladophora* spp. in shallow waters, *Ceramium virgatum* and *Laurencia obtusa* at 0.2 - 5 m depth, were also found in sampled stations. *Cystoseira* plays an important role in the diversification of existing habitats, acting as a second substrate for the epibionthic vagile species such as the gastropods or the cryptic decapode *Pilumnus minutus*. Generally phytobenthic vegatation is dominated by *Cystoseira crinita*, while *Zostera noltei* forms patchy meadows on fine sand infralittoral.

Biomass of macrophytes species

The biomass values of macrophytes sampled in the region were given in Table 20. *Cystoseira, Ceramium virgatum* and *Cladophora* spp. were the dominant species in the region from this point of view.

Table 20. Biomass (wet weight. $g.m^{-2}$) of the macrophytes during the sampling seasons

Sampling Period	Stations	Species	Biomass
Nov-2012	**B-1_HB**	*Cladophora laetevirens*	51,05
		Cladophora sericea	26,6
		Rhizoclonium tortuosum	24,625

		Ceramium virgatum	130,625
		Laurencia obtusa	191,575
		Lomentaria clavellosa	27,1
		Parviphycus antipai	4,675
		Polysiphonia fucoides	161,125
		Cystoseira crinita	1432,25
	B-2_HB	*Cladophora glomerata*	9,4
		Cladophora laetevirens	68,75
		Ulva intestinalis	239,2
		Ceramium virgatum	104,375
		Parviphycus antipai	6,025
		Zostera (Zosterella) *noltei*	1029
May-2013	**B-1_HB**	*Ceramium virgatum*	180,35
	B-2_HB	*Cladophora fracta*	21,025
		Cladophora laetevirens	81,5
		Ulva intestinalis	504,55
		Ceramium virgatum	110,875
		Parviphycus antipai	2,325
July-2013	**B-1_HB**	*Cladophora laetevirens*	196,575
		Ulva intestinalis	813,65
		Parviphycus antipai	11,375
		Polysiphonia fucoides	228,425
		Cystoseira crinita	1594,55

Table 21. Ecological status, ecological quality ratio of ecological index in Turkish part at 0-0.2 m depth (yellow-moderate ecological status, green- good ecological status)

B 3- j 13	B 3- n 12	B 3- n 12	EI-EQR (aver)
0	0	0	0.64

3.3. Ecological state of the zooplankton populations

STRANDZHA AREA

Material and methods

The sampling for all chemical and biological parameters, including zooplankton was conducted in July 2013. Totally 3 samples were taken from three stations **Veleka, Rezovo 1** and **Rezovo 2.** Closing "Juday" zooplankton net with mouth diameter of 36 cm (mouth area: 0.1 m^2) and mesh size of 150 µm (Korshenko & Alexandrov, 2005) was used for the sampling procedure. Zooplankton samples (1 l) were collected following routine standard methods, unified for all Black Sea countries (Korshenko & Alexandrov, 2012). The samples were collected from integral vertical layer (bottom to surface) and fixed in buffered with disodiumtetraborate (borax) ($Na_2B_4O_3.10H_2O$) 4 % formaldehyde solution after removing, counting and measuring of gelatinous species (*Aurelia aurita, Pleurobrachia pileus, Mnemiopsis leidyi* and *Beroe ovata*) if they were present in the samples.

Fixed samples were concentrated to 100 ml in the lab. A sub-sample (approximately 1/5 of sample) was used for qualitative and quantitative analysis. Taxonomic identification was done to species or to the possible lowest taxonomic level and based on the list of the Black Sea zooplankton (Korshenko & Alexandrov, 2012 - Annex 1), using mainly taxonomic guidance of Morduhai-Boltovskoi (1968, 1969, 1972). The species identification was done under stereomicroscope **"Olympus" SZ 51** and zooplankton counting was processed as in Korshenko & Alexandrov, 2012. Abundance is given in $ind.m^{-3}$; standard individual weight of each species is applied for biomass calculation (Petipa, 1959) in $mg.m^{-3}$. Systematic classification and nomenclature of zooplankton species were made according to WoRMS.

Proposed/applied zooplankton indicators

The Water Framework Directive did not require the zooplankton as biological quality element. Monitoring report (2012) has tried to implement WFD approach for zooplankton. Classification system was developed on seasonal base where it was appropriate (Table 22).

- Mesozooplankton biomass
- Biomass of *Noctiluca scintillans*
- Biomass of invasive species *Mnemiopsis leidyi*
- Biodiversity index Shannon-Wiener

Table 22. Zooplankton metrics, relevant scales and references

Metrics/dimension	Scale	References
1. Mesozooplankton biomass [мг.м$^{-3}$]		(Korshenko, Alexandrov, 2012)
- spring	<10 - 400	
- summer	<30 – (900-1300)	
- autumn	<10 – (350-500)	
2. Biodiversity index of [bit.ind^{-1}]		(Korshenko, Alexandrov, 2012)
Shannon-Wiener	<1 - >4	
3. N. scintillans biomass [mg.m^{-3}]		(Korshenko, Alexandrov, 2012)
- spring/summer	<60 - >4000	
4. M.leidyi biomass [g.m]		(Vinogradov et al. 2005)
- Summer	< 1 - > 50	

General characteristic of zooplankton community

On the base of limited data (national monitoring 2012, 2013) and literature (Konsulov, 1975, 1991, Kamburska &Valcheva, 2003, Kamburska, 2004) for the area adjacent to the MPA, main patterns of zooplankton community structure were extracted. A total of 26 zooplankton species and taxa distributed among to phyla of holoplankton Protozoa (1), Nemathelminthes (2), Ctenophora (3), Cnidaria (2), Arthropoda (10), Chaetognatha (1), Chordata (1), meroplankton – Annelida (1), Mollusca (2), Arthropoda (2) and ichthyoplankton (Vertebrata) were listed (Konsulov, 1975, 1991). Key groups Copepoda (*Acartia clausi, Paracalanus parvus, Oithona nana, Oithona similis, Centropages ponticus, Pseudocalanus elongatus*), Cladocera (*Pleopis polyphemoides, Penilia avirostris, Evadne spinifera*, *Pseudevadne tergestina*), and Meroplankton (Bivalvia veliger, Gastropoda veliger, Polychaeta larvae, Cirripedia nauplii Cirripedia cypris, Decapoda larvae) constituted a major component of plankton fauna with an ecological importance in the zooplankton structure (Konsulov, 1975, 1991). Opportunistic dinoflagellate *Noctiluca scintillans* was evaluated as an important part of the zooplankton community as well, especially in spring. Spatial distribution pattern of zooplankton biomass in the study area revealed decreasing trend from north to south close to MPA with lower values but relatively high biodiversity indices and ecological quality status. (Kamburska&Valcheva, 2003, Kamburska, 2004)

Species composition and taxonomic structure during the MISIS project investigation

Results studies indicated the occurrence of maximum 23 taxa (Veleka) (Table 23) ranked by the main taxonomic divisions belonging to phyla Protozoa, Cnidaria, Ctenophora, Annelida, Arthropoda, Mollusca, Chaetognatha, Chordata. The phylum Arthropoda was the most diverse (8 species and 4 taxa).

Diversity richness was due to the presence of copepoda species *Acartia clausi, A. tonsa, Paracalanus parvus, Centropages ponticus, Oithona davisae* and cladoceras *Pleopis polyphemoides, Penilia avirostris* and *Pseudevadne tergestina* and benthic larvae (meroplankton). Obviously, the key groups of Copepods, Cladocera, and Meroplankton constituted a major component of plankton fauna together with *Noctiluca scitntillans*, Appendicularia and Chaetognatha (Fig. 51).

Table 23. Zooplankton species composition during the MPA exercise in July 2013.

Station	Veleka	Rezovo1	Rezovo2
Layer	**10-0**	**18-0**	**18-0**
Species /Taxa			
Acartia (Acantacartia) tonsa Dana, 1849	*	*	*
Acartia (Acartiura) clausi Giesbrecht, 1889	*		*
Paracalanus parvus parvus (Claus, 1863)	*		
Centropages ponticus Karavaev, 1895	*	*	*
Oithona davisae Ferrari F.D. &Orsi, 1984	*	*	*
Harpacticoida sp.	*		
COPEPODA			
Pleopis poliphemoides (Leuckart, 1859)	*	*	*
Penilia avirostris Dana, 1849	*	*	*
Pseudevadne tergestina (Claus, 1877)	*		
CLADOCERA			
Polychaeta larvae	*	*	*
Bivalvia veliger	*	*	*
Gastropoda veliger	*	*	*
Cirripedia nauplii +cypris	*	*	*
Decapoda zoea	*	*	*
Decapoda mysis		*	*
Larvae Bryozoa	*	*	*
Ascidacea larvae	*		
MEROPLANKTON			
Oikopleura (Vexillaria) dioica Fol, 1872	*	*	*
APPENDICULARIA			
Parasagitta setosa (Müller, 1847)	*	*	*
CHAETOGNATHA			
Engraulis encrasicolus (Linnaeus, 1758) ova+larvae	*	*	*
Pisces ova	*	*	
PISCES			
Noctiluca scintillans (Macartney) Kofoid & Swezy, 1921	*	*	*

Station	Veleka	Rezovo1	Rezovo2
Layer	10-0	18-0	18-0
DINOFLAGELLATA			
Aurelia aurita (Linnaeus, 1758)	*		
SCYPHOZOA			
Mnemiopsis leidyi A. Agassiz, 1865	*	*	
Beroe ovata Bruguière, 1789	*	*	*
Pleurobrachia pileus (O. F. Müller, 1776)		*	
CTENOPHORA			
TOTAL	23	20	18

Copepoda formed 40 % of the abundance community taxonomic structure in Veleka station followed by meroplankton (26 %) and *N. scintillans* (13%). Veleka station has differentated of the Rezovo 1 and 2, very similar in the taxonomic structure, by the benthic larvae domination (53 % and 59 % respectively) (Fig. 51 left panel). Biomass evenness among key groups in Veleka is obvious (figure 3.2-1 right panel) and resulted in higher Pielou index (J= 0.75). In Rezovo 2 *Beroe ovata* occurence leaded to its domination in the community structure (figure 3.2-1 right panel) while in Veleka and Rezovo 2 zooplankton community was shifted to *Noctiluca* (about 36 %) and meroplankton (19% and 32 %).

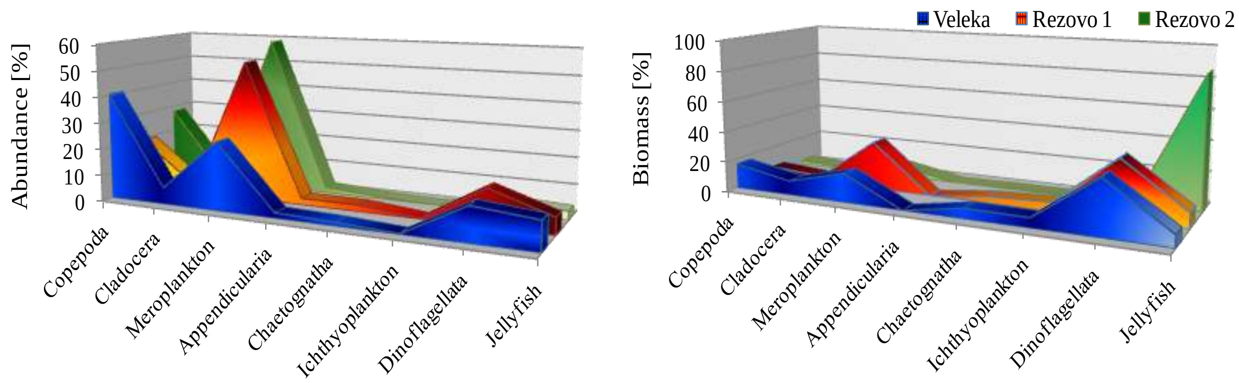

Figure 51. Percentage composition of different groups of zooplankton abundance (left panel) and biomass (right panel)

Zooplankton abundance and biomass

The obtained results for zooplankton abundance revealed a slight variation, only 1.5 fold (from 4063 ind.m^{-3} in Rezovo 1 to 6111 ind.m^{-3} – Rezovo 2), while the respective figures for the total biomass were from 119.856 mg.m^{-3} to 813.428 mg.m^{-3} (the range about 7 times) (Fig. 52). The numerically dominant copepods were *Acartia tonsa, Oithona davisae, A. clausi* and *Centropages ponticus*, Meroplankton, including the larvae of cirripedia, large crustaceans, various worms, bivalve and gastropod molluscs, represented a large fraction (average 2043 ind.m^{-3}±1074) of total zooplankton abundance. A number of other zooplankton taxa were also present, including harpacticoid, cladocerans, the larvacean *Oikopleura dioica*, chaetognaths and gelatinous medusa (Fig. 53A). Copepods and meroplankton were the most important groups in zooplankton community with large fluctuations. According to biomass presence of eggs and larvae of *B.ovata* (ctenophors) shifted the plankton community fauna (Fig. 53B).

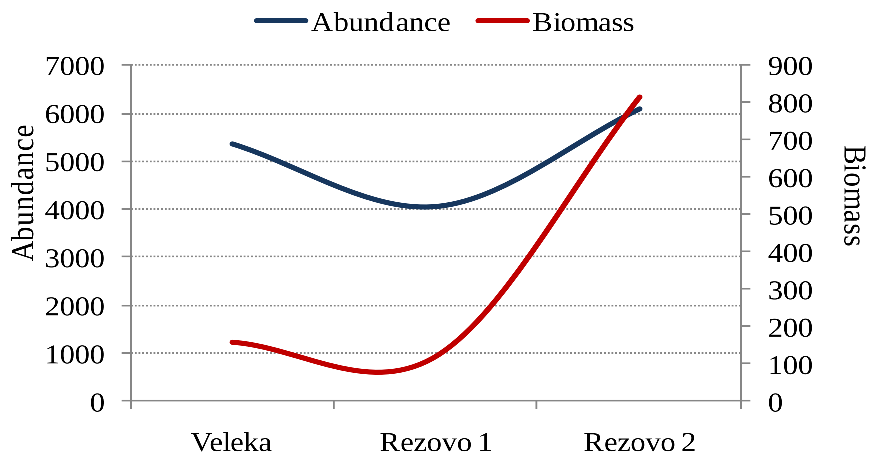

Figure 52. Variability of the total zooplankton abundance [ind.m^{-3}] and biomass [mg.m^{-3}] by sampling stations

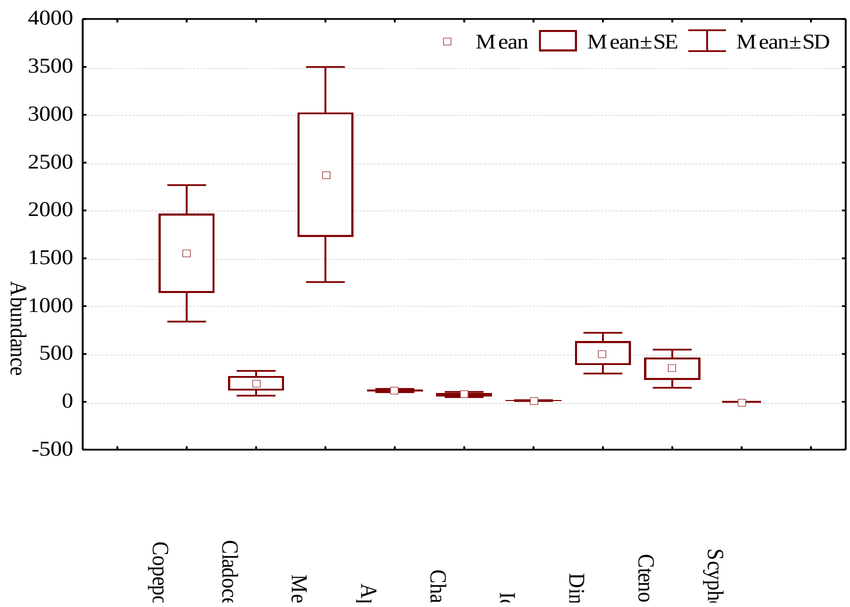

Figure 53A. Box-whiskers plots of zooplankton abundance

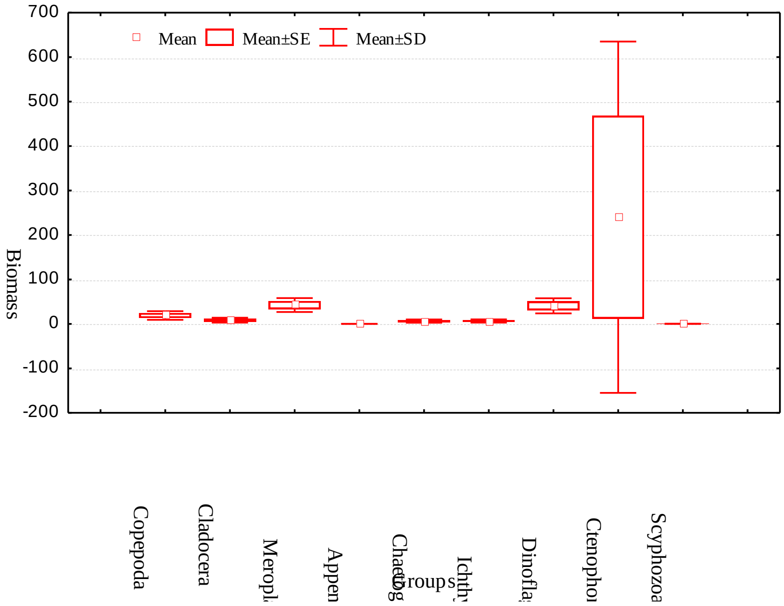

Figure 53B. Box-whiskers plots of zooplankton abundance and biomass by key groups in the study area.

Ecological quality status

Zooplankton constitutes a diverse group of organisms with respect to size, life cycle and behaviour. Plankton fauna is an important link between the phytoplankton and higher trophic levels such as fish. Despite the importance of zooplankton as consumers of primary production and as agents of energy transfer and nutrient cycling they have not been widely used as indicators of environmental condition and zooplankton is not included as a relevant quality element for the assessment of ecological status within Water Framework Directive. One of the methods for classification of ecological state of coastal ecosystems is the determination of the conditions under (near-) pristine period, namely reference conditions which were deduced from historic records. Based on the available long term zooplankton data (1967 – 2009) reference values of proposed indicators and the extent of deviation from these reference conditions were determined to classify the water quality to five status classes: high, good, moderate, poor and bad. To establish baselines and acceptable variability for specific indicators percentile approach was applied. 5 percentile (lower quartile) of a long term data set for definition of reference values based on the best available data and the 95 percentile (upper) for the selection of "bad values" (from the period of intensive eutrophication). Ecological Quality Ratio was evaluated as equal intervals between "high" and "bad" values and where it was appropriate expert judgment was applied.

Interannual variations in zooplankton density and biomass were very broad in space and time and not normally distributed ($p<0.05$). Long-term data analysis showed that zooplankton community with related metrics passed through positive (1966-1973) to negative phase (1980-1993) (Stefanova et al, 2008)

- ***Mesozooplankton biomass***

Proposed classification thresholds are presented in the Table 24 A in seasonal aspect. According to the classification limits for the summer season the state of three stations is poor due to very low biomass index (Table 24 B). Development of *N.scintillans* and *M.leidyi* in summer reflected on mesozooplankton biomass, since both negatively correlated with the biomass of plankton fauna. From other hand the period of investigation coincided with storm conditions which also lead to lower biomass values.

Table 24. Classification scheme and EQR based on mesozooplakton biomass [mg/m^3] A) by seasons and B) mesozooplankton biomass in July 2013

A)

Season/State	High	Good	Moderate	Poor	Bad
Spring	400-270	269-140	139-70	69-11	10
EQR	1	0.7	0.3	0.2	
Summer	1300-900	900-500	500-200	200-30	30
EQR	1	0.8	0.5	0.3	
Autumn	500-350	350-200	200-50	50-10	10
EQR	1	0.6	0.4	0.1	

B)

Index	Veleka	Rezovo I	Rezovo 2
Mesozooplankton biomass	76.5	62.5	95.4

- ***N. scintillans biomass***

The wide feeding spectrum (phytoplankton, zooplankton and detritus) of the species, development in high bloom concentrations especially in spring, usually after the mass development of phytoplankton, determines its ecological importance for the pelagic ecosystem (Kiørboe, Titelman 1998, Kiørboe et al. 1998, Dela-Cruz et al. 2003). *N.scintillans* density is usually higher in coastal areas where maximum phyto- and zooplankton were registered. For detection of classification limits the period of intensive eutrophictaion (1980-1993) was selected as "low" ecological state. According to the index, ecological status was defined as high with range from 21.84 to 54.96 mg.m^{-3} (Table 25).

Table 25. Classification and EQR based on *N. scintillans* biomass [mg/m^3] index (A) and *N. scintillans* biomass in July 2013 (B)

A)

	High	Good	Moderate	Poor	Bad
N.scintillans	< 60	60-250	250-500	500-4000	> 4000
EQR	1	0.95	0.9	0.2	

B)

State	Veleka	Rezovo 1	Rezovo 2
N.scintillans	54.960	45.28	21.84

- ***Shannon Wiener index***

Classification scheme was based on the maximum number of species found in the reference period, without taking into account the seasons. Initial separation to 5 environmental classes (according to WFD) is presented in Table 26. According to the proposed classification limits of Shannon Wiener index the ecological state varied between moderate (Rezovo1) and good (Veleka) with exception of Rezovo 2 (less than 2 bit/ind) where *B.ovata* occurrence in the sample decreases the ecological status.

Table 26. Classification and EQR based on *Shannon Wiener* index (A) and diversity index in July 2013 (B)

A)

	High	Good	Moderate	Poor	Bad
H ‘	> 4	4 -3	3 - 2	2 -1	<1
EQR	1	0.78	0.56	0.33	

B)

	Veleka	Rezovo 1	Rezovo 2
H (A)	3.78	2.87	2.81
H (B)	3.41	2.97	1.05

- ***M. leidyi biomass index***

Assessment of populations of non-native species in the Black Sea could be used as a biological indicator for stability and health of the ecosystem (Moncheva, Kamburska, 2003). As a key factor for the mesozooplankton development, *M. leidyi* became a reliable indicator for the pelagic ecosystem dynamic and functioning of other trophic levels in the Black Sea food web. As threshold 4 gr/m^3 was taken under consideration (Vinogradov et al. 2005) (Table 27). Like most plankton metrics, changes in biomass of *M.*

leidyi in the last 10 years widely ranged from 0.1 to 136 gr.m^{-3} ± 34. The National monitoring observations (2012-2013) also confirmed the large fluctuations of the species (average 12 g.m^{-3} ± 34.5, maximum – 209 g/m^3).

According to the *M. leidyi* biomass index ecological state varied from high to good (Table 27).

Table 27. Classification and EQR based on *M.leidyi* biomass (mg/m^3) index

A)

	High	Good	Moderate	Poor	Bad
***M. leidyi* biomass**	0	1-4	4-20	20-50	>50
EQR	1	0.96	0.75	0.38	

B)

State	Veleka	Rezovo 1	Rezovo 2
M. leidyi biomass	2.35	1.04	0.0

Comparison with 2012 and 2013 state

Prevalence in determining ecological state in the monitoring reports 2012, 2013 was the mezozooplankton biomass index. Nevertheless, we are considering hypothesis of lower mesozooplankton biomass values in southern part of the Black Sea coast (Kamburska &Valcheva, 2003, Kamburska, 2004) and the fact that according to various indices cases of high status were 35%, good and moderate (20%) and poor condition were only 25% (Table 28).

Table 28. Classification of ecological state of MPA area according to zooplankton indicators, comparison with monitoring data (2012-2013) in summer.

Indicators	Veleka		Veleka	Rezovo 1	Rezovo 2
	2012	2013	2014		
Mesozooplankton biomass	poor	poor	poor	poor	poor
Noctiluca scintillans biomass	high	high	high	high	high
Mnemiopsis leidyi biomass	high	good	good	good	high
Shannon-Wiener index	moderate	moderate	good	moderate	moderate

Analyzing zooplankton data used for determination of the classification could be conclude that status of the MPA coastal areas in July 2013 was defined from good to moderate. Differences in zooplankton taxonomic structure among areas were not insignificant. According to applied indicators and on the base of expert judgment (south area of Bulgarian coast close to MPA demonstrated lower biomass values but relatively higher biodiversity indices) the status of zooplankton community in Veleka station was evaluated as good, in Rezovo 1 and Rezovo 2 – moderate.

IGNEADA AREA

Material and Method

The zooplankton samples were collected by vertically towing a Standard Zooplankton Net, with mouth diameter of 50 cm and 112 µm mesh size. There were preserved on spot with borax buffered formalin solution (final concentration 4%) until subsecquent laboratory analysis.

In laboratory, the zooplankton samples underwent siphoning method and then there were transferred into a container of smaller known volume. For quantitative and qualitative analysis of zooplankton samples, these were first subsampled by extracting twice in a row as much as 1 ml pipette from a known volume container. This operation proceeded with counting and identification of organisms under a microscope equipped with zooplankton counting chamber. Species which didn't come across during sub-sampling and the rare groups (like Chaetognatha, Decapod larvae, fish eggs and larvae) were integrally counted (Harris et al*.,* 2000).

Samples were analyzed under Novex TZB-SF stereomicroscope. The main references used for the identification of major zooplanktonic groups were Zhong (1988), Özel (2003), Bradford-Grieve et al. (1999), Conway et al., (2003) and Razouls et al. (2012). Systematic classification and nomenclature of zooplankton species were done according to Appeltans et al. (2012). Biomass transformations were based on wet individual weights (Niermann and Kideys, 1995). The abundance and biomass results were given in ind.m^{-3} and mg.m^{-3}.

Abundance data (X) were transformed using Log10(X+1) as result of application of Taylor's Power Law (Taylor 1961). Species abundance among sites was tested using Cluster, MDS and ANOSIM (multivariate analyses) (Clarke and Green, 1988; Clarke and Warwick, 1993).

Species Composition of Zooplankton

The overall results evinced a composition made of 7 holoplankton and 12 meroplankton groups. Holoplanktonic copepods and cladocerans were identified to genus and species level. Totally, there were 12 species of copepods and 4 species of cladocers found (Table 29).

Table 29. The species list of zooplankton in cruise periods.

SPECIES LIST	SAMPLING PERIOD			
	Nov-12	May-13	Jul-13	Oct-13
APPENDICULARIA				
Oikopleura (Vexillaria) dioica Fol, 1872	+	+	+	+
CLADOCERA				
Penilia avirostris Dana, 1849	+	-	+	+
Pleopis polyphaemoides (Leuckart, 1859)	-	+	+	+
Pseudevadne tergestina (Claus, 1877)	-	-	+	+
Evadne spinifera P.E. Müller, 1867	-	-	-	+
CHAETOGNATHA				
Parasagitta setosa (Müller, 1847)	+	+	+	+
COPEPODA				
Acartia (Acartiura) clausi Giesbrecht, 1889	+	+	+	+
Acartia (Acantacartia) tonsa Dana, 1849	+	-	+	-
Acartia sp.	+	+	+	-
Calanus euxinus Hulsemann, 1991	+	-	-	+
Centropages ponticus Karavaev, 1895	+	+	+	+
Oithona davisae Ferrari F.D. &Orsi, 1984	+	+	+	+
Oithona similis Claus, 1866	-	-	-	+
Oncaea sp.	+	-	-	-
Paracalanus parvus (Claus, 1863)	+	+	-	+
Semiparasitic Copepoda	-	-	+	+
Pseudocalanus elongatus (Boeck, 1865)	-	-	+	+
Harpacticoida	+	+	-	-
Copepoda nauplii	+	+	+	+
Copepoda egg	-	-	+	+
DINOFLAGELLATA				
Noctiluca scintillans (Macartney) Kofoid&Swezy, 1921	+	+	+	+
FORAMINIFERA	+	-	+	+
TINTINNIDA	+	+	-	+
MEROPLANKTON				
Actinotrocha larvae	+	-	+	+
Ascidacea larvae	-	-	+	-
Bivalvia larvae	+	+	+	+
Bryozoa larvae	-	-	+	+
Cirripedia larvae	+	+	+	+
Decapoda larvae	+	+	+	+
Fish larva	+	+	+	-

Fish egg	+	+	+	-
Gastropoda larvae	+	+	+	+
Medusae planula	-	-	+	-
Microniscus sp.	+	-	-	+
Polychaeta larvae	+	+	+	+

November 2012

In this month, seven copepods species were identified (*Acartia (Acartiura) clausi*, *Acartia (Acantacartia) tonsa*, *Calanus euxinus*, *Centropages ponticus*, *Oithona davisae*, *Oncaea* sp., *Paracalanus parvus*). The numerical and biomass abundance values of Copepoda ranged between 1728.41 - 7240.76 ind.m^{-3} (St I-3-1 and St I-2-1) and 6.24 - 22.14 mg.m^{-3} (St I-1-1 and St I-1-3), respectively. *O. davisae*, *A. clausi* and *Acartia* sp. constituted the bulk of Copepoda populations. Among the Copepoda, *O. davisae* dominated over the other groups. In terms of abundance and biomass the highest values were recorded in St I-2-1 (5477.71 ind.m^{-3}-9.6 mg.m^{-3}). Instead, the minimum abundance and biomass values were encountered in St I-3-1 (1452.23 ind.m^{-3}-2.70 mg.m^{-3}).

Cladocera was represented only by *Penilia avirostris*, which has distinguished with high abundance and biomas values in St I-2-1 (50.96 ind.m^{-3} and 1.43 mg.m^{-3}).

Appendicularia ranged between 1.27-70.06 ind.m^{-3} (St I-2-3 and St I-1-3) as abundance and 0.55-2.34 mg.m^{-3} (St I-1-1 and St I-1-2) as biomass. The peak of abundance and biomass of Chaetognatha was observed in St I-1-3 (27.26 ind.m^{-3}-23.19 mg.m^{-3}), while the lowest in St I-1-1 (4.08 ind.m^{-3}- 1.37 mg.m^{-3}). The heterotrophic dinoflagellate *Noctiluca scintillans* constituted the major component of zooplankton samples. Abundance and biomass values of *N. scintillans* ranged between 25.48 – 1783.44 ind.m^{-3} and 2.24 – 156.94 mg.m^{-3} (St I-3-1 and St I-1-2). Tintinnid and Foraminifera composed an important fraction of the mesozooplankton abundance and biomass.

Abundance and biomass values of meroplankton ranged between 277.2 and 1535.8 ind.m^{-3} and 1.63 – 11.46 mg.m^{-3} (St I-3-3 and St I-2-1), respectively. Meroplanktonic groups (larvae of Bivalvia, Gastropoda and Polychaeta) yielded the zooplankton community abundance. Among them, Bivalvia larvae had a mass dominance over the other groups. The maximum abundance and biomass values of Bivalvia larvae were achieved in St I-1-3 (1,445.86 ind. m^{-3} and 7.23 mg. m^{-3}), while the minimum has been observed in St I-3-3 (261.15 ind.m^{-3} – 1.31mg.m^{-3}).

Copepoda furnished 71% of total abundance of zooplankton community. Besides, the meroplankton with 15% and Dinoflagellata with 11% were the main elements in the overall quantitative composition. In terms of biomass, the highest contribution rendered Dinoflagellata with 67%, followed by Copepoda - 16% and Chaetognatha - 9%.

May 2013

In this month, four copepods species (*Acartia (Acartiura) clausi*, *Centropages ponticus*, *Oithona davisae*, *and Paracalanus parvus*) were identified. Abundance and biomass values of Copepoda ranged between 501.91- 35424.2 ind.m^{-3} and 3.31-51.48 mg.m^{-3} (St I-3-3 and St I-2-1), respectively. There were no *Acartia tonsa* or *Calanus euxinus* observed in sub-samples. *Acartia sp.* was the dominant species followed by *O. davisae* and *C. ponticus*. The highest abundance and biomass values of *Acartia* sp. were recorded in St I-2-1 (2038 ind.m^{-3}-10.66 mg.m^{-3}), while the minimum values in St I-3-3 (254.78 ind.m^{-3}-2.02 mg.m^{-3}).

Comparative to November, Cladocera was represented this month by *Pleopis polyphaemoides*. Their abundance and biomass ranged between 38.22 – 1, 121.02 ind.m^{-3} and 0.38 – 11.21 mg.m^{-3} (St I-1-3 and St I-2-1). Appendicularia numerical and weight values oscillated between 30.57- 611.46 ind.m^{-3} (St I-2-1 and St I-3-2) and 0.31- 4.38 mg.m^{-3} (St I-2-1 and St I-3-2), respectively. The peak of Chaetognatha abundance (186. 5 ind.m^{-3}) and biomass (3. 85 mg.m^{-3}) was observed in the St I-2-1 and the lowest in the St I-2-3 (1.78 ind.m^{-3}-0.03 mg.m^{-3}). Abundance and biomass values of *N. scintillans* varied between 2445.86 – 13503.18 ind.m^{-3} and 215.24 – 1188.28 mg.m^{-3} (St I-1-3 and St I-3-1). No Foraminifera were observed in sub-samples. Tintinnids were found only in the St I-3-2.

Abundance and biomass values of meroplankton were comprised between 573.50 – 14679.24 ind.m^{-3} and 5.02 – 196.34 mg.m^{-3} (St I-2-3 and St I-2-1), respectively. The meroplanktonic stages of Bivalvia, Cirripedia, Gastropoda and Polychaeta enriched the zooplankton commnunity. Bivalvia larvae had a mass dominance over the other groups. The maximum abundance and biomass values of Bivalvia larvae were achieved in St I-2-1 (8, 203.82 ind. m^{-3}; 41.02 mg. m^{-3}). The minimum abundance and biomass values of Bivalvia larvae were observed in St I-2-3 (445. 86 ind.m^{-3} – 2. 23 mg.m^{-3}).

Dinoflagellata acquired 44% of entire zooplankton composition. The other groups included Copepoda with 32% and meroplankton with 21%. In terms of biomass, Dinoflagellata attained 91% of total, followed by Meroplankton (6%) and Copepoda (2%).

July 2013

In this month, five copepods species (*Acartia (Acartiura) clausi*, *Acartia (Acantacartia) tonsa*, *Centropages ponticus*, *Oithona davisae*, *and Pseudocalanus elongatus*) were identified. The Copepoda abundances varied from a minimum of 811.72 to a maximum of 2, 054.52 ind.m^{-3} (St I-2-2 and St I-3-1). In the same time, the biomass reached values from 6.34 to 40.12 mg. m^{-3} (St I-2-3 and St I-2-1). There were no *Calanus euxinus* or *Paracalanus parvus* in the sub-samples. Instead, in this month, *O. davisae*, *A. tonsa* and *Acartia* sp. formed the key assamblages within the Copepoda. Among the above mentioned species, *O. davisae* was the dominant species after abundance, achieving the highest populational concentration and biomass (484 ind.m^{-3} and 1.20 mg.m^{-3}) in the St I-1-1, whilst the minimum ones (178.85 ind.m^{-3}-0.39 mg.m^{-3}) in the St I-1-2.

Among Cladocera group, there were identified three species: *Penilia avirostris*, *Pleopis polyphaemoides*, and *Pseudevadne tergestina*. The minimum (50.96 ind.m^{-3}) and maximum abundance (345.48 ind.m^{-3}) were estimated in the St I-1-1 and in the St I-3-1, respectively. Similarly, the biomass values oscilated between a minimum of 0.66 in the St I-1-2 and a maximum of 4.81 mg. m^{-3} in the St I-3-1. Out of the four species, *P. polyphaemoides* was the dominant ones issuing the highest values of abundance and biomass in St I-3-1 (244.59 ind.m^{-3} and 2.20mg.m^{-3}).

Appendicularia was recorded in only three stations (St I-1-1, St I-2-3 and St I-3-3). The densities and biomasses of opportunistic predator species of Chaetognatha were situated within the range 19.36 - 98.09 ind.m^{-3} and 1.35 - 9.77 mg.m^{-3} (St I-3-3 and St I-1-3), respectively. The maximum abundance and biomass of *N. scintillans* were recorded in St I-2-1 (2583.44 ind. m^{-3}; 227.34 mg. m^{-3}). In terms of minimum abundance and biomass, there were recorded in St I-3-2 (27.01 ind.m^{-3}; 2.38 mg.m^{-3}). No Tintinnid was observed in the sub-samples. Foraminifera were found only in St I-1-3.

Abundance and biomass values of meroplankton fluctuated between 1754.9 – 41254.52 ind.m^{-3} and 13.31 – 232.96 mg.m^{-3} (St I-2-2 and St I-3-1), respectively. The meroplanktonic forms, such as Bivalvia larvae, Cirripedia larvae, Gastropoda larvae and Polychaeta larvae presented important contributions. Among the meroplankton groups Bivalvia larvae had a mass dominance over the other groups. The maximum abundance and biomass values of Bivalvia larvae were achieved in St I-3-1 (38140.13 ind. m^{-3} – 190.70 mg. m^{-3}). The minimum abundance and biomass values of Bivalvia larvae were observed in St I-2-2 (1346.75 ind.m^{-3} – 6.73 mg.m^{-3}).

Meroplankton was the most abundant zooplankton group with 84%. The other groups included Copepoda with 10% and Dinoflagellata with 5%. In terms of biomass, highest contribution was found to be Meroplankton with 44%. It was followed by Dinoflagellata (39%) and Copepoda (12%).

October 2013

In this month, seven copepods species were identified (*Acartia (Acartiura) clausi*, *Calanus euxinus*, *Centropages ponticus*, *Oithona davisae*, *Oithona similis*, *Paracalanus parvus*, *Pseudocalanus elongatus*). The minimum and maximum abundance values of Copepoda ranging between 2037.71-4769.94 ind.m^{-3} in October 2013 (St I-1-2 and St I-1-3). The minimum and maximum biomas values of Copepoda ranging between 13.38-63.17 mg.m^{-3} (St I-1-3 and St I-1-1).There were no *A. tonsa* in sub-samples. *O. davisae*, *A. clausi* and *P. parvus* presented important contributions in Copepoda. Among the Copepoda species, *O. davisae* had a mass dominance over the other groups. In terms of abundance and biomass the lowest values of *O. davisae* were recorded in St I-1-1 (764.33 ind.m^{-3}-1.59 mg.m^{-3}). The maximum abundance and biomass values were encountered in St I-3-2 and I-1-2 (2191.08 ind.m^{-3}-26.30 mg.m^{-3}).

Four copepods species were identified Cladocera (*Penilia avirostris*, *Pleopis polyphaemoides*, *Pseudevadne tergestina*, *Evadne spinifera*). Abundance and biomass values of Cladocera ranging between were 26.50 – 188.54 ind.m^{-3} and 0.72 – 5.03 mg.m^{-3} (St I-2-1 and St I-3-2). Amongst cladocerans, *P. avirostris* was dominant species. In terms of abundance and biomass the highest values were recorded in St I-3-2 (178.34 ind.m^{-3}-4.99 mg.m^{-3}).

Abundance and biomass values of Appendicularia ranging between were 45.86-407.64 ind.m^{-3} and 0.48-3.92 mg.m^{-3} (St I-1-1 and St I-3-2). The minimum and maximum abundance values of Chaetognatha ranging between 18.85-400 ind.m^{-3} (St I-1-3 and St I-3-2). The minimum and maximum biomas values of Chaetognatha ranging between 2.56-91.62 mg.m^{-3} (St I-1-2 and St I-3-2). Abundance and biomass values of Dinoflagelata ranging between were 7.64-50.96 ind.m^{-3} and 0.24-4.48 mg.m^{-3} (St I-1-2 and St I-3-1). Tintinnid and Foraminifera forms also contributed to the mesozooplankton abundance and biomas .

The minimum and maximum abundance values of Meroplankton ranging between 85.10-587.52 ind.m^{-3} (St I-1-2 and St I-3-2). The minimum and maximum biomas values of Meroplankton ranging between 1.17-6.9 mg.m^{-3} (St I-3-1 and St I-3-2).

This month, meroplanktonic forms, such as Bivalvia larvae, Cirripedia larvae, Gastropoda larvae and Polychaeta larvae presented important contributions. Among the meroplankton groups Gastropoda larvae had a mass dominance over the other groups. Abundance and biomass values of Gastropoda ranging between were 15.29-267.52 ind.m^{-3} and 0.17-2.92 mg.m^{-3} (St I-3-1 and St I-3-2). Copepoda was the most abundant of zooplankton group with 81%. The other groups included Meroplankton with 6% and Appendicularia with 5%. In terms of biomass, highest contribution was found to be Chaetognatha with 49%. It was followed by Copepoda (34%) and Meroplankton (5%).

Seasonal Analysis of Zooplankton

The results of the cluster analysis of total species abundance and of MDS analysis performed on quantitative data are given in Figure 54a and Figure 54b. Discrimination was prominent with a significant stress factor of 0.01. As figure suggests, four significant clusters (A, B, C and D) are formed among the stations at a similarity level of 0.60 (Fig. 54). The cluster analysis of seasonal results rendered two groups, explained by seasonal change of zooplankton community of the region. In order to support the results of MDS and Cluster analyzes, AnoSIM (Analyses of Similarity) analysis was performed. A statistically significant difference was found among seasons (Sample statistic-Global R: 0.947, Significance level of sample statistic: 0.001). No statistically significant difference was found among depths (Sample statistic-Global R: -0.033, Significance level of sample statistic: 0.744).

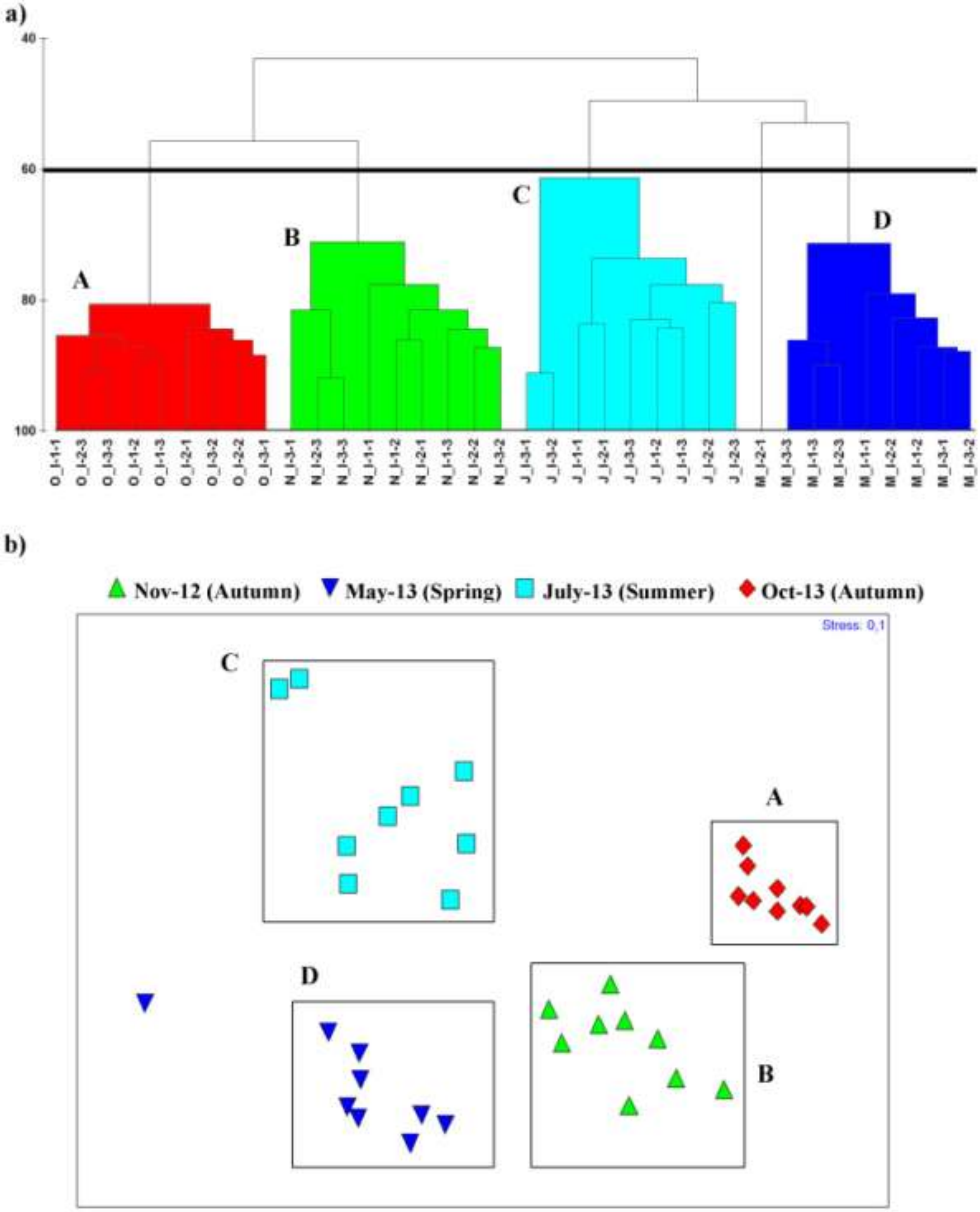

Figure 54. The dendogram (a) and MDS diagram (b) of quantitative clustering analysis of zooplankton in sampling seasons.

3.4. Marine habitats and fauna

STRANDZHA AREA

Marine habitats of European conservation importance, national subtypes and the associated benthic invertebrate fauna

The marine area of SCI Strandzha covers seven types of natural habitats listed in Annex I of the Habitats Directive as follows (MOEW):

1110 Sandbanks which are slightly covered by seawater all the time

1130 Estuaries

1140 Mudflats and sandflats not covered by seawater at low tide

1160 Large shallow inlets and bays

1170 Reefs

8330 Submerged or partially submerged sea caves

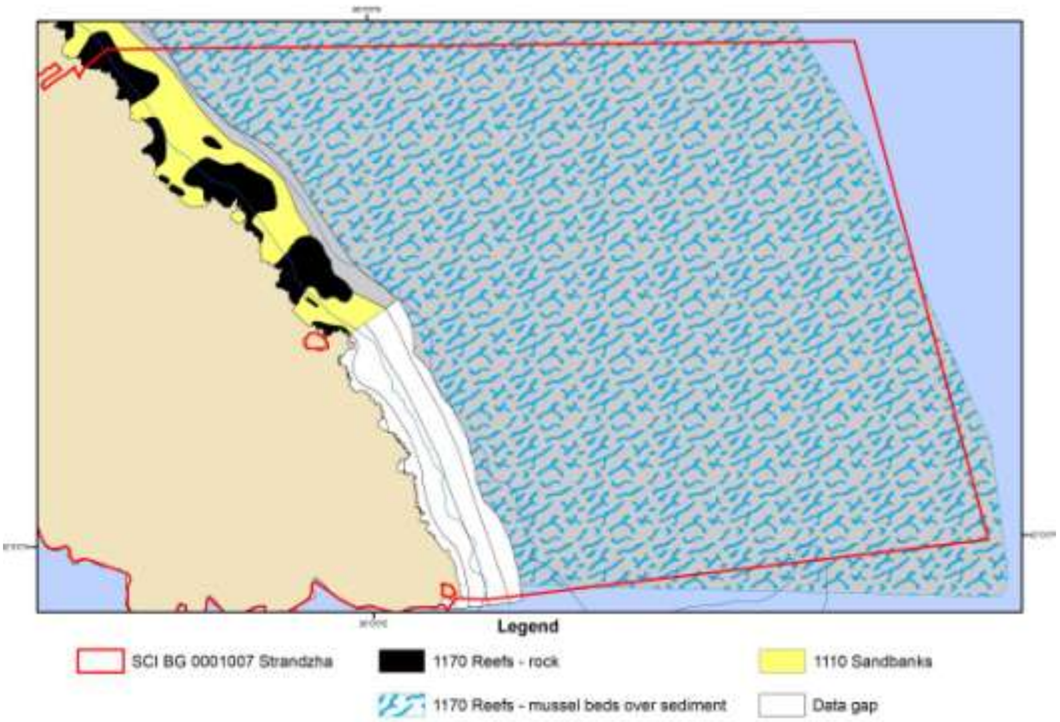

Figure 55. Map of the habitats of European importance 1110 Sanbanks and 1170 Reefs distribution in SCI Strandzha. Source: Todorova et al., 2012. Project "Extension of the marine Natura 2000 in the Bulgarian Black Sea", Contract № 7976/04.04.2011 between EMEPA and IO-BAS.

The predominant marine habitats in the area are the types 1110 Sandbanks and 1170 Reefs with two main subtypes – rocky reefs and mussel beds over sediments, as shown on the map of Fig. 55. The mussel beds distribution is reconstructed from pictures available in the grey literature (Kaneva-Abadzhieva, Marinov 1960, 1967). This information is already outdated, therefore the distribution and coverage of mussel beds is currently uncertain. The distribution of the sandbanks and rocky reefs is mapped based on recent and historical surveys of IO-BAS on the seabed substrates (Todorova et al., 2012).

1110 Sandbanks which are slightly covered by sea water all the time.

The habitat area is estimated at 2835.81 ha, comprising 7.6 % of the national habitat coverage (MOEW, Todorova et al., 2012, Todorova, Panayotova, 2011-D).

A range of national habitat subtypes/biotopes have been observed at the site encompassing coarse to fine sand and shell rubble as follows (Todorova et al., 2008, 2012):

- 1110-2. Coarse and medium shallow sand with *Donax trunculus*
- 1110-3. Fine and medium sand with *Lentidium mediterraneum*
- 1110-5. Sand and muddy sand with *Chamelea gallina*
- 1110-7. Organogenic sand and shelly gravel with *Modiolus adriaticus u Gouldia minima*

MISIS data on the invertebrate fauna from the characteristic habitat were collected in front of Rezovo and Silistar river mouths. The similarity analysis of the abundance and biomass data separated the coarse shelly sediments at Resovo from the fine sand at Silistar (Fig. 56). There are 4 communities differentiated:

- Community of the shelly gravelly fine sand at 5-10 m depth. The community is composed of typical psammophilous polychaetes *Protodorvillea kefersteini, Microphthalmus fragilis, Shistomeringos rudolfi* and turbellarians of the genus *Leptoplana*. Due to widely spread rocky bottom with interspersed patches of sand a number of species typical of the algal communities overgrowing the reefs were found too, such as the gastropods *Gibbula divaricata* and *Rissoa splendida,* the nereid worm *Perinereis cultrifera* and the clam *Irus irus.*

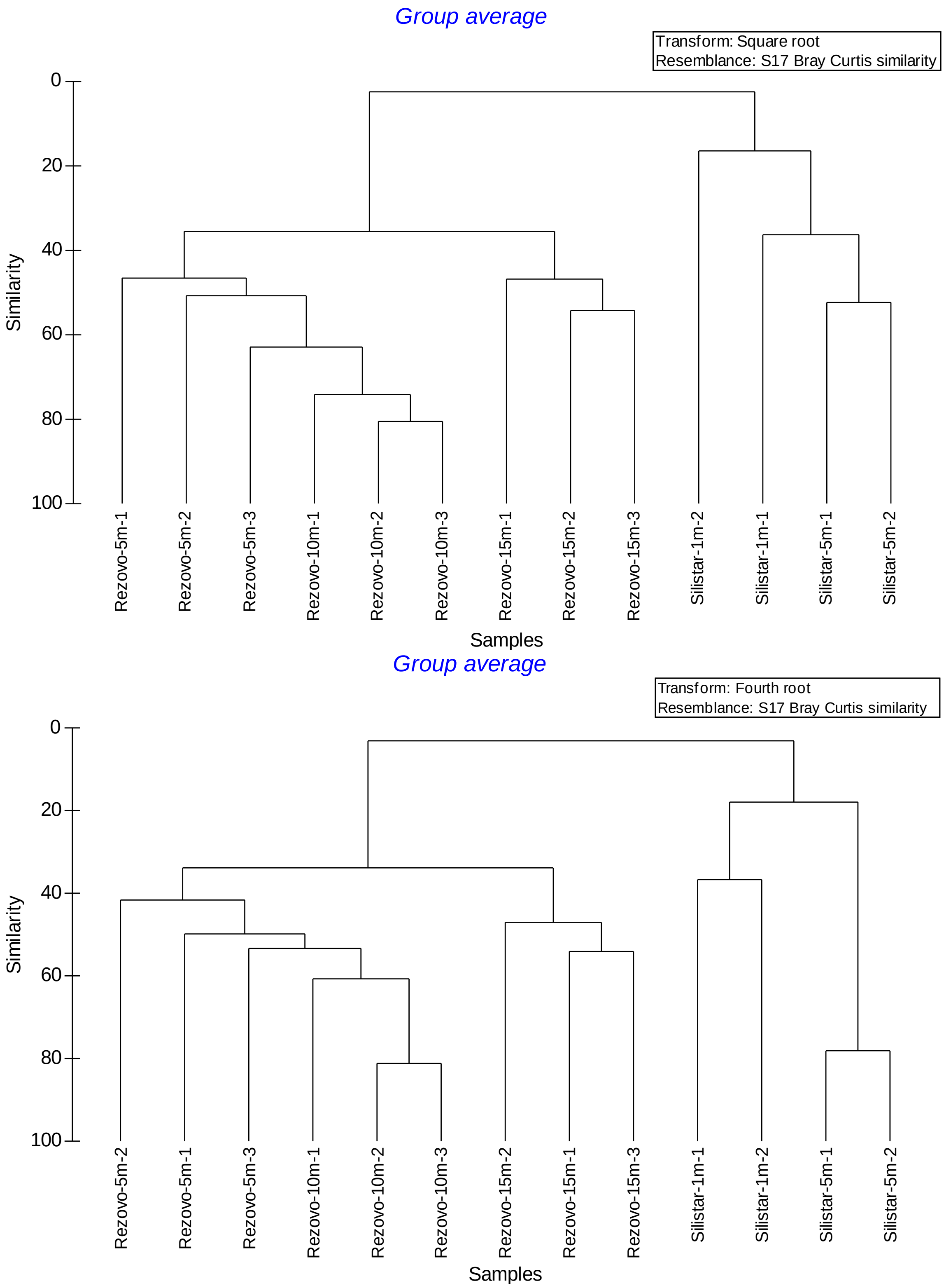

Figure 56. Dendrograms of the community similarity based on the abundance and biomass data of zoobenthos.

- Community of the shelly gravelly fine sand at 15 m depth. The community is distinguished by the gastropod *Cyclope neritea,* the lancelet *Branchiostoma lanceolatum,* the polychaetes *Lagis koreni* and *Glycera tridactyla* in addition to the above mentioned psammophilous polychaetes *Protodorvillea kefersteini, Microphthalmus fragilis*, and *Shistomeringos rudolfi*.
- Community of the fine sand at 1 m depth. The community is poor due to being disturbed by high wave energy in the mediolittoral zone, distinguished by the good swimmer isopod *Eurydice dollfusi*.
- Community of the fine-medium sand at 5 m depth. This is a typical example of *Donax trunculus* dominated community in shallow clean sand well flushed by wave action.

The complete list of the encountered zoobenthos species is given in Annex 3 to the Report. The overall zoobenthos diversity established by MISIS survey is high – 65 species recorded in 13 samples. The polychaetes are the richest taxonomic group with 30 species. Community indices (Table 30) indicate the highest zoobenthos diversity in the shelly gravelly fine sand at 5-10 m depth, while the lowest is observed in heavily wave disturbed, very shallow fine sands.

Table 30. Community indices of macrozoobenthos at the sampling stations in the sandy habitats at SCI Strandzha: S-species richness, N-abundance, d-Margaleff richness, J' – Pielou's evenness, H' Shannon diversity

Station-depth-replicate	S	N	d	J'	H'(log2)
Community of the shelly gravelly fine sand at 5-10 m depth					
Rezovo-5m-1	26	658	3.85	0.67	3.17
Rezovo-5m-2	15	142	2.82	0.75	2.94
Rezovo-5m-3	17	453	2.62	0.65	2.64
Rezovo-10m-1	25	1117	3.42	0.47	2.18
Rezovo-10m-2	26	670	3.84	0.52	2.44
Rezovo-10m-3	24	752	3.47	0.50	2.28
Community of the shelly gravelly fine sand at 15 m depth					
Rezovo-15m-1	22	121	4.38	0.76	3.41
Rezovo-15m-2	19	630	2.79	0.24	1.01
Rezovo-15m-3	30	270	5.18	0.43	2.11
Community of the fine sand at 1 m depth					

Station-depth-replicate	S	N	d	J'	H'(log2)
Silistar-1m-1	4	8	1.44	0.95	1.91
Silistar-1m-2	3	3	1.82	1.00	1.58
Community of the fine-medium sand at 5 m depth					
Silistar-5m-1	6	31	1.46	0.80	2.06
Silistar-5m-2	4	11	1.25	0.81	1.62

Ecological state according to the biological quality element (BQE) zoobenthos

The ecological state of the coastal marine waters of SCI Strandzha is assessed within the national marine monitoring under the WFD carried out by IO-BAS. As shown on the map of Fig. 57 the results for the BQE zoobenthos in the sediments at the monitoring stations situated in front of the river mouths of Varvara and Veleka Rivers the ecological status of the coastal water body BG2BS000C012 was good in 2013 (Todorova, 2014).

According to Todorova (2014) during the period 2006-2013 the benthic macrofauna in the coastal waters of SCI Strandzha suggests good ecological status maintained on the overall at Varvara station, however, a decreasing trend evident in the values of the biotic index M-AMBI and a drop to bad status in 2012 signal ecological degradation (Table 31). At Veleka station the status decreased from high to good, a trend that is warning of environmental risk.

Table 31. Ecological state of the coastal marine waters at Varvara and Veleka monitoring stations during 2006-2013 according to the multivariate biotic index M-AMBI, BQE macrozoobenthos; Blue-high state, green – good state, orange – poor state

Water body	Monitoring station	2006	2007	2008	2012	2013
BG2BS000C012	Varvara	0.84	0.83	0.74	0.28	0.56
	Veleka	0.91	0.82	0.92	0.65	0.62

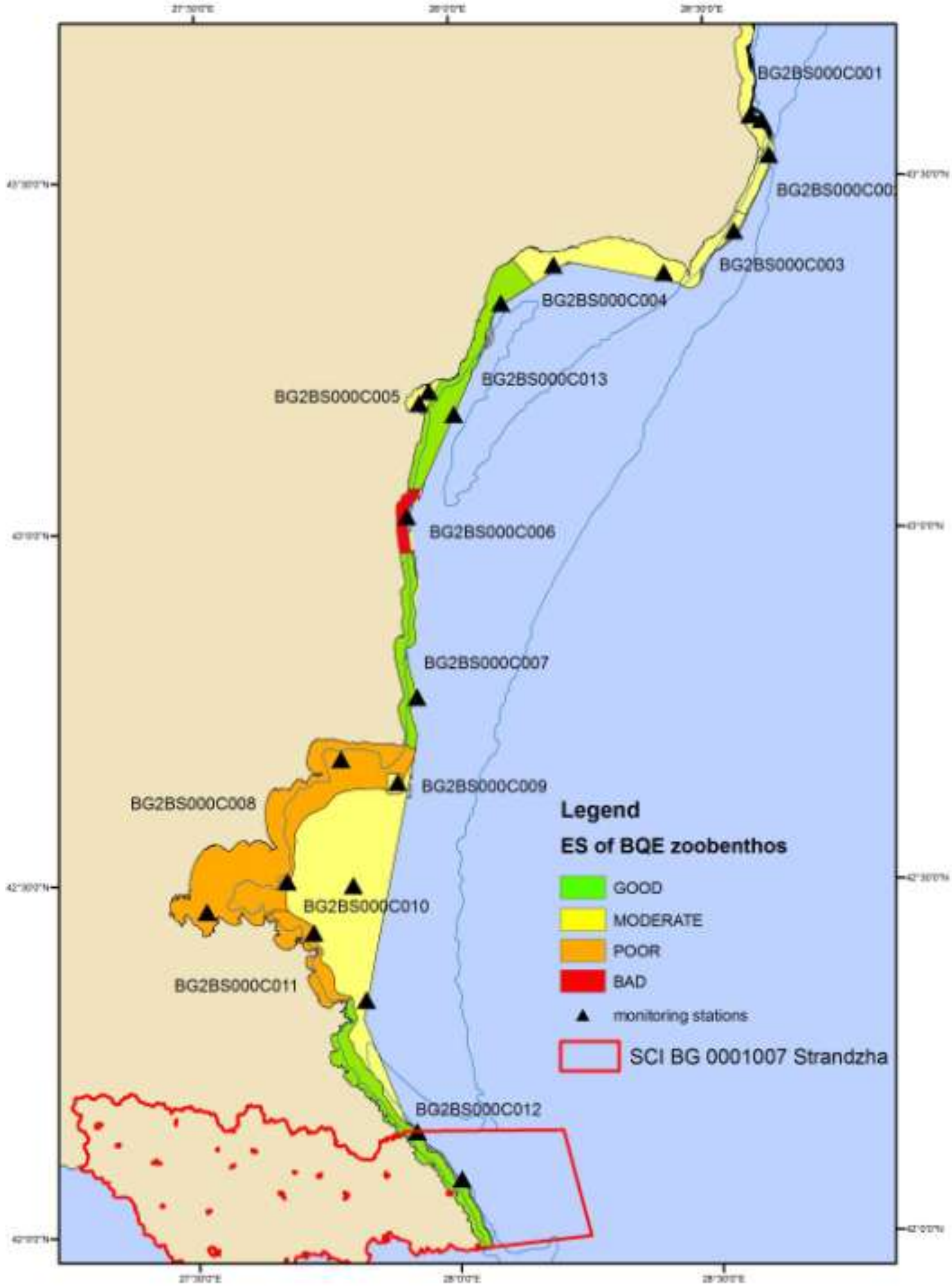

Figure 57. Map of the ecological state of the coastal marine waters according to the BQE macrozoobenthos in 2013.

1130 Estuaries

There are two large estuaries of Veleka and Resovska rivers and two smaller estuaries of Silistar and Butamiata rivers in SCI Strandzha.

The habitat area is estimated at 20.33 ha (MOEW).

The typical of the estuaries higher plants are *Phragmites australis, Typha latifolia, T. angustifolia, Sparganum erectum, Equisetum maximum, Ceratophillum spp., Zostera marina, Lemna* spp.

The estuaries provide shelter for a number of species of European importance: 1032 *Unio crassus*, 1171 *Triturus karelinii*, 1188 *Bombina bombina*, 1130 *Aspius aspius*, 1134 *Rhodeus amarus*, 1137 *Barbus plebejus*, 1141 *Chalcalburnus chalcoides*, 1220 *Emys orbicularis* and 1222 *Mauremys caspica*.

1140 Mudflats and sandflats not covered by seawater at low tide

The habitat area is estimated at 7.56 ha (MOEW).

The mediolittoral sands, well flushed by the wave action, are inhabited by dense populations of the small wedgeclam *Donacilla cornea* (Fig. 58, Todorova et al., 2008, 2012). The habitat is included in the Red Book of Bulgaria as vulnerable (Todorova, 2011).

Figure 58. Mediolittoral sand with *Donacilla cornea.* (Todorova et al., 2008)

1170 Reefs

SCI Strandzha contains almost the complete complex of the habitat 1170 national subtypes with high conservation importance listed as follows (Todorova et al., 2008, 2012,):

- 1170-1. Mediolittoral rock with barnacles *Chthamalus stellatus* and mussels *Mytilaster lineatus, Mytilus galloprovincialis*
- 1170-2. Mediolittoral rock with Corallina, Nemalion, Scytosiphon
- 1170-3. Infralittoral rock with perennial brown algae of the genus Cystoseira
- 1170-5. Lower Infralittoral rock with sciophilous association of *Phyllophora crispa*
- 1170-6. Infra- and circalittoral rock with mussels *Mytilus galloprovincialis* and *Mytilaster lineatus*
- 1170-8. Animal (sponge, hydroid) cover on rock
- 1170-9. Biogenic reefs of *Ostrea edulis*
- 1170-10. *Mytilus gallorpovinvialis* beds on sublittoral sediment

The majority of the above listed biotopes are also included in the Red Book of Bulgaria as nationally vulnerable or endangered (Todorova, Panayotova, 2011-A, B, C).

According to the historical information available in grey literature (Kaneva-Abadzhieva, Matrinov, 1960, 1967) the biotope of mussel beds 1170-10 covers vast area of the seabed, comprising 8 % of the national habitat area (Fig. 55).

A remarkable unknown habitat - huge biogenic reefs built by the native flat oyster *Ostrea edulis* were found in 2007. This newly discovered marine habitat is deemed unique for European seas and probably the world, therefore a habitat of high conservation interest too (Micu and Todorova, 2007; Todorova et al. 2009).

The rocky reefs are characterized by an outstanding biodiversity of macrophytes, invertebrates and fish some of the representative species listed as follows:

Algae: *Ceramium strictum, C. diaphanum, Polysiphonia subulifera, Acrochaetium secundatum, Porphyra leucostica*, *Sphacelaria cirrhosa, Myriactula rivulariae, Corynophlaea umbellate*, *Gelidium spinosum, G. crinale, C. rubrum*, *Cladostephus spongiosus, Apoglosium ruscifolium, Polysiphonia elongata, Lomentaria clavellosa, Antithamnion cruciatum*, *Zanardinia typus.*

Invertebrates: Hydrozoa: *Aglaophenia pluma*, *Coryne* sp. *Lucernaria* sp.; Bryozoa: *Electra pilosa*; Mollusca: *Bittium reticulatum, Mytilaster lineatus, Rissoa splendida, Tricolia pulus*; Crustacea: *Athanas* *nitescens*, *Clibanarius erythropus, Eriphia verrucosa, Hippolyte leptocerus, Palaemon adspersus, P. elegans, Pilumnus hirtellus;*

Fishes: *Gaidropsarus mediterraneus, Aidablennius sphinx, Chelon labrosus, Coryphoblennius galerita, Dicentrarchus labrax, Diplodus annularis, D. puntazzo, D. sargus, D. vulgaris, Gobius cobitis, G. niger, G. paganellus, Hippocampus guttulatus, Lisa aurata, L. saliens, Mesogobius batrachocephalus, Mugil cephalus, Neogobius cephalargoides, N. melanostomus, N. platyrostris, N. ratan, Nerophis ophidion, Parablennius sanguinolentus, P. tentacularis, P. zvonimiri, Pomatoschistus marmoratus, P. minutus, Salaria pavo, Scorpaena porcus, Symphodus cinereus, S. ocellatus, S. roissali, S. tinca, Syngnathus abaster, S. tenuirostris, S. typhle, S. variegates*.

Species of European importance

Fish

The Standard data form for SCI Strandzha inventories three resident marine fish species listed in Annex II of the Habitats Directive (MOEW):

1103 *Alosa falax*

4125 *Alosa immaculata*

4127 *Alosa tanaica*

Alosa falax is deemed vagrant to the Bulgarian Black Sea.

The review of the available data on *Alosa spp.* occurrence in the frame of the project "Extension of ecological network of NATURA 2000 in Bulgarian Black Sea" (Todorova et al., 2012) indicates significant population of *A. immaculata* and *A. tanaica* present in the marine area of SCI Strandzha. The fresh water inflow from the relatively large and very clean rivers Veleka and Resovska along the Strandzha coast is a prerequisite for Alosa spp to be attracted and kept in front of the estuaries being an anadromous species. The marine area is deemed important feeding grounds for Alosa spp, as well as a migration route towards the Danube River. The site covers the complete habitat complex for the shad including marine and estuarine habitats of high ecological status, good trophic conditions and relatively low fishing pressure.

The marine area included in the SCI is estimated to encompass 3 % of the national marine habitat for shad, based on the potentially suitable area to 200 m depth.

Mammals

Two small cetaceans listed in Annex II of the Habitats Directive are resident in the marine area of SCI Strandzha (MOEW):

1349 *Tursiops truncatus*

1351 *Phocoena phocoena*

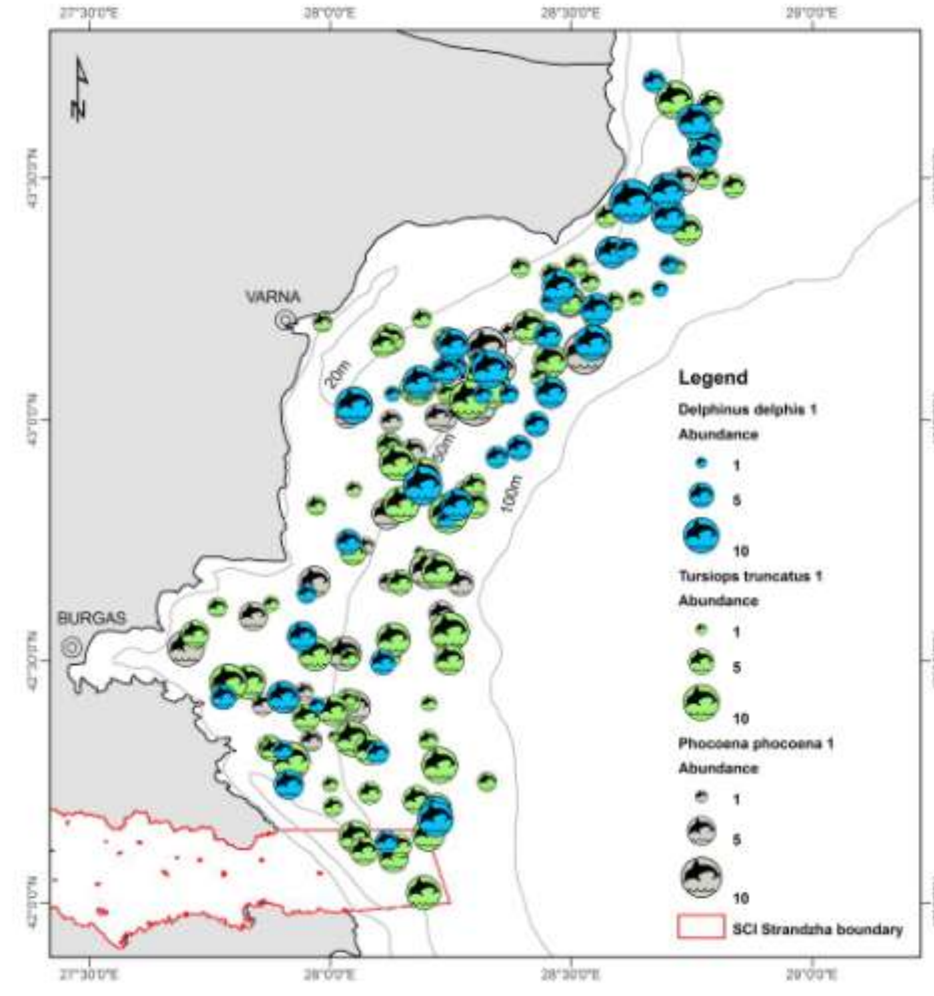

Figure 59. Opportunistic sightings of marine cetaceans in the Bulgarian Black Sea during the period 2006 – 2010 (Raykov, Panayotova, 2012)

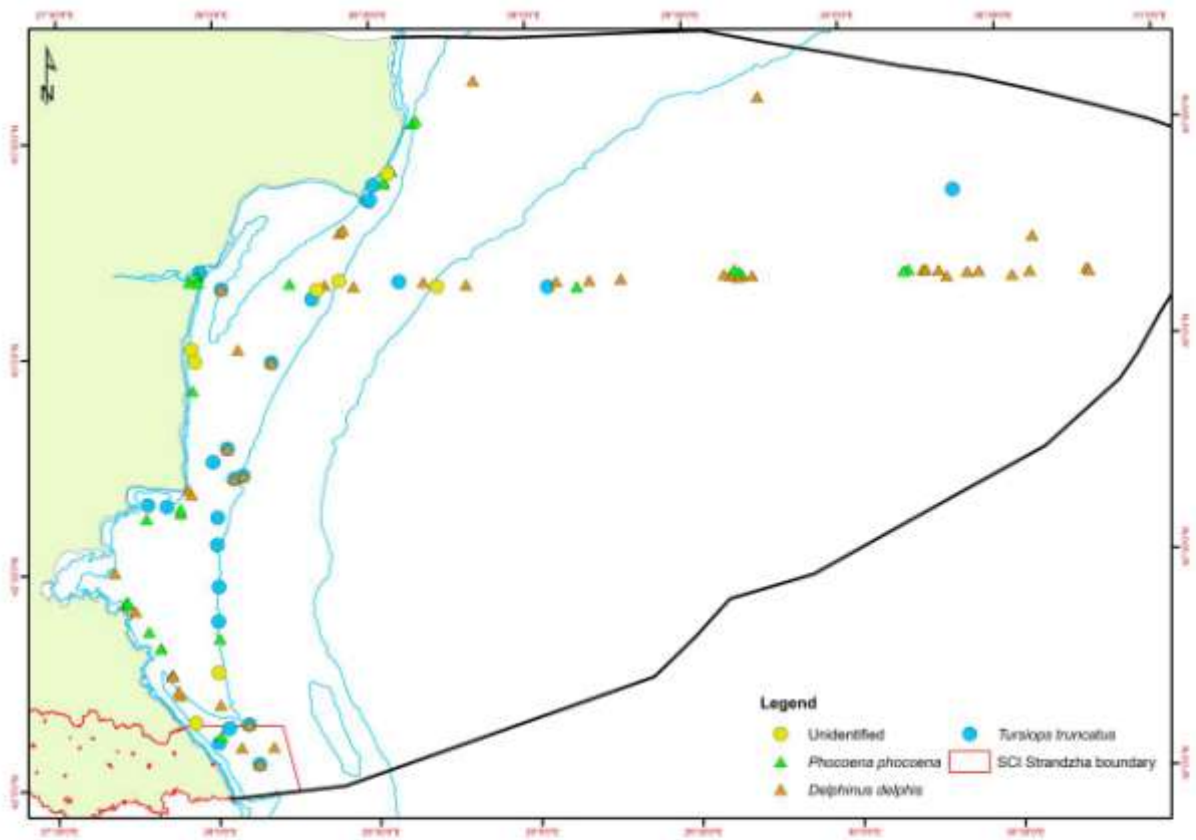

Figure 60. Opportunistic sightings of marine cetaceans in the Bulgarian Black Sea during the period 2006 – 2010 (Panayotova, Raykov, 2013)

The area is deemed an excellent habitat for the cetaceans (Todorva et al., 2012). There are significant stocks of demersal fishes that are the main food for the bottlenose dolphin and the harbour porpoise. The main pelagic fish stocks migrate through the area providing food for the cetaceans during the reproduction and nursery period. Relatively low disturbance from human pressure also contribute to the conservation importance of the site for the cetaceans.

It is estimated that SCI Strandzha covers 3.4 % and 4.7 % of the potential national habitats of *T. truncatus* and *Ph. phocoena* respectively (Todorva et al., 2012).

Recent reviews by Panayotova (2013) and Raykov, Panayotova (2012) on opportunistic sightings of the cetacean species in the Bulgarian Black Sea validate the residence of all three species (including *Delphinus delphis*) in the Strandzha marine area (Fig. 59 and Fig. 60).

The three cetacean species have high conservation priority. They are object of special protection at the national level being listed in the Biodiversity act, the Fisheries and Aquaculture Act, the Protection of the Environment Act and the Bulgarian Red Data Book. The cetaceans are also protected by a number of international agreements and conventions to which Bulgaria is a signatory country: Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and contiguous Atlantic area (ACCOBAMS); Convention on the protection of the Black Sea against pollution (Bucharest convention), Convention on the Conservation of European Wildlife and Natural Habitats (Berne convention), Convention on the Conservation of Migratory Species of Wild Animals (Bonn convention).

Other important species of flora and fauna

The Standard data form for SCI Strandzha inventories other species of conservation importance being listed in the national Red Data Book and/or International Conventions and/or Endemics.

The list accounts for 1 marine mammal, 22 marine fish species, 9 marine invertebrates and 3 algae (Table 32).

Table 32. Other important species of marine flora and fauna listed in the Standard Data Form for SCI Strandzha and motivation for their listing.

	Bulgarian Red Data Book	Endemic	Bucharest Convention	International conventions	Other reason
MAMMALS					
Delphinus delphis			**	Berne, Bonn	
FISH					
Acipenser gueldenstaedtii	CR		**		
Acipenser stellatus	CR		**		
Aidablennius sphynx			**		
Anguilla anguilla	EN				
Atherina boyeri					
Coryphoblennius galerita					
Dasyatis pastinaca					
Hippocampus guttulatus			**	Berne	
Huso huso	CR		**	Berne	
Liza ramada			*		
Mesogobius batrachocephalus		x	*		
Neogobius melanostomus		x			
Pegusa lascaris					
Pomatoschistus microps		x			
Raja clavata					
Lypophris (Salaria) pavo			**		
Sarda sarda			**		
Squalus acantias					
Symphodus ocellatus					

	Bulgarian Red Data Book	Endemic	Bucharest Convention	International conventions	Other reason
Syngnathus typhle			*		
Trachinus draco					
Uranoscopus scaber					
INVERTEBRATES					
Eriphia verrucosa			**		
Pachigrapsus marmoratus			*		
Chamelea galina					Habitat defining
Ostrea edulis			**		Ediphicator
Donacilla cornea			**		Habitat defining
Lentidium mediterraneum					Habitat defining
Mythilus galloprovinciallis					Ediphicator
Xantho poressa			**		
Donax trunculus					Habitat defining
ALGAE					
Cystoseira barbata			**		Ediphicator
Cystoseira crinita			**		Ediphicator
Phyllophora crispa			**		Ediphicator

Notes:
* Rare species according to Black Sea Biodiversity and Landscape Conservation Protocol
** Endangered species according to Black Sea Biodiversity and Landscape Conservation Protocol

IGNEADA AREA

Material and Method

Soft-bottom samples were collected by a Van Veen Grab (sampling an area of 0.1 m^2). Benthic samples were sieved through a 0.5 mm mesh and the retained fauna was collected in jars containing 10% seawater–formalin solution. The samples brought to the laboratory were washed through 1 mm and 0.5 mm sieve mesh sizes. The material obtained was examined under stereo binocular dissecting microscope and zoobenthic organisms were sorted into higher systematic groups.

Meiobenthos samples were collected with a metal sediment corer of 4 cm diameter (sampling area 12.56 cm2) positioned into grab material to a depth of 10 cm. Fixation was done using 75% ethanol. Material was washed through sieves of 1 mm, 500 µm and 64 µm mesh sizes and those captured on 64 µm were analyzed for meiobenthos. Bengal rose solution was added to the samples prior to sorting and counting under a dissecting microscope by use of modified Bogorov chambers.

Soft bottom zoobenthos analyzes were performed at 3 transects and 9 stations. Hard bottom sampling was done at 2 stations by quadrate (20x20cm).

Community parameters such as number of species, number of individuals, Shannon-Weaver's diversity index (log_2 base) (H') and Pielou's evenness index (J') were calculated. The Soyer's Frequency Index (F) was applied to the abundance data in order to determine the characteristic species of the area. To better determine temporal distribution patterns, the abundance data of all stations were analyzed using cluster analysis, based on the Bray-Curtis similarity (group average technique), using the PRIMER package (Clark & Warwick, 2001).

Meiobenthos population

Meiobenthic organisms are known to be the most abundant component of marine bottom communities. They inhabit a wide range of bitopes, even the areas where other metazoans are not able to survive. In İğneada, meiofaunal diversity was found to be quite diverse with 13 major taxa in the sampling season (November-2012) (Annex 2). Abundance of the meiofauna at sampled stations ranged between $67x10^3$ - $757x10^3$ ind/m^2. The highest density was found at St. I-2-2 with 10 m water depth (Fig. 61).

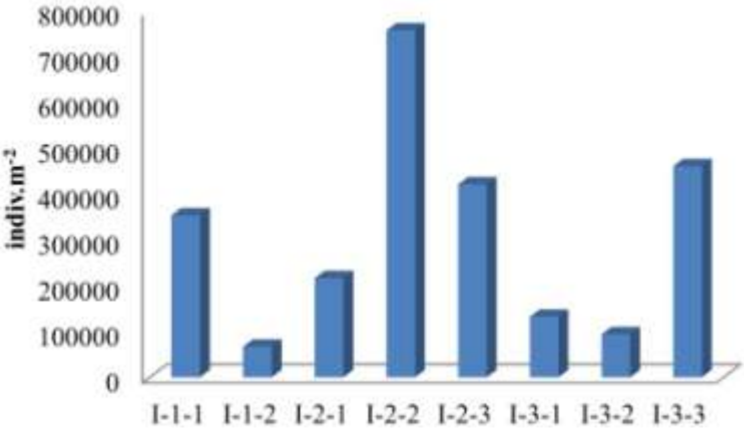

Figure 61. Meiofaunal abundances at sampling stations

Nematoda

Nematodes found to comprise a significant portion of the meiofauna and observed at all sampled stations with three stations presenting with the highest nematode percentages (Fig. 62). 52 species belonging to 18 families were found. Family Desmodoridae was the dominant family accounting for

24% of total individuals and the highest number of individuals were recorded at station I-3-3 with a sediment characteristic of fine sand+coarse sand mixture. Desmodoridae was followed by Xyalidae (16%) and Oncholaimidae (16%). Dominant species were *Desmodora pontica* (14%), *Viscosia* sp. (9%), *Neochromadora sabulicola* (8%) and *Sabatieria* sp. (7%) (Fig. 63). Trophic group 2A (epistrate feeders) were the most abundant feding group with a dominance of 46 %. The high presence of 2A trophic group may be attributed to the presence of coarse sand at most of the sampling stations. Second abundant feeding group was predator/omnivors with a dominance of 28 %. These results are typical findings of habitats presenting with coarse sand /low organic matter (Wieser, 1953).

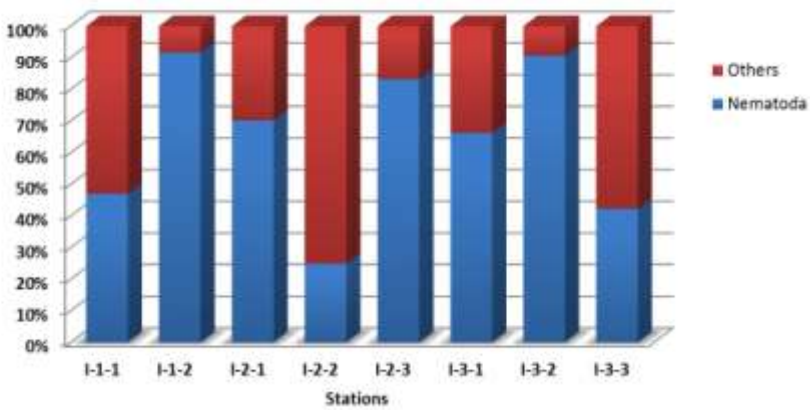

Figure 62. Percentage of Nematodes in total meiofaunal density of the stations

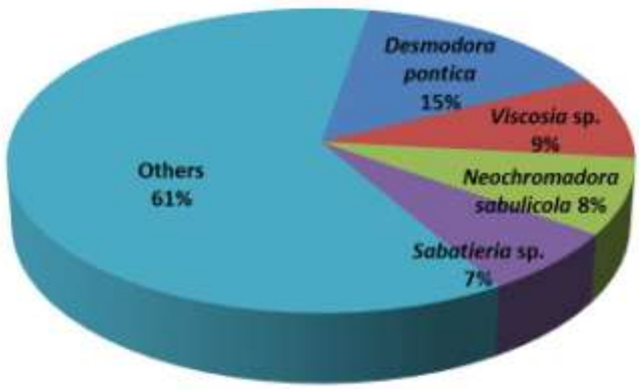

Figure 63. Dominant nematode species by number of individuals in total samples

Harpacticoida

As a result, 16 genera distributed within 10 families were identified. Among the families, Ectinosomatidae was the dominant group in terms of number of individuals accounting for 48% of the total, followed by Miraciidae (16%), Paramesochridae (%11) Ameridae (%10), and Laophontidae (5%) (Fig. 64). The dominant species in the area were *Ectinosoma melaniceps* Boeck, 1865 (21% of total individuals), *Halectinosoma herdmani* (Scott T. & A., 1896) (19%), *Paramesochra* sp. (11%) and *Ameira parvula parvula* (Claus, 1866) (%9), all comprising 60% of total specimens. Genuine interstitial vermiform and lanceolate Harpacticoida (which inhabit the space between sediment particles) were represented by the families Ectinosomatidae, Paramesochridae and Laophontidae, and made up 64% of the total number of individuals (Fig. 65).

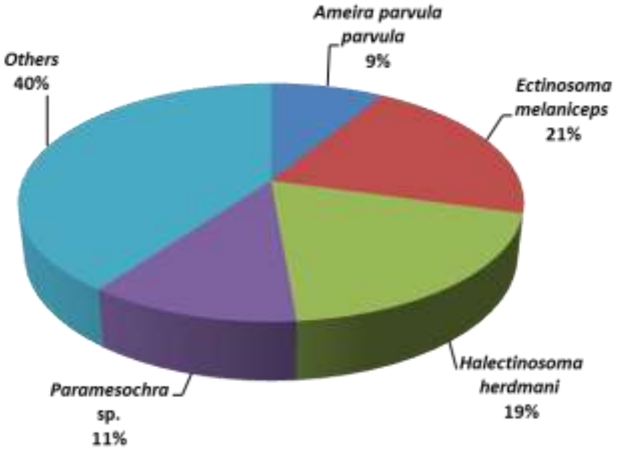

Figure 64. The distribution of the number of individuals belonging to families

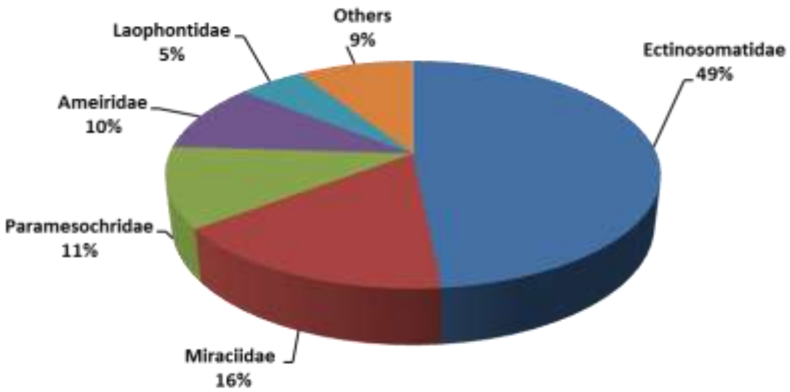

Figure 65. The dominance of the families by number of individuals

Seasonal dynamics in abundance of Harpacticoida is related to periodic reproduction. European sites where harpacticoid copepod reproduction occurs in early spring and non-reproductive adults dominate the harpacticoid assemblage during the summer (Barnett, 1970). Since the results belong to autumn samplings, the species diversity and abundance are expected to increase towards summer.

Foraminifera

Recent benthic foraminifera were the third dominant group, however revealed a low diversity as a result of the evaluation of the samples. There were 12 species belonging to 3 families found. As it is expected in Black Sea, *Ammonia* and *Elphidium* species from the family Rotalidae were the dominant group (Fig. 66).

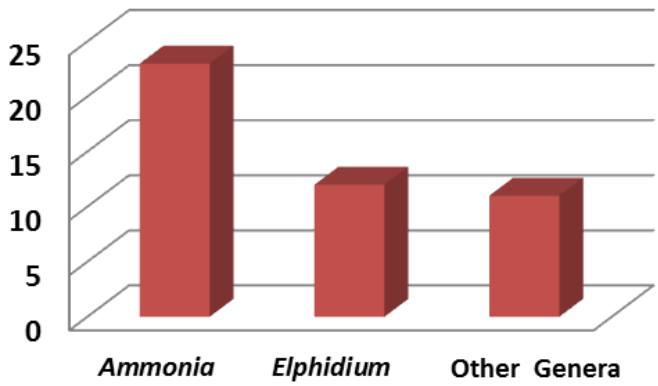

Figure 66. Total number of individuals of different Foraminifera

Particularly *Ammonia compacta* (Hofker, 1969), *Ammonia tepida* (Cushman, 1926), *Ammonia parkinsoniana* (d'Orbigny, 1839) and juvenile *Ammonia* and *Elphidium macellum* (Fichtel & Moll, 1798) and *Elphidium crispum* (Linnaeus, 1758) were frequently encountered. Additionally benthic simbiont foraminifera (with algae) at the stations of 5 and 10 m were often found. These are the species of the genera *Adelosina* and *Spiroloculina*, *Elphidium crispum* (Linnaeus, 1758) and juvenile specimens of the family Hauerinidae. Individuals of *Ammonia* and *Elphidium* were generally encountered at the stations with 20 m depth. Therefore, species diversity is higher at stations with 5 and 10 meters (Fig. 67).

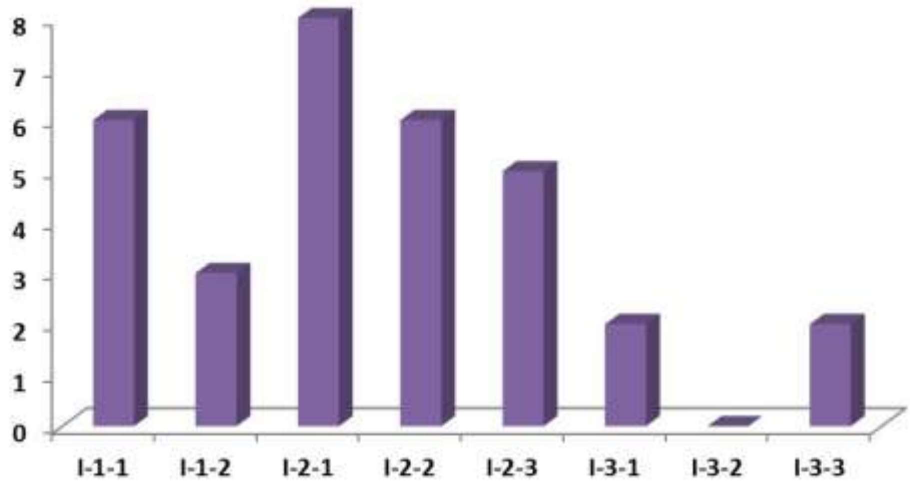

Figure 67. Number of species at the stations

A preliminary quantitative survey of meiobenthos along İğneada coasts has been conducted for the first time. It is observed that a quite diverse meiofauna occurs with a spatial variability. The major factor determining meiobenthos is considered to be the structure of the sediment composition and also currents that influence the food supply for meiofauna. Spatial variability of the abundance of nematodes, and also to some extent some other groups, can be attributed to different granulometric characteristics of the sediment. However, data set being small, limit for the moment the discussion about the factors influencing their abundance and patchiness.

Soft Bottom Macrozoobenthos community

November 2012

Following the taxonomic analysis performed on macrobenthic organisms from Igneada area a total of 67 species and 2984 individuals belonging to 3 main taxonomic groups (Polychaeta, Crustacea, Mollusca) were reported (Annex 3). Out of all, Mollusca came on the first place with 35 species, followed by Polychaeta (18 species) and Crustacea (11 species).

The comparison of diversity and abundance distribution among all 9 stations emphazised two of them (St I-1-3 and St I-2-2), one for the highest number of species (27 species) and the other for the highest number of individuals (15590 ind.m^{-2}).

In terms of dominance, Mollusca shared 82% of abundance, followed by Polychaeta (14%), Crustacea (1%) and others (3%).

Bittium reticulatum, *Lucinella divaricata*, *Chamelea gallina*, *Caecum trachea* and *Tricolia pullus pullus* were the dominant species from Molusca phyllum.

The highest diversity index value among the stations was found in St I-2-1 (H'= 3.47) and the lowest in St I-3-1 (H'=1.30). Evenness index values ranged between (J') 0.34 (St I-2-2) and 0.80 (St I-2-1). Excepting the St. I-2-2, the species had in general an even distribution within the stations.

May 2013

In May 2013, a total of 111 species and 14487 individuals belonging to 3 main taxonomic groups (Polychaeta, Crustacea, Mollusca) were identified. Mollusca came on the first place with 47 species (42%) followed by Polychaeta - 35 species (32%) and Crustacea - 26 species(23%). As abundance, the moluscs formed 71% of total benthic population, Polychaeta - 13% and the rest was covered by Crustacea (1%) and other groups.

The stations I-1-3, I-2-2 and I-3-1 have distinguished from the others due to higher number of species and individuals.

The species *Bitium reticulatum, Chamelea gallina* constituted the major species components of the soft bottom habitats, in association with a rich population of oligochaets.

The highest diversity index value was found at station St I-3-1 (H'=3.38) and the lowest at station St I-3-3 (H'=1.20). According to the Evenness index (J') the species population were evenly distributed within almost all stations

July 2013

In July 2013, a total of 97 species and 19284 individuals were identified belonging to 3 main taxonomic groups (Polychaeta, Crustacea, Mollusca) (Annex 3) and others. Mollusca was ranked first with 41 species (42%), followed by Polychaeta – 31 species (32%) and Crustacea (23 species) (24%), others (2%). In total abundance, Mollusca accounted for 88% of all taxa, Polychaeta for 11% and Crustacea for 1%.

Both the number of species found in the stations I-1-2, I-2-2, and I-2-3 and the number of individuals (105280 ind.m^{-2}) from the St I-2-2 exceeded few times the values found in other stations. In the same time a populational shift in terms of abundance distribution between transects is evident from May to July. Thus, the most obvious changes occurred in St I-1-2, where the species number increased dramatically, while their abundance sharply decreased, and in the St I-2-3, where the number of species as well as the abundances have almost doubled.

Bitium reticulatum (42%) and *Caecum trachea* (25%), *Lucinella divaricata* (6%) along with other diverse groups (24%) molded the characteristic faunistic ansamblages found in sandy habitats.

Generally, the diversity index as well as the evenness index in all stations, particularly in St I-1-2 and I-3-2, escalated to their almost maximum limit. However, in three stations (I-1-3, I-2-1 and I-2-2), the evenness index values were the lowest of all stations. The similarities between stations is reflected by the Bray – Curtis cluster analysis performed on species abundance data. Two main clusters have been detached, with a similarity level of about 50% between them.

October 2013

A total of 82 species and 83010 individuals were identified belonging to 3 main taxonomic groups (Polychaeta, Crustacea, Mollusca) (Annex 3). Similarly to the other sampling periods, Mollusca - 32 species, Polychaeta 28 species - and Crustacea - 19 species – contributed with more than 90% at total species diversity

Remarkable as number of species (41 species) and individuals have been proved the stations St I-3-2 and I-2-2. On the contrary, the station I-1-1 has barely reached the forth or the tenth part, respectively, from the richness of the previous ones.

Mollusca had an outstanding contribution of 90% of total abundance, followed by Polychaeta (9%) and in very low proportion - Crustacea with 1%.

Bitium reticulatum (53%) and *Caecum trachea* (14%) were responsible for the most numerous populations of molluscs identified in the area

Very slightly different from the other sampling periods, the highest diversity index value was found to be at station St I-2-3 (H'=3,30), and the lowest at station I-2-2 (H'=1.92) (Fig. 57). Evenness index (J') values ranged between 0.39 (St I-2-2) and 0.70 (St I-1-2).

As a result of the samplings conducted in the survey area the highest number of species was recorded in May - 111 species, followed by July with 97 species, October with 82 species and November with 67 species (Fig. 68).

The highest number of species in all four periods was determined at station I-2-2 in May with 53 species, while the lowest one was recorded at station I-3-1 in November with 3 species (Fig. 59).

Distribution of the number of individuals among stations revealed that the highest number of individuals was found at station I-2-2 with 105,280 ind.m^{-2} in July, while the lowest one was at station I-3-1 with 80 ind.m^{-2} in November (Fig. 68).

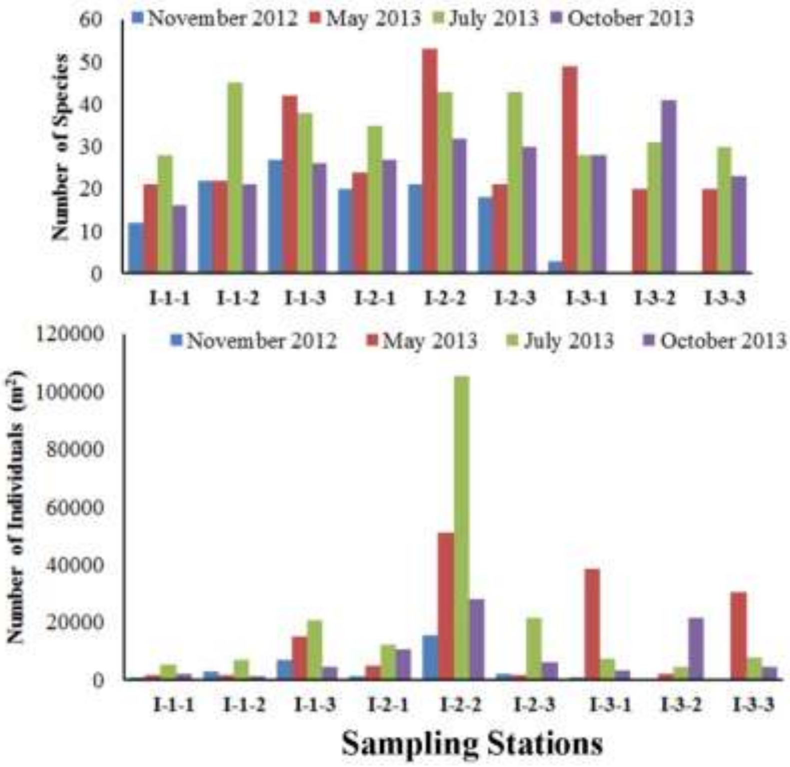

Figure 68. Distribution of number of species and individuals among stations

Hard-Bottom Macrozoobenthos

As a result of the evaluation of the obtained material, the identified taxa from the three different periods are given in the Annex 4.

The areas of İğneada close to the Bulgaria borderline are charactarized by steep rocks streched on relatively short distance along the coastal line. These rocks are observed to be densely covered by the algae *Cystoseira.* These algae provide shelter to many invertebrates against strong wave actions. Extensive sandy shores lies between İğneada Harbour and Lake Mert.

The taxonomic assessment of hard bottom communities of the area carried out in November 2012 revealed a number of 20 main taxa inhabiting here. The dominant species were *Polyophthalmus pictus* from Polychaeta and *Mytilaster lineatus* from Mollusca. In May 2013, an increase number of species (30 taxa) was recorded. *Mytilaster lineatus* and *Mytilus galloprovincialis* from Mollusca were found to be the dominant species along with *Idotea baltica* from Crustacea. *Pilumnus minutus* which is an exotic species was also encountered at rocky shores covered by algae. A total of 22 taxa were identified in July 2013. *Polyophthalmus pictus* from polychaetes was found to be the dominant species.

In addition to the quadrate sampling, observations showed that the sponge *Dysidea fragilis* frequently occurs on rocks at 2-5 meters. These rocks were found to locally extend to a depth of 10 meters. *Eriphia verrucosa* and *Pachygrapsus marmoratus* from Decapoda were frequently seen on rocks.

Benthic Ecological Quality of the Region

The ecological quality of the region was tried to be estimated using AMBI (Borja et al., 2000) and M-AMBI (Muxika et al., 2007) indices depending on the zoobenthic taxa obtained from samplings. Accordingly, the general ecological quality of the research area was found to be good (Fig. 69 and 70).

According to the AMBI index, the results were found to range between 0 and 1.3 among all the stations and replicates showing that the general health of the benthic community is normal in the research area (Fig. 69).

AMBI	Dominating Ecological Group	Benthic Community Health	Site Disturbance Classification
0.0 < AMBI ≤ 0.2	I	Normal	Undisturbed
0.2 < AMBI ≤ 1.2		Impoverished	
1.2 < AMBI ≤ 3.3	III	Unbalanced	Slightly disturbed
3.3 < AMBI ≤ 4.3		Transitional to pollution	Meanly disturbed
4.3 < AMBI ≤ 5.0	IV-V	Polluted	
5.0 < AMBI ≤ 5.5		Transitional to heavy pollution	Heavily disturbed
5.5 < AMBI ≤ 6.0	V	Heavy polluted	
Azoic	Azoic	Azoic	Extremely disturbed

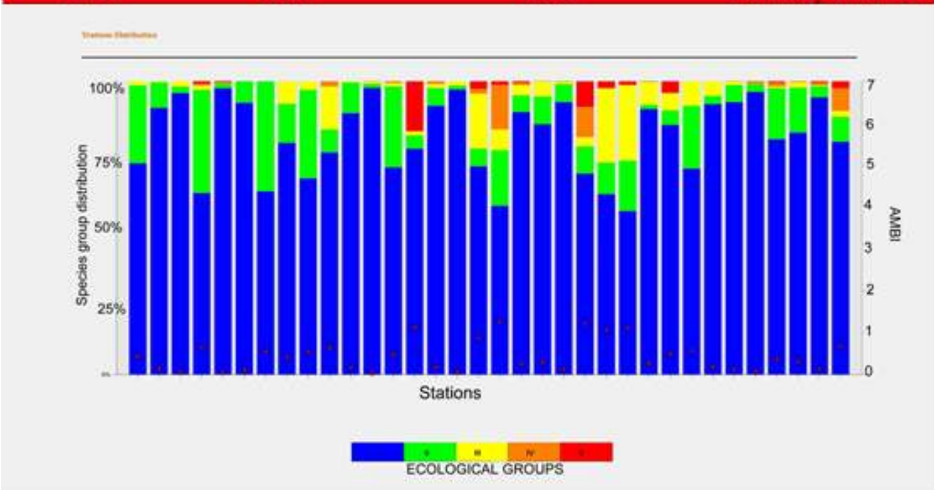

Figure 69. AMBI results of studied area.

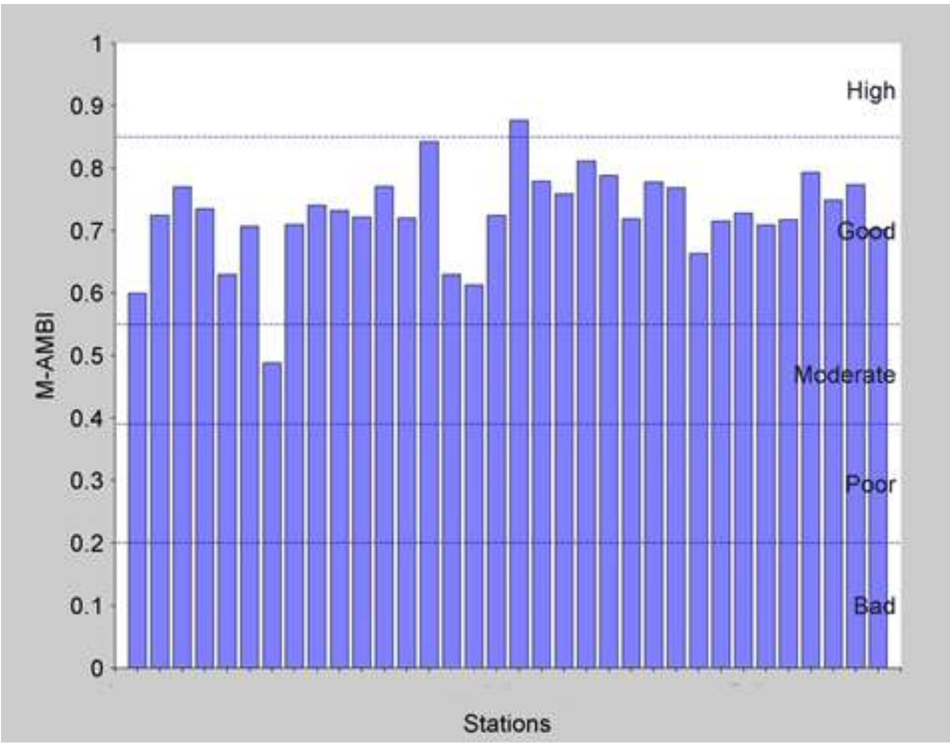

Figure 70. M-AMBI results of studied area.

Habitats Description of the Region

The habitat types determined in the region are as follows.

1. Boulders and blocks: This habitat is host for many microhabitats. Big sized rock and boulder piles appear on the midlittoral of rocky shores, at the base of rocky cliffs (Fig. 71).

Figure 71. Boulders and blocks from İgneada coast.

2. Supralittoral rocks: The upper-littoral rock is situated above the sea level and becomes wet to due wave foam or during storms. This type of habitat is populated by the lichens, isopod crustaceans *Halophiloscia couchii* and *Ligia italica* and the *Pachygrapsus marmoratus* crab (Fig. 72).

Figure 72. Supralittoral rocks from İgneada coast.

3. Lower Midlittoral rocks: The lower midlittoral rock is located in the lower part of the wave breaking area and it is covered by water most of the time. *Cystoseira*, calcified *Corallina officinalis* and *Ulva*, *Cladophora* and *Ceramium* algae occur (Fig. 73).

The fauna is characterized by *Balanus*, *Mytilus* and *Mytilaster*, bryozoa, amphipod and isopod crustaceans, *Pachygrapsus marmoratus* and *Eriphia verrucosa* crabs.

Figure 73. Lower Midlittoral rocks from İgneada coast.

4. Infralittoral rock with photophilic algae: This habitat type is situated immediately under the lower midlittoral level and stretches down to the inferior limit of the spreading of the photophilic algae. It include *Cystoseira* and other algae (Fig. 74).

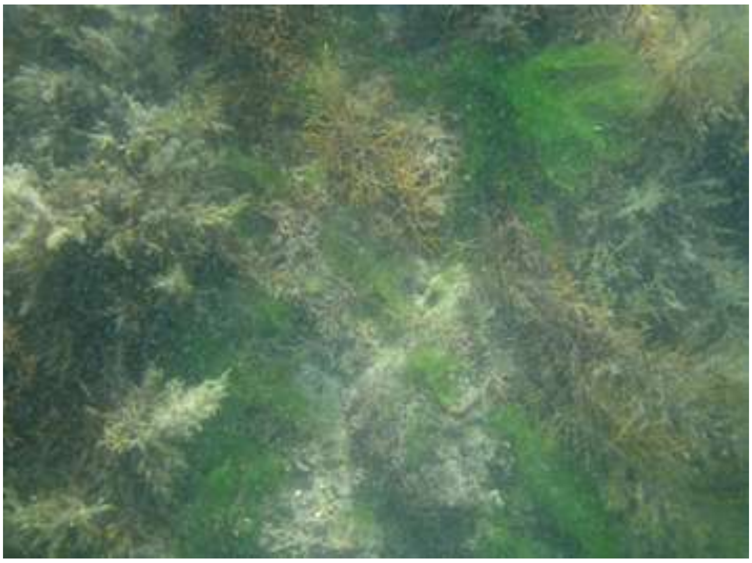

Figure 74. Infralittoral rock with photophilic algae from İgneada coast.

5. Infralittoral rock with Mytilus: This habitat type is laying down to 20 m depth. The fauna is diverse, including some sponge, hydrozoas, bryozoans, polychaets, mollusk, crustacean and tunicats (Fig. 75).

Figure 75. Infralittoral rock with *Mytilus* from İgneada coast.

6. Supralittoral algal deposit areas: This habitat type occupies the beach part that is covered by water only during storms. The deposits are made of the materials brought by the sea (algae, phanerogams leaves, wood pieces, organism corpses). This habitat host talitrid amphipods and isopods (Fig. 76).

Figure 76. Supralittoral algal deposit zone from İgneada coast.

7. Zostera meadows on fine sand: *Zostera* (*Zosterella*) *noltei* and *Z. marina* forms vegetation in sheltered areas at 7 meters depth (Fig. 77).

Figure 77. *Zostera* meadows from İgneada coast.

8. Muddy sands inhabited by *Upogebia* (Fig. 78): encountered between 10 and 20 m depth.

Figure 78. *Upogebia pusilla* from İgneada coast.

The shores of İgneada are generally rich in habitat diversity. Sand, gravel, rock, mud, alage and phanerogams caused formation of different types of habitats.

CONCLUSIONS

- The assessment of ecological status of Strandzha and Iğneada areas in 2012 and 2013 showed that the areas present in general a moderate to good ecological status, varying according to environmental natural and anthropogenic pressures.
- Thus, based on physico -chemical parameters analysed (O_2 saturation, pH, salinity, nitrates and phosphates concentration in water and sediments) the Strandzha area was in high Ecological Quality Status (EQS) in 2012, while its status slightly decreased in 2013, the evaluation based on nutrients load and O_2 saturation revealing only a good ecological status. Similarly, the ecological quality varried seasonally from low (July and October 2013) to high (November 2012 and May 2013) in Igneada area.
- According to Phytoplankton Integrated Index used to assess the ecological status in the Strandzha area, the quality of environment is moderate to good. In Iğneada, the quality status was determined based on diversity indeces and population quantitative structure. Accordingly, the best condition of phytoplankton population was found in July and October 2013, while the poorest in May 2013.
- The evaluation of Ecological Quality Ratio Indices (EQR) of macrophytes in Strandzha area showed a high ecological status in 2012 and 2013 and a good ecological status in Iğneada.
- The zooplankton status was assessed in Strandzha based on several indices proposed by the Bulgarian specialists. Coroborating the results of calculation of diffent indices it was estimated a good to moderate status. In Igneada, on the other hand, the evaluation of ecological status based on species richness, abundance and density in different seasons revealed a general healthy state of zooplankton population.
- According to Benthic Quality Element (BQE), the ecological status based on macrozoobenthic community was good in Strandzha area, taking into consideration the results of assessment of 2006 - 2013 period, although some signs of slight degradation in Varvara station in 2012, but also in Veleka station were recorded, according to M-AMBI index. The results of assessment using also AMBI and M-AMBI indexes in Iğneada indicated a moderate to good ecological status.
- The evaluation of Strandzha and Igneada areas from the point of view of presence of species and habitats found under different protection status according to European, Regional or

international legislation, pointed out on that both areas are unique but in the same time very sensitive places which host species of plants and animals mentioned in Bulgarian and Turkish Red Books, Habitat and Birds Directives, Bonn and Berne Conventions, ACCOBAMS etc.

- Species such as *Donacilla cornea*, *Alosa* spp., *Tursiops truncatus, Phocoena phocoena* and a series of habitats of conservation importance mentioned in Annex I of the Habitat Directive are common to both sites, their interconnectivity being maintained by geomorphological continuity of their habitats and also by feeding grounds, breeding and migration routes of species.

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***Bulgarian Biodiversity act (http://lex.bg/laws/ldoc/2135456926)

***Bulgarian Red data book (http://e-ecodb.bas.bg/rdb/bg/)

***Convention on the Conservation of European Wildlife and Natural Habitats http://conventions.coe.int/Treaty/en/Treaties/Html/104.htm

***Information system for Protected areas from ecological network NATURA 2000 http://natura2000.moew.government.bg/Home/NewsReader/30#

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***Strandzha nature park management plan
http://www.biodiversity.bg/files/File/STRANDJA_ManagPlan.pdf

***Strandzha nature park website - http://www.strandja.bg/

***National Estuary Program (www.epa.gov/nep)

ANNEX

ANNEX 1. The species list of phytoplankton in cruise periods

SPECIES LIST	SAMPLING PERIOD			
Bacillariophyceae	**Nov-12**	**May-13**	**Jul-13**	**Oct-13**
Achnanthes longipes C.Agardh	+	-	-	-
Cylindrotheca closterium (Ehrenberg) Reimann & J.C.Lewin	+	-	-	+
Nitzschia longissima (Brébisson) Ralfs	-	-	-	+
Nitzschia tenuirostris Mer.	-	-	-	+
Gyrosigma sp.	+	-	-	+
Navicula sp.	+	-	-	-
Pleurosigma elongatum W. Smith	+	+	+	+
Pseudo-nitzschia delicatissima (Cleve) Heiden	+	+	+	+
Pseudo-nitzschia seriata (Cleve) H.Peragallo	-	-	-	+
Coscinodiscophyceae				
Biddulphia mobiliensis (J.W.Bailey) Grunow	+	-	-	-
Cerataulina pelagica (Cleve) Hendey	-	-	+	+
Chaetoceros affinis Lauder	+	+	+	+
Chaetoceros compressus Lauder	+	+	+	-
Chaetoceros curvisetus Cleve	-	+	+	+
Chaetoceros decipiens Cleve	-	+	-	+
Chaetoceros didymus Ehrenberg	-	-	-	+
Chaetoceros diversus Cleve	-	-	-	+
Chaetoceros peruvianus Brightwell	-	-	-	+
Chaetoceros radicans F.Schütt	-	-	+	-
Chaetoceros similis P.T. Cleve	-	-	-	+
Chaetoceros simplex Ostenfeld	+	-	-	+
Chaetoceros sp.	+	-	-	-
Coscinodiscus centralis Ehrenberg	-	-	-	+
Coscinodiscus granii Gough	+	-	+	+
Coscinodiscus gigas Ehrenberg	+	-	-	-
Coscinodiscus sp.	-	-	-	+
Dactyliosolen fragilissimus (Bergon) Hasle	-	+	+	-
Ditylum brightwellii (T.West) Grunow	+	-	-	+
Hemiaulus hauckii Grunow ex Van Heurck	+	-	-	-
Leptocylindrus danicus Cleve	+	+	+	+
Melosira moniliformis (O.F.Müller) C.Agardh	-	-	-	+
Melosira sp.	-	-	-	+
Proboscia alata (Brightwell) Sundström	+	+	+	+
Pseudosolenia calcar-avis (Schultze) B.G.Sundström	+	+	+	+
Rhizosolenia setigera Brightwell	-	-	-	+

SPECIES LIST	SAMPLING PERIOD			
Rhizosolenia styliformis T.Brightwell	-	-	-	+
Skeletonema costatum (Greville) Cleve	+	-	+	+
Thalassiosira eccentrica (Ehrenberg) Cleve	+	+	+	+
Thalassiosira parva Pr.-Lavr.1955	-	-	-	+
Fragilariophyceae				
Licmophora abbreviata C.A. Agardh	-	-	+	-
Licmophora ehrenbergii (Kützing) Grunow	+	-	-	-
Licmophora flabellata (Grev.)C.Agardh	+	-	+	+
Striatella unipunctata (Lyngbye) C.Agardh	+	-	+	-
Thalassionema nitzschioides (Grunow) Mereschkowsky	+	+	+	+
Dinophyceae				
Akashiwo sanguinea (Hirasaka, 1924) G. Hansen et Moestrup	-	-	+	-
Alexandrium tamarense (Lebour) Balech	-	-	-	+
Biceratium furca (Ehrenberg) Vanhoeffen	+	+	+	+
Dinophysis acuminata Claparède & Lachmann C	+	-	-	-
Dinophysis acuta Ehrenberg	-	-	-	+
Dinophysis caudata Saville-Kent	+	-	+	+
Dinophysis fortii Pavillard	+	-	-	+
Dinophysis sacculus Stein, 1883	-	-	-	+
Glenodinium sp.	-	-	-	+
Gonyaulax monacantha Pavillard	-	-	+	-
Gonyaulax polygramma Stein	-	-	+	+
Gonyaulax scrippsae Kofoid	-	-	-	+
Gonyaulax spinifera (Claparède & Lachmann, 1859) Diesing	-	-	-	+
Gymnodinium sp.	-	-	+	+
Gyrodinium fusiforme Kofoid & Swezy	+	+	+	+
Gyrodinium lachryma (Meunier) Kofoid & Swezy	+	-	-	+
Gyrodinium sp.	-	-	-	+
Lingulodinium polyedra (F.Stein) J.D.Dodge	+	+	+	+
Neoceratium fusus (Ehrenberg) F.Gomez, D.Moreira & P.Lopez-Garcia	+	+	+	+
Neoceratium tripos (O.F.Müller) F.Gomez, D.Moreira & P.Lopez-Garcia	-	+	+	+
Neoceratium lineatum (Ehrenberg) F.Gomez, D.Moreira & P.Lopez-Garcia	+	-	-	-
Phalacroma rotundatum (Claparéde & Lachmann) Kofoid & Michener	+	-	+	+
Podolampas palmipes Stein	+	-	-	-
Polykrikos schwartzii Bütschli	-	-	+	-
Prorocentrum compressum (J.W.Bailey) Abé ex Dodge	+	+	+	+
Prorocentrum cordatum (Ostenfeld) Dodge	-	-	+	+
Prorocentrum micans Ehrenberg	+	+	+	+
Protoceratium reticulatum (Claparède & Lachmann) Bütschli	-	-	-	+
Protoperidinium brochii (Kofoid & Swezy) Balech	+	-	-	-
Protoperidinium claudicans (Paulsen) Balech	+	-	+	+
Protoperidinium curtipes (Jorgensen) Balech	+	-	-	+
Protoperidinium depressum (Bailey) Balech	+	+	+	+

SPECIES LIST	SAMPLING PERIOD			
Protoperidinium divergens (Ehrenberg) Balech	+	-	+	+
Protoperidinium grande (Kofoid) Balech	+	-	-	+
Protoperidinium granii (Ostenfeld) Balech	+	+	+	+
Protoperidinium steinii (Jörgensen) Balech	+	-	+	+
Protoperidinium pallidum (Ostenfeld) Balech	+	-	+	+
Protoperidinium pellucidum Bergh ex Loeblich Jr.& Loeblich III	+	-	-	+
Scrippsiella trochoidea (Stein) Balech ex Loeblich III	+	+	+	+
Dictyochophyceae				
Dictyocha polyactis Ehrenberg	-	-	-	+
Distephanus speculum (Ehrenberg) Haeckel	+	-	-	+
Octactis octonaria (Ehrenberg) Hovasse	+	-	-	+
Ebriophyceae				
Ebria tripartita (Schumann) Lemmermann	+	-	-	+
Prymnesiophyceae				
Emiliania huxleyi (Lohmann) W.W.Hay & H.P.Mohler	+	+	+	+

Annex 2. Meiofaunal density (ind./m^2) at the stations sampled along the coasts of İğneada

Stations	I-1-1		I-1-2		I-2-1		I-2-2		I-2-3		I-3-1		I-3-2		I-3-3	
Biotope	**FS+CS**		**CS+FS+ shells**		**FS+Silt**		**FS+ shells**		**CS+FS +Shells**		**Silt**		**FS+CS+ shells**		**FS+CS**	
Meiobenthos	**Indiv.**	**Density**	**Indiv.**	**Density**	**Indiv.**	**Density**	**Indiv.**	**Density**	**Indiv.**	**Density**	**Indiv.**	**Density**	**Indiv.**	**Density**	**Indiv.**	**Density**
Nematoda	209	166364	77	61292	191	152036	237	188652	440	350240	110	87560	107	85172	245	195020
Harpacticoida	141	112236	4	3184	20	15920	553	440188	10	7960	46	36616	-	-	192	152832
Polychaeta	-	-	3	2388	-	-	10	7960	2	1592	-	-	-	-	37	29452
Foraminifera (Hard Shelled)	25	19900	-	-	53	42188	72	57312	14	11144	2	1592	6	4776	5	3980
Foraminifera (Soft Shelled)	-	-	-	-	-	-	4	3184	-	-	3	2388	-	-	-	-
Bivalvia	43	34228	-	-	1	796	7	5572	23	18308	-	-	-	-	7	5572
Gastropoda	14	11144	-	-	4	3184	16	12736	35	27860	3	2388	4	3184	8	6368
Ostracoda	4	3184	-	-	2	1592	8	6368	3	2388	-	-	-	-	-	-
Turbellaria	3	2388	-	-	-	-	18	14328	-	-	2	1592	-	-	3	2388
Oligochaeta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	34	27064
Nemertea	-	-	-	-	-	-	1	796	-	-	-	-	-	-	1	796
Acarina	-	-	-	-	-	-	3	2388	-	-	-	-	-	-	36	28656
Nauplii	-	-	-	-	-	-	16	12736	-	-	-	-	-	-	-	-
Others	5	3980	-	-	1	796	6	4776	2	1592	-	-	1	796	11	8756
TOTAL	**444**	**353424**	**84**	**66864**	**272**	**216512**	**951**	**756996**	**529**	**421084**	**166**	**132136**	**118**	**93928**	**579**	**460884**

Annex 3. Macrozoobenthos density (ind./m^2) at the stations sampled along the coasts of İğneada

Crt. nr.	TAXA	Nov. 2012	May 2013	July 2013	Oct 2013
1	Turbellaria (sp.)				1.11
2	Nemertea (sp.)	1.11	26.67	24.4	11.11
3	Oligochaeta (sp.)	95.56	2422.22		
4	*Aonides paucibranchiata* Southern, 1914	11.11	10.00		5.56
5	*Aricidea claudiae* Laubier, 1967		38.89		183.33
6	*Aricidea* sp.1	37.78	34.44	143.3	156.67
7	*Capitella capitata* (Fabricius, 1780)		393.33		
8	*Capitomastus minima* (Langerhans, 1881)	7.78	332.22	272.2	34.44
9	*Cirratulus* sp.			1.1	
10	*Cirriformia tentaculata* (Montagu, 1808)		1.11	3,3	
11	*Eumida sanguinea* (Örsted, 1843)		1.11		
12	*Eunice* sp.	1.11			
13	*Exogone (Exogone) naidina* Örsted, 1845			8.9	1.11
14	*Exogone* sp.		125.56		1.11
15	*Glycera alba* (O.F. Müller, 1776)		3.33	12.2	2.22
16	*Glycera* sp.			77.8	1.11
17	*Glycera* sp.1	1.11	2.22		
18	*Glycera* sp.2	2.22			
19	*Glycera* sp.3			1.1	7.78
20	*Harmathoe* sp.		8.89	6.7	
21	*Harmothoe imbricata* (Linnaeus, 1767)			1.1	
22	*Hediste diversicolor* (O.F. Müller, 1776)		3.33		
23	*Heteromastus filiformis* (Claparède, 1864)		16.67	368.9	93.33
24	*Lagis koreni* Malmgren, 1866			1.1	
25	*Laonice cirrata* (M. Sars, 1851)	2.22			
26	*Leiochone leiopygos* (Grube, 1860)		3.33	31.1	3.33
27	*Magelona* sp.1	1.11	1.11		1.11
28	*Magelona* sp.2	2.22	7.78	13.3	1.11
29	Maldanidae (sp.)				1.11
30	*Melinna palmata* Grube, 1870			4.4	
31	*Micronephthys stammeri* (Augener, 1932)			230.0	44.44
32	*Microphthalmus* cf. *sczelkowii* Metschnikow, 1865		71.11	53.3	
33	*Mysta picta* (Quatrefages, 1866)			2.2	
34	*Nephthys hystricis* McIntosh, 1900	56.67			
35	*Nepthys* sp.	12.22	101.11	73.3	151.11
36	*Nereis* sp.			2.2	6.67
37	*Odontosyllis* sp.		3.33		
38	Ophelia sp.	11.11	7.78	52.2	4.44
39	*Owenia fusiformis* Delle Chiaje, 1844				3.33
40	*Pholoe inornata* Johnston, 1839		7.78	2.2	
41	*Phyllodoce* sp.			8.9	6.67
42	*Pisione* sp.	13.33	7.78		
43	*Platynereis dumerilii* (Audouin & Milne Edwards, 1834)		2.22	61.1	5.56
44	*Polycirrus* sp.		2.22		
45	*Polydora cornuta* Bosc, 1802		15.56	1.1	
46	*Polygordius* sp.	103.33	278.89		

Crt. nr.	TAXA	Nov. 2012	May 2013	July 2013	Oct 2013
47	*Polyophthalmus pictus* (Dujardin, 1839)		1.11		
48	*Prionospio* (*Minuspio*) *maciolekae* Dagli & Çinar, 2011	3.33	232.22	53.3	8.89
49	*Prionospio* sp.				2.22
50	*Protodorvillea* sp.	203.33	264.44	124.4	105.56
51	*Scolaricia* sp.	2.22			
52	*Scolelepis* (*Parascolelepis*) *tridentata* (Southern, 1914)	4.44	2.22		
53	*Sphaerosyllis hystrix* Claparède, 1863		12.22		
54	*Spio* cf. *filicornis* (Müller, 1776)		25.56	1.1	1.11
55	*Spio decoratus* Bobretzky, 1870		23.33	727.8	16.67
56	*Spiophanes* sp.		3.33		
57	*Syllis* sp.		2.22		2.22
58	*Terebella* sp.			1.1	
59	Terebellidae (sp.)				3.33
60	*Terebellides stroemii* Sars, 1835			1.1	
61	Phoronida (sp)				2.22
62	*Ampelisca diadema*		2.22	6.7	7.78
63	*Ampelisca pseudospinimana*		3.33	60.0	7.78
64	*Ampelisca sp.*	2.22			
65	*Ampithoe raimondi*		13.33	8.9	2.22
66	*Apseudopsis ostroumovi*				7.78
67	*Atylus massilensis*	2.22	25.56	3.3	
68	*Balanus improvisus*		15.56	1.1	
69	*Bathyporeia guilliamsoniana*	2.22	28.89	41.1	5.56
70	*Bodotria arenosa mediterranea*		4.44	1,1	
71	*Bodotria scorpioides*	2.22			
72	*Bodotria sp.*	1.11			
73	*Brachynotus sexdentatus*		1.11		
74	*Callianassa truncata*			1.1	2.22
75	*Crangon crangon*			2.2	
76	*Cumopsis goodsir*	3.33	38.89	52.2	5.56
77	*Dexamine spinosa*		3.33	3.3	
78	*Diogenes pugilator*		7.78	6.7	12.22
79	*Dynamene bidentata*	1.11			
80	*Ericthonius brasiliensis*			2.2	
81	*Eurydice pulchra*	5.56	2.22		6.67
82	*Eurydice racovitzai*	2.22	4.44	1.1	1.11
83	*Gammarus aequicauda*		3.33		
84	*Idotea baltica*		2.22		2.22
85	*Iphinoe maeotica*			7.8	1.11
86	*Iphinoe serrata*			1.1	1.11
87	*Iphinoe tenella*				2.22
88	*Iphinoe trispinosa*		1.11	1.1	
89	*Leptochelia savignyi*				2,22
90	*Megaluropus massiliensis*	2.22	2.22	21.1	2.22
91	*Microdeutopus gryllotalpa*		2.22		
92	*Microdeutopus versiculatus*		1.11	2.2	
93	*Monocorophium acherisicum*		7.78	10.0	4.44
94	*Perioculodes longimanus longimanus*	2.22	40.00	16,7	1.11

Crt. nr.	TAXA	Nov. 2012	May 2013	July 2013	Oct 2013
95	*Pisidia longimana*		1.11		
96	*Pseudocuma longicornis*		5.56		
97	*Siriella jaltensis jaltensis*		2.22		
98	*Tanais dulongii*			1.1	
99	*Ubogebia pusilla*		1.11	1.1	6.67
100	*Anadara inaequivalvis*	1.11	1.11		
101	*Bela nebula*	1.11	23.33	41.1	30.00
102	*Bittium reticulatum*	1831.11	8310.00	8908.9	4934.44
103	*Caecum trachea*	267.78	150.00	5284.4	1321.11
104	*Calyptrae chinensis*		6.67	63.3	131.11
105	*Chamelea gallina*	50.00	817.78	573.3	347.78
106	*Chrysallida interstincta*	1.11	2.22	3.3	5.56
107	*Cyclichnina robagliana*		4.44	7.8	1.11
108	*Cyclope neritea*	10.00	114.44	120.0	44.44
109	*Cylichnina umbilicata*	1.11	24.44	20.0	55.56
110	*Donax trunculus*	1.11			
111	*Donax venustus*	3.33	10.00	4.4	2.22
112	*Ecrobia ventrosa*	2.22	3.33	310.0	125.56
113	*Epitonium commune*			4.4	
114	*Epitonium turtonis*		4.44	15.6	5.56
115	*Gibbula albida*	1.11	3.33	17.8	5.56
116	*Gibbula divaricata*	8.89	4.44	2.2	2.22
117	*Gouldia minima*	1.11	8.89	5,6	
118	*Hydrobia acuta*	4.44	23.33		15.56
119	*Lentidium mediterraneum*	36.67	55.56	1.1	5.56
120	*Lucinella divaricata*	141.11	281.11	1352.2	291.11
121	*Mangelia coarctata*		1.11	12.2	
122	*Mangelia pontica*	3.33	16.67	27.8	2.22
123	*Mangelia sp.*	3.33	10.00	2.2	
124	*Manzonia crassa*		1.11		
125	*Marshallora adverse*	3.33	1.11	26.7	
126	*Modulus sp.*		4.44		
127	*Monophorus perversus*	7.78	18.89	11.1	6.67
128	*Mytilaster lineatus*	1.11	6.67	2.2	
129	*Mytilus galloprovincialis*		12.22	3.3	
130	*Nassarius reticulatus*	10.00	65.56	200.0	53.33
131	*Paphia aurea*		2.22	3.3	3.33
132	*Parvicardium exiguum*	1.11	6.67	5.6	
133	*Pitar rudis*		3.33	26.7	
134	*Pusillina lineolata*		3.33	13.3	37.78
135	*Pusillina radiata*			155,6	
136	*Pusillina sp.*	10.00	76.67	32.2	
137	*Rapana venosa*		3.33		3.33
138	*Retusa truncatula*	17.78	13.33	405.6	2.22
139	*Rissoa labiosa*		67.78	104.4	
140	*Rissoa lineolata*		7,78		
141	*Rissoa membranaceae*	1.11	72.22	540.0	601.11
142	*Rissoa sp.*	6.67	17.78		

Crt. nr.	TAXA	Nov. 2012	May 2013	July 2013	Oct 2013
143	*Rissoa splendida*	6.67	965.56	155.6	130.00
144	*Rissoa ventricosa*	2.22	1.11		
145	*Setia pulcherrima*	1.11			
146	*Spisula subtruncata*		60.00	72.2	8.89
147	*Tellina tenuis*	2.22	14.44	5.6	20.00
148	*Theodoxus fluviatilis*	1.11		1.1	3.33
149	*Tricolia pullus pullus*	267.78	461.11	181.1	42.22
150	*Tritaeta gibbosa*		1.11		
151	*Turbonilla delicata*		7.78		4.44
152	*Turbonilla pusilla*	3.33	5.56	82.2	27.78
153	*Branchiostoma lanceolatum* (Pallas, 1774)	2.22	1.11	1.1	
TOTAL		**3315.6**	**16496.7**	**21426.7**	**9223.3**

Annex 4. Macrozoobenthos on the hard bottom stations (İğneada)

TAXA/400 cm^2	November 2012		May 2013		July 2013	
	B1	B2	B2	B1	B1	B2
Eteone sp.			1			
Harmothoe sp.						1
Hediste diversicolor	140	31	32	12		
Nereis sp.	42	16				
Nereis zonata						26
Platynereis dumerilii			14	7	57	87
Perinereis cultrifera	3	4			12	42
Polyophthalmus pictus	409	88	47	3	17	397
Syllis armillaris	17	1				2
Syllis sp.					1	
Ampithoe raimondi			1	20	11	4
Atylus massilensis	2					
Balanus improvisus			1			
Coroghium achenicum			2		4	
Dexamine spinosa	27			12	1	
Ericthonius brasiliensis				2	9	4
Gammarus insensibilis			15			
Gammarellus angulosus	43	1				
Heterotanais sp.	11	9				
Hyale crassipes	23	62	4	2	21	33
Hyale perieri		15				
Hyale pontica			4			6
Idotea baltica		3	126	55	28	150
Idotea sp.		4				
Melita palmata						1
Microdeutopus gryllotalpa				4		
Pachygrapsus marmoratus			1			
Pilumnus minutus			1	1		
Sphaeroma serratum	3					

TAXA/400 cm^2	November 2012		May 2013		July 2013	
	B1	B2	B2	B1	B1	B2
Stenothoe monoculoides			4	1		
Tanais dulongii		5	16	101	123	29
Bittium reticulatum				3	28	
Mytilaster lineatus	200	2010	235	450		7
Mytilus galloprovincialis	125	6	105	254	94	48
Rapana venosa	3			1		
Rissoa splendida	80				86	
Tricolia pullus pullus	403		21	3	7	