

Contribution to the designation of the Platamuni marine protected area

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ABSTRACT

*During the present research, we registered 108 benthic marine taxa in the future Platamuni marine protected area (MPA). Among the identified taxa, 21 species are of national and international importance. The research of the fish community has shown that this area is inhabited by species that are common and characteristic for the Mediterranean Sea. The Platamuni area is populated by a large number of commercial organisms (fish – 31; echinoderms – 4; arthropods – 4; cephalopods – 3; shells – 3). In the research area, the presence of the seagrass *Posidonia oceanica* and of sea caves should be emphasised, since they are priority habitats under the EU Habitats Directive. The study shows that the future Platamuni MPA is characterised by a high biodiversity, but anthropogenic impacts are also evident.*

Keywords: Platamuni, MPA, marine biodiversity, Adriatic Sea.

INTRODUCTION

A marine protected area (MPA) is an area in the sea especially dedicated to the protection and maintenance of biodiversity, and of natural and associated cultural resources, that should be managed through legal or other effective means (Otero *et al.*, 2013). MPAs include marine parks, nature reserves and locally managed marine areas that protect reefs, seagrass beds, archaeological sites, saltmarshes, underwater areas on the coast and the seabed in deep water, as well as open water habitats (the water column). In 1988, The World Conservation Union (IUCN) General Assembly called upon national governments, international agencies and the non-governmental community to provide for the protection, restoration, wise use, understanding and enjoyment of the marine heritage of the world through the creation of a global, representative system of marine protected areas and through management in accordance with the principles of the World Conservation Strategy of human activities that use or affect the marine environment (Tempesta, 2013). The main reasons for the protection of such marine areas are related to modern technologies that have increased the range of uses of, and access to, marine environments, supporting industries such as fishing, tourism and aquaculture, as well as the development of new forms of drugs from tissues of marine organisms. However, unless managed sustainably, the users of marine ecosystems can threaten, change and destroy resources that they depend on (Kenchington *et al.*, 2003). The most obvious effect is visible in impacts on the longstanding and widespread use of marine resources for seafood. The global fish catch has been in consistent decline since 1989, and the downward trend is projected to continue (FAO, 2004). The marine biodiversity,

ecosystems and resources are also threatened by impacts reaching the sea from the land, through pollution by nutrients, chemicals and silt, and through changed river flows. Marine protected areas are helping to protect important habitats and representative samples of marine life, and can assist in restoring the productivity of the oceans and avoid further degradation. They are also sites for scientific study and can generate income through tourism and sustainable fishing. MPAs provide a range of benefits for fisheries, local economies and the marine environment (Kenchington *et al.*, 2003).

The need for protection of the Adriatic areas along the Montenegrin coast has come from a series of national and international commitments and the fact that Montenegro is almost the only country in the Mediterranean area without a declared marine protected area. For the purpose of the screening the current status and quality of the marine ecosystem, research *in situ* has been done, as well as gathering of existing literature data that are summarised and presented in this paper.

MATERIAL AND METHODS

Study Area

The explored area extends from the Žukovac inlet (in the north) to Cape Platamuni (in the south) (Figure 1). The investigated part is characterised by vertical and less-vertical limestone cliffs that descend steeply down to a depth of 20–30 (40) m in the sea, and therefore, the isobath of 50 m is located at a relatively short distance from the coastline. In deeper areas, the rocky bottom is sparse and more often the seabed is covered by sand.



Figure 1. The explored area. 1. Cape Sipavica, 2. Žukovac inlet, 3. Cape Žukovac, 4. and 5. Seka Albaneze, 6. Nerin inlet, 7. Velika Krekavica inlet, 8. Cape Platamuni, 9. Đurđeva vala, 10. Stapac, 11. Sv. Nikola, 12. Zli potok, 13. Krekavica cave, 14. Saletova cave, 15. Sv. Nikola, 16. Cape Kostovica.

Field and laboratory work

The biodiversity of the study area was verified *in situ* using the non-destructive visual scuba diving method (Eleftheriou and McIntyre, 2005). Investigations included the coastal

strip from the coastline down to 40 m of depth. The identification of organisms was done partially during the diving. Organisms that were not determined *in situ* were photographed, collected and transported to the Institute of Marine Biology in Kotor. The collected material was preserved by standard methods in 70% alcohol or 4% formalin. The determination of the organisms was done in the laboratory on the basis of keys for specific groups of organisms and harmonised by WoRMS (2014).

Data analyses

Part of the information contained in the paper was collected from grey literature (reports, studies), as well as from scientific papers. Locations investigated in the past and locations investigated in 2014 are shown in Figure 1. The geographical coordinates of locations investigated in 2014 are presented in Table 1.

Table 1. Geographical coordinates of locations investigated in March 2014.

Number	Locations	N	E
1.	Cape Sipavica	42.33368°	18.70797°
2.	Žukovac inlet	42.32699°	18.71120°
5.	Seka Albaneze	42.32793°	18.69958°
7.	Velika Krekavica inlet	42.29038°	18.75026°
9.	Đurđeva vala	42.30990°	18.72424°
10.	Stapac	42.29449°	18.74333°
11.	Sv. Nikola	42.27575°	18.76644°
12.	Zli potok	42.31366°	18.71721°

RESULTS AND DISCUSSION

The results show that the study area is populated by 108 benthic species. The total collected material included 24 algae, 2 phanerogams, 11 sponges, 6 cnidarians, 7 polychaetes, 17 mollusks, 7 crustaceans, 4 bryozoans, 27 echinoderms and 3 ascidia (Table 2).

Table 2. List of taxa of marine organisms recorded in the area from the Žukovac inlet to Cape Platamuni (*species of economic interest).

Algae	<i>Gastrochaena dubbia</i>
<i>Acetabularia acetabulum</i>	<i>Hexaplex trunculus</i>
<i>Caulerpa cylindracea</i>	<i>Lithophaga lithophaga</i> *
<i>Codium bursa</i>	<i>Luria lurida</i> *
<i>Codium vermilara</i>	<i>Pinna nobilis</i> *
<i>Corallina officinalis</i>	<i>Patella</i> sp.
<i>Cystoseira amentacea</i> var. <i>stricta</i>	<i>Vermetus arenarius</i>

Cystoseira corniculata
Cystoseira discors var. *latiramosa*
Cystoseira spp.
Cystoseira compressa
Dasycladus vermicularis
Dilophus spp.
Flabellia petiolata
Halimeda tuna
Halopteris spp.
Jania rubens
Lophocladia lallemandii
Lithophyllum
Padina pavonica
Palmophyllum crassum
Peyssonnelia rubra
Pseudolithophyllum expansum
Sargassum spp.
Sphaerococcus coronopifolius

Ascidia

Microcosmus sp.
Halocynthia papillosa
Sydnium sp.

Porifera

Agelas oroides
Anchinoe sp.
Axinella sp.
Chondrila sp.
Chondrosia sp.
Clatrina sp.
Clionaidae
Crambe crambe
Ircinia spp.
Petrosia ficiformis
Spirastrella cunctatix

Polychaeta

Harmodice carunculata
Protula sp.
Pomatoceros triqueter
Sabella penicillus

Vermetus sp.
*Octopus vulgaris**
*Loligo officinalis**
*Sepia officinalis**
Echinodermata
Antedon mediterranea
Arbacia lixula
Anseropoda placenta
Astropecten bispinosus
Astropecten irregularis pentacanthus
Brissus unicolor
Cidaris cidaris
Centrostephanus longispinus
Coscinasteria tenuispina
Chaetaster longipes
Echinaster sepositus
Hacelia attenuata
Holothuria forskali *
*Holothuria tubulosa**
Holothuria polii
Holothuria sanctori
Luidia ciliaris
Marthasterias glacialis
*Ophiaster ophidianus**
Ophioderma longicauda
Ophiotrix fragilis
Ophiura ophiura
*Paracentrotus lividus**
Peltaster placenta
Parastichopus regalis
Sphaerechinus granularis
Spatangus purpureus

Crustacea

Balanidae
Cirripedia
*Homarus gammarus**
*Scyllarus arctus**
*Palinurus elephas**
*Scyllarides latus**

Sabella spallanzani
Serpula vermicularis
Terebellidae
Phanerogamae
Posidonia oceanica
Cymodocea nodosa

Mollusca

Arca noae
Bittium latreilli
Chromodoris krohni
Discodoris atromaculata
Fasciolaria lignaria
Flabellina affinis

Bryozoa

Myriapora truncata
Porella cervicornis
Schizoporellidae
Smittina cervicornis

Cnidaria

Aglaophenia sp.
Anemonia sulcata
Balanofillia sp.
Cerianthus sp.
Cladocora cespitosa
Parazoanthus axinellae

Among the identified taxa, 21 are present either in the list of the Barcelona Convention (1976), or the Berne Convention (1979), IUCN (2014) or Official Gazette of Montenegro (76/06).

Fish species living in this area are common and characteristic for the Mediterranean Sea. (Badalamenti *et al.*, 2012). However, it is important to underline a very low abundance and small body size of species that have commercial value for fishing and diving tourism (*Epinephelus* sp., *Diplodus* sp., *Sparus aurata*). The most abundant fish species belonged to the Labridae, Sparidae and Serranidae families. The largest fish diversity was registered at the Cape Kostovica site (30 species), while the lowest diversity of fish was at the Sveti Nikola site (18 species) (Table 3). The most abundant species throughout the research was *Boops boops* in the Cape Platamuni where an average number of 155 individuals was registered (Fant *et al.*, 2012).

The invasive algal species *Womersleyella setacea* was registered at locations Seka Albaneze, Cape Žukovac, Nerin inlet, Velika Krekavica inlet and Mala Krekavica inlet during a previous investigation (Fant *et al.*, 2012). This algae covers a significant area of the seabed and sometimes sessile organisms, so the highly invasive character represents a threat to the local marine biodiversity (Mačić, 2008). Surveys done in 2014 confirmed the presence of this species in the study area, as well as earlier registered invasive alga *Caulerpa cylindracea* in Žukovac inlet, Cape Sipavica, Đurdeva vala, Stapac and Velika Krekavica inlet (Mačić & Kaščelan, 2007). In the vicinity of the studied locations in the Jaz inlet the blue crab *Callinectes sapidus* was also found, which is also an invasive, but edible, species (Mačić & Kljajić, 2012).

Table 3. Species abundance, mean abundance, total abundance and species richness 250 m² (\pm standard error of the mean, SEM) of the fish assemblage observed in each site in the quantitative assessment of the Platamuni by visual census using scuba diving (from Badalamenti *et al.*, 2012).

Species	Year									
	2008									
	PLATAMUNI									
Locality	Eastern Grbalj		Sv. Nikola		Seka Albaneze		Rat Kostovica		Krekavica	
Zone	Rat Platamuni	Sv. Nikola	Western Grbalj	Rat Kostovica	Velika Krekavica	Mala Krekavica				
Site										
<i>A. antithias</i>			6.00 \pm 1.13							
<i>A. imberbis</i>	0.33 \pm 0.06		0.33 \pm 0.06	0.67 \pm 0.06	1.67 \pm 0.23	1.33 \pm 0.25				
<i>B. boops</i>	155.67 \pm 17.78	131.00 \pm 17.94	153.00 \pm 17.32	118.67 \pm 18.86	47.33 \pm 8.95	6.00 \pm 1.13				
<i>C. chromis</i>	112.67 \pm 15.95	19.00 \pm 2.13	178.00 \pm 26.64	18.00 \pm 2.15	177.33 \pm 26.71	173.67 \pm 8.51				
<i>C. julis</i>	18.00 \pm 0.66	6.67 \pm 0.25	20.00 \pm 0.66	13.67 \pm 0.54	36.33 \pm 2.33	18.33 \pm 1.09				
<i>D. annularis</i>	2.33 \pm 0.44	4.67 \pm 0.62	2.00 \pm 0.11	21.33 \pm 3.47	11.00 \pm 2.08					
<i>D. puntazzo</i>				0.33 \pm 0.06	0.33 \pm 0.06	2.00 \pm 0.19				
<i>D. sargus</i>		0.33 \pm 0.06		1.33 \pm 0.17	0.33 \pm 0.06	2.67 \pm 0.41				

<i>D. vulgaris</i>	1.67 ± 0.23	5.67 ± 0.88	3.00 ± 0.22	4.33 ± 0.73	11.33 ± 1.22
<i>E. costae</i>			0.33 ± 0.06		
<i>E. marginatus</i>			0.33 ± 0.06		
<i>L. bimaculatus</i>	0.33 ± 0.06	0.33 ± 0.06			0.33 ± 0.06
<i>L. merula</i>			1.00 ± 0.11		
<i>M. helena</i>	0.33 ± 0.06	3.00 ± 0.57	1.00 ± 0.19	0.33 ± 0.06	
<i>M. surmuletus</i>	2.67 ± 0.06	2.33 ± 0.17	2.33 ± 0.23	8.00 ± 0.61	9.00 ± 1.24
<i>O. melanura</i>			1.00 ± 0.19	3.33 ± 0.54	0.33 ± 0.06
<i>P. pagrus</i>			0.33 ± 0.06		
<i>P. phycis</i>				0.33 ± 0.06	
<i>S. aurata</i>			0.33 ± 0.06		0.33 ± 0.06
<i>S. cabrilla</i>	3.33 ± 0.17	3.00 ± 0.11	3.00 ± 0.19	10.00 ± 0.82	9.33 ± 0.54
<i>S. cantharus</i>	2.33 ± 0.23	1.00 ± 0.11	10.00 ± 0.89	12.33 ± 1.17	0.67 ± 0.06
<i>S. doderleini</i>	0.67 ± 0.06	0.67 ± 0.06	2.33 ± 0.23	1.00 ± 0.11	0.33 ± 0.06
<i>S. maderensis</i>			0.33 ± 0.06	1.00 ± 0.11	0.67 ± 0.06
<i>S. maena</i>	1.33 ± 0.25			19.00 ± 2.13	1.00 ± 0.19
<i>S. mediterraneus</i>	2.67 ± 0.33	0.67 ± 0.06	0.67 ± 0.13	1.33 ± 0.13	1.33 ± 0.06

<i>S. melanocercus</i>	1.33 ± 0.17	1.33 ± 0.13	0.67 ± 0.06	0.33 ± 0.06			1.00 ± 0.19
<i>S. ocellatus</i>	1.00 ± 0.19		16.00 ± 2.83	4.33 ± 0.73	7.33 ± 0.62		
<i>S. roissali</i>				0.33 ± 0.06			
<i>S. rostratus</i>		0.33 ± 0.06	0.33 ± 0.06	1.00 ± 0.11			
<i>S. salpa</i>				1.00 ± 0.19	2.67 ± 0.50		
<i>S. scriba</i>	0.33 ± 0.06	0.33 ± 0.06	0.33 ± 0.06	2.67 ± 0.06	0.33 ± 0.06		1.00 ± 0.11
<i>S. scrofa</i>				0.33 ± 0.06			
<i>S. smarvis</i>	121.33 ± 18.67	2.67 ± 0.50	5.33 ± 1.01				
<i>S. tinca</i>	1.33 ± 0.17	1.33 ± 0.06	0.67 ± 0.06	1.67 ± 0.23	1.00 ± 0.11		1.33 ± 0.17
<i>T. pavo</i>		1.00 ± 0.11		0.33 ± 0.06	0.33 ± 0.06		0.67 ± 0.13
Total abundance	429.67 ± 55.60	182.33 ± 23.39	418.33 ± 54.04	212.00 ± 29.55	347.00 ± 48.24	242.67 ± 15.81	
„Reduced“ abundance	38.00 ± 2.83	29.67 ± 2.82	57.00 ± 5.85	73.33 ± 8.23	100.33 ± 10.06	60.00 ± 5.66	
Richness	19	18	20	30	23	21	

The Platamuni area is populated by a large number of commercial organisms. The most numerous are fish (31 species), followed by echinoderms (4), arthropods (4), cephalopods (3) and shell (3) species. The commercial value of these organisms is expressed through human consumption, as well as their use as souvenirs. Of special importance are the representatives of the cephalopods and of the mollusk *Lithophaga lithophaga*. Collection of octopus in recent years has been very intensive and beyond amounts allowed for sport fishing, and so this activity often becomes illegal and should be regulated (Ikica *et al.*, 2013). During the survey, overfishing of the mollusks (illegally collecting date mussels) was noted and should be stopped.

The research of the marine biodiversity in the study area of Platamuni also included the study of benthic habitat types. The supralittoral zone was not analysed. The mediolittoral belt is characterised by steep cliffs and it is quite narrow. It is dominated by rich settlements of the brown algae *Cystoseira amentacea*, which is an indicator of the good ecological quality of seawater and preserved biotope. These settlements are either continuous or in small groups, and in some locations are mixed with *Cystoseira compressa*. In addition to these biocenosis builders, in the mediolittoral belt, there is a whole range of other organisms, of which *Mytilus galloprovincialis* (mussels) and *Coscinasterias tenuispina* (starfish) were the most common (Figure 2). The large number of young mussels living like epiphytes on *Cystoseira* species indicates the degradation of the biocenosis (Mačić *et al.*, 2010).

Below the narrow mediolittoral belt, rocky substrates are generally followed by the degraded form of the rocky biocenosis, the so-called barren. At these locations, the rocky surface is partially covered with calcified algae, while other representatives of algae are very rare or completely absent. As dominant species, sea urchins *Paracentrotus lividus* and *Arbacia lixula* are present, and in some places sponge *Chondrilla nucula* (Environmental protection agency Montenegro, 2014). Barren areas in previous studies (Fant *et al.*, 2012) are represented as the dominant community in localities Mala Krekavica, Sveti Nikola, Seka Albaneze and Cape Kostovica (Figure 2). In the area of Seke Albaneze, the rocky bottom was largely covered by algae of the genus *Cystoseira*, *Sargassum* and *Dyctiota*les.

Large areas of the barren region along the investigated area are the result of overfishing (very often by explosive devices), but predominantly because of intensive illegal collecting of date mussels (*Lithophaga lithophaga*). Their collection leads to changes in the structure of the substrate, which causes changes in the composition and structure of benthic communities.

Along the research areas, there are three small pebble beaches situated in the Žukovica, Nerin and Velika Krekavica inlets. Except for the first one, access from the land is relatively difficult and these small beaches are under small anthropogenic influence. Besides the pebble beaches already mentioned, a seabed in the form of sandy substrates is found at many other sites, but mainly in the deeper areas.

An infralittoral area covered by photophilic algae was present at the Seke Albaneze and Cape Kostovica sites, while the turf community was dominant in the area of Cape Platamuni, Sv. Nikola, Velika and Mala Krekavica. The barren areas were the most dominant type of community on the rocky infralittoral area (Figure 2).

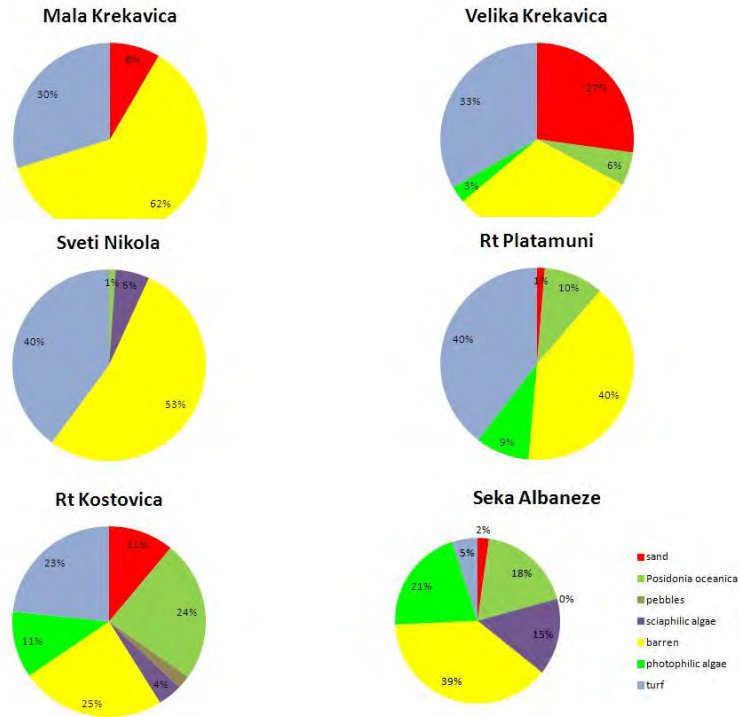


Figure 2. Percentage of different types of substrates in the study area.

In the research area, the presence of the seagrass *Posidonia oceanica* and of sea caves should be emphasised, since they are a priority habitat under the EU Habitats Directive (Habitat Directive 92/43 / EEC). *P. oceanica* is protected by the national legislation (Official Gazette No. 76/2006), as well as by the Barcelona Convention (1976), Berne Convention (1979) and IUCN (2014). This habitat type is typical for the Mediterranean Sea and is characterised by a high productivity of primary organic matter and high biodiversity (Den Hartog, 1970). Furthermore, meadows of *P. oceanica* are habitat for a large number of organisms, and they play a very important role in strengthening the seabed and reducing erosion on the coast (De Falco *et al.*, 2000). In the study area, the largest meadows of *P. oceanica* was observed at the north (Žukovica inlet) and the south (Cape Platamuni). In addition, in the Nerin and Velika Krekavica inlets, smaller patches formed by this seagrass were present. The reason for this distribution of underwater meadows lies primarily in the configuration of the bottom. Specifically, in this area very high cliffs steeply descend into the water down to 20 or 30 (40) m, which is not favourable for the development of larger settlements of *P. oceanica*.

Sea caves are specific habitats characterised by unique biodiversity, and they are classified as an important and threatened habitat under the EU Habitats Directive (Habitat

Directive 92/43/EEC). This specific habitat in the Mediterranean Sea stands as one of the centres of biodiversity that is of great interest to scientists and deserves further research and protection. The bottom of the sea caves and rocky sides have a specific community of many marine invertebrates, while in free water, there are numerous species of crustaceans plankton (Bussotti *et al.*, 2006). Thus, for example, the area of the future Platamuni MPA caves are home to yellow cup-coral (*Leptopsammia pruvoti*), numerous colourful sponges of which, for example, sponge *Chondrosia reniformis* in dark caves is completely white, boxer shrimp (*Stenopus spinosus*), Neptune's lace (*Reteporella grimaldii*), goby leopard (*Thorogobius ephippiatus*), sessile polychaetes, bryozoans and many others. In the study area, the presence of five sea caves is marked and one has an underwater entrance. All the caves are simple and have only one channel, but are rather different from each other (Mačić *et al.*, 2013).

CONCLUSIONS

During the present research, 108 benthic species were found in the study zone. Among them, 21 species are listed in national and international documents as protected or endangered species. Fish species recorded in this area are common for the Mediterranean Sea and they are characterised by a very low abundance and small body size. The presence of two invasive species (*Womersleyella setacea*, *Caulerpa cylindracea*) was confirmed in the area. Among the different benthic habitats types described, *P. oceanica* meadows and sea caves are priority habitats under the EU Habitats Directive.

The Platamuni area is populated by a large number of commercial species. The exploitation of illegally collected mollusks and some fish species is very intensive and beyond allowed amounts. Their collection leads to changes in the structure of the substrate and of the populations, which causes changes in the composition and structure of benthic and pelagic communities. As a strong anthropogenic impact is evident in the zone of the future MPA, proclamation of a MPA and sustainable management of this area is needed.

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