LARGE SCALE MARINE HABITAT AND SPECIES MAPPING ON THE CROATIAN SIDE OF THE ADRIATIC SEA

KARTIRANJE MORSKIH HABITATOV IN VRST V VELIKEM MERILU NA HRVAŠKI STRANI JADRANSKEGA MORJA

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Key words: Adriatic Sea, benthic habitats and species, mapping, large scale, scuba diving, volunteers, GIS, methodology, Brijuni National Park, Lastovo Islands Nature Park, northwestern part of Dugi otok, Pakleni Islands

Ključne besede: Jadransko morje, bentoški habitati in vrste, kartiranje, v velikem merilu, potapljanje s potapljaško opremo, prostovoljci, GIS, metodologija, Narodni park Brioni, Naravni park Lastovsko otočje, severozahodni del Dugega otoka, Peklenski otoki

ABSTRACT

Croatian side of the Adriatic Sea is featured by over 1000 islands. This complex landscape continues underwater, providing conditions for diversity of habitats and species. Distribution maps of marine habitats and species are necessary for the identification and management of priority conservation areas. Due to the complexity of underwater features and lack of human and financial resources, both protected and unprotected marine areas still lack large scale habitat and species distribution maps. The existing maps have been developed based on mathematical modelling; they cover only few habitat types and are on small scales (1:100,000) with significant errors on scales necessary for management (1:25,000 and larger).

In 2005, the Association Sunce engaged in the process of large scale marine habitats and species mapping with the objective of collecting information necessary for the identification of new marine protected areas and improving management of the existing ones. Prerequisite for such mapping was to develop methodology that suits Croatian capacities and to invest in building capacity of network of partners, trained biologists that can collect data.

Until 2010, Sunce engaged in the mapping process by over 60 scuba divers, biologists and biology students, who mapped over 300 locations in the Adriatic. Most systematic mapping was conducted in the area of Brijuni National Park, Lastovo Islands Nature Park, northwestern part of Dugi otok and Pakleni Islands. The mapped area within these sites covers about 200 km^2. Our paper presents the used methods, the attained results and lessons learned in developing and implementing habitat and species mapping.

IZVLEČEK

Hrvaška stran Jadranskega morja se lahko pohvali s prek tisoč otoki. Ta kompleksna krajina se nadaljuje tudi pod morjem, kar zagotavlja ugodne razmere za veliko pestrost tamkajšnjih habitatov in vrst. Za identifikacijo in upravljanje prednostnih naravovarstvenih območij so zato nujno potrebne karte razširjenosti morskih habitatov in vrst. Toda zaradi kompleksnosti podvodnih posebnosti in pomanjkanja človeških in finančnih virov še vedno niso bile izdelane karte razširjenosti morskih habitatov in vrst tako za zavarovana kot nezavarovana območja. Obstoječe karte so bile razvite na

osnovi matematičnega modeliranja; pokrivajo le nekaj habitatnih tipov in so v majhnem merilu (1:100.000), se pravi z večjimi napakami na lestvicah, ki so pomembne za upravljanje območij (1:25.000 in večje).
Leta 2005 se je združenje Sunce vključilo v proces kartiranja morskih habitatov in vrst v velikem merilu, in sicer z namenom, da zbere podatke, potrebne za identifikacijo novih morskih zavarovanih območij in da hkrati izboljša upravljanje že obstoječih območij. Toda pogoj za takšno kartiranje je bil razvoj metodologije, ki bi ustrezala hrvaškim zmožnostim, kot tudi naložba v povečevanje kapacitete mreže partnerjev, predvsem izurjenih biologov, ki bi bili sposobni zbirati potrebne podatke.
Do leta 2010 je bilo združenje Sunce zaposleno v procesu kartiranja že z več kot 60 potapljači (s potapljaško opremo), biologi in študenti biologije, ki so izrisali več kot 300 lokacij v Jadranskem morju. Najbolj sistematično kartiranje je bilo opravljeno v območjih Narodnega parka Brioni, Naravnega parka Lastovsko otočje, severozahodnega dela Dugega otoka in Peklenskih otokov, in sicer na skupni površini kakih 200 km^2. Pričujoči članek opisuje uporabljene metode, pridobljene rezultate in tudi lekcije, ki so se jih sodelujoči naučili pri razvijanju in samem opravljanju kartiranja morskih habitatov in vrst.

1. INTRODUCTION

Croatian side of the Adriatic Sea is featured by over a thousand islands, rocks and reefs. This complex landscape continues underwater, providing suitable conditions for diversity of habitats and species.

Distribution maps of marine habitats and species are necessary for the identification and future management of priority conservation areas. Due to the complexity of underwater features and lack of human and financial resources, both protected and unprotected marine areas in Croatia still lack large scale habitats and species distribution maps. National marine habitats maps were developed in 2004 by mathematical modelling (OIKON d.o.o. 2004). These maps do not provide sufficient information for management purposes, as they include only few habitat types and are on small scales (1:100,000) with significant errors on scales necessary for management purposes (1:25,000 and larger).

In 2005, the Association Sunce from Split, Croatia, engaged in the process of large scale marine habitats and species mapping with the objective of collecting information necessary for the identification of new marine protected areas and improving management of the existing ones.

Habitats and species mapping was based on building procedures, methodologies and tools how to map species and habitats by amateur divers biologists and building a network of partners among scientists, diving clubs and centres and protected area management institutions.

Since 2005, over 350 locations in the Adriatic have been mapped covering wider areas of Brijuni, Lošinj, Dugi otok, Kornati, Murter, Rogoznica, Lastovo, Vis, Brač, Pakleni Islands and Šolta. Most systematic mapping was conducted in 2009 and 2010 in the areas of Brijuni, Dugi otok, Pakleni Islands, Brač and Lastovo Islands, allowing development of detailed 1:25,000 habitats and species distribution maps.

2. METHODS

In the 2005-2008 period, the Association Sunce developed a system for marine habitats and species mapping by amateur divers - biologists. It included development of mapping data collection protocols, diving slates, diving profiles, GPS data collection system and management, Excel and GIS data management system, and educational material necessary for the training of volunteers.

Over the period, the Association Sunce trained and engaged over 60 volunteer scuba divers in the species and habitats identification and mapping, with each year at least 4 new volunteers joining the group. Volunteers were biology students or graduated biologists. Trainings and networking allowed the Association Sunce to reach enough capacity to conduct series of systematic species and habitat mapping over the Croatian Adriatic and to gain enough experience to usefully store, manage and interpret the collected data. It also increased relevance and respectability of the organisation in field mapping among relevant institutions and donors.

Main strength of the network and the organisation is the ability to recruit and motivate several people that can map large areas in a limited c time.

2.1 HABITATS AND SPECIES MAPPING

Mapping of habitats and species was conducted through scuba diving transects, focused on covering depth and surface distribution of coastal marine habitats and marking presence/absence of benthic species. During each dive, profiles were usually made first vertically, then at maximum depth parallel to the coastline. Profiles depended a great deal on the morphology of the area and were designed in a way to cover large areas in order to get best possible insight into present species and habitats distribution.

An important step before the actual field mapping was to compile the existing information, on which dive profiles are planned in advance. Information compiling included collection of available digital and paper maps of the area; the existing scientific and local knowledge on present habitats, species, significant locations, diving locations. The objective was to have as few dive profiles as possible, through which most data could be retrieved in the field. Both in field mapping and later habitat map development various maps had to be combined. Maps usually included 1:100,000 nautical maps, 1:25,000 topographic maps, 1:5,000 orthophoto maps, when possible digital and georeferenced. Orthophoto maps gave indication of the habitats' borders within depth range of up to 10 m and topographic maps for deeper areas.

Field mapping diving was conducted in groups of 3 to 5 divers, in which one diver was handling reel and rope with a GPS device fixed to a diving buoy, while others were marking habitats, species and photo documenting the area. Diving was conducted to maximum depths of 40-50 m or less, depending on the morphology of the area.

Depth distribution of habitats was mapped by marking on a diving slate average habitat depth distribution, meaning the upper and lower habitat depth distribution. Spatial distribution of habitat was identified by marking time on positions where changes of dominant habitats were

registered. Time on diving computers and GPS device were previously synchronized and GPS data were later transported into ArcGIS 9.3. Habitat depth distribution information was used for extrapolating habitats coverage during habitats maps development process. Information from GPS time points was used to precisely define habitat borders, especially in areas where less quality bathymetric maps are available or where habitat change is not strictly connected to depth.

During each dive profile, marine benthic species were mapped by marking on a pre-printed diving slates presence/absence of 170 predefined benthic species. Species abundance was not quantified, facies or association of significant species were drawn on a dive profile and textually described in the excel database. Species included in the mapping were chosen based on following criteria: easy to identify under the sea (no need for sampling or specific taxonomic experts), rare, endangered, protected, listed on Natura 2000 and SPAMI lists, indicator of certain habitat, potential indicator of changes, low range of movement (benthic species), plus some rather common species were added. In Annex 1, species included in the mapping are listed. Presence of other rare or invasive species, such as *Caulerpa racemosa*, was also marked within special notes of the excel database.

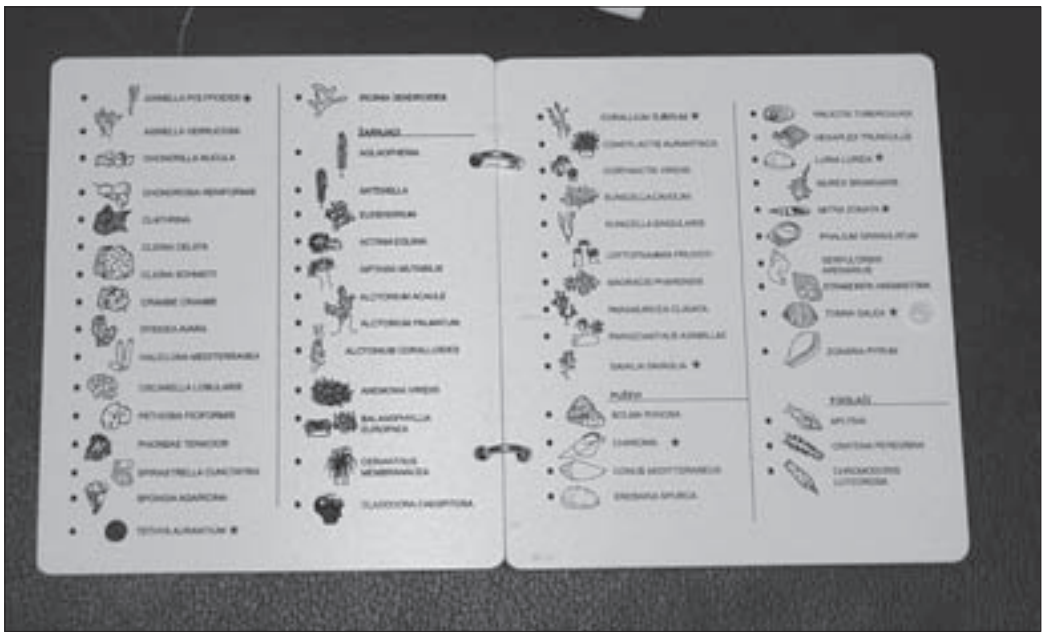

Figure 1: Underwater diving slate for the identification and mapping of benthic species and habitats
Slike 1: Podvodna potapljaška tablica za identifikacijo in kartiranje bentoških habitatov in vrst

Habitats were identified using Handbook for Inventarisation and Monitoring of Marine Habitats (Bakran-Petricioli 2007), and species using Handbook for Inventarisation of Adriatic Marine Species (Jakl et al. 2008).

The collected data were entered into MO Excel database, which was then integrated, through MO Access, into the GIS system (ArcGIS 9.3 program), allowing search of habitats

and species distribution through mapped locations and development of habitat maps. Dive profiles were also described by text, generalised dive profile drawings and photo and video documented that are all part of the database.

Database contains data as well as information on data collection: date, project and funding of data collection, organisation implementing mapping, contact, name of the area and the location, GPS, people implementing mapping, existing photo and video documentation, special notes, description of the location, upper and lower depth border of habitats, presence/absence of 170 benthic species.

2.2 *POSIDONIA OCEANICA* MEADOWS SAMPLING

Data on the baseline state of *Posidonia oceanica* meadows was also collected in addition to species and habitats mapping. Sampling was conducted by scuba diving, counting number of posidonia shoots within standard 40 x 40 cm quadrates and meadow coverage estimation at each 5 m depth. At each sampling depth, triple measurement was made in order to ensure that sample was statistically representative.

Additional data on length and width of posidonia leaves were also collected. At each 5 m depth, 3 posidonia shoots were sampled, all leaves were measured as to their length and width, and necrosis coverage. The collected data were inserted into MO Excel, assessed using standard statistical methods and compared with UNEP RAC/SPA (2007) standard posidonia meadow classes: abnormal (A), subnormal (S-), normal (N), supra-normal (S+).

2.3 HABITAT MAPS PRODUCTION

Habitat maps were developed based on information collected during filed mapping and by using available orthophoto, topographic and bathymetric maps. In addition to field data, bathymetry and underwater terrain slope were used as main factors of habitat distribution. Based on these factors, field data were extrapolated from dive profiles to wider areas and habitats mapped in ArcGIS 9.3. Mapping was conducted to scuba diving maximum safety depths of 40 to 50 m. For all areas deeper that 50 m that were not mapped, an assumption was made that they were composed of coastal detritus bottoms, habitat widely distributed on Croatian side of the Adriatic at greater depths. It is very likely that this habitat is combined with other deep water habitats and therefore covers much less surfaces than mapped.

Habitat maps were made in GIS shapefiles; they include information on main habitat types, information on association/facies where possible, bottom type and codes according to the Croatian National Habitat Classification (NKS), Natura 2000 and Corine.

2.4 SPECIES DISTRIBUTION MAPS

For the purpose of visualisation of species distribution, all dive profiles were stored in the GIS database in the form of point shapefiles. Distribution of each of the 170 mapped species can be retrieved from the database and visualised in maps.

3. RESULTS

Since 2005, over 350 locations in the Adriatic were mapped by using this methodology, covering wider areas of Brijuni, Lošinj, Dugi otok, Kornati, Murter, Rogoznica, Lastovo, Vis, Brač, Pakleni Islands and Šolta. Most systematic mapping was conducted in 2009 and 2010 in the areas of Brijuni, Dugi otok, Pakleni Islands, Brač and Lastovo Islands, where mapping was a continuation of the work initiated in 2005. Systematic mapping allowed point and line data to be extrapolated and used for the development of detailed 1:25,000 habitats maps, while for other sites only point habitat and species information is available.

Figure 2: Areas of systematic habitat and species mapping
Slika 2: Območja, kjer je bilo opravljeno sistematsko kartiranje habitatov in vrst

3.1 BRIJUNI NATIONAL PARK

Brijuni National Park is located in the northern Adriatic. It was established in 1983 and covers a total land area of 33.97 km^2 and a total sea area of 26.51 km^2. Its coastline is 44.83 km long. It is also part of the Ecological Network and a potential future Natura 2000 site. It is composed of 14 islands; it is a rather shallow area, with coastal depths usually not greater than 20 m and with maximum depths of around 30 m. Field mapping was conducted in May 2010,

with total duration of 10 days. In total, 60 locations were mapped; the state of posidonia was not assessed, as only small patches with indication of larger meadow were detected during the last days of survey. Through this survey, the existing marine species list expanded for over 50 benthic species. In total, 11 people participated in the survey, out of which 9 were volunteers. Work was done in close cooperation and logistical support of the protected area management authority and funds of the MedPAN South pilot project in Croatia. Additional information on coastal habitats (beaches) was collected in the summer 2010 by the national park authority. Data interpretation and map production is in progress. In 2011, an additional mapping of the area of Mali Brijun is planned to be carried out.

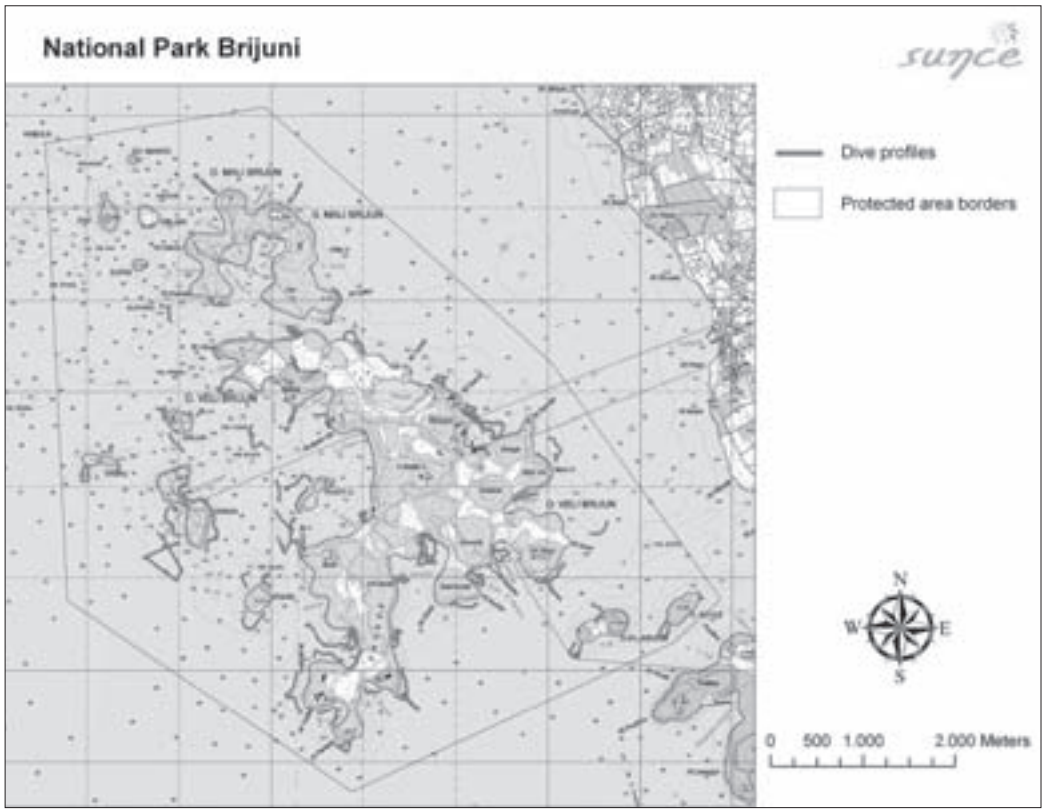

Figure 3: National Park Brijuni – dive profiles
Slika 3: Narodni park Brioni – profili potopov

3.2 NORTH-WESTERN PART OF DUGI OTOK

The north-western part of Dugi otok is situated in the central Adriatic. The wider project area covers a total surface of around 54 km^2 and the mapped sea surface a total of 41.2 km^2. Its coastline is 58.89 km long. The area contains several Ecological Network marine sites that are also potential future Natura 2000 sites, as well as a wide range of marine habitats and coastal

depths ranging from 50 to 60 m. Field mapping was conducted in June and September 2009, with a total duration of 16 days. In total, 44 locations were mapped and state of posidonia meadows assessed on 14 locations. Additional information was collected by snap surveys from the coast and the boat, and apnea diving. In total, 11 people participated in the survey, out of which 9 were volunteers. The work was performed for the Public Institution for the Protected Areas of Zadar County Management, with international funds provided by the European Union and GEF (UNDP project Coast). Full report with maps and recommendations was completed in 2009.

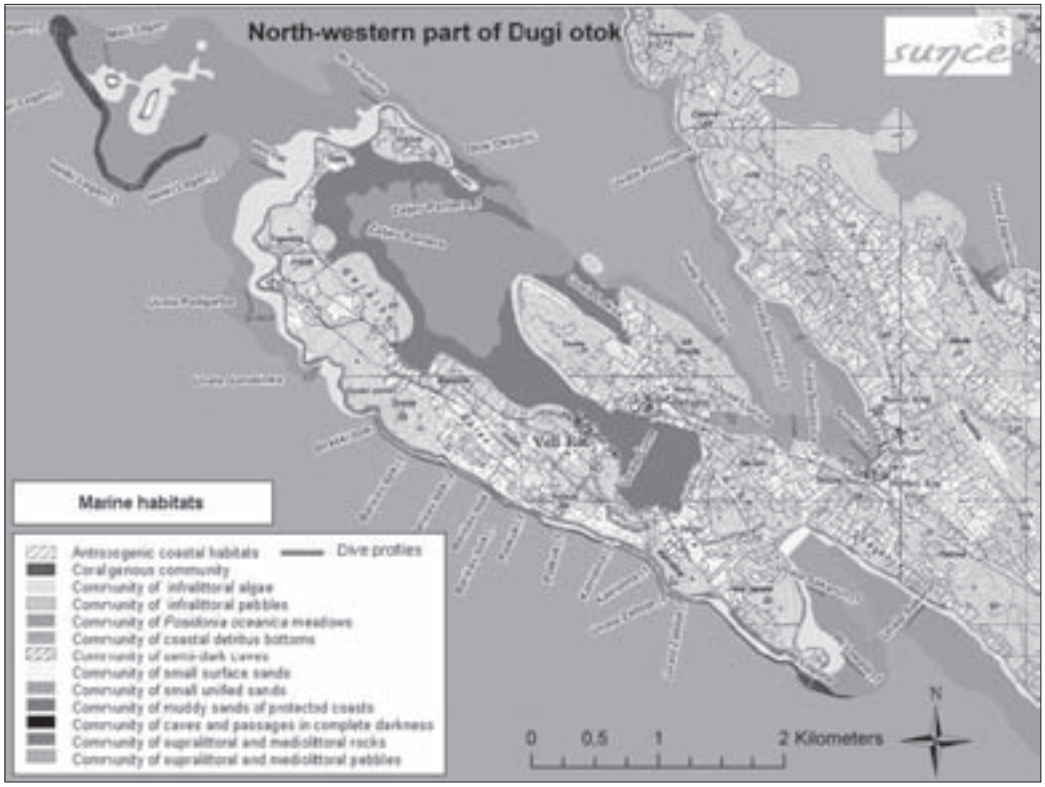

Figure 4: North-western part of Dugi otok - dive profiles and map of habitats
Slika 4: Severozahodni del Dugega otoka – profili potopov in karta habitatov

3.3 PAKLENI ISLANDS (PAKLENI OTOCI)

Pakleni Islands constitute a small archipelago of around 20 islets and reefs, situated south of the town of Hvar (Hvar Island). The area is an Ecological Network marine site and also a potential future Natura 2000 site. The Ecological Network covers an area of 26.98 km^2: its sea surface measures 19.81 km^2, while its coastline is 53.32 km long. The area consists of a wide range of marine habitats and coastal depths of up to 70 m. Field mapping was conducted in July 2010, with a total duration of 11 days. In total, 49 locations were mapped and the state of posidonia meadows assessed on 12 locations. In total, 13 participants attended the survey,

out of which 10 were volunteers. The work was done within the Matra funded project "Marine Natura 2000 Sites of Split-Dalmatia County" and with support of the Public Institution for the f Protected Areas of Split-Dalmatia County Management. Data interpretation and map production are in progress.

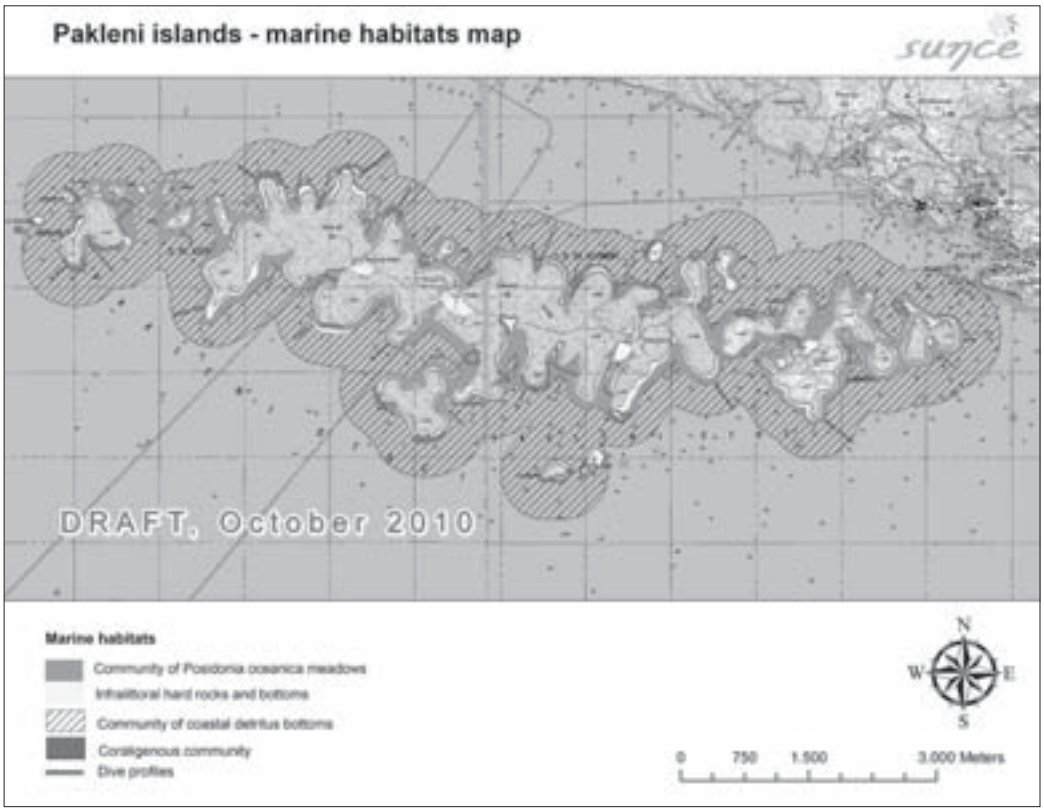

Figure 5: Pakleni Islands – dive profiles and map of habitats
Slika 5: Peklenski otoki – profili potopov in karta habitatov

3.4 LASTOVO ISLANDS NATURE PARK

Lastovo Islands Nature Park is located in the southern Adriatic. It was established in 2006, with a total land area of 195.83 km^2 and a total sea area of 143.12 km^2; its coastline is 132 km long. It is an Ecological Network marine site and a potential future Natura 2000 site. The area is composed of 46 islands and islets, complex underwater morphology and rather deep waters surrounding the area. Along the coastline, depths very quickly reach 50 m and, in many areas, even up to 100 m. As the Association Sunce was involved in the protected area establishment, we started developing methodology of habitats and species mapping within this area in 2005. Over the years, 113 locations have been mapped; out of these, 37 are GPS line profiles collected in 2010, whereas all other are GPS point data. In 2010, the state of posidonia was assessed on 8 locations. This is the area, where most of the volunteers were suitably trained and where we

began to develop the network of our associates, with Bius – Biology Students Association from Zagreb – among them. Until now, a systematic mapping has been completed for the central Lastovo Island. The Park area is large, complex and distant, with poor basline maps, making the mapping very challenging. The mapping has been conducted by the support of several donors, although most of it has been funded by WWF MedPO and 2010 mapping by the MedPAN South project. Data interpretation and map production is in progress.

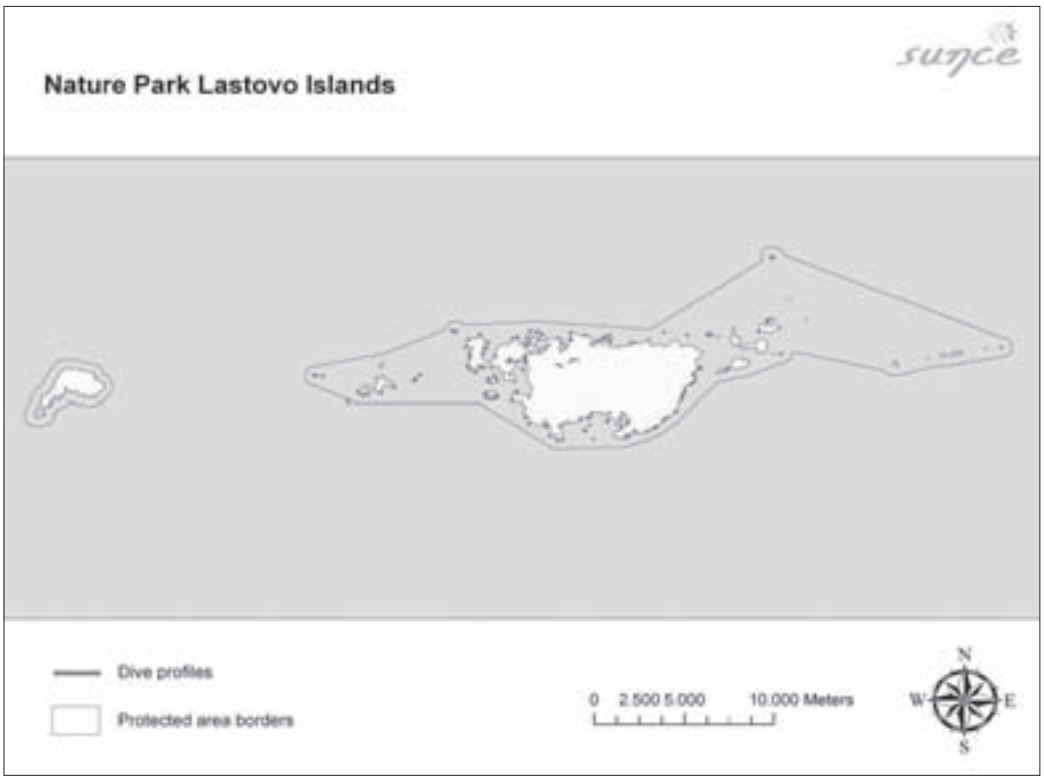

Figure 6: Lastovo Islands Nature Park – dive profiles
Slika 6: Naravni park Lastovsko otočje – profili potopov

4. DISCUSSION

4.1 METHODOLOGY

The methodology used in species and habitat mapping was developed after several trials as well as errors made during field mapping. When developing the methodology, several constraints needed to be taken in consideration, most of them related to human capacities and difficulties of working under the sea.

In order to properly identify the habitats and species, the people involved in mapping had to receive suitable training and, even more important, to gain experience in diving, underwater

orientation, identification of species and habitats, and filling in the mapping protocols. Considering these constraints, habitats and especially species included in the mapping could only be those that could easily be identified under the sea.

In order to decrease any chance of errors, mapped species were limited to a predefined list of easily identifiable 170 benthic species, which would further demand sampling, laboratory work and experts in various taxonomic groups. Number and availability of such experts in Croatia is, however, very limited, so this approach was discarded early in the process. There was also a lack of motivation of volunteers for laboratory work and certain difficulties regarding the access to a suitable laboratory.

Density of populations of dominant species was described textually as a part of location description. Some attempts were made to estimate species populations, but this was shown to be very subjective, connected to experience, and therefore unnecessary for this scale of mapping.

Combination of horizontal and vertical georeferenced dive profiles was used for habitat mapping. Experience from the first mapping attempts showed that standard vertical or horizontal rope measured profiles were logistically demanding for implementation. They gave very detailed information for one small area, but with high probability of missing habitats and species in the very vicinity of the profiles. Such profiles provided more precise scientific data, but less information necessary for the production of maps. Therefore a trade off was made between the detail of the information and the possibility of covering large areas necessary for producing maps.

Georeferencing data were also a challenge since standard GPS devices do not work under the sea. Using diving buoy with GPS connected to a diver by a rope and a reel was shown to be most cost effective method for georeferencing dive profiles. When testing dive profiles with orthophoto maps, there were some errors in accuracy due to depth, sea currents and waves. Errors were of only several meters, a scale we considered irrelevant for this type of mapping.

4.2 HABITAT MAP PRECISION

When interpreting produced habitat maps and using data in further research, several limitation factors needed to be taken in mind:

- In nature, habitats gradually transform from one into another and there are no clear and strict borders between two habitats. Maps are generalised representation of reality.
- Habitats in sea are distributed in 3D, while on maps they are visualised in 2D. Such visualisation may be adequate for more horizontal habitats such as *Posidonia oceanica* meadows and infralittoral algae but questionable in respect of vertically distributed habitats as well as those developed within cracks, caverns and caves.
- Surface of habitats that are in sea more vertically distributed (such as coralligenous community or community of semi-dark caves) can adequately be presented only in more complex 3D format or estimated by multiplying length distribution with depth distribution.

Taking into account all listed difficulties, we may say that habitat maps developed under this methodology are still of greater precision than any other currently available marine habitat maps in Croatia. This is especially true in respect of habitats such as coralligenous community,

community of semi-dark caves, community of caves and passages in complete darkness. Habitat maps also include information on associations/facies of significant species such as gorgonians (*Eunicella cavolini*, *Paramuricea clavata*). Quality of produced habitat maps is much related to the quality of available baseline topographic maps and orthophoto maps. Habitat maps are expected to be most accurate around dive profiles with possible error increasing with the distance from the dive profiles. Maps accuracy percentage should be assessed by additional field work, checking control points defined by standardised statistical methods of map accuracy assessment. Funding for such assessment still needs to be provided.

National 1:100,000 marine habitat maps were produced based on mathematical modelling with final output maps with estimated precision of 76%. National marine habitat maps compared to maps produced by this direct field mapping take into consideration fewer habitats, have errors in habitat coverage, errors in habitat position, overestimation and underestimation of the habitats' surface area. These differences can be observed by comparing habitats coverage between two different source marine habitat maps of one part of Lastovo Islands Nature Park (Figures 7 and 8).

4.3 SPECIES DISTRIBUTION MAPS

Figure 7: Marine habitat map produced by direct field mapping (Sunce)
Slika 7: Karta morskih habitatov, izdelana na osnovi neposrednega terenskega kartiranja (Sunce)

Spatial distribution of each of the 170 species can be extracted from the GIS database. It is point data providing information only on the presence/absence of a species and no information on the population sizes. Such information can only partially be extracted from the textual description of locations. Nevertheless, currently there is no other similar information source on benthic species distribution in Croatia.

Figure 8: National marine habitat map produced through mathematical modelling (Oikon d.o.o.)
Slika 8: Nacionalna karta morskih habitatov, izdelana na osnovi matematičnega modeliranja (Oikon d.o.o.)

4.4 CAPACITIES

Main strength of the used methodology is that large areas can be mapped in a relatively short time. Using volunteers significantly decreases mapping costs, allows development of social bonds, local involvement, exchanges of experiences and knowledge. Estimation is that 8 trained divers can collect in 1 day enough information to map in detail approximately 4 km of coastline. This estimation varies a great deal, depending on the morphology of the area, bathymetry, available baseline maps and logistical support.

Methodology also has it weaknesses. When working with volunteers, there is a need for continuous education, data quality control, motivation and leadership. It also increases workload in respect of planning, communication, logistics and equipment management. This

type of data collection involves scuba diving, which is a higher risk level activity so significant efforts are spent in ensuring security measures, mentorship and assessment of diving skills of volunteers involved. Important part of preparation is compiling suitable mapping teams that include people skilled both in diving and in species/habitats recognition, while still allowing new volunteers to get engaged.

Coordination, planning, data management and interpretation represents significant part of the work and it cannot be implemented in volunteer way, as it demands another level of knowledge, skills and motivation.

5. SUMMARY

In the 2005-2008 period, the Association Sunce developed a system for marine habitat and species mapping by amateur divers - biologists. It included development of mapping data collection protocols, diving slates, diving profiles, GPS data collection system and management, Excel and GIS data management system, and educational material necessary for the training of volunteers. Over the period, the Association Sunce trained and engaged over 60 volunteer scuba divers in the species and habitat identification and mapping. Since 2005, over 350 locations in the Adriatic were mapped, covering the wider areas of Brijuni, Lošinj, Dugi otok, Kornati, Murter, Rogoznica, Lastovo, Vis, Brač, Pakleni Islands and Šolta. Most systematic mapping was conducted in 2009 and 2010 in the areas of Brijuni, Dugi otok, Pakleni Islands and Lastovo Islands, allowing data extrapolation and development of detailed 1:25,000 habitats and species distribution maps. On 34 sites of the same area, baseline data on the state of *Posidonia oceanica* meadows was also collected. Maps produced by the proposed methodology lack precision of maps produced by modern technologies such as sonar, but are substantially more precise that current available maps, cheaper to produce and detailed enough for basic management planning. It has been shown that volunteers can significantly contribute to marine data collection, but only when suitably trained, guided and motivated. In order to insure data quality and usage, planning, filed work coordination, data interpretation and compilation should be done by professionals.

6. REFERENCES

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ANNEX 1: Marine Benthic Species Included in the Mapping Methodology
PRILOGA 1: Morske bentoške vrste vključene v metodologijo kartiranja

Zelene alge (Chlorophyta)
1. *Acetabularia acetabulum* (L., 1952), klobučić
2. *Codium bursa* ((L.), C.Agardh, 1822)
3. *Codium effusum* ((Rafinesque), delle Chiaje)
4. *Codium fragile* ((Suringar) Hariot, 1889)
5. *Flabellia petiolata* ((Turra), Nizamuddin)
6. *Halimeda tuna* (Elis et Sol.J.V.Lamouroux, 1816)
7. *Palmophyllum crassum* ((Naccari), Rabenhorst 1868)
8. *Ulva* spp.
9. *Valonia macrophysa* (Kuetz, 1843)
10. *Valonia utricularis* ((Roth) C.Agardh, 1823)

Smeđe alge (Phaeophyta)
1. *Cystoseira* spp.
2. *Fucus virsoides* (J. Agardh), jadranski bračić
3. *Padina pavonica* ((L.) Thivy, 1960)
4. *Sargassum* spp.

Crvene alge (Rodophyta)
1. *Lithophyllum* spp.
2. *Lithophyllum frondosum*
3. *Osmundaria volubilis* ((L.), R.E. Norris, 1991)
4. *Peyssonnelia* spp.

MORSKE CVJETNICE (Magnoliophyta)
1. *Cymodocea nodosa* ((Ucria), Ascherson)
2. *Posidonia oceanica* ((L.), Delile)
3. *Zostera marina* (L., 1753)
4. *Zostera noltii* (Hornemann)

SPUŽVE (Porifera)
1. *Agelas oroides* (Schmidt, 1864)
2. *Aplysina aerophoba* (Nardo, 1843), žuta sumporača
3. *Aplysina cavernicola* (Vacelet, 1959)
4. *Axinella cannabina* (Esper, 1794)
5. *Axinella damicornis* (Esper, 1794)
6. *Axinella polypoides* (Schmidt, 1862)
7. *Axinella verrucosa* (Esper, 1794)
8. *Chondrilla nucula* (Schmidt, 1862)
9. *Chondrosia reniformis* (Nardo, 1847)
10. *Clathrina* spp.
11. *Cliona celata* (Grant, 1826)
12. *Cliona schmidti* (Ridley, 1881)
13. *Crambe crambe* (Schmidt, 1862)
14. *Dysidea avara* (Schmidt, 1862)
15. *Haliclona mediterranea* (Griessinger, 1971)
16. *Ircinia dendroides* (Schmidt, 1862)
17. *Oscarella lobularis* (Schmidt, 1862)
18. *Petrosia ficiformis* (Poiret, 1798)
19. *Phorbas tenacior* (Topsent, 1925)
20. *Spirastrella cunctatrix* (Schmidt, 1868)
21. *Spongia agaricina* (Pallas, 1766), slonovo uho
22. *Tethya aurantium* (Pallas, 1766), morska naranča

ŽARNJACI (Cnidaria)
Obrubnjaci (Hydrozoa)
1. *Aglaophenia* spp., morsko perce
2. *Antenella* spp.
3. *Eudendrium* spp.

Koralji (Anthozoa)
1. *Actinia equina* (L., 1758), crvena moruzgva
2. *Aiptasia mutabilis* (Gravenhorst, 1831), staklena moruzgva

3. *Alcyonium acaule* (Marion, 1878), crvena ručica
4. *Alcyonium corralloides* (Pallas, 1766), lažni koralj
5. *Alcyonium palmatum* (Pallas 1766), morska ručica
6. *Anemonia viridis* (Forsskål, 1775), smeđa vlasulja
7. *Balanophyllia europaea* (Risso, 1826), široka čaška
8. *Cerianthus membranacea* (Spallanzani, 1784), opnena voskovica
9. *Cladocora caespitosa* (L., 1758), busenasti koralj
10. *Condylactis aurantiaca* (delle Chiaje, 1825), zlatna moruzgva
11. *Corallium rubrum* (L., 1758), crveni koralj
12. *Corynactis viridis* (Allman, 1846), draguljarka
13. *Eunicella cavolini* (Koch, 1887), žuta rožnjača
14. *Eunicella singularis* (Esper, 1791), uspravna rožnjača
15. *Leptopsammia pruvoti* (Lacaze-Duthiers, 1897), žuta čaška
16. *Madracis pharensis* (Heller, 1868), hvarski koralj
17. *Paramuricea clavata* (Risso, 1826), velika rožnjača
18. *Parazoanthus axinellae* (Schmidt, 1862), žuta korasta moruzgva
19. *Savalia savaglia* (Bertholoni, 1819), žuta Savalia

MEKUŠCI (Mollusca)

Puževi (Gastropoda)

1. *Bolma rugosa* (L., 1767), turban
2. *Charonia* spp., tritonova truba
3. *Conus meditteraneus* (Hwass in Bruguiere, 1792), stožac
4. *Erosaria spurca* (L., 1758), venerin puž
5. *Haliotis tuberculata* (L., 1758), velika puzlatka, Petrovo uho
6. *Hexaplex trunculus* (L., 1758), kvrgavi volak
7. *Luria lurida* (L.,1758), zupka
8. *Murex brandaris* (L., 1758), bodljikavi volak
9. *Mitra zonata* (Marryat, 1818), prugasta mitra
10. *Phalium granulatum* (Born, 1778), izbrazdani šljem
11. *Serpulorbis arenarius* (L., 1767)
12. *Stramonita haemastoma* (L., 1766), crvenousna purpura
13. *Tonna galea* (L., 1758), puž bačvaš
14. *Umbraculum mediterraneum* (Lamarc, 1819)
15. *Zonaria pyrum* (Gmelin, 1791), kruška

PUŽEVI „GOLAĆI“

1. *Aplysia* spp., morski zekan
2. *Chromodoris luteorosa* (Rapp, 1827)
3. *Cratena peregrina* (Gmelin, 1791)
4. *Discodoris atromaculata* (Bergh, 1880), puž dalmatiner
5. *Flabellina affinis* (Gmelin, 1791)
6. *Hypselodoris* spp.
7. *Hypselodoris elegans* (Cantraine, 1835)
8. *Janolus cristatus* (delle Chiaje, 1841)
9. *Phyllidia flava* (Aradas, 1847)
10. *Thuridilla hopei* (Vérany, 1853)

Školjkaši (Bivalvia)

1. *Arca noae* (L., 1758), kunjka
2. *Barbatia barbata* (L., 1758)
3. *Gastrochaena dubia* (Pennant, 1777), otvoreni klinčić
4. *Lithophaga lithophaga* (L., 1758), prstac
5. *Mytilus galloprovincialis* (Lamarck, 1819), dagnja
6. *Ostrea* spp., kamenica

7. *Pecten jacobeus* (L., 1758), Jakobova kapica
8. *Pinna nobilis* (L., 1758), plemenita periska
9. *Spondylus gaederopus* (L., 1758), kopito
10. *Venus verrucosa* (L., 1758), prnjavica

Glavonošci (Cephalopoda)
1. *Octopus vulgaris* (Cuvier, 1797), hobotnica
2. *Sepia officinalis* (L., 1758), sipa

Mnogoljušturaši (Polyplacophora)
1. *Chiton* spp.

ZVJEZDANI (Echiuroidea)
1. *Bonellia viridis* (Rolando, 1821), zeleni zvjezdan

MNOGOČETINAŠI (Polychaeta)
1. *Bispira volucatornis* (Montagu, 1804)
2. *Eupolymnia nebulosa* (Montagu, 1818)
3. *Filograna* spp.
4. *Hermodice carunculata* (Pallas, 1776)
5. *Myxicola infundibulum* (Renier, 1804), pješčani perjaničar
6. *Sabella spallanzanii* (Viviani, 1805)
7. *abella pavonina* (Savigny, 1820)

MAHOVNJACI (Bryozoa)
1. *Hornera frondiculata* (Lamouroux, 1821)
2. *Margaretta cereoides* (Ellis & Solander, 1786)
3. *Myriapora truncata* (Pallas, 1766)
4. *Reteporella* spp., morska čipka

BODLJIKAŠI (Echinodermata)
Ježinci (Echinoidea)
1. *Arbacia lixula* (L., 1758)
2. *Centrostephanus longispinus* (L., 1845), igličasti ježinac
3. *Paracentrotus lividus* (Lamarck, 1816)
4. *Spatangus purpureus* (OF Müller, 1776)
5. *Sphaerechinus granularis* (Lamarck, 1816)

Stapčari (Crinoidea)
1. *Antedon mediterranea* (Lamarck, 1816), Sredozemna dlakavica

Zvjezdače (Asteroidea)
1. *Astropecten aranciacus* (L., 1758), narančasta križalina
2. *Coscinasterias tenuispina* (Lamarck, 1816)
3. *Echinaster sepositus* (Retzius, 1783)
4. *Hacelia atenuata* (Gray, 1840)
5. *Luida ciliaris* (Philippi, 1837)
6. *Marthasterias glacialis* (L., 1758)
7. *Ophidiaster ophidianus* (Lamarck, 1816)
8. *Peltaster placenta* (Müller - Troschel, 1842), pločasta zvjezdača

Trpovi (Holothuroidea)
1. *Holothuria* spp.

Zmijače (Ophiuroidea)
1. *Ophioderma longicauda* (Retzius, 1805), velika zmijača
2. *Ophiotrix fragilis* (Abildgaard, 1789)

PLAŠTENJACI (Tunicata)
Mješčićnice (Ascidiacea)
1. *Clavelina* spp.
2. *Halocynthia papillosa* (L., 1767), crvena bradavičarka
3. *Microcosmus* spp., morsko jaje
4. *Phallusia mammilata* (Cuvier, 1815)

RAKOVI (Crustacea)
1. *Dromia personata* (L., 1758)
2. *Homarus gammarus* (L., 1758), hlap
3. *Maja squinado* (Herbst, 1788), velika rakovica

4. *Maja verrucosa* (Milne Edwards), mala rakovica
5. *Palinurus elephas* (Fabricius, 1787), jastog
6. *Scyllarides arctus* (L., 1758), zezavac
7. *Scyllarides latus* (Latreille, 1803), kuka
8. *Stenopus spinosus* (Risso, 1826), antenska kozica

RIBE (Fish)

1. *Scyliorhinus* spp. (L., 1758), morska mačka
2. *Anthias anthias* (L., 1758), jera
3. *Apogon imberbis* (L., 1758), matulić
4. *Chromis chromis* (L., 1758), crnej
5. *Conger conger* (L., 1758), ugor
6. *Coris julis* (L., 1758), knez
7. *Dentex dentex* (L., 1758), zubatac
8. *Diplodus annularis* (L., 1758), špar
9. *Diplodus sargus* (L., 1758), šarag
10. *Diplodus vulgaris* (Geofr., 1817), fratar
11. *Diplodus puntazzo* (Cetti, 1777), pic
12. *Epinephelus marginatus* (Lowe, 1834), kirnja
13. *Gobius cruentatus* (Gmelin, 1789), glavoč krvoust
14. *Hippocampus* spp., morski konjić
15. *Labrus bimaculatus* (L., 1758), smokva
16. *Labrus viridis* (L., 1758), drozd
17. *Mullus* spp., trlja
18. *Muraena helena* (L., 1758), murina
19. *Oblada melanura* (L., 1758), ušata
20. *Parablennius gattorugine* (L., 1758), velika babica
12. *Phycis phycis* (L., 1766), tabinja mrkulja
22. Sarpa salpa (L., 1758), salpa
23. Sciaena umbra (L., 1758), kavala
24. *Scorpaena scrofa* (L., 1758), škrpina
25. *Serranus cabrilla* (L., 1758), kanjac
26. *Serranus scriba* (L., 1758), pirka
27. *Sparisoma cretense* (L., 1758), papigača
28. *Sparus aurata* (L., 1758), komarča
29. *Symphodus tinca* (L., 1758), lumbrak
30. *Sygnathus* spp., šilo
31. *Thalassoma pavo* (L., 1758), vladika
32. *Zeus faber* (L., 1758), kovač

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THE EFFECTIVENESS OF A NATIONAL NETWORK OF MPAS - THE EXPERIENCE ACQUIRED IN ITALY AND THE ROLE THE TRANSNATIONAL NETWORK SUCH AS ADRIAPAN COULD PLAY

UČINKOVITOST NACIONALNE MREŽE MORSKIH ZAVAROVANIH OBMOČIJ – IZKUŠNJE, PRIDOBLJENE V ITALIJI, IN VLOGA, KI BI JO LAHKO IGRALE NADNACIONALNE MREŽE, KAKRŠNA JE ADRIAPAN

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Key words: Marine Protected Areas; Management Effectiveness; Ecological Network

Ključne besede: morska zavarovana območja, učinkovitost upravljanja, ekološke mreže

ABSTRACT

In 2005, WWF Italy and Federparchi started - with the assistance of the Ministry of Environment – an initiative aiming at spreading the tools for a management effectiveness evaluation.
The project was led by Miramare MPA, together with 4 other MPAs (Torre Guaceto, Isole Ciclopi, Torpaterno and Penisola del Sinis). The objectives – defined in further text – were stipulated in view of the relevant indicators and management priorities. The data were collected in a specific document, which accompanies the translation of the IUCN-WWF guidebook "How is your MPA doing?".
The results describe the capability of fulfilling the tasks assigned by each institutional decree, specifically in the fields of use of the maritime public domain, the environmental conservation, the communication/information, the management of resources, the local development.
Facilities for visitors, communication and information systems are the most developed; on the other hand, most of MPAs complain a low level of monitoring, control and management of tourist flows.
The 5 MPAs have a suitable range of tools and expertise, such as a cartographic GIS, studies running on the biological communities, and are compliant to the European "EMAS" environmental certification standards. Finally, the help provided in encouraging sustainable local productions is fairly good, while resources management is poor, same as the programs for the development of green energy, the adoption of waste separation schemes and garbage management.
The AdriaPAN network may enable monitoring of efficiency indicators among MPAs, as part of a shared method to evaluate the results of the management efforts.

IZVLEČEK

Leta 2005 sta italijanski WWF in Federparchi ob pomoči nacionalnega Ministrstva za okolje sprožila idejo o uporabi orodja za ocenjevanje učinkovitost upravljanja.
Projekt je vodilo MPA (morsko zavarovano območje) Miramare MPA ob pomoči še štirih MPA-jev (Torre Guaceto, Isole Ciclopi, Torpaterno in Penisola del Sinis). Cilji projekta – opisani v nadaljnjem besedilu – so bili začrtani glede na obstoječe indikatorje in prioritete upravljanja. Potrebni podatki so bili

zbrani v posebnem dokumentu, ki je nastal ob prevodu vodnika svetovnih organizacij IUCN in WWF z naslovom »How is your MPA doing?« (Kako pa kaj vaš MPA?).
Rezultati kažejo na zmožnosti uresničevanja nalog, ki jih nalaga vsak predpisani odlok, specifično na področjih uporabe javnega morskega območja, okoljevarstva, komuniciranja/informiranja, upravljanja z viri in lokalnega razvoja.
Medtem ko je razvitost objektov in naprav za goste, komunikacijo in informacijski sistem na visoki ravni, pa se v večini MPA-jev pritožujejo o nizki ravni monitoringa in nadzorovanja turističnih tokov. Pet MPA-jev ima sicer ustrezna orodja in strokovno znanje, kot na primer kartografski GIS in tekoče študije o bioloških združbah, ki so v skladu z evropskimi okoljskimi standardi "EMAS". Kar dobra je tudi pomoč za spodbujanje lokalne trajnostne proizvodnje, medtem ko je upravljanje z viri revno, tako kot so tudi programi za razvoj zelene energije, vpeljavo shem za ločevanje odpadkov in upravljanje z njimi. Mreža AdriaPAN bi lahko omogočila monitoring kazalcev učinkovitosti med MPA-ji kot del skupne metode za ocenjevanje rezultatov upravljalskih naporov.

1. INTRODUCTION

In 2000, the IUCN's World Commission on Protected Areas-Marine (WCPA-Marine) and the World Wide Fund for Nature (WWF) initiated the MPA Management Effectiveness Initiative (MEI) to provide MPA managers and practitioners with a simple instrument to conduct an evaluation. A major product of this initiative is the guidebook "How is your MPA Doing? A Guidebook of Natural and Social Indicators for Evaluating Marine Protected Area Management Effectiveness" (Pomeroy et al. 2004).

The Miramare MPA has been taking part since the beginning to the field-testing process of this methodology (Costantini et al. 2003). In 2004, its staff brought the experience outlined in the guidebook to the attention of the Italian Ministry of Environment. This started a project where the first set of 5 MPA has been evaluated, aiming at spreading this practice to the whole set of national MPAs.

→ This initiative represented a first opportunity to share work methods among managers, and to discuss on goals, objectives and priorities among peers which have the same institutional framework, with its opportunities and constraints, in common.

→ A transnational network such as AdriaPAN is therefore useful to share the above mentioned experience in a broader context - but which has in common the same biogeographical region - in order to be more effective towards overall environmental conservation and help in finding the gaps in the common efforts.

2. METHODS

In 2005, WWF Italy and Federparchi (Italian Federation of Parks and Nature Reserves) embarked on the project on behalf of the Ministry of Environment. It involved 5 MPAs: Miramare (northern Adriatic), Torre Guaceto (southern Adriatic), Isole Ciclopi (Sicily), Secche di Tor Paterno (Tyrrhenian sea) and Penisola del Sinis (Sardinia). All activities have been funded by the Ministry in full.