REPUBLIC OF CROATIA
MINISTRY OF ENVIRONMENTAL AND NATURE PROTECTION

State Institute for Nature Protection

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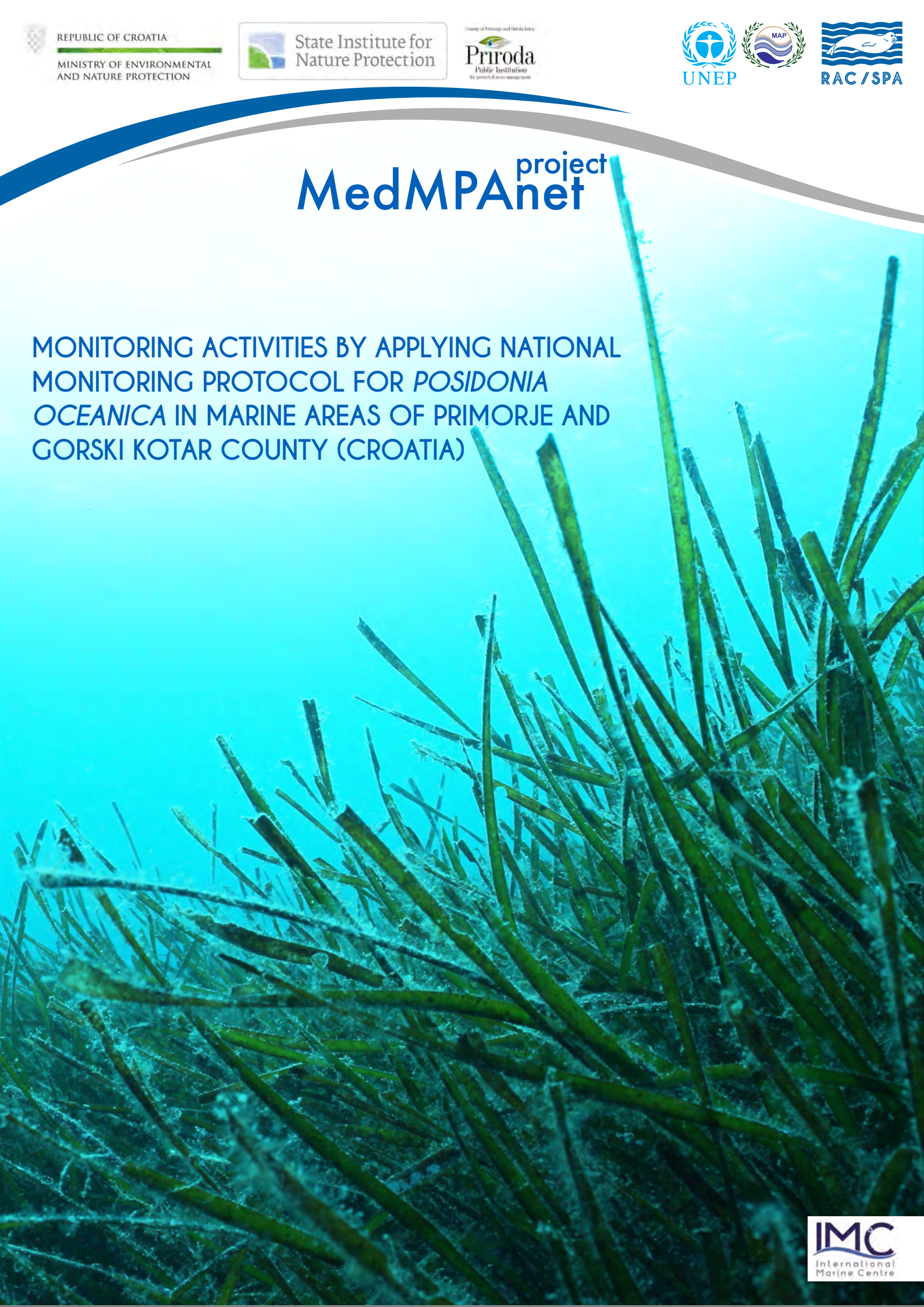
UNEP MAP RAC/SPA

MedMPAnet project

MONITORING ACTIVITIES BY APPLYING NATIONAL MONITORING PROTOCOL FOR *POSIDONIA OCEANICA* IN MARINE AREAS OF PRIMORJE AND GORSKI KOTAR COUNTY (CROATIA)



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Report preparation
Ivan Guala i.guala@imc-it.org

Contributors
Željka Rajković, National Technical Coordinator of the MedMPAnet Project;
Patrik Krstinić, Public Institution Priroda, Rijeka, Croatia;
Ljiljana Iveša, Ruđer Bošković Institute, Center for Marine Research, Rovinj, Croatia;
Ante Žuljević, Institute of Oceanography and Fisheries, Split, Croatia;
Ivan Cvitković, Institute of Oceanography and Fisheries, Split, Croatia;
Milena Šijan, Association for Nature, Environment and Sustainable Development Sunce, Split, Croatia;
Mosor Prvan, Association for Nature, Environment and Sustainable Development Sunce, Split, Croatia;
Maya Sertić, Association for Nature, Environment and Sustainable Development Sunce, Split, Croatia;
Matea Špika, Association for Nature, Environment and Sustainable Development Sunce, Split, Croatia.

Fondazione IMC Onlus
International Marine Centre
Loc. Sa Mardini, Torregrande, 09170 – Oristano (Italia)
Anagrafe Nazionale Ricerche cod. 11881273
Tel +39 0783 22027 - 22032 - 22136 - Fax +39 0783 22002
web: http://www.imc-it.org
e-mail: info@imc-it.org - direzione@imc-it.org

This report has been produced in the framework of the agreement between the Public Institution Priroda and the IMC - International Marine Centre (June 5th 2014) for the conduction of scientific research and monitoring of Posidonia meadows through application of Croatian National Monitoring Protocol (for the habitat type Posidonia meadow) developed within the scope of MedMPAnet Project.

CONTENTS

FOREWORD

Monitoring activities by applying National Monitoring Protocol for *Posidonia oceanica* in marine areas of Primorje and Gorski Kotar County (Croatia) have been carried out in the framework of the **"MedMPAnet Project – Pilot project Croatia"**.

The pilot project in Croatia is part of the Regional Project for the Development of a **Med**iterranean **M**arine and Coastal **P**rotected **A**reas (MPAs) **Net**work through the boosting of MPAs creation and management (MedMPAnet) that includes 12 Mediterranean riparian countries.

The objective of the regional project consists of 'enhancing the effective conservation of regionally important coastal and marine biodiversity features, through the creation of an ecologically coherent MPA network in the Mediterranean region', as required by the Barcelona Convention's Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean (SPA/BD protocol).

Project objectives in Croatia are to improve MPA management at the local level by filling gaps in ecological and fisheries knowledge, and better enforcement and monitoring, and by assisting the Croatian Government in implementing the SPA/BD Protocol and developing the marine section of the Natura 2000 network through inventorying and mapping, as well as further development of national monitoring protocols.

Project partners in Croatia are the Ministry of Environmental and Nature Protection (MENP), the State Institute for Nature Protection (SINP) and the Public Institution "Priroda".

The project in Croatia is coordinated by the Ministry of Environmental and Nature Protection of the Republic of Croatia, whilst the regional project is coordinated by the Regional Activity Centre for Specially Protected Areas (RAC/SPA) based in Tunis.

The project is funded by the European Commission (EC), Spanish Agency for International Development Cooperation (AECID) and the French Global Environment Facility (FFEM). The MedMPAnet project is part of the MedPartnership GEF full size project "Strategic Partnership for the Mediterranean Sea Large Ecosystem" lead by UNEP/MAP.

SUMMARY

This paper reports details of the activities and results of the survey carried out within the agreement between the Public Institution Priroda (PI Priroda) and the Fondazione IMC - International Marine Centre for monitoring *Posidonia oceanica* meadows in marine areas of Primorje and Gorski Kotar County (Croatia).

Monitoring activities were addressed to assess the status of Posidonia beds in Primorje and Gorski Kotar County by applying the National Monitoring Protocol (NMP) for the habitat type Posidonia meadow (*Posidonia oceanica*).

Monitoring activities were implemented in accordance with the Terms of Reference (ToR) that are attached in Annex 1 and to the Letter of Agreement between the PI Priroda and the IMC. The following steps have been developed starting from June 2014:

- ✓ Collection and synthesis of the existing literature on *Posidonia oceanica* meadows;
- ✓ Selection of sites to be surveyed in Primorje and Gorski Kotar County;
- ✓ Scientific research of the Posidonia beds conservation status in Primorje and Gorski Kotar County (fieldwork);
- ✓ Analysis and interpretation of the collected data;
- ✓ Drafting the Research Report;
- ✓ Regular communication with the National Technical Coordinator and PI Priroda.

All the activities were carried out in close cooperation with the National Technical Coordinator of the MedMPAnet Project; fieldwork, data analysis and reporting were accomplished with the collaboration of national experts. Project activities were implemented according to the schedule in Table 1:

Table 1. Activities outline.

Activity No.	Months 2014					
	5	6	7	8	9	10
1. Collection and synthesis of scientific data on Posidonia beds (based on existing scientific data)	■	■				
2. Selection of the sites in Primorje and Gorski Kotar County where field work will be conducted	■	■				
3. Scientific research and application of NMP at selected sites of Primorje and Gorski Kotar County (fieldwork)		■			■	
4. Data analysis and interpretation and drafting of the research report				■	■	
5. Regular communication with the National Technical Coordinator and Public Institution "Priroda"	■	■	■	■	■	■

Fieldwork was carried out, in June and September 2014, with the methodological approach described in the NMP and applied in five sites during the previous monitoring campaign in 2013. Three sites were investigated for the first time, thus increasing to 8 the number of meadows investigated with this method in the Primorje-Gorski Kotar County. Two sites, already surveyed in 2013, were investigated once again in order to compare data of subsequent years and point out any differences due to the methodology defined within NMP.

Overall, results indicated signs of regression at several meadows as testified by low values of shoot density and abundance of dead matte. They also emphasised the need of intercalibration procedures among operators for the implementation of the NMP.

This report includes:

- ✓ A description of the applied methodology / NMP;
- ✓ Research results and review of the researched sites;
- ✓ Results of the analysis to assess the effectiveness of the methodology defined within the NMP;
- ✓ Recommendations for further work on the development of the NMP.

1. INTRODUCTION

Posidonia oceanica meadows are considered the most important biocoenosis of the Mediterranean because of their ecological roles and functions for littoral ecosystems (Pergent *et al.*, 1995; Francour *et al.*, 1999; Boudouresque *et al.*, 2006). *Posidonia* meadows are able to colonize sandy and rocky substrates at depths between 1 and 40 meters; under favourable conditions, healthy meadows develop with high density of shoots and can cover the whole available substrate (Boudouresque *et al.*, 2006).
Natural and anthropogenic disturbances, of both abiotic and biotic origin, can be detrimental to the seagrass systems (Hemminga & Duarte, 2000) and lead to regression of *Posidonia* meadows Boudouresque *et al.*, 2006). Changes in hydrodynamic and sedimentary regimes (Boudouresque & Jeudy de Grissac, 1983; De Falco *et al.*, 2008), high turbidity and consequent decrease of light availability (Pergent *et al.*, 1995; Francour *et al.*, 1999; Boudouresque *et al.*, 2006), the increase of the organic load in water and sediments (Cancemi *et al.*, 2000; Cancemi *et al.*, 2003; Pérez *et al.*, 2008; Apostolaki *et al.*, 2009) and mechanical damages (Francour *et al.*, 1999; Milazzo *et al*., 2004; Boudouresque *et al.*, 2006; Di Carlo et al., 2011) are among the main limiting factors for plant growth and can cause a meadow's decline. Human activities are the main factor responsible for the regression recorded in several areas of the Mediterranean (Boudouresque *et al.*, 2006; Montefalcone *et al.*, 2010; Di Carlo *et al*., 2011); land-based sources represent the greatest threat (Duarte, 2002). Meadow's regression can occur as a change of the depth and the morphology of upper and lower limits, a reduction in shoot density and a decrease of meadow cover and extension (Pergent *et al.*, 1995; Boudouresque *et al.*, 2006; Montefalcone *et al.*, 2006; 2008).

Posidonia oceanica meadows in the Adriatic Sea are insufficiently studied and limited information is available on their distribution and condition (Kružić, 2008; SINP, 2012). In the framework of the MedMPAnet Project a proposal for the NMP for Posidonia meadows has been developed in accordance with the requirements of the Habitat Directive 92/43/EEC (HD). The aim was to gather data useful to preserve the habitats type 1120 'Posidonia beds' and to highlight any degradation or change in their conditions (Guala *et al.*, 2014a; 2014b). The proposed NMP is based on non-destructive approach that uses the most fundamental descriptors that are present in programmes to measure health conditions of *Posidonia oceanica* in nearly all Mediterranean countries (Pergent-Martini *et al*., 2005). For some descriptors, a standardized interpretation scale is available to be applied at a Mediterranean level (UNEP-RAC/SPA, 2011).

This document reports details of additional activities carried out within the MedMPAnet Project. The aim of the monitoring activities was to assess the health conditions of *Posidonia* beds in Primorje and Gorski Kotar County by applying the National Monitoring Protocol (NMP) for the habitat type Posidonia meadow (*Posidonia oceanica*) that was developed within the previous phase of the MedMPAnet Project (Guala *et al.*, 2014a). For this purpose, five sites (Cres-west, Unije, Losinj-south, Uvala Planka and Frkanj) were surveyed. The meadows located in Cres-west, Unije and Losinj-south have not been formerly investigated with the same methodology; studying them helps to increase the number of sites and the data to be used as a baseline for the implementation of the NMP in accordance with the Habitats Directive. The other two sites located in the island of Rab (Uvala Planka and Frkanj) were chosen to compare the results with those obtained during the survey of the previous year (Guala *et al.*, 2014b), in order to test any differences due to the methodology defined within NMP.

2. METHODS

In accordance with the NMP (Guala *et al.*, 2014a) the following terminology have been used:

Site is defined as a continuous area (segment of coastline) where the meadow is relatively homogenously distributed for about 1 km in length (the width depends on the bathymetric distribution of the meadow).

Zone is an area, within each site, in which monitoring is carried out at different bathymetric positions: e.g. shallow (<10 m); intermediate (~15 m); deep (close to the lower limit).

Monitoring station is an area, within each zone, characterized by a single defined depth (so, there are shallow, intermediate and deep stations). A station is defined as an approximately 20x20 m area in which divers carry out monitoring activities by collecting data on target variables.

At each site, three zones about 100 m apart were chosen and three monitoring stations were randomly selected at each zone. Thus, for each site, three shallow, three intermediate and three deep stations were investigated.

2.1. Site selection

In order to increase the number of monitoring sites and the knowledge on the conditions of *Posidonia oceanica* in Primorje and Gorski Kotar County, three sites were chosen around the islands of Cres and Losinj (Cres-west, Unije and Losinj-south). Wherever possible, sites were selected taking into account the indications of the proposed NMP (Guala *et al.*, 2014a). Figure 1 reports the Croatian coastal region under investigation divided into squares with different priorities:

- ✓ red, MPAs, important Natura 2000 areas, sites with data available;
- ✓ orange, a mix with pressure/no pressure sites;
- ✓ green, existing Water Framework Directive (WFD) sites;
- ✓ blue, possible future WFD sites (2014-2016);
- ✓ yellow, further filling gaps (potential additional sites).

Cres-west is located in an area where *Posidonia oceanica* is expected to be monitored according to the WFD (blue square in Figure 1); Unije in a yellow area that was chosen because of the occurrence of a potential source of pressure: here the meadow is characterized by unvegetated circles, located at regular distances from each other, whose origin and nature are still unknown; Losinj-south is located in an area that is supposed to be free of direct human pressure (orange square in Figure 1).
The other two sites (Uvala Planka and Frkanj at Rab Island) are located in an area that is relevant for other monitoring purposes (i.e. it is currently monitored under the WFD, Nikolić V., personal communication). Both sites have already been investigated during the first year of monitoring (Guala *et al.*, 2014b); the temporal comparison in a row was planned to assess any differences between years and to provide indications on the effectiveness of the applied methodology. In fact, since *Posidonia oceanica* is a slow-growing plant (Marbà *et al.*, 2005), it is not likely that the treated variables can change to a great extent after one year, unless a strong perturbation occurs; hence, no significant difference is expected for these variables among subsequent observations.
It is worth noting that, in accordance with the proposed NMP (Guala *et al.*, 2014a), and the indications of the Guidelines developed within the IPA MANMON Project (VV.AA., 2012) the site selection was based on the following criteria:

- ✓ ensure *Posidonia oceanica* meadow is the dominant habitat at the site;
- ✓ the seagrass distribution should be homogeneous across the site;

- ✓ the site should be logistically (e.g., weather, access, safety) feasible and with the possibility to be sampled again;
- ✓ the site is relevant for conservation purposes, e.g. it is located inside a coastal or a marine protected area (MPA); about 70% of Natura 2000 sites should be selected;
- ✓ the meadow is relevant in terms of surface covered, high density, bathymetric position of the lower limit (or other reasons) or it is subjected to various anthropogenic pressures or threats;
- ✓ the site is relevant for other monitoring purposes or monitoring is already implemented (e.g. WFD sites) or is planned to be implemented in the very near future (e.g. WFD and/or MSFD sites);

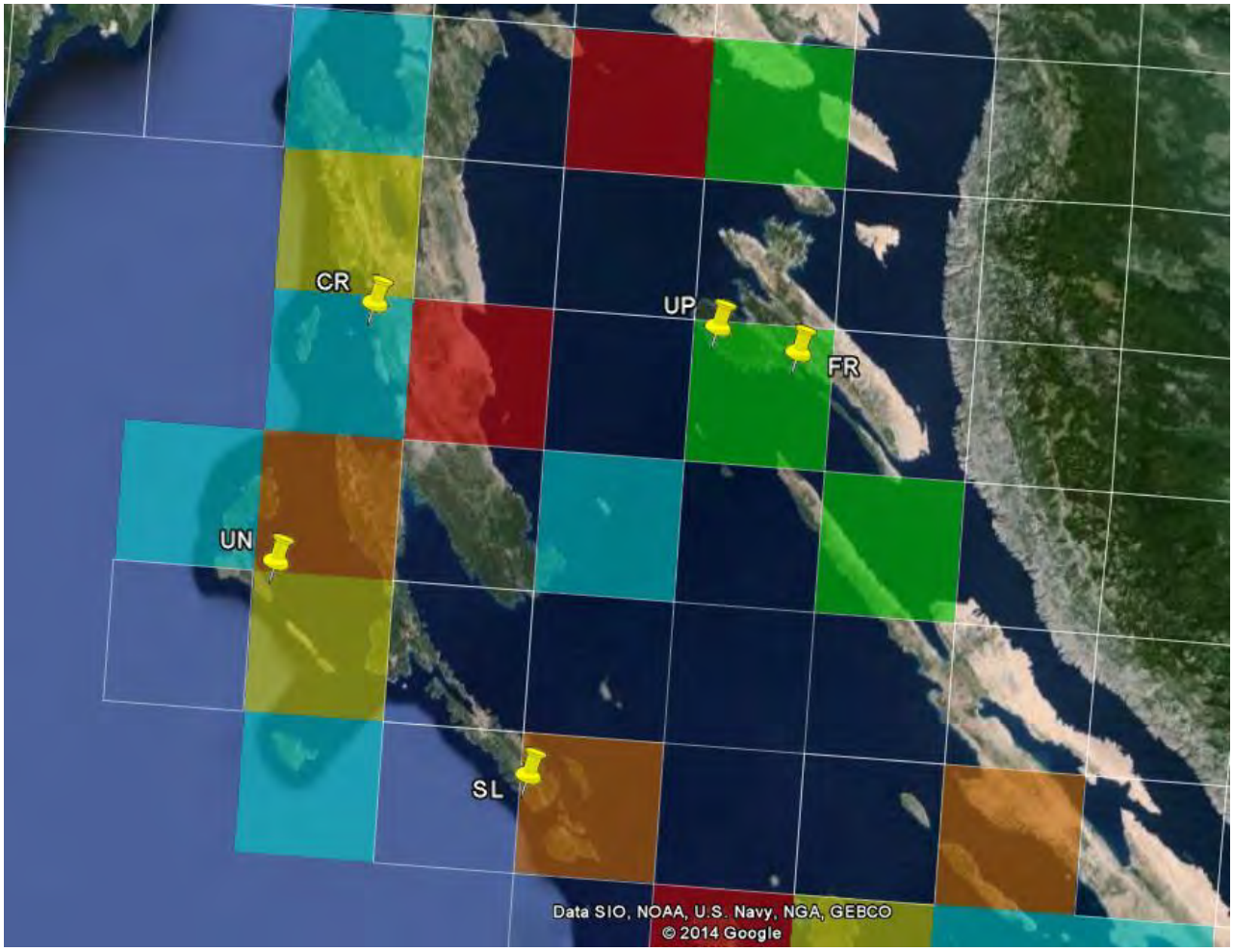

Figure 1. The coastal region under investigation divided into areas with different priority (10x10 km grid). Colours identify different priorities; CR=Cres-west, UN=Unije, SL=Losinj-south, UP=Uvala Planka, FR=Frkanj (from Guala *et al*., 2014a, modified).

Selection procedure involved “Google map” investigation, interviews with local people, and preliminary field investigation. At the sites that were monitored for the first time (Cres-west, Unije and Losinj-south) monitoring stations were randomly chosen and GPS coordinates were marked so that they remain fixed at each following monitoring event. In Uvala Planka and Frkanj, the survey was carried out at the exact positions marked on the GPS the previous year.

2.2. Field activities

The fieldwork was conducted from 12th to 19th of June and from 20th to 22nd of September 2014, along with national consultants and with support of the representative of the PI Priroda; the working group was constituted by:

Ivan Guala, International Marine Centre, Oristano, Italy;

Željka Rajković, National Technical Coordinator of the MedMPAnet Project;

Patrik Krstinić, Public Institution Priroda, Rijeka, Croatia;

Ante Žuljević, Institute of Oceanography and Fisheries, Split, Croatia;

Ivan Cvitković, Institute of Oceanography and Fisheries, Split, Croatia;

Milena Šijan, Association for Nature, Environment and Sustainable Development Sunce, Split, Croatia;

Mosor Prvan, Association for Nature, Environment and Sustainable Development Sunce, Split, Croatia;

Maya Sertić, Association for Nature, Environment and Sustainable Development Sunce, Split, Croatia;

Matea Špika, Association for Nature, Environment and Sustainable Development Sunce, Split, Croatia.

Petronije Tasić, Ameba Ltd., Croatia.

At each site, general information on coastal features (e.g. exposition) and potential human pressures (e.g. anchoring) was recorded and the meadow was described on the basis of the observations carried out in the three zones at each monitoring station (meadow type, type and depth of upper and lower limits).

At each new site, the GPS coordinates of monitoring stations were recorded by marking the position of the safety buoy of the divers. Physical, physiographical, structural and biological descriptors were recorded by two divers for each monitoring station.

Lower limit depth was recorded by means of dive computer, and type was visually assessed as progressive, sharp, sparse or regressive limit (see Pergent *et al*., 1995; Montefalcone, 2009; UNEP-RAC/SPA, 2009).

Density values were detected by counting the number of leaf shoots within 8 replicated quadrats (40x40 cm) placed randomly at a distance of at least 1 meter from one another; depth was measured in each quadrat.

The coverage is the surface of seabed, expressed as a percentage, covered with live plants of *Posidonia oceanica* compared to that non-covered and consisting of sand, rock or dead *matte* (Buia *et al*., 2004). Percentage cover was assessed using the Line Intercept Transect (LIT) technique (Bianchi *et al*., 2004; Montefalcone *et al*., 2007). Four 10 m transects were positioned in each station; for each transect (i.e. centimetre-marked line laid on the bottom), the intercept to the nearest centimetre corresponding to the point where the key attributes and the nature of the substrate (live *Posidonia oceanica*, dead *matte*, sand, mud, rock) changed under the line was recorded. Depth was measured at the beginning and the end of each transect.

Data on presence of other seagrasses, bivalve *Pinna nobilis*, and alien species as well as evidences of impact and signs of damage were recorded by both divers in each station within each quadrat or transect or outside them.

2.3. Data processing

All the information on coastal features, potential pressures and other descriptors and features of the meadow were gathered and summarized for each spatial scale as follows (see Annex I):

Site

Date of sampling	day/month/year
Coastal features	type of coast, wind exposure
Potential human pressures along the coast	e.g. anchoring, presence of mooring facilities, tourist structures, wastewater, camping area, villages…
General description of the meadow	

Zone

Meadow type	distribution with respect to the nature of the bottom (e.g. flat/steep and continuous/discontinuous beds)
Main substrate	rock, *matte*, sand, mud
Lower limit depth	maximum depth along the limit (recorded at the scale of station)
Type of the lower limit	progressive, sharp, erosive, sparse or regressive (evaluated at the scale of station)
Upper limit depth	minimal depth along the limit (recorded at the scale of station)
Operators	field workers

Station

Depth	shallow, intermediate or lower limit
GPS coordinates	GPS position recorded once divers reach the bottom and fix the buoy
Pinna nobilis	presence/absence
Other seagrasses	presence/absence
Aien species	presence/absence
Evidences of potential pressures	presence/absence (e.g. mooring systems, concrete blocks, pier, chains, ropes, trash)
Sign of damage	presence/absence (e.g. detached shoots, detached plates of *matte*, damages due to trawling or anchoring)
Notes	

Shoot density, percentage cover of live *Posidonia oceanica* and dead *matte* and the surface of different substrate types (sand/mud and rocks), as well as Conservation Index, were calculated for each replicate. For shoot density, the value in each quadrat was extrapolated to the m^2 and averaged for each station and for each depth. Based on the number of shoots per m^2, the meadows were categorized according to the depth using the classification system proposed by UNEP-RAC/SPA (2011).

In order to assess the coverage of *Posidonia oceanica*, dead *matte* and the main substrate types, the length of each key attribute (L_x) was calculated by subtraction, as the distance occurring between two recorded intercepts along each transect (Bianchi *et al*., 2004). The percentage cover (R%) along a transect of 10 m length, was calculated by the formula:

$$\mathbf{R\%=\sum(L_x/10*100)}.$$

The Conservation Index (CI), as proposed by Moreno *et al*. (2001) and Montefalcone *et al*. (2006), was calculated for each replicate transect. CI is an environmental index useful to assess the state of health of the meadows, related to the proportional abundance of dead *matte* relative to live *Posidonia oceanica* and is expressed by the formula:

$$\mathbf{CI=P/(P + D)},$$

where P is the percentage cover of live *Posidonia oceanica* and D is the percentage cover of dead *matte*. CI ranges between 0 (minimum state of conservation) and 1 (maximum state of conservation).

Based on the values of CI calculated for each depth, meadows were classified according to the criterion proposed by Moreno *et al*. (2001) and reviewed by Montefalcone *et al*. (2006):

class 1 - advanced degree of regression: $CI<(x–½sd)$;

class 2 - impacted meadow: $(x–½sd)\leq CI<x$;

class 3 - low-to-moderate conservation status: $x\leq CI<(x+½sd)$;

class 4 - high state of conservation: $CI\geq(x +½sd)$;

where the mean (x) and the standard deviation (sd) are calculated taking into account CI values of all the transects at a regional scale (considering the whole set of data collected during the field work in 2013 and 2014).

Values of density and CI were averaged for each zone and each bathymetric range and plotted to obtain an overview of the status of the investigated meadows. Meadows were then classified according to the values of density and CI and the descriptors of lower limit (depth, type and coverage) following the standard thresholds suggested by UNEP-RAC/SPA (2009) to get immediate information on health conditions of the meadows.

Data of density and CI detected in Uvala Planka and Frkanj were used for the comparison between sites and years of sampling. Data were analysed by using a four way-ANOVA with ‘year’ (two levels, fixed), ‘site’ (two levels, random and orthogonal), ‘depth’ (three levels, fixed and orthogonal) and ‘station’ (three levels, random and nested in site and depth). Before each analysis, Cochran’s test was performed to check the assumption of homogeneity of variances and data were transformed when necessary; if transformations did not produce homogeneous variances, ANOVA was, nevertheless, done because of the wide sample size and high number of degree of freedom in the residual (Benedetti-Cecchi, 2004). Student-Newman-Keuls test (SNK test) was used for post-hoc multiple comparisons of means (Underwood, 1997).

Furthermore, for each descriptor, and for each site at each depth range, the percentage variation between the two years of investigation was calculated as $(P_{13}-P_{14})/P13$, where P_{13} and P_{14} represent the mean value (of both density and CI) assessed in 2013 and 2014.

3. RESULTS

Nine stations, three for each bathymetric range, were investigated at each meadow. Fieldwork was carried out by three dive buddy teams; five working days were needed for monitoring of 45 stations. Overall, 360 counts were done for assessing the shoot density and 180 transects for the coverage of *Posidonia oceanica* and substrates.

Table 2 reports the mean values of CI and standard deviation (x±sd) calculated for each depth range (shallow, intermediate and lower limit) in the whole study area by merging the data collected during both surveys in 2013 (Guala *et al.*, 2014b) and 2014.

Overall, 120 samples were considered for shallow and for intermediate stations, 108 for those at the lower limit. Based on these parameters, the rating system for assessing the health conditions of *Posidonia oceanica* meadows is reported as proposed by Moreno *et al.* (2001) and revised by Montefalcone *et al.* (2006); for each depth, four classes of CI are defined and the corresponding thresholds are provided (Table 2).

Table 2. Mean values (x) and standard deviation (sd) of CI calculated for each depth range in the whole study area (bold); below, the rating of conservation status of the meadow based on CI according to Moreno *et al.* (2001) and Montefalcone *et al*. (2006) are reported for each depth range.

	depth range	**Shallow**	**Intermediate**	**Lower limit**
class	**CI in the study area (x±sd)**	**0.91±0.10**	**0.85±0.17**	**0.68±0.28**
1	advanced degree of regression	CI<0.87	CI<0.76	CI<0.54
2	impacted meadow	0.87≤CI<0.91	0.76≤CI<0.85	0.54≤CI<0.68
3	moderate conservation status	0.91≤CI<0.96	0.85≤CI<0.93	0.68≤CI<0.82
4	high state of conservation	CI≥0.96	CI≥0.93	CI≥0.82

3.1. Cres-west

The monitoring site is located along the western coast of Cres Island (Figs. 1 and 2). The rocky coast is exposed to the winds blowing from South-East to North-West; the island of Zeča, about 2 miles West, represents a weak shelter from westerly winds. Three small villages, Miholašćica, Zaglav and Martinšćica, are at a distance between 1 and 2 NM; no evident human pressures were detected along the coast.

The meadow is patchy, on rocks and sand in the shallow stations (upper limit is 4 m deep), sparse on dead *matte* at intermediate and lower depths; lower limit is regressive at 26.7 m.

Shallow stations ranged from 5.8 to 6.7 m deep and the meadow density at this depth varied from 410±40 (mean±se) to 557±56 shoots per m^2. Intermediate depths ranged from 15.3 to 15.5 m and density from 209±17 to 228±17 shoots per m^2. The stations at the lower limit were sampled between 23.3 to 24.4 m deep; shoot density ranged from 59±6 to 90±8 shoots per m^2 (Fig. 3). According to the rating suggested by UNEP-RAC/SPA (2009), the values of shoot density indicate poor conditions of the meadow in 8 stations and moderate conditions in only one shallow station.

In the shallow stations the difference in substrates, with a prevalence of rocks in the northernmost one (zone 1), results in a heterogeneous distribution of *Posidonia oceanica*, with coverage varying from 59 to 83%. The percentage cover of live *Posidonia oceanica* ranged from 68 to 76% in the intermediate stations and dead *matte* varied from 32 to 24%; no other substrate was recorded at this depth range. At the lower limit dead *matte* prevails with values that exceed 50% of the coverage in all three stations; *Posidonia oceanica* varied from 29 to 41%, other substrates are negligible (Fig. 4).

Figure 2. Zones (1, 2 and 3) and monitoring stations (S=shallow, I=intermediate, L=lower limit) at Cres-west.

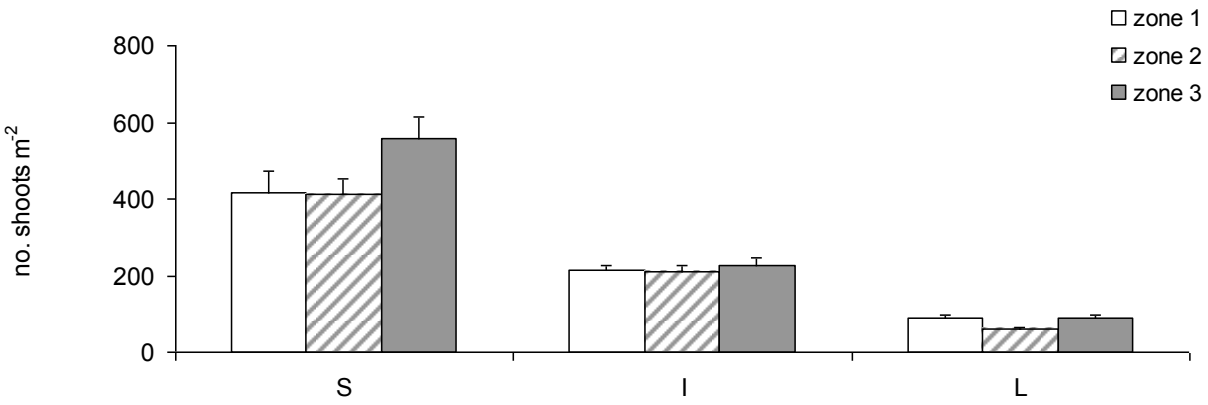

Figure 3. Mean values (+se) of the shoot density at each zone and depth range (S=shallow, I=intermediate, L=lower limit).

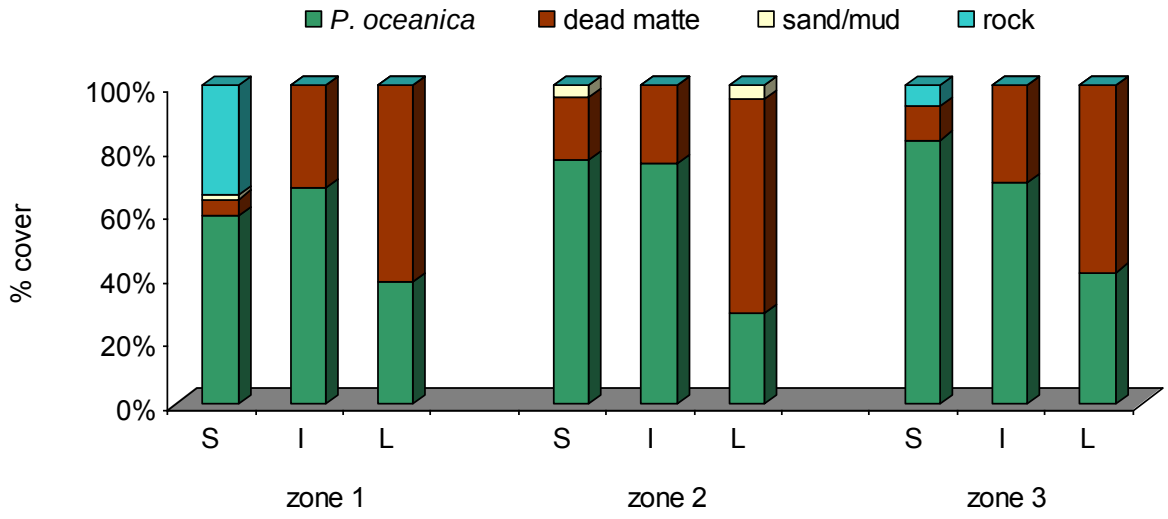

Figure 4. Percentage cover of *Posidonia oceanica*, dead *matte* and surface of main substrates recorded at each zone and depth range (S=shallow, I=intermediate, L=lower limit).

Because of the percentages of *Posidonia oceanica* and dead *matte* above, CI varied from 0.80±0.04 and 0.93±0.03 in the shallow, from 0.68±0.03 to 0.76±0.06 in the intermediate stations, and from 0.30±0.07 to 0.41±0.10 at the lower limit (Fig. 5).

Mean values of Conservation Index compared to the mean of the whole study area correspond to a meadow in advanced degree of regression at all three depths (Table 3).

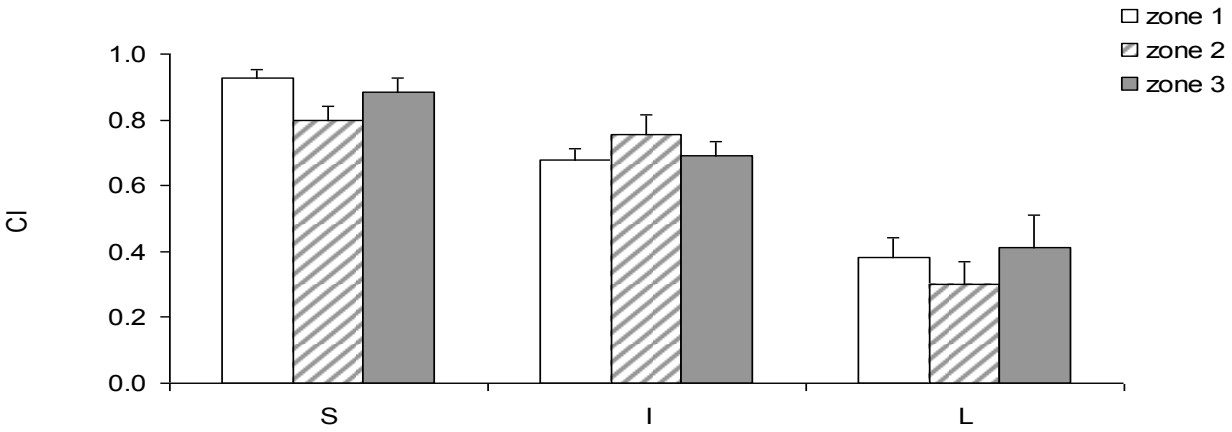

Figure 5. Mean values (+se) of Conservation Index (CI) at each zone and depth range (S=shallow, I= intermediate, L=lower limit).

Table 3. Rating of conservation status of the meadow at both depth ranges based on CI according to Moreno *et al.* (2001) and Montefalcone *et al.* (2006).

depth	**mean value of CI**	**classification** (Moreno *et al*., 2001; Montefalcone *et al*., 2006)
shallow	0.87	class 1, advanced degree of regression
intermediate	0.71	class 1, advanced degree of regression
lower limit	0.37	class 1, advanced degree of regression

Lower limit features indicate moderate conditions for depth (26.7 m), bad for type (regressive) and good/high for percentage coverage of *Posidonia oceanica* according to the rating systems suggested by UNEP-RAC/SPA (2009).

3.2. Unije

The studied meadow is located along the South-East coast of the island of Unije (Figs. 1 and 6). The rocky shore is exposed to winds from I and II quadrants. The site is located away from any kind of direct human pressure.

The meadow starts at about 6 m deep on rocky substrate; it is continuous on sand and *matte* towards the lower limit, which is sparse and progressive up to 27.8 m deep. It is worth mentioning the presence of unvegetated circular areas within the *Posidonia oceanica* meadow, evenly distributed along the coast (Fig. 6); they have about 50 m radius and regular edges; inside, dead *matte* is present on the bottom below the sediment. The origin and the nature of circles are unknown, but they seem to be signs of a past human pressure.

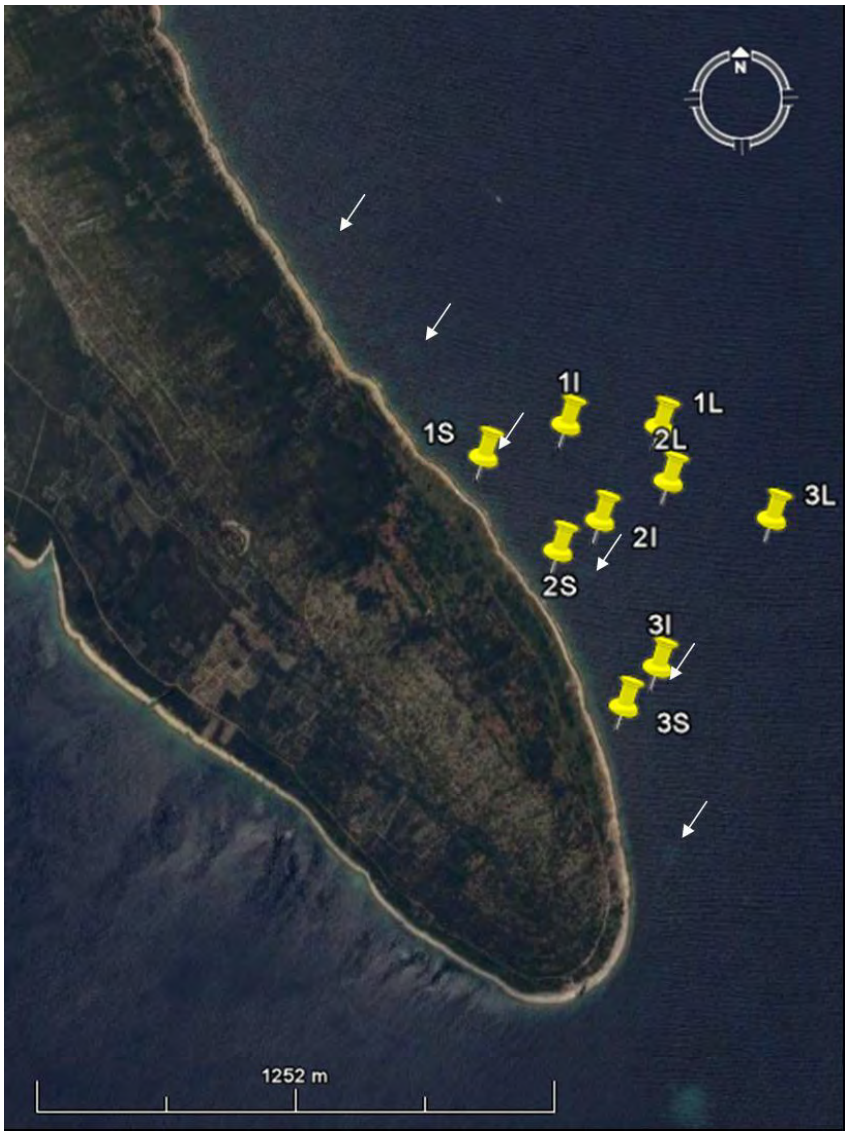

Figure 6. Zones (1, 2 and 3) and monitoring stations (S=shallow, I=intermediate, L=lower limit) at Unije. White arrows indicate the position of unvegetated circles.

At shallow stations the depth ranged from 6.4 to 6.9 m and the meadow density varied from 240±27 (mean±se) to 524±37 shoot per m^2. Intermediate depths ranged from 14.3 to 15.5 m and density from 152±23 to 312±23 shoot per m^2. At the lower limit the depth varied from 25.4 to 27.1 m deep and density from 89±12 to 163±16 shoot per m^2 (Fig. 7). According to UNEP-RAC/SPA (2009) shoot densities recorded in the meadow of Unije indicate bad (1 shallow station), poor (1 shallow, 2 intermediate and 2 deep stations) and moderate (all the 3 depths in the southernmost zone) conditions.

Figure 8 reports the percentage coverage of *Posidonia oceanica*, dead *matte* and unvegetated bottoms. In the shallow stations, *Posidonia oceanica* coverage ranged from 67 to 82% and dead *matte* varied from 9 to 15%; rocks are the main unvegetated substrate (6 to 18%) while sandy bottoms are scarcely represented (0 to 5%). In the intermediate stations, *Posidonia oceanica* ranged from 68 to 76%, dead *matte* from 0 to 24% and unvegetated sandy substrate from 0 to 32%; rocky bottom are not present. At the deep stations *Posidonia oceanica* varied from 35 to 44%, dead *matte* from 0 to 26% and unvegetated sandy substrate from 32 to 65%; rocky bottom are not present.

CI ranged from 0.83±0.03 to 0.90±0.05 in the shallow stations, from 0.76±0.04 to 1 in the intermediate ones and from 0.74±0.15 to 1 at the lower limit (Fig. 9).

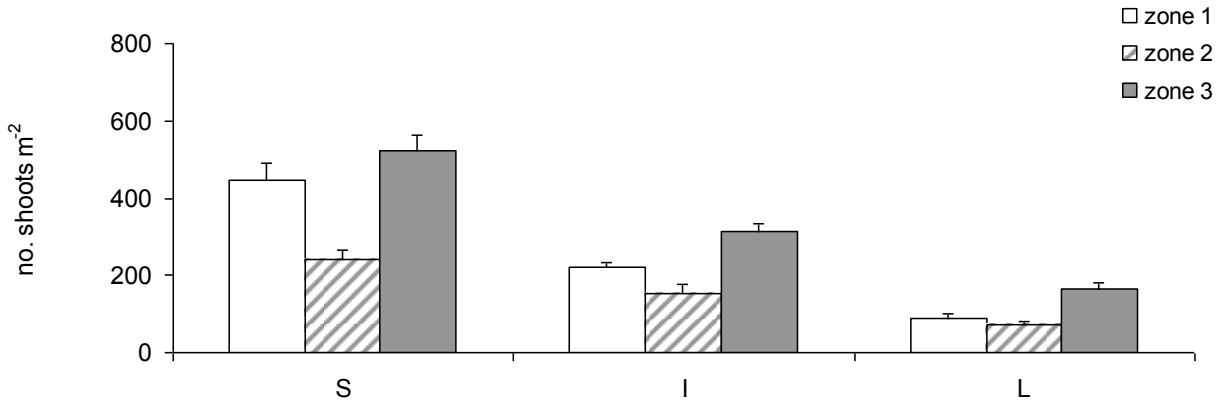

Figure 7. Mean values (+se) of the shoot density at each zone and depth range (S=shallow, I=intermediate, L=lower limit).

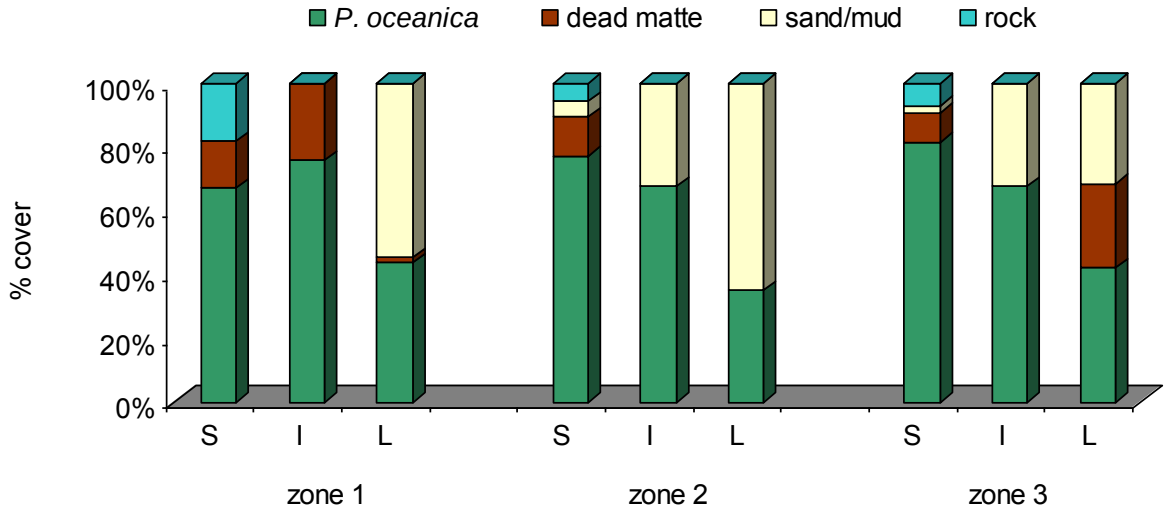

Figure 8. Percentage cover of *Posidonia oceanica*, dead *matte* and surface of main substrates recorded at each zone and depth range (S=shallow, I=intermediate, L=lower limit).

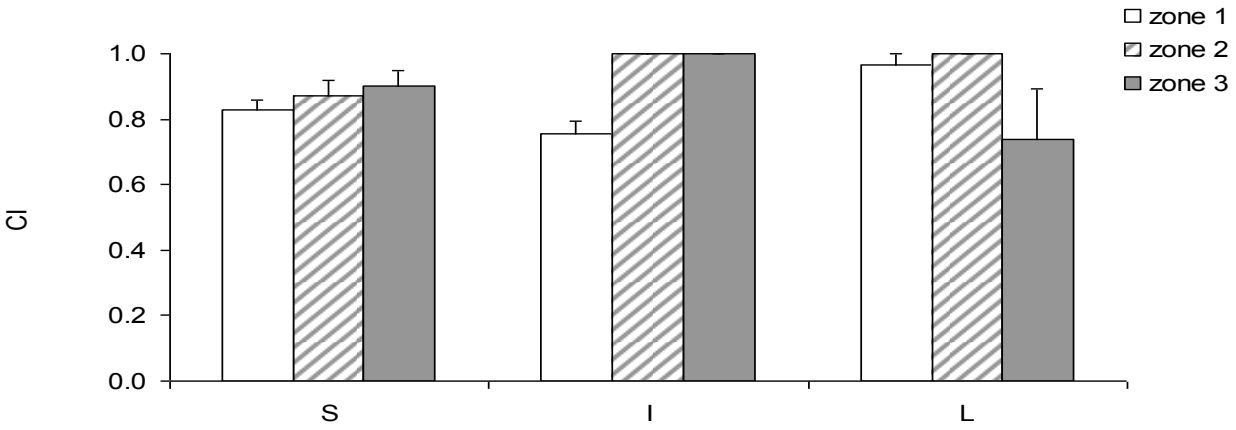

Figure 9. Mean values (+se) of Conservation Index (CI) at each zone and depth range (S=shallow, I=intermediate, L=lower limit).

Mean values of Conservation Index compared to the mean of the whole study area correspond to a meadow in advanced degree of regression at shallow stations, while the intermediate and deep portions of the meadow have a moderate and high conservation status, respectively (Table 4).

Table 4. Rating of conservation status of the meadow at both depth ranges based on CI according to Moreno *et al.* (2001) and Montefalcone *et al.* (2006).

depth	**mean value of CI**	**classification** (Moreno *et al*., 2001; Montefalcone *et al*., 2006)
shallow	0.87	class 1, advanced degree of regression
intermediate	0.92	class 3, moderate conservation status
lower limit	0.90	class 4, high state of conservation

According to the rating systems suggested by UNEP-RAC/SPA (2009), lower limit features indicate moderate conditions for depth (27.8 m) and high conditions for both type (progressive) and percentage coverage.

3.3. Losinj-south

The monitoring site is located along the South-western coast of Losinj Island (Figs. 1 and 10). The rocky coast is exposed to the winds from III and IV quadrants. The area is probably subjected to modest anchoring of recreational boats; no other pressure is evident.

The meadow is discontinuous on rocks, sand and *matte*; it is very patchy and heterogeneous at both upper (6 m) and at the lower limits; the latter is progressive and sharp, sometimes sparse on rocks up to 27.6 m depth.

Depths at shallow stations ranged from 6.8 to 7.4 m and meadow density from 577±37 (mean±se) to 691±37 shoots per m^2. Intermediate stations ranged from 14.7 to 15.8 m and density from 257±24 to 351±23 shoots per m^2. At the lower limit the depth ranged between 24.9 to 27.1 m and density from 135±18 to 186±14 shoots per m^2 (Fig. 11). According to the rating suggested by UNEP-RAC/SPA (2009), the values of shoot density indicate moderate (1 shallow, 3 intermediate and 2 deep stations) or good (2 shallow and 1 deep stations) conditions of the meadow.

Figure 10. Zones (1, 2 and 3) and monitoring stations (S=shallow, I=intermediate, L=lower limit) at Losinj-south.

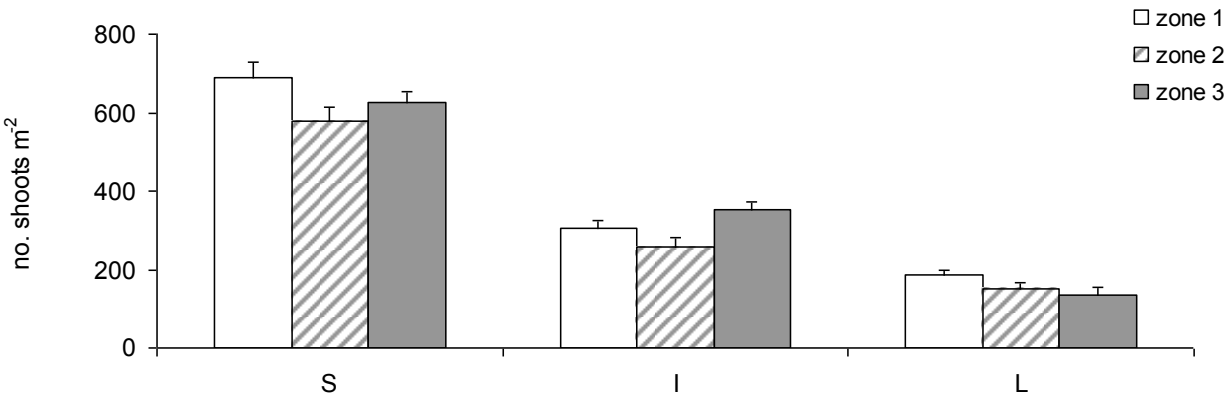

Figure 11. Mean values (+se) of the shoot density at each zone and depth range (S=shallow, I=intermediate, L=lower limit).

Posidonia oceanica coverage varied from 75 to 88% at shallow stations, from 76 to 90% at the intermediate stations and from 42 to 67% at the lower limit. Dead *matte* varied from 2 to 20% at the shallow, from 5 to 9% at the intermediate and from 20 to 33% at the deep stations. The other substrates (both hard and sandy bottoms) were recorded at the three depths with values ranging between 0 and 29% (Fig. 12).

Because of the percentages of *Posidonia oceanica* and dead *matte* above, CI varied from 0.80±0.06 and 0.98±0.01 in the shallow, from 0.90±0.05 to 0.94±0.02 in the intermediate, and from 0.67±0.09 to 0.78±0.13 at the lower limit (Fig. 13).

Mean values of Conservation Index compared to the mean of the whole study area correspond to a meadow in moderate conservation status in all three depths (Table 5).

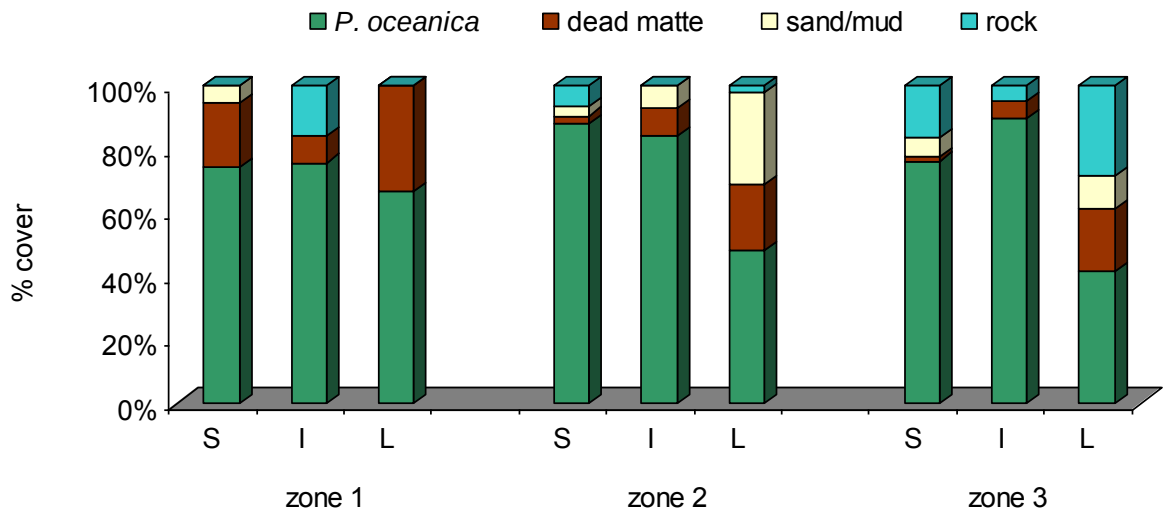

Figure 12. Percentage cover of *Posidonia oceanica*, dead *matte* and surface of main substrates recorded at each zone and depth range (S=shallow, I=intermediate, L=lower limit).

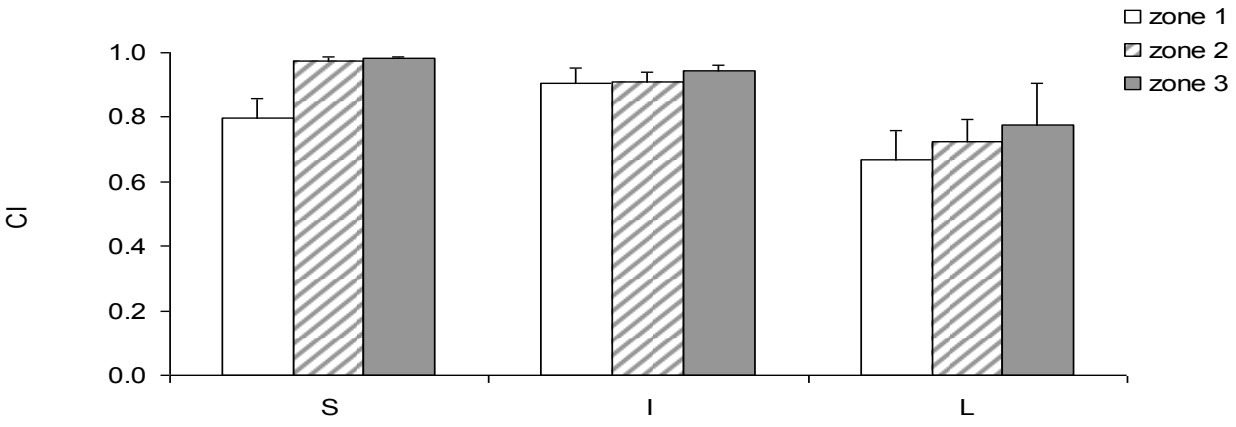

Figure 13. Mean values (+se) of Conservation Index (CI) at each zone and depth range (S=shallow, I=intermediate, L=lower limit).

Table 5. Rating of conservation status of the meadow at both depth ranges based on CI according to Moreno *et al.* (2001) and Montefalcone *et al.* (2006).

depth	mean value of CI	classification (Moreno *et al*., 2001; Montefalcone *et al*., 2006)
shallow	0.92	class 3, moderate conservation status
intermediate	0.92	class 3, moderate conservation status
lower limit	0.72	class 3, moderate conservation status

Lower limit features indicate moderate conditions for depth (27.6 m), high for type (progressive) and high for percentage coverage of *Posidonia oceanica* according to the rating systems suggested by UNEP-RAC/SPA (2009).

3.4. Uvala Planka

Uvala Planka is located along the western coast of Rab Island (Figs. 1 and 14). The rocky coast is exposed to the winds blowing from South-East to North-West. All the area is subjected to modest anchoring of recreational boats; no other pressures are evident.

The meadow is continuous and steep and colonizes rocky substrates mainly in the shallow water (upper limit varies from 6 and 12 m deep) as well as sandy and muddy bottom up to 27.8 m; lower limit is progressive.

Shallow stations ranged from 7.1 to 7.8 m deep and the meadow density at this depth varied from 380±32 (mean±se) to 400±45 shoot per m^2. Intermediate stations ranged from 14.6 to 15.9 m deep and density from 212±11 to 265±25 shoot per m^2. At the lower limit, depth ranged from 23.1 to 24.0 m and density from 120±14 to 146±13 shoot per m^2 (Fig. 15). These values indicate poor (2 shallow, 3 moderate and 2 deep stations) to moderate (1 shallow and 1 deep station) conditions according to the rating suggested by UNEP-RAC/SPA (2009).

At the shallow stations, the percentage cover of live *Posidonia oceanica* ranged from 86 to 89% and dead *matte* from 0 to 7%; sandy substrate varied from 1 to 8% and rocks from 0 to 11%. At the intermediate stations *Posidonia oceanica* ranged from 79 to 81% and dead *matte* from 1 to 16%; sand covers from 5 to 19% while rocks were not recorded. Close to lower limit *Posidonia oceanica* varied from 41 to 49%, dead *matte* from 0 to 30% and unvegetated sandy substrate from 22 to 60%; rocks were not recorded at the lower limit (Fig. 16).

As a consequence of the percentages of *Posidonia oceanica* and dead *matte* above, CI values ranged from 0.92±0.04 to 1 in the shallow, from 0.83±0.02 to 0.99±0.01 in the intermediate, and from 0.66±0.12 to 1 at the lower limit (Fig. 17).

The Conservation Index points out a high state of conservation of the meadow at shallow and deep stations and moderate conservation status at intermediate stations (Table 6).

Lower limit features indicate moderate conditions for depth (27.8 m), high for type (progressive) and high for percentage coverage (>35%) according to the rating systems suggested by UNEP-RAC/SPA (2009).

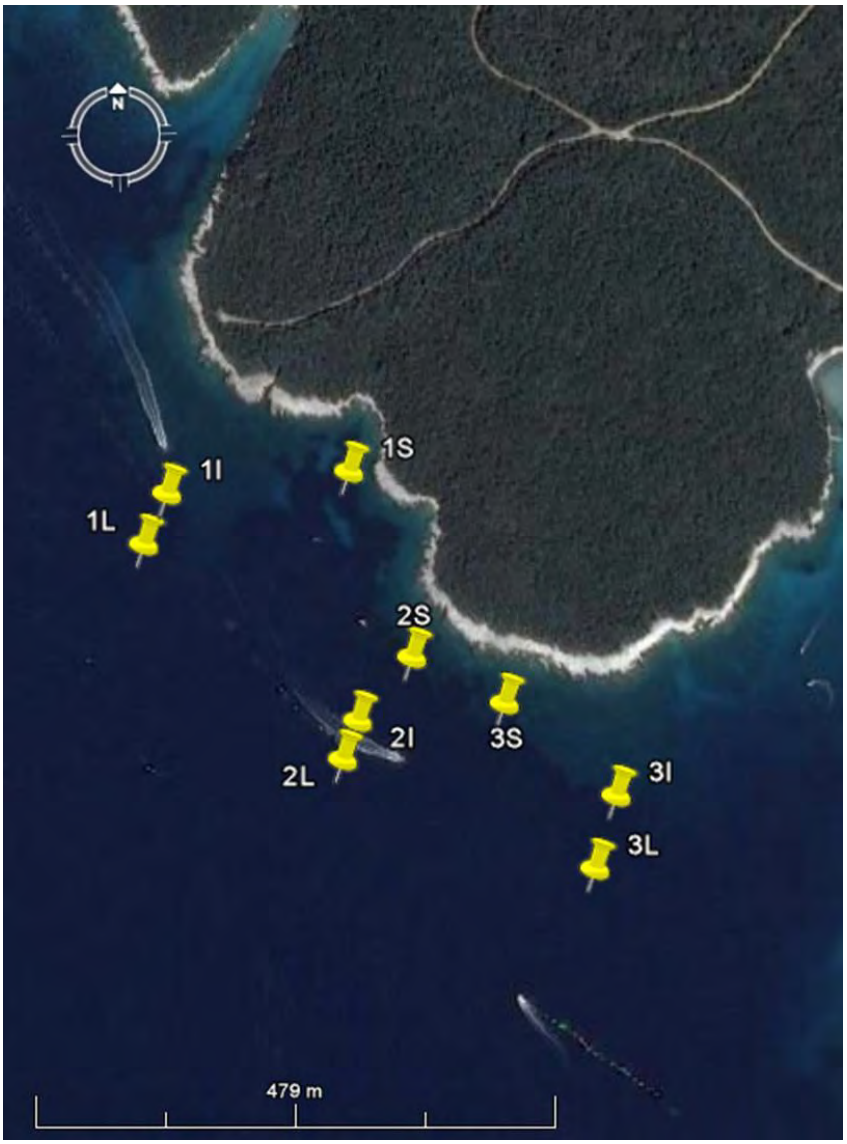

Figure 14. Zones (1, 2 and 3) and monitoring stations (S=shallow, I=intermediate, L=lower limit) at Uvala Planka.

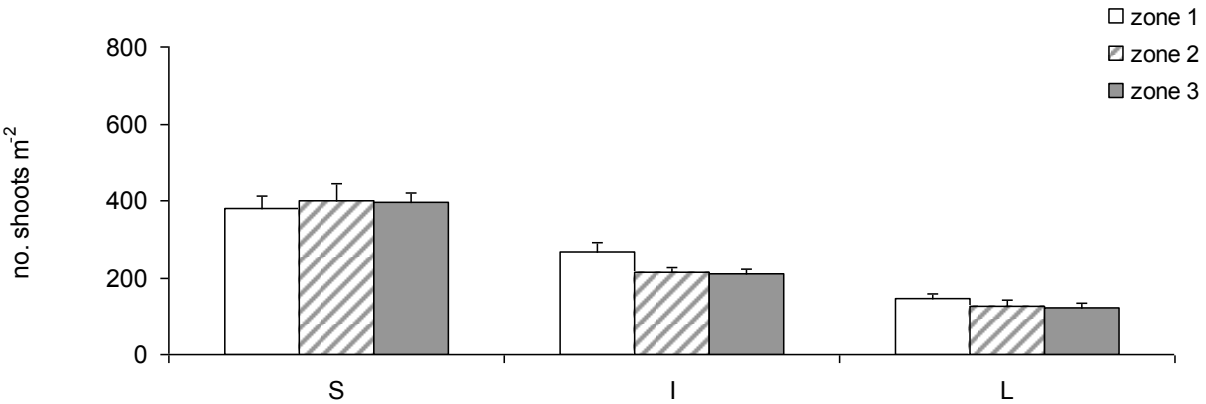

Figure 15. Mean values (+se) of the shoot density at each zone and depth range (S=shallow, I=intermediate, L=lower limit).

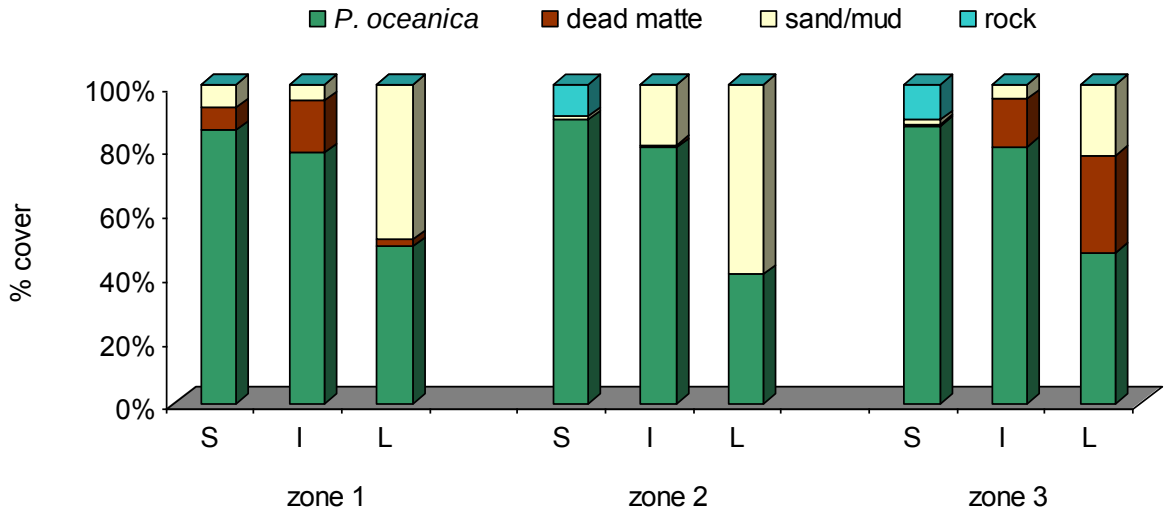

Figure 16. Percentage cover of *Posidonia oceanica*, dead *matte* and surface of main substrates recorded at each zone and depth range (S=shallow, I=intermediate, L=lower limit).

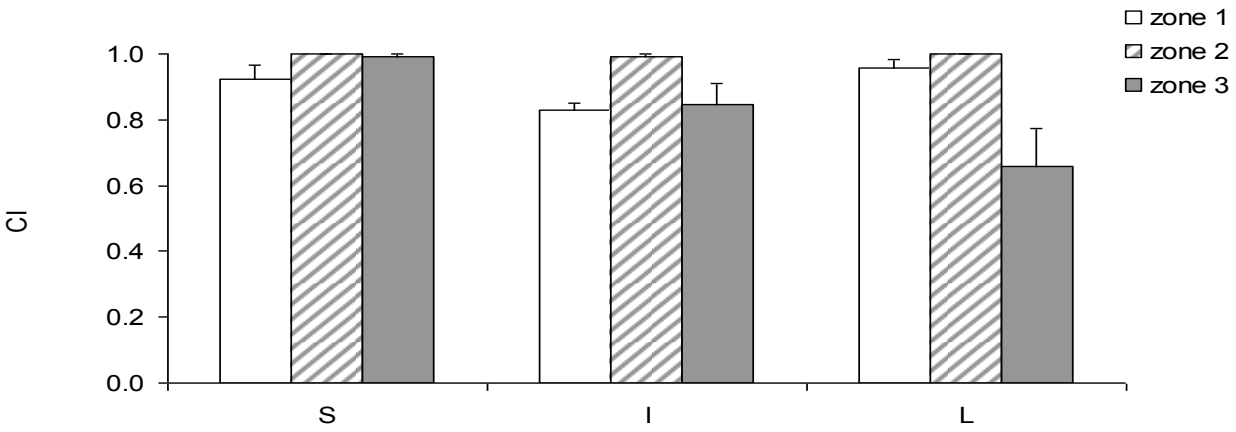

Figure 17. Mean values (+se) of Conservation Index (CI) at each zone and depth range (S=shallow, I=intermediate, L=lower limit).

Table 6. Rating of conservation status of the meadow at both depth ranges based on CI according to Moreno *et al.* (2001) and Montefalcone *et al.* (2006).

depth	**mean value of CI**	**classification** (Moreno *et al*., 2001; Montefalcone *et al*., 2006)
shallow	0.97	class 4, high state of conservation
intermediate	0.89	class 3, moderate conservation status
lower limit	0.87	class 4, high state of conservation

3.5. Frkanj

Frkanj is located along the western coast of Rab Island (Figs. 1 and 18). The rocky coast is exposed to the winds blowing from South-East to West. The town of Rab is about 1 NM away and mooring facilities (concrete blocks, pier) and small tourist structures are spread along the coast; the area is subjected to modest anchoring of recreational boats.

Steep meadow, patchy at shallow stands, continuous in deep; upper limit, on *matte*, sand and sparse rocks, lies from 5 to 13 m deep. The lower limit is regressive with sparse shoots on mud down to 26 m.

Shallow stations ranged from 6.5 to 8.5 m deep and the meadow density at this depth varied from 494±47 to 759±48 shoot per m^2. Depth at intermediate stations ranged from 14.5 to 16.1 m and density from 198±23 to 327±26 shoot per m^2. At the lower limit, depth ranged from 19.9 to 25.1 m and density from 93±8 to 158±13 shoot per m^2 (Fig. 19). In summary, according to UNEP-RAC/SPA (2009), shoot densities recorded at Frkanj indicate moderate (2 stations) and good (1) conditions for shallow stations, poor (1) and moderate (2) conditions for intermediate stations, and poor (2) and moderate (1) conditions for the meadow at the lower limit.

Figure 18. Zones (1, 2 and 3) and monitoring stations (S=shallow, I=intermediate, L=lower limit) at Frkanj.

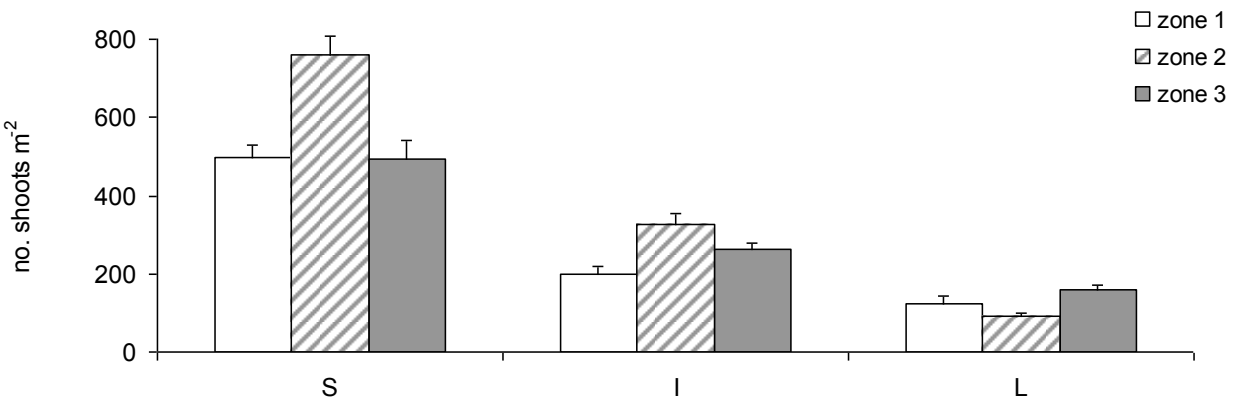

Figure 19. Mean values (+se) of the shoot density at each zone and depth range (S=shallow, I=intermediate, L=lower limit).

At the shallow stations, the percentage cover of live *Posidonia oceanica* ranged from 87 to 92% and dead *matte* from 5 to 13%; unvegetated sandy substrate was negligible (1% at only one station) while rocks varied from 0 to 6%. At the intermediate stations, *Posidonia oceanica* ranged from 49 to 91% and dead *matte* from 9 to 52%; sand was recorded only at one zone (8%) and rocks were not found. Close to lower limit, *Posidonia oceanica* varied from 28 to 38% and dead *matte* from 35 to 72%; rocky substrate ranged from 0 to 17% and unvegetated sandy bottom from 0 to 10% (Figure 20).

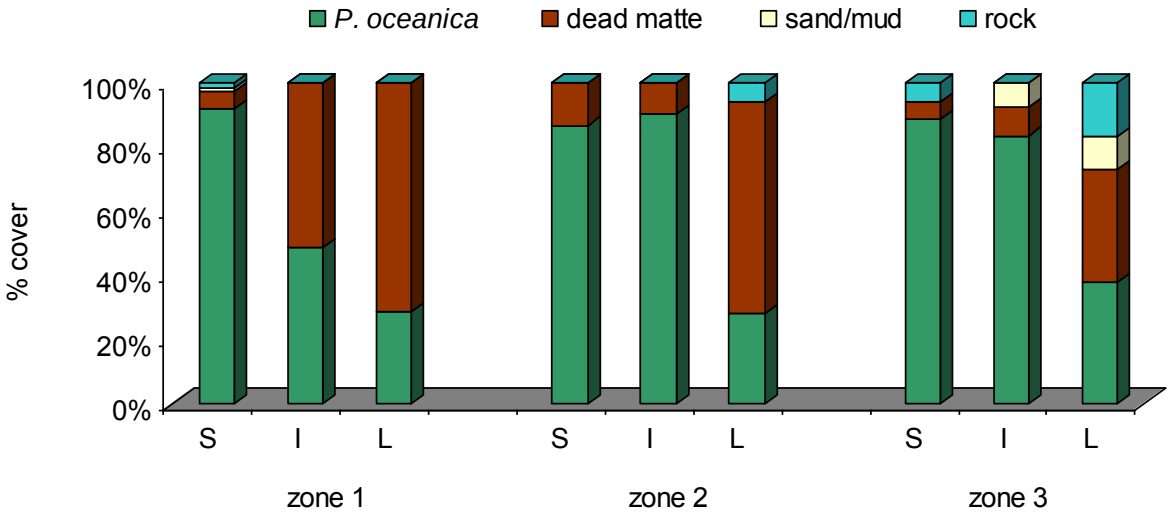

Figure 20. Percentage cover of *Posidonia oceanica*, dead *matte* and surface of main substrates recorded at each zone and depth range (S=shallow, I=intermediate, L=lower limit).

CI values ranged from 0.87±0.02 to 0.95±0.02 at the shallow stations, from 0.49±0.10 to 0.91±0.03 at the intermediate ones and from 0.29±0.05 to 0.59±0.14 at the lower limit (Fig. 21).

Mean values of Conservation Index compared to the average mean of the whole study area correspond to moderate conservation status at shallow stations, impacted meadow at intermediate and advanced degree of regression at the lower limit (Table 7).

Lower limit features indicate poor conditions for depth (26 m), bad for type (regressive) and good/high for percentage coverage according to the rating systems suggested by UNEP-RAC/SPA (2009).

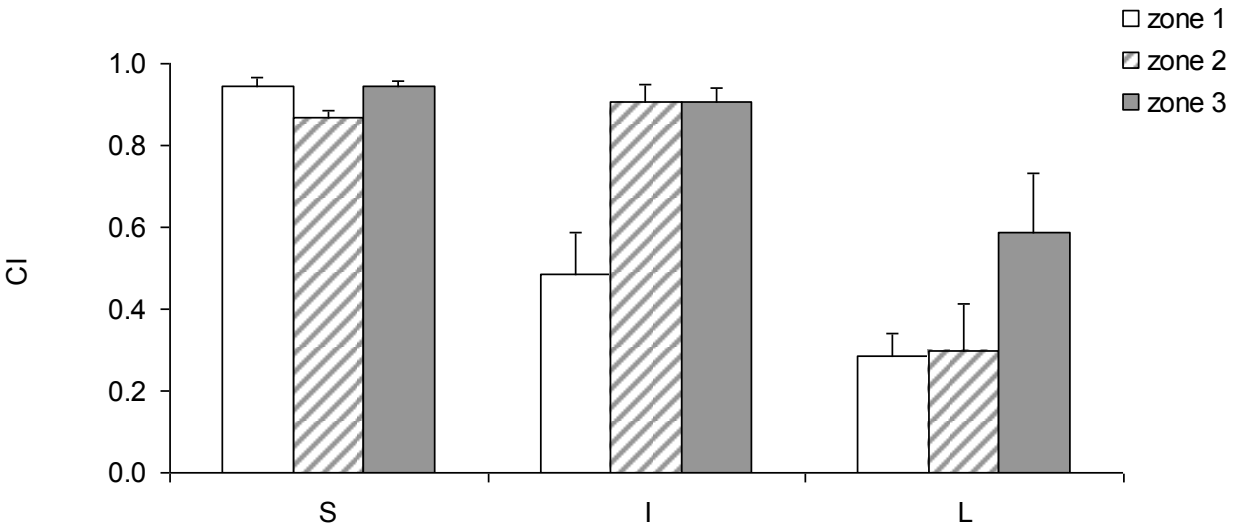

Figure 21. Mean values (+se) of Conservation Index (CI) at each zone and depth range (S=shallow, I=intermediate, L=lower limit).

Table 7. Rating of conservation status of the meadow at both depth ranges based on CI according to Moreno *et al.* (2001) and Montefalcone *et al.* (2006).

depth	**mean value of CI**	**classification** (Moreno *et al*., 2001; Montefalcone *et al*., 2006)
shallow	0.92	class 3, moderate conservation status
intermediate	0.77	class 2, impacted meadow
lower limit	0.39	class 1, advanced degree of regression

3.6. Comparing 2013 vs. 2014

Figures 22 and 23 show the values of shoot density and CI assessed for the meadows of Uvala Planka and Frkanj for each station at each depth range and for both years of monitoring. Table 8 reports the results of four-ways ANOVA for both variables.

The mean density ranged from 73±16 to 759±48 number of shoots per m^2. No significant difference emerged between the two years of survey, as well as between the two sites. Significant differences ($p<0.001$) were detected among stations; the SNK test (Table 8) highlights that the meadow in Uvala Planka is homogeneous in terms of density at the various depths, while in Frkanj it varied among stations at all three depths. The number of shoots per m^2 varied significantly ($p<0.05$) among depths. However, the SNK test, unexpectedly, did not reveal a difference between the intermediate stations and lower limit.

The mean values of CI ranged from 0.29±0.05 to 1. The significant interaction among the factors year, site, and depth (yeXsiXde, $p<0.05$) indicates that CI varied significantly at the lower limit, with higher values in 2014 in Uvala Planka, lower in 2013 at Frkanj; on the contrary, CI did not change in the two years of monitoring at shallow and intermediate stations. Moreover, at the lower limit, Uvala Planka had higher values of CI than Frkanj in both 2013 and 2014. At Uvala Planka CI was found higher at shallow and intermediate stations than that recorded at the lower limit in 2013, while no difference among depths were evident in 2014. Even at Frkanj CI was

higher in shallow and intermediate portions of the meadow in 2013, while a gradient was found in 2014, with higher values at the surface and progressively lower at the deepest stations.

The significant interaction among the factors year and station (yeXst(siXde), $p<0.05$) indicates that at Uvala Planka in 2014 CI decreased significantly at one intermediate station and increased at one station at the lower limit; in Frkanj CI varied significantly at only one station at the lower limit, with higher values in 2014. The SNK test also reveals a significant variability among stations at both sites at intermediate depth and, particularly, at the lower limit.

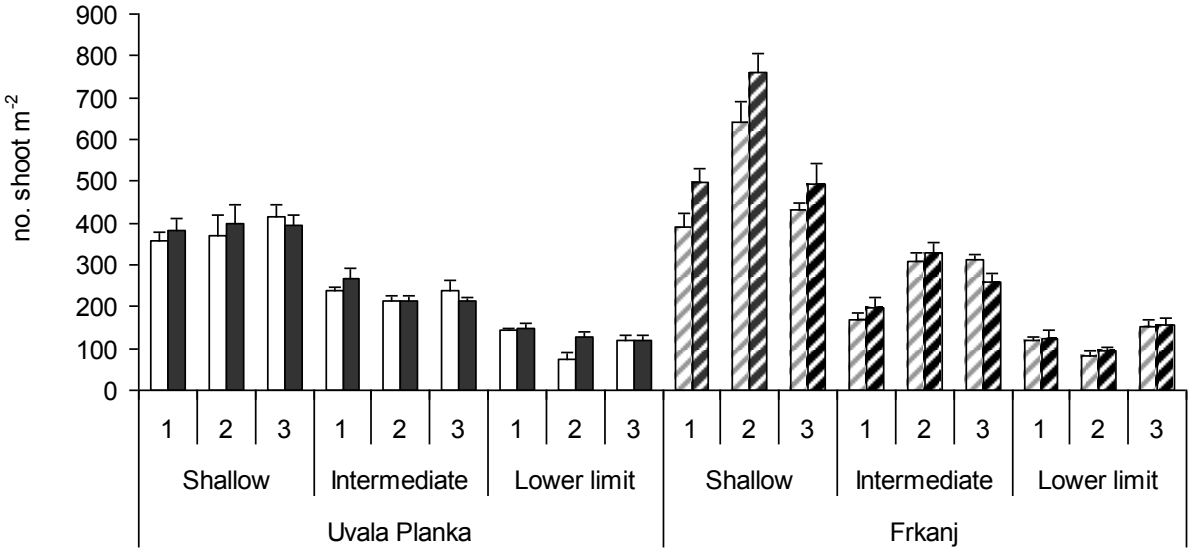

Figure 22. Mean values (+se) of shoot density assessed for both years of survey (light bars=2013, dark bars=2014) at each station (1, 2 and 3) at each depth range in the meadows of Uvala Planka and Frkanj.

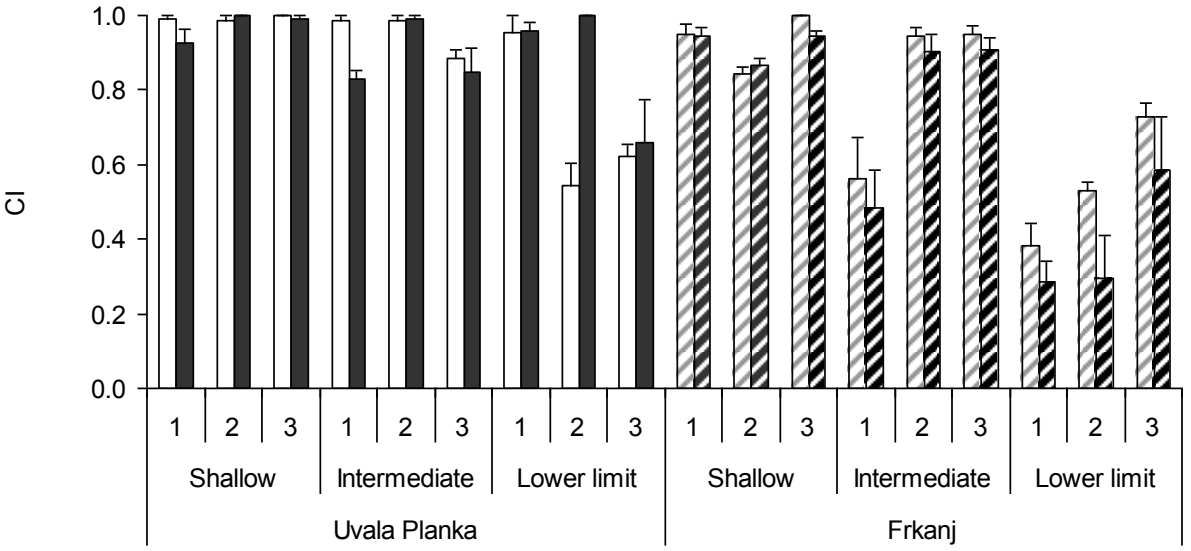

Figure 23. Mean values (+se) of Conservation Index (CI) assessed for both years of survey (light bars=2013, dark bars=2014) at each station (1, 2 and 3) at each depth range in the meadows of Uvala Planka and Frkanj.

Table 8. Results of four-ways ANOVA on shoot density and CI (UP=Uvala Planka; FR=Frkanj; S=shallow; I=intermediate; L=lower limit; ye=year; si=site; de=depth; st=station).

	density			CI		
source of variation	**df**	**MS**	**p**	**df**	**MS**	**p**
ye	1	24.595	0.203	1	0.019	0.729
si	1	142.912	0.117	1	1.029	0.024
de	2	2589.791	**0.027**[b]	2	1.331	0.145
st(siXde)	12	49.966	**0.000**[a]	12	0.155	0.000
yeXsi	1	2.671	0.439	1	0.090	0.090
yeXde	2	8.314	0.514	2	0.012	0.904
yeXst(siXde)	12	4.158	0.386	12	0.026	**0.010**[d]
siXde	2	72.046	0.275	2	0.225	0.273
yeXsiXde	2	8.788	0.164	2	0.109	**0.043**[c]
RES	252	3.887		108	0.011	
TOT	287			143		
Cochran's Test	C=0.0761 (not significant)			C=0.2046 (p<0.01)		
Transformation	sqrt(x+1)			none		

SNK tests:

[a] st(siXde)	UP	S: st1=st2=st3	I: st1=st2=st3	L: st1=st2=st3
	FR	S: st1=st3<st2**	I: st1<st2=st3**	L: st2<st1<st3*
[b] de	S>I=L*			
[c] yeXsiXde	UP	S: 2013=2014	I: 2013=2014	L: 2013<2014*
	FR	S: 2013=2014	I: 2013=2014	L: 2013>2014*
	2013	S: UP=FR	I: UP=FR	L: UP>FR*
	2014	S: UP=FR	I: UP=FR	L: UP>FR**
	2013	UP: S=I>L**	FR: S=I>L**	
	2014	UP: S=I=L	FR: S>I>L**	
[d] yeXst(siXde)	UP	S st1: 2013=2014	st2: 2013=2014	st3: 2013=2014
		I st1: 2013>2014*	st2: 2013=2014	st3: 2013=2014
		L st1: 2013=2014	st2: 2013<2014**	st3: 2013=2014
	FR	S st1: 2013=2014	st2: 2013=2014	st3: 2013=2014
		I st1: 2013=2014	st2: 2013=2014	st3: 2013=2014
		L st1: 2013=2014	st2: 2013<2014**	st3: 2013=2014

2013	UP	S: st1=st2=st3	I: st1=st2=st3	L: st1>st2=st3**
	FR	S: st1=st2=st3	I: st1<st2=st3**	L: st1=st2<st3**
2014	UP	S: st1=st2=st3	I: st1=st2=st3	L: st1=st2>st3**
	FR	S: st1=st2=st3	I: st1<st2=st3**	L: st1=st2<st3**

Considering the mean values of shoot density for each site at each depth range (Table 9), the highest variability was found in the shallow meadow at Frkanj (+19%) and at the lower limit at Uvala Planka (+17%). However, the assessment of meadow conditions based on shoot density and depth, as suggested by UNEP-RAC/SPA (2009), indicates that the status of the meadows did not change in any case: for both years poor conditions were recorded at all three depths at Uvala Planka, while at Frkanj moderate conditions at shallow and intermediate depths, and poor condition at the lower limit.

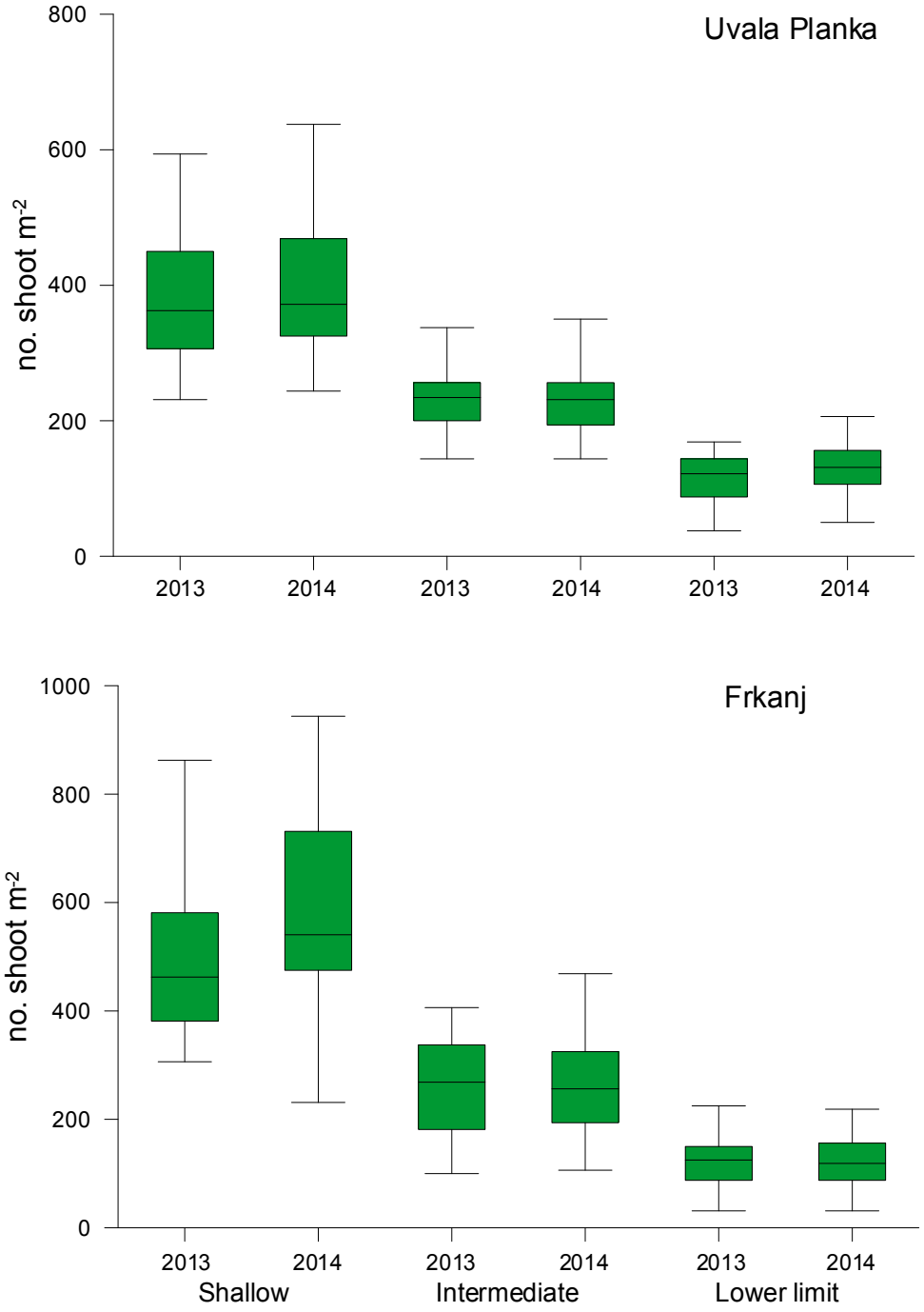

Figure 24. Box-plot of shoot density assessed for both years of survey at each depth range in the meadows of Uvala Planka (above) and Frkanj (below).

As regard to CI, considering the mean values for each site at each depth range (Table 9), the highest variability was found at the lower limit of both meadows, -29% at Frkanj and +23% at Uvala Planka.

According to the rating system proposed by Moreno *et al.* (2001), at shallow depth none of the two meadows changed their status between the two years of survey (high state of conservation at Uvala Planka and moderate at Frkanj), not even at the intermediate depth at Frkanj (impacted meadow). At Uvala Planka, the conservation status shifted from high to moderate (CI variation -

7%) in the intermediate meadow and from moderate to high (CI variation +23%) at the lower limit; at Frkanj, at the lower limit, the meadow was impacted in 2013 and in advanced degree of regression in 2014 (CI variation -29%).

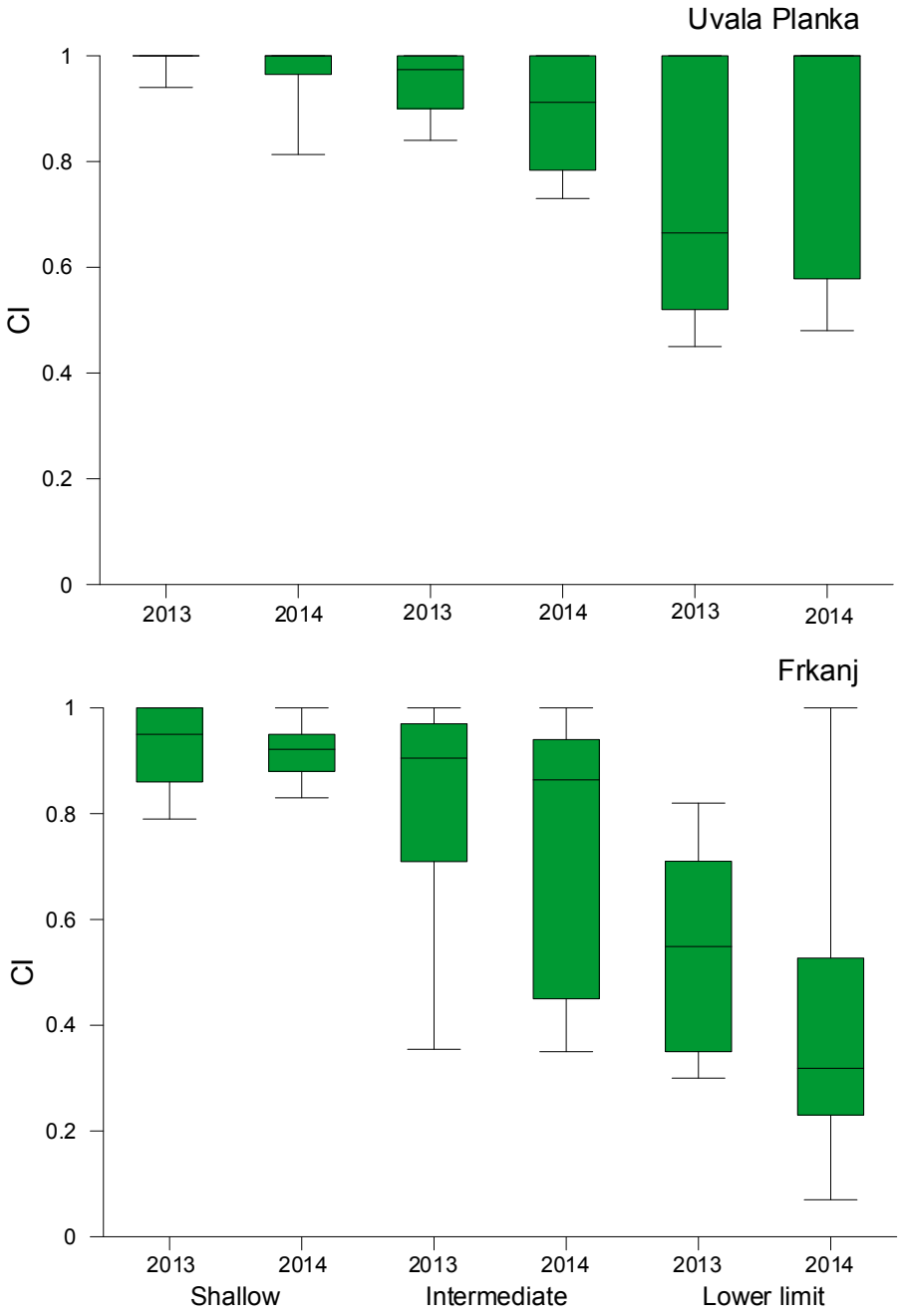

Figure 25. Box-plot of CI assessed for both years of survey at each depth range in the meadows of Uvala Planka (above) and Frkanj (below).

Table 9. Percentage variation of both descriptors, calculated at each site and depth range, between 2013 and 2014.

	density			CI		
	Shallow	Intermediate	Lower limit	Shallow	Intermediate	Lower limit
Uvala Planka	3%	0%	17%	-2%	-7%	23%
Frkanj	19%	0%	6%	-1%	-6%	-29%

4. SYNTHESIS OF RESULTS AND CONCLUSIONS

Results indicate signs of deterioration at Cres-west as testified by both poor density and advanced regression of live plants of *Posidonia oceanica* at all depths. Even the lower limit features were not optimal because of the regressive edge at depth not reaching 27 meters.

Also at Unije, the density is poor in all depth ranges; however, the status of the meadow appears to be better at lower depths, with the highest CI value at the lower limit; the latter is progressive and is one of the deepest among those surveyed in the whole area. The shallow and intermediate portions of the meadow could be affected by some kind of unknown pressure represented by the unvegetated circles present along the coast.

The meadow in Losinj-south is one of the healthiest among those recorded throughout the study, with values of density and CI from moderate to good, and features of the lower limit that show high degree of maintenance. These conditions probably depend on the position of this meadow that is the southernmost and the least confined (i.e. less subjected to anthropogenic disturbance) among those investigated during the two-year survey.

The meadows at Uvala Planka have a progressive lower limit, one of the deepest among those surveyed throughout the area, and the highest values of CI, as a consequence of the low abundance of dead *matte*. On the contrary, shoot density was poor at all the investigated depths.

Posidonia oceanica shows clear evidences of regression at Frkanj where, despite the moderate density at shallow and intermediate depths, the meadow is impacted or even in an advanced state of regression at the lower limit (the latter is the shallowest and regressive).

At all sites, with the exclusion of Losinj-south, at least one of the descriptors used to assess the status of the meadows was found negative (bad, poor or advanced state of regression), and their conditions were not favourable. Overall, these results are consistent with what is well known for the Northern Adriatic about the lack of good conditions for plant growth due to low water transparency (Gamulin-Brida, 1967; Bakran-Petricioli *et al*., 2006).

For the two meadows investigated at the island of Rab (Uvala Planka and Frkanj), it was possible to make a first comparison in order to assess the potential temporal differences of the variables considered. With regard to meadow density, the results of ANOVA (no significant difference recorded between the two surveys in 2013 and 2014) are consistent with the findings obtained through the evaluation scale suggested by UNEP-RAC/SPA (2011), for which there are no changes of classes during the two surveys, for any site and any bathymetric range. On the contrary, for CI some changes between the two years were detected in the deepest portions of both meadows: at both lower limits, the sea bottom covered by live *Posidonia oceanica* was, on average, lower than 50% (see Figs. 16 and 20 for 2014) and the surfaces covered by dead *matte* and sediment were highly variable between the two years of investigation (see Guala *et al.*, 2014 for the data assessed in 2013). In fact, at Uvala Planka, dead *matte* coverage was reduced by 61% and sediment increased by 188%; at Frkanj, dead *matte* increased by 188%, while the change in percentage cover of sediment was negligible. Such remarkable changes, that explain the significant differences of CI at the lower limits, could be due to an inaccurate assessment of the percentage of dead *matte* and sediment in one or both surveys rather than a real variation of the Posidonia/dead *matte* ratios in less than one year. Here, it is worth highlighting that dead *matte* covered with sediment is very common in Croatian meadows (Nikolić V., personal communication), and this is particularly true at the lower limit in the studied area. Large variations in the percentage of CI between two successive investigations may result from misidentification of the dead *matte* whenever it is covered with sand or mud. This aspect highlights the importance, for the future monitoring campaigns, of careful checks of the bottom with a hand (digging with fingers if necessary) in order not to substitute dead *matte* with sediment that often

covers them in a thin layer; moreover, it strongly suggests to take care of the intercalibration process among operators in order to obtain reliable data within the implementation of the NMP.

The investigation conducted in 2014 adds up to the first study carried out with the same approach in 2013 in the Primorje-Gorski Kotar County. It enables the increase in number of investigated meadows in the region (for a total of 8). Collecting data of the most fundamental descriptors for *Posidonia oceanica* monitoring provides the opportunity to fill the gaps and improve the level of knowledge on the status of meadows. Thus, within the framework of the MedMPAnet project, a pivotal baseline is being constructed to provide information on the conservation status of *Posidonia oceanica* meadows and assess trends on a long-term temporal scale.

Monitoring of additional sites with a higher number of surveys with respect to what has been done in these phases of the project is necessary to increase the power for testing the source of variations in analyses of variance. However, doing surveys every two years, as suggested in the NMP, seems to be the most practical option, due to the high number of sites to be monitored, the available resources and time, and taking into account that the structural descriptors of the meadows change slowly (but this should be confirmed, at least for CI).

In any case, as pointed out in the previous report (Guala *et al.*, 2014b), the protocol has to be considered flexible and, if necessary, the monitoring approach (methods and timing, as well as the sites, whether those indicated are inadequate or insufficient) could be adapted, according to the concept of adaptive management based on the immediate integration of results.

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ANNEXES

Annex I

Summary of information collected in each monitoring sites during the fieldwork.

Site	Cres-west								
date of sampling	19/06/2014								
coastal features	rocky coast exposed to the winds from W								
potential human pressures along the coast	no								
general description of the meadow	patchy meadow on rock at shallow stands, sparse on dead *matte* at intermediate and lower depths; upper limit 4 m; lower limit regressive at 26.7 m								
Zone	**1**			**2**			**3**		
meadow type	discontinuous and sparse meadow, patches at upper limit			discontinuous meadow, patches at upper limit			discontinuous meadow, patches at upper limit		
main substrate	rock, *matte*, mud			rock, *matte*, sand			rock, *matte*, sand		
lower limit, depth (m)	26.7			26.4			26.3		
lower limit, type	regressive			regressive			regressive		
upper limit, depth (m)	4			4			4		
operators	Patrik Kristinić, Ivan Guala			Milena Šijan, Maya Sertić			Ante Žuljević, Ivan Cvitković		
Station	**shallow**	**intermediate**	**lower limit**	**shallow**	**intermediate**	**lower limit**	**shallow**	**intermediate**	**lower limit**
GPS latitude	44,78660	44,78665	44,78645	44,78465	44,78487	44,48460	44,78209	44,78210	44,78194
GPS longitude	14,36385	14,36358	14,36318	14,36632	14,36545	14,36475	14,36571	14,36503	14,36449
presence of *Pinna nobilis*	no	no	no	no	no	no	no	no	no
other seagrasses	no	no	no	no	no	no	no	no	no
alien species	no	no	no	no	no	no	no	no	no
evidence of potential pressures	no	no	no	no	no	no	no	no	no
signs of damage	no	no	no	no	no	no	no	no	no
pictures	no	no	no	no	no	no	no	no	no
note									

Site	Unije								
date of sampling	12/09/2014								
coastal features	rocky shore exposed to winds from I and II quadrants								
potential human pressures along the coast	no (unvegetated circular areas within Posidonia meadow along the coast)								
general description of the meadow	continuous meadow; upper limit on rocks, 6 m; lower limit sparse, progressive up to 27,8 m								
Zone	**1**			**2**			**3**		
meadow type	flat, continuous			flat, continuous			flat, continuous		
main substrate	rock, sand			rock, sand			rock, sand		
lower limit, depth (m)	sparse patches and rhizomes up to 26 m			sparse parches and rhizomes up to 28 m			sparse parches and rhizomes up to 26 m 27		
lower limit, type	progressive (no clear limit)			progressive (no clear limit)			progressive (no clear limit)		
upper limit, depth (m)	6			6			6		
operators	Matea Špika, Mosor Prvan			Željka Rajković, Ivan Guala			Milena Šijan, Patrik Kristinić		
Station	**shallow**	**intermediate**	**lower limit**	**shallow**	**intermediate**	**lower limit**	**shallow**	**intermediate**	**lower limit**
GPS latitude	44.61370	44.61435	44.61518	44.61028	44.61113	44.61432	44.61579	44.61646	44.61638
GPS longitude	14.28042	14.28170	14.28380	14.28232	14.28337	14.28693	14.27818	14.28071	14.28356
presence of *Pinna nobilis*	no	no		no	no		no	no	
other seagrasses	no	no		no	no		no	no	
alien species	no	no		no	no		no	no	
evidence of potential pressures	no	no		no	no		no	no	
signs of damage	no	no		no	unvegetated circular area close to the sampling station		no	no	
pictures	no	no		no	no		no	no	
note									

Site	Losinj-south								
date of sampling	16/06/2014								
coastal features	rocky coast exposed to the winds from W								
potential human pressures along the coast	anchoring								
general description of the meadow	meadow on rock, patchy at shallow stands and at the lower limit; upper limit 6-7 m; lower limit progressive and sharp, sometimes sparse on rocks at 26-27.6 m								
Zone	**1**			**2**			**3**		
meadow type	discontinuous meadow, patches at upper limit			discontinuous meadow, patches at upper limit			discontinuous meadow, patches at upper limit		
main substrate	*matte*, rock, sand			rock, *matte*, sand			rock, *matte*, sand		
lower limit, depth (m)	26.1			27.6			26.2		
lower limit, type	progressive			progressive			progressive		
upper limit, depth (m)	7			6			7		
operators	Ante Žuljević, Ivan Cvitković			Milena Šijan, Maya Sertić			Patrik Krstinić, Ivan Guala		
Station	**shallow**	**intermediate**	**lower limit**	**shallow**	**intermediate**	**lower limit**	**shallow**	**intermediate**	**lower limit**
GPS latitude	44,48551	44,48537	44,48442	44,48285	44,48211	44,48218	44,47882	44,47903	44,47879
GPS longitude	14,50871	14,50517	14,50513	14,50917	14,50742	14,50574	14,51366	14,50986	14,50815
presence of *Pinna nobilis*	No	no	no	no	no	no	yes, outside	no	no
other seagrasses	No	no	no	no	no	no	no	no	no
alien species	No	no	no	no	no	no	no	no	no
evidence of potential pressures	No	no	no	no	no	no	no	no	no
signs of damage	No	no	no	anchoring signs	no	no	anchoring signs	no	no
pictures	No	no	no	no	no	no	no	no	no
note									

Site	Uvala Planka								
date of sampling	13/06/2014								
coastal features	rocky coast exposed to SE to NW								
potential human pressures along the coast	boat anchoring								
general description of the meadow	continuous steep meadow; upper limit on rocks, 6 to 12 m; lower limit progressive up to 27,8 m								
Zone	**1**			**2**			**3**		
meadow type	steep, continuous meadow			steep, continuous meadow			steep, continuous meadow		
main substrate	rock, sand			*matte*, sand, rock			rock, *matte*, sand, mud		
lower limit, depth (m)	27.3			27.8			27.5		
lower limit, type	progressive			progressive			progressive		
upper limit, depth (m)	6 to 12			5.5			6		
operators	Matea Špika, Mosor Prvan			Željka Rajković, Ivan Guala			Milena Šijan, Patrik Kristinić		
Station	**shallow**	**intermediate**	**lower limit**	**shallow**	**intermediate**	**lower limit**	**shallow**	**intermediate**	**lower limit**
GPS latitude	44.77195	44.7718	44.771383	44.7704	44.769883	44.769567	44.77	44.769217	44.768617
GPS longitude	14.671667	14.669533	14.66925	14.67235	14.6717	14.671517	14.673417	14.674698	14.674433
presence of *Pinna nobilis*	no	no	no	no	no	no	no	no	no
other seagrasses	no	no	no	no	no	no	no	no	no
alien species	no	*no*	no	no	*W. setacea*	*W. setacea*	no	*no*	*no*
evidence of potential pressures	no	no	no	no	no	no	no	no	no
signs of damage	no	no	no	no	no	no	no	no	no
pictures	yes	yes	yes	no	no	no	yes	yes	yes
note									

Site	Frkanj								
date of sampling	18/06/2014								
coastal features	rocky coast is exposed to the winds from SE to W								
potential human pressures along the coast	anchoring, mooring facilities (concrete blocks, pier), small tourist structures along the coast, Rab town about 1 NM away								
general description of the meadow	steep meadow, patchy at shallow stands, continuous in depth; upper limit on *matte* and sand, sparse rocks, 5 to 13 m; lower limit regressive, sparse shoots on mud up to 26 m								
Zone	**1**			**2**			**3**		
meadow type	steep, continuous meadow, patches at upper limit			steep, continuous meadow, patches at upper limit			steep, continuous meadow		
main substrate	*matte*, rock, sand			rock, *matte*, sand, mud			rock, *matte*, sand		
lower limit, depth (m)	20.2			26			25.5		
lower limit, type	regressive			regressive			regressive		
upper limit, depth (m)	5			5 to 13			5		
operators	Milena Šijan, Maya Sertić			Ante Žuljević, Ivan Cvitković			Patrik Krstinić, Ivan Guala		
Station	**shallow**	**intermediate**	**lower limit**	**shallow**	**intermediate**	**lower limit**	**shallow**	**intermediate**	**lower limit**
GPS latitude	44.757798	44.757523	44.757247	44.755344	44.755804	44.755973	44.754329	44.754197	44.754011
GPS longitude	14.739231	14.737952	14.737687	14.744543	14.742437	14.740822	14.745512	14.745077	14.744752
presence of *Pinna nobilis*	no	no	no	no	no	no	no	no	no
other seagrasses	no	no	no	no	no	no	no	no	no
alien species	no	no	no	no	no	no	no	no	no
evidence of potential pressures	no	no	no	mooring systems (concrete blocks, pier)	no	no	no	no	trash
signs of damage	no	no	no	no	no	no	yes	no	yes
pictures	no	no	no	no	no	no	no	no	no
note									

Regional Activity Centre
for Specially Protected Areas (RAC/SPA)

Boulevard du Leader Yasser Arafat
B.P. 337 - 1080 Tunis Cedex - TUNISIA
Tel. : +216 71 206 649 / 485 / 765
Fax : +216 71 206 490
E-mail : car-asp@rac-spa.org
www.rac-spa.org