UNIVERZA NA PRIMORSKEM
FAKULTETA ZA MATEMATIKO, NARAVOSLOVJE IN
INFORMACIJSKE TEHNOLOGIJE

MASTER'S THESIS
(MAGISTRSKO DELO)

PROTECTION OF THE NORTHERN ADRIATIC: PRESENT SITUATION AND PERSPECTIVES - PROPOSAL FOR THE ESTABLISHMENT OF A MARINE PROTECTED AREA LOWER KAMENJAK AND MEDULIN ARCHIPELAGO

ZAŠČITA SEVERNEGA JADRANA: TRENUTNO STANJE IN OBETI - PREDLOG MORSKEGA ZAVAROVANEGA OBMOČJA SPODNJI KAMENJAK IN MEDULINSKI ARHIPELAG

VEDRAN ŠUGAR

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(Zaščita severnega Jadrana: trenutno stanje in obeti - Predlog morskega zavarovanega območja Spodnji Kamenjak in Medulinski arhipelag)

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Izvleček:

Severni Jadran je eden izmed najbolj produktivnih območjih Sredozemlja donosa slatke vode (vglavnem reka Po) obogaćene dušikovim i fosforjevim spojima, pomembno za primarno proizvodnjo in s tem ribištva (sardele in sardoni). Morsko območje je pod dolgotrajnim antropogenim vplivom, ki sega nazaj več kot 2000 let. Za vzhodno obalo (istrski polotok) so bili značilni obsežni travniki morske cvetnice Posidonia (*Posidonia oceanica*). Danes pa obstajajo le še na Brionih, ozka obalna območja v Tržaškem zalivu (Žusterna), kjer so tudi zaščitena, in na skrajnem jugu Istre, na rtu Kamenjak. Na Kamenjaku se dejavnosti, ki lahko negativno vplivajo na travnike Posidonie ne sprelja sistematično, za razliko od Brionov in Žusterne. Magistersko delo daje vpogled v kakovost travnikov posidonije Spodnjega Kamenjaka, kot ključnih habitatnih tipov ki uživajo pravno varstvo. Travniki Posidonie so prioritetna območja prema Direktivi EU (92/43/EEC) in rabi se kot kazalnik dobrega stanja na območjih Natura 2000. Na osnovi turistične ponudbe in zmogljivosti Občine Medulin navajam možnosti za trajnostno upravljanje morskega dela Spodnji Kamenjak in Medulinski arhipelag, tudi obveznost, glede na to da to področje spada pod omrežje Natura 2000, eden od največjih omrežja zavarovanih območij na ravni EU. Na podlagi tega in s pomočjo anketiranja obiskovalcev Kamenjaka sam predstavio objektivnih slik o priložnostih za trajnostni in učinkovit turizam na jugu Istre, s spodbujanjem raziskav in razvoja.

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Abstract:

The northern Adriatic is one of the most productive Mediterranean areas, because of the input of fresh waters (mainly from river Po) enriched with nitrogenous and phosphorus chemicals, crucial for primary production and thus fishery (sardines and anchovies). Marine area is under a long anthropogenic influence that reaches back more than 2000 years. The eastern coast (Istrian peninsula) was, just a few decades before, abundant with a seagrass meadow (*Posidonia oceanica*). In recent years meadows have been identified and researched around the Brijuni islands, the narrow coastal area in the Gulf of Trieste (Žusterna), and the south coast of Istria (Cape Kamenjek). On Cape Kamenjak human activities that might have a negative effect on a *Posidonia* meadow have never been tracked nor monitored, like in Nature Parks Brijuni and Žusterna. This document presents insight into the quality of the *Posidonia* habitat, as a keystone (habitat) species that requires sustainable protection, since (legal) obligation exist. Based on tourist offer and facilities of the Municipality of Medulin there are proposed guidelines for sustainable management of the marine part of Lower Kamenjak and Medulin archipelago. *Posidonia* meadow is a priority habitat for conservation, under the Habitat Directive, and serve as a indicator for good status in Natura 2000 areas. Marine area of Cape Kamenjak falls under the Natura 2000 network and on this basis, with the help of surveying visitors Kamenjaka proposed are the opportunities for sustainable and efficient tourism in the south of Istria, by promoting research and development.

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LIST OF ABBREVIATIONS

CBD – Convention on Biological Diversity

CCE – Croatian Chamber of Economy

EC – European Commission

EEC – European Economic Community

EU – European Union

GIS – Geographic Information System

IMO – International Maritime Organization

IUCN – International Union for Conservation of Nature

LKMA – Lower Kamenjak and Medulin Archipelago

LMF – Law on Marine Fishery

MAB – Man and the Biosphere Programme

MPA – Marine Protected Area

NHC – National Habitat Classification

NP – National Park

NPA – National Protection Act

OPCC – Operational Programme “Competitiveness and Cohesion”

PA – protected area

PI – Public Institution

RAC/SPA – Regional Activity Centre for Specially Protected Areas

RC – Republic of Croatia

SAC – Special Area of Conservation

SCI – Site of Community Importance

SINP – State Institute for Nature Protection

SPA – Specially Protected Area

SPA / BD Protocol – Specially Protected Areas and Biological Diversity Protocol for the Mediterranean

UNEP/MAP – United Nations Environment Programme/Mediterranean Action Plan

UNESCO-WHC – United Nations Educational, Scientific and Cultural Organization – World Heritage Convention

WCMC – World Conservation Monitoring Center

WCPA – World Commission on Protected Areas

WORMS – World Register of Marine Species

WWF – World Wildlife Fund

1 INTRODUCTION

The northern Adriatic is the largest and northernmost shallow sea of the Mediterranean (Ott, 1992) into which flows a significant amount of fresh water, mainly from the River Po (Palmeri et al., 2005), one of the largest rivers in the Mediterranean (Cavazzoni-Galaverni, 1972), the flow of which has been monitored since 1917 in several places (Cozzi and Giani, 2011). The basin of the River Po is located in a heavily populated area with high agricultural input (De Wit and Bendoricchio, 2001), which affects the nutrient inflow and other substances in the northern Adriatic (Degobbis et al., 2000). This is why the northern Adriatic is one of the most productive areas of the Mediterranean (Becky et al., 1984).

Hydrographic measurements for the northern Adriatic did not confirm a trend of warming in the last 20 to 30 years (Supić et al., 2004; Solidoro et al., 2009). Neither the whole Mediterranean, for the period 1985-2006 (Nykjaer, 2009). Seasonal, inter-annual, and multi-annual climate changes of the northern Adriatic are well known (Camuffo et al., 2000). The fresh water of the River Po comes all the way to the eastern side of the northern Adriatic (the coast of Rovinj) affecting the circulation of water masses between the northern and middle Adriatic (Degobbis et al., 2000), i.e. the creation of cyclonic and anticyclonic circuits due to the influence of the opposite current on the Istrian coast (Đakovac et al., 2015), which fosters the development of hypoxic and anoxic conditions, especially in the western area (delta of the River Po). In 1977 and 1989, hypoxia culminated in anoxia in the greater part of the northern Adriatic (Đakovac, 2006). Anoxic conditions regularly cause mass killing of fish populations and other organisms, having a great impact on the reduction of biodiversity (Benović et al., 1987; Stachowitsch, 1992). Massutí et al. (2010) mentioned that these conditions are increasing in frequency and severity. This is a process that cannot be controlled, only monitored, and may become even more severe by warming and the predicted increased frequency of extreme events like heat waves, caused by climate change.

Worldwide, coastal ecosystems, as well as in the northern Adriatic, record a change in the structure and function from the loss of large predators and herbivores, key habitats, and filtration ability to maintain water quality (Lotze et al., 2006). Marine exploitation in the northern Adriatic began very early, when the waters took this form after the last glaciation, 10000 years ago (Kovačević, 2002). Now its use has increased with population increase and the progress of civilisation (Lotze et al., 2006). In the second half of the 20th century, the northern Adriatic was a major tourist destination (Cencini, 1998). That is why it is estimated that Adriatic Sea is one of the areas of Mediterranean with the highest anthropogenic impacts (Micheli et al., 2013).

Nowadays, the northern Adriatic ports (Trieste, Rijeka, Koper) annually carry out the transport of many oils and organic compounds, of which many “accidentally” spill in open water (Vidas, 2009; Ferraro et al., 2008). Open water cargo shipping, accordingly, has a profound effect on transporting non-indigenous species which may have invasive[1]

[1] If some species by its relocation negatively effects on a function and structure of the habitat and its

characteristics. Galile (2012) documented over 660 non-indigenous species, while project on EU level as supplement on Marine Strategy Framework Directive (MSFD) recorded even more, in total 986 alien species in the Mediterranean (Zenetos et al. 2012); most of them with established populations (Galile, 2012). Molluscs are the dominant group of alien species (with 215 species), followed by crustaceans (159) and polychaetes (132). In Adriatic, macrophytes (algae) are the leading group, reaching 26-30% of all alien species, whereas it is assumed that many of them are introduced via ballasts or fouling (Zenetos et al., 2012). There is an increasing trend in new introductions via the Suez Canal and via shipping (Zenetos et al., 2012). The spread of invasive species may reduce populations of indigenous species and bring them to extinction at the local level (Ricciardi, 2004). Authors (Dulčić et al., 1999; Lipej and Dulčić, 2004) pointed out that a large number of species have migrated from the south to the northern parts of Adriatic due to increases in temperature. This spread (bio-invasion) is one of the four major threats to biodiversity[2] (IMO, 2000-2004) and it is considered to be the second largest cause of biodiversity loss, after habitat degradation (Breithaupt, 2003). Worldwide biological invasion is a threat not only to living communities, but also has an impact on the economy and human health (Streftaris and Zenetos, 2006). The results of the bio-invasion in the northern Adriatic have only been explored in the last decade, and has already shown pronounced effect on biodiversity in many natural ecosystems (Occhipinti-Ambrogi, 2007; Tamburello et al., 2013).

Species of special importance for protection

Bottlenose dolphin (*Tursiops truncatus*) is the only species of cetacean (order *Cetacea*) known to live and reproduce in the northern Adriatic (Bearzi et al., 2008b), more accurately in Cres-Lošinj archipelago (UNEP, 2011). They are found in variety of habitats, ranging from lagoons and river deltas to the oceanic waters (Bearzi et al. 2008b). Dolphins live in groups, and individuals within the group are linked by stronger or weaker social ties. Today we know that local populations (meta-populations[3]) of bottlenose dolphins in the Adriatic exist based on mitochondrial (mtDNA) and nuclear DNA analysis[4] (Gaspari et al., 2013), in particular the population of the northern Adriatic generally avoid from the population of central and southern Adriatic. Also, there is low gene flow between western and eastern Adriatic population, in general (RAC/SPA - UNEP/MAP, 2015). Although the size of the Adriatic population before it is not known, it is believed that since the mid-20th century to the present days, it has been reduced, that is why this subpopulation of the bottlenose dolphin is listed as "Vulnerable" under IUCN (World Conservation Union) criterion A2dce (Bearzi and Fortuna, 2006, 2012).

species, it is considered as invasive (IUCN, 2002).

2 Climate change, deforestation and habitat loss, overexploitation, pollution.

3 Population that are discrete or relatively discrete entities in space, which interact via migration and gene flow (Hanski and Gaggiotti, 2004).

44 Genetic differentiation at 12 microsatellite loci, and mitochondrial DNA revealed diverse levels of genetic differentiation among five putative populations from the Tyrrhenian Sea to the Aegean Sea.

Other cetacean species recorded in Adriatic (northern as well) is Risso's dolphins (*Grampus griseus*)**.** Most records originate from stranded animals, while live specimen were found individually (a single animal); only in two cases more animals were observed; three animals were observed near the Gulf of Trieste (Francese et al., 1999) and two animals were found stranded together on Island of Molat (Gomerčić et al., 2006b). Regardless of their presence throughout the Adriatic basin, it is concluded that Risso's dolphin is only occasionally present in the Adriatic Sea (Bearzi et al., 2004), and the Mediterranean subpopulation is listed as "Data Deficient" (Gaspari and Natoli, 2012).

The humpback whale (*Megaptera novaeangliae*) and the false killer whale (*Pseudorca crassidens*) were reported in northern Adriatic, although it is assumed that the northern part due to its shallowness is not a suitable habitat for whales (RAC/SPA - UNEP/MAP, 2015).

Sea turtles in Croatia are protected by the National Protection Act (NPA) as well by a number of international conventions due to its endangered (VU) status by IUCN (2015). The northern Adriatic as a neritic habitat is an important feeding area for the population of loggerhead turtles (*Caretta caretta*) during the winter (Casale et al., 2012). The Adriatic population mostly comes (93.5%) all the way from the shores of Greece (Lazar et al., 2004). The biggest impact on mortality comes from fishing activities, i.e. application of gillnets and trawl, the main fishing practice in Croatia and Slovenia (Lazar and Heppell, 2008). It is estimated that annually, this fishing method catches 486 to 4034 individuals; the estimated mortality rate for the area on the north-eastern Adriatic was 74% (Lazar et al., 2009). It is clear that the application of these two fishing methods should be restricted for some time period or excluded completely in some areas.

Despite new technologies and knowledge, the fishing industry is still a major problem for endangered species (e.g. mammals, sea turtles, cephalopods, crustaceans); not only do they cause unwanted deaths and injuries (e.g. sharks, marine mammals, juvenile fish), but the methods can harm the marine environment (http://www.worldwildlife.org/threats/bycatch). Also, many endangered species (mammals, sea turtles) have long period of sexual maturation and low reproductive capacity (K type species) most sensitive to common exploitation, so in fishery biology are used as indicator species for detection of changes (structural-functional) in living communities (UNDP, 2012).

Legal protection (legislation)

Protection of biodiversity on the level of the European Community[5] operates primarily through the implementation of EC Directives 79/409 and 92/43, known as the Birds Directive and Habitats Directive, which oblige Member States to establish Protected Areas (PAs) into a network known as Natura 2000, one of the largest international networks of PAs (http://ec.europa.eu/environment/nature/natura2000/index_en.htm). The marine component of the Natura 2000 network is an integral component of the total European

[5] Republic of Croatia is a member since 1. July 2013.

ecological network and as such, aims to protect habitats defined in Annex I and species in Annex II[6]. The Habitat Directive (92/43/EEC) contains the legal basis for the conservation of natural habitats and wild taxa, by acting as a legislative instrument of the Community. In those areas it is necessary to define and implement the management measures that will ensure good status of habitats and species for which it is protected. Regular monitoring is required for those species whose status most obviously reflects the changes in living communities (algal bloom), but also for endangered types of habitats and species. Actions that can lead to the destruction or some other significant or permanent damage to the ecologically significant area are restricted.

Protocol concerning Specially Protected Areas of the Mediterranean Sea and Biological Diversity (SPA/BD Protocol, Barcelona Convention), together with the signatory states (including Croatia and Slovenia) has drafted criteria for selection of the marine protected areas (MPAs) important for the Mediterranean (Annex I), which includes areas of concern for the conservation of biodiversity in the Mediterranean, a special ecosystem in the Mediterranean, or the habitats of endangered species and areas of special interest at the scientific, aesthetic, cultural, or educational level.

The adoption of the Regulation on proclamation of the Natura 2000 network (Official Gazette, OG 109/07) management of areas of ecological networks is given to the jurisdiction of the county public institutions or certain public institutions set up by the regional self-government units (OG 70/05), which is required to draw up and implement a Management Plan (preferably for a period of 10 years) in order to preserve area, conserve biological and landscape diversity, and protect natural values prescribed by the Regulation (OG 109/07).

1.1 *POSIDONIA OCEANICA*

Posidonia oceanica (l.) Delile is a seagrass species evolved from terrestrial Magnoliophyta before approx. 120 Mill. years. Species is endemic to the Mediterranean Sea listed in the Red List of marine macroflora in Croatia (Antolić et al., 2011). It forms large underwater meadows of great ecological importance, that can persist for thousands of years (Mateo et al., 1997) and whose colonization of new space occurs very slowly (Meinesz and Lefevre, 1984).

Reference: Bakran-Petricioli, 2011, Boudouresque et al., 2012, 2014, RAC/SPA - UNEP/MAP, 2014

1.1.1 Morphology

Unlike algae, *Posidonia* has developed ‘real’ root (rhizome), steam, leaf and flower.

[6] Annex I is a list of natural habitat types in danger of disappearance, which require protection through establishment of Special Areas of Conservation (SAC). Annex II is a list of 1000 plant and animal species, which require protection through establishment of Special Areas of Conservation (SAC) EU Directive 92/43 EEC (DG Environment 2007, http://eunis.eea.europa.eu).

Crawling steams are buried in sediment with roots up to 70 cm deep in the bottom surface. Rhizomes up the surface are variable depending on turbidity. Not to be buried, rhizomes become bigger, leafs also. Depending on the general space rhizomes can be layed on ground (plagiotropic) and upright (ortotropic); see figure below.

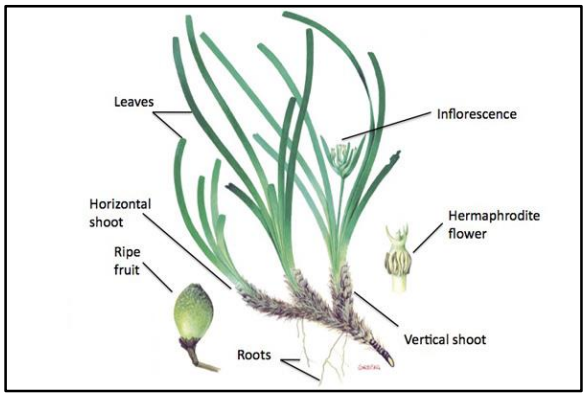

Figure 1. *Posidonia* structure

The leaves, as they age, change colour from light to dark green and finally become brown (before falling). When the leaves die (in autumn), sea currents drag them out and depose on the shore providing ecosystem services (e.g. organic material for building bird nests).

1.1.2 Propagation

Posidonia propagates in two ways, sexually and asexually. The flowers are hermaphroditic and can be a single or gathered in blossom. Fruit resulted by fertilisation separate from the plant and rise to the surface when mature. It is possible because fruit is filled with gas bubbles giving buoyancy; sea olive (Figure 2). This way allows the plant to colonize new broader regions (long range dispersal) and provides genetic diversity. Every fruit contains one seed which roots in sediment when the husk breaks. Plants do not bloom every year.

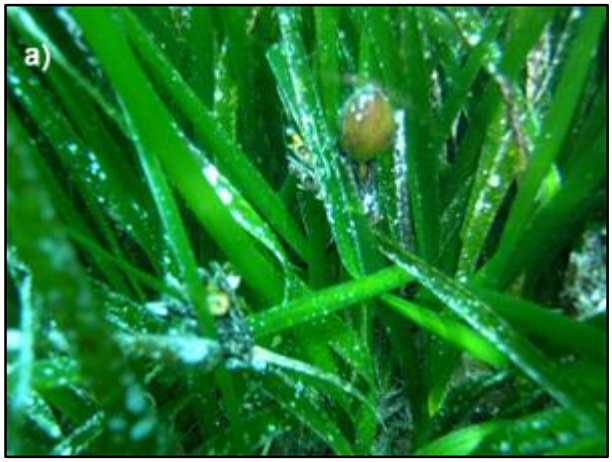

Figure 2. Fruit of *P. oceanica* (Source: http://www.alexandracaron.com/posidonia-oceanica/)

In a contrary, asexual reproduction takes place to enhance production of new shoots (maintaining parent genotype, short range dispersal). Changes in temperature, environmental changes, fungal infection or stress can lead to facultative pseudovivipary, both sexual and asexual reproduction during the flowering event. It is not known how

frequent reproduction mechanisms are triggered.

1.1.3 Ecology

P. oceanica is found at depths from 1 to 35 metres, depending on water transparency. It grows best in clean waters, and its presence is an indicator of good water quality. Seagrass meadows have several essential ecosystem functions ("*ecosystem services*") in Mediterranean coastal areas. Due to high primary production and large biomass, many organisms (including those economically important) use it for feeding, breeding and as a shelter. It supports high biodiversity and a complex trophic network. A quarter of all Mediterranean species, including many protected (e.g. *Pinna nobilis*) and commercial species (a few shellfish, crustaceans, and fish) are associated with the settlement of the *Posidonia*.

Posidonia meadows grow in areas where the pressure of human activities is very high which is why the northern (the Adriatic) and middle-eastern part of the Mediterranean shows distinct regression, estimated to 34% in the last 50 years (Telesca et al., 2015). It is ascribed to cumulative effects of multiple local stressors such as marine works, beach nourishment, dredging, dumping at sea of construction materials, dispersion of pollutants from urban and industrial wastewater, changes in fluvial and sedimentary flows, have direct or indirect effects on the meadows (Boudouresque et al., 2006). On a smaller spatial scale (in bays/lagoons) biocenoses of seagrass meadow endangered mainly due to mechanical damage caused by anchoring boats, which has a direct negative impact on their surface and the density of the shoots, while on a higher spatial scale (in open waters) it retreats due to illegal trawling, modifying the hydrodynamic regime and the quality of the sea, marinas construction, sewage outfalls, aquaculture and other. Anchors and chains destroy the small bottom (sedentary) organisms within *Posidonia* biocenoses, biocenoses of infralittoral algae and corals. For these reasons, proper management and monitoring of recreational activities is particularly important if we want to preserve the settlement of *Posidonia*, looking at the fact that recovery of settlement is estimated as a few centimetres per year, while regression can be up to 100-times faster.

Beds of *P. oceanica* (1120, Interpretation Manual – EUR28, 2013) is classified as a priority habitat of the interest of the whole EU at risk of disappearance, in which Member States must pay particular attention when determining areas of conservation by encouraging the establishment of the SAC through Habitat Directive (92/43/EEC, Annex I) and the SPA/BD Protocol (Annex II[7]; UNEP (DEPI)/MED IG.19/8).

European projects aimed at the protection, education, and training of employees of a certain organisation/public institution today are many, including those specified only for *Posidonia* research and management (Guala et al., 2012).

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[7] Annex II is a list of endangered species that the signatory countries are committed to manage in order to be in a favourable state protection.

1.2 MARINE PROTECTED AREAS

Protected areas provides basic strategies for environmental conservation on international level and international level (Dudley, 2008). Marine protected areas (MPAs) and its network are recognised as good scientifically-based instrument for overtaking the goals for preservation of biodiversity, cultural, and historical resources and possibilities of sustainable commercial exploitation of species, based on scientific research and knowledge; including traditional knowledge if the current work do well (IUCN-WCPA, 2008; Gaines et al., 2010). They encourage communication and cooperative learning, an increased ability to address the environmental, social, management and economic goals (IUCN-WCPA, 2008). The exploitation of marine resources, used to be based exclusively on fishing, now is under significant pressure due to tourism (Govan, 2011), economically profitable sector that has a direct impact on health of the marine environment and coastal ecosystems (Milazzo et al., 2004). MPAs can have economic benefits (Dixon, 1993; Sanchirico et al., 2002; Alban et al., 2006) and also social benefits (Sanchirico et al., 2002; WWF International, 2005) with the primary goal of conservation. They promote the expansion of the tourist offer/attractiveness due to the growing interest in marine ecosystems and the associated flora and fauna (Badalamenti et al., 2000). The possibility of observing pristine environment or numerous and diverse marine flora and fauna is very attractive to tourists (Badalamenti et al., 2000).

Sustainability includes a balanced environmental, social, and economic gain (Deery et al., 2005; Pfueller et al., 2011). Only such tourism can support the conservation of biodiversity and at the same time provide economic benefits and increase cooperation between protected areas and local communities (Andrade and Rhodes, 2012; Lee, 2013). Former UNEP Executive Director Klaus Töepfer emphasises that "*responsible and sustainable tourism needs to enable the local community to benefit from the protection of nature*" (IUCN, 2004, p. 14). The general interest of tourism that includes "learning while traveling" in special programmes related to wildlife is growing, so the natural and cultural value of the protected areas is suitable for this form of tourism (Eagles et al., 2002).

There are different categories of protection in MPA; some part contains more (per area) key habitats for legal protection based on good science with established clear and detailed goals a priori (Agardy, 1994, 1997). Some species use habitat seasonally for growth and reproduction, some (mostly sedentary/demersal) the whole cycle (year). Areas which provide at least one development benefit for target species (nursery, reproduction) are strictly protected areas, also known as no-take zones. They are under strict protection mainly to renew fish stocks and key habitats. Other areas still under MPA do not have ecological significance but still provide economical/social benefit. It still may not have any negative effect on the function and the structure of the ecosystem, as long as all stakeholders of the protected areas are following the common work of the spatial planning and managing.

Perspective

Despite the annual increase in the volume of MPAs, it continues to represent 3.4% of the total area of the world ocean, and only 0.25% of the area is protected beyond national jurisdiction, or outside the Exclusive Economic Zone (Juff-Bignoli et al., 2014). The slight increase is evident if we compare the data for 2010, where the marine protected areas represent only 1.17% of the world ocean (Olsen et al., 2013; Juff-Bignoli et al., 2014) and are mainly dominated by coastal protected areas (www.nature.org). According to the objectives of the Convention on Biological Diversity and its Strategic Plans ("Strategic Plan for Biodiversity 2011-2020" and "Aichi Targets", UNEP-WCMC, 2012) all signatories should protect at least 10% of the marine areas at the level of State and/or region by 2020, and special effort should be devoted to the protection of coral species to recover at least 15% of degraded habitat through protection and restoration plans (CBD, 2011). The protected area covers 4.6% of the Mediterranean. If Reserve Pelagos are not counted, protected areas cover only 1.1% of the Mediterranean (Gabrio et al., 2012), and no-take zones make up less than 0.1% (www.medpan.org).

Protected areas cover 8.56% of the total surface in Croatia, including 12.20% land territory and 1.94% of internal waters and territorial sea (Operational Programme 2014 - 2020). There are seven marine protected areas currently in the northern Adriatic, according to MedPAN (www.medpan.org), none in open waters. A study (Turk and Odorico, 2009) shows that there are twelve of them. MPAs presented in study, like the islands of Prvić and Tegnue are not in the MedPAN database. Lower Kamenjak and Medulin archipelago (hereafter: LKMA) is also listed as marine protected areas due to published Spatial Plan[8] (hereafter: Plan) of that landscape (Robert Turk, personal communication), although are there activities for implementation management measures consistent for sustainable use (tourism) know?

1.3 PURPOSE OF THE THESIS

The purpose of this thesis is to present the state of *Posidonia* meadows measuring meadow density and inspect the quality (category) of the meadows on two distinct areas (referent and impacted, according to Pergent et al. (1995). Also, main threats will be highlited using scuba diving *on site*, analyzing the change in the volume of the human impact from a period of time on the study area based on the information of (a) local households in the Municipality of Medulin (hereafter: MM), (b) attendance rate of significant landscape LKMA, (c) the scope of private society (stakeholders) that provide services of maritime tourism ("rent a boat services").

Survey of the visitors of Cape Kamenjak will provide an insight of general weakness and strengths of signifant landscape and possibility for the implementation of green tourism that will encourage ecological awareness of marine ecosystem. I will present up tu date inventory of marine species, biocenoses and species that are enjoying legal protection, as a base for Management Plan of the MPA in the Cape Kamenjak marine area. The concept of

[8] Spatial plan of an area with special features Lower Kamenjak and Medulin archipelago (Official Gazette of Istria County, OGIC 2/2009).

this work strives to get closer to the future protection of the marine area, which has already been mentioned (Požar-Domac and Bakran-Petricioli, 1996; Vučetić and Vučetić, 2000), in a way that it becomes a part of the network of specially protected areas (SPAs) with organised and sustainable management of the environment together with stakeholders, building upon the information of Plan, in which are proposed four special marine reserves resulted by a review of *Posidonia* meadows.

1.4 THE OBJECTIVES AND HYPOTHESIS

The objectives of the thesis are:

- Present the state of *Posidonia* meadows in the marine area of LKMA,

- Identify the key factors that threaten *Posidonia* biocenoses,

- Put together an inventory of species, biocenoses and keystone species,

- Determine the tourist infrastructure that needs improvement, number of visitors that have some relation to the marine environment (boating, fishing) and provide management plan that could ensure better future management of the area,

- Present a regime proposal for protection and zonation for the MPA of Kamenjak.

The thesis is founded on the following two hypothesis:

(1) Use of LKMA marine area is currently not sustainable and as such could cause the gradual disappearance (local extinction) of *Posidonia* habitats.

(2) Tourist infrastructure on Kamenjak is well developed; with proper future management actions in relation to the marine activities (e.g. mooring system, anchoring, fishing, diving), marine area can/needs to be protected, while supporting green tourism.

2 METHODS AND MATERIALS

2.1 DESCRIPTION OF THE THEMATIC AREA

Subject area is located in the northernmost part of Mediterranean Sea known as the northern Adriatic (Figure 3). It is located on the very south of the Istrian peninsula (Croatia) as a part of significant landscape[9] Lower Kamenjak and Medulin archipelago protected in 1996 on the basis of the NPA (OGIC, 5/96). Only the mainland part is protected, including all nine surrounding islands between Cape Kamenjak and Cape Marlera (easternmost part of Medulin Bay). Public institution (hereafter: PI) Kamenjak manages activities of maintenance and preservation of significant landscape LKMA.

Figure 3. Marine area of LKMA (Source: Google Earth)

The coastal sea has three time bigger surface area than the land part (11.69 km^2). Cape Kamenjak borders deep open waters of the northern Adriatic which ensures exchange of water masses due to constant and partly strong (sea) currents, providing transfer of nutrients, elementary process for primary production of the marine area. On its east side extends the Medulin Bay, a shallow and partially closed area. The inner part of Medulin Bay is suitable for anchoring, so the habitat is under intense anthropogenic pressure. It is also used for commercial exploitation of cultivated shellfish species, others (people) illegally extract protected species *Lithophaga lithophaga* and in addition there is a problem with illegal filling of the coast and building infrastructure. Breaking the rocks for mussel extraction (*L. lithophaga*) causes the destruction of the entire habitat and the disappearance of the indigenous communities of *Posidonia* as well (Bakran-Petricioli, 2011). According to the NPA (OG, 80/13) and the Law on Marine Fishery, LMF (OG, 81/13, 14/14, and 152/14), actions like harvesting, possession, killing, purchase, sale, acquisition and alienation by other means, export or import, and damaging or destroying habitats of *L. lithophaga* on the whole territory of the Republic of Croatia are prohibited.

[9] Significant landscape is a natural or cultivated area of great landscape value and biodiversity or cultural and historical value, or a landscape of conserved unique characteristic features of a particular area intended for rest and recreation (NPA, OG, 30/94 and 72/94, Article 18).

Marine area of Kamenjak is an important area for larger species (K species), such as dolphin (*T. truncatus*), monk seal (*Monachus monachus*), and loggerhead turtle (*C. caretta*). According to the Plan[10] of Istria County there are several defined areas of the Natura 2000 network[11] in marine waters of the Cape Kamenjak important for wild taxa, except birds and habitats types and protected areas, shown in Figure 4. Nevertheless, the general issue about jurisdiction management over the bays of Medulin and Pomer (Natura 2000 areas) are still unresolved (Annual program of PI Kamenjak, 2015) so there are no long-term conservation plan and programme on marine area of Kamenjak.

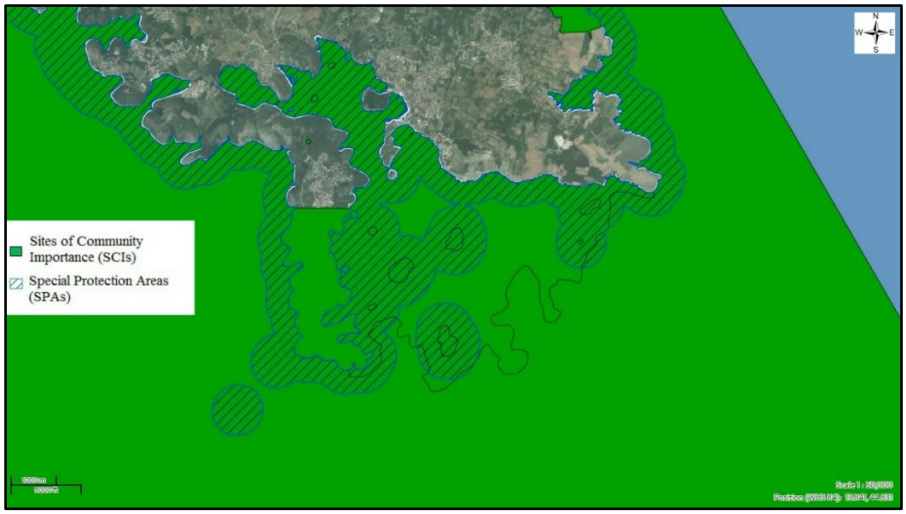

Figure 4. Areas of the Natura 2000 network around the Cape of Kamenjak (Source: The Spatial Plan for the Istria County, OGIC, 03/02)

PI Kamenjak has been since 2015 included in the AdriaPAN network of marine protected areas (http://www.adriapan.org/index.php/en/network-it/19-map/east/143-javna-ustanova-kamenjak-public-institution-kamenjak). It is an initiative that aims to connect and improve partnership effectiveness, both in management and planning activities between MPAs in the Adriatic region. Partner organisations are required to cooperate and establish an effective management model based on sustainable development (Vallarola, 2013). The only activity for conservation of *Posidonia* meadows was undertaken in the summer of 2015, where the bay of Debeljak was enclosed with a grid to prevent anchoring.

The "Blue World" Institute (Mali Lošinj, Croatia) is carrying out several projects aimed at gathering information about the life of endangered marine organisms (especially marine mammals and sea turtles), education the public and other stakeholders. In 2014, the Institute collaborated with PI Kamenjak during the implementation of the project "Determination of the number and range of movement of bottlenose dolphins (*T. truncatus*)

[10] The Spatial Plan of the Istria County is the basic planning document for the entire county with a range of targeting and implementing regulations, which affect regional planning at the municipal level.

[11] HR 2000147 – Cave near Premantura, HR 2000616 - Lower Kamenjak and Medulin archipelago, HR 2000630 - Upper Kamenjak, HR 3000173 – Medulin Bay (border), HR 3000174 – Medulin Bay - lagoon (border), HR 3000227 – Cave near Gomile, HR 5000032 – Waters of western Istria (border), HR 2001136 – Corridor for sea turtles (border).

in the coastal region of Istria". The project recorded 239 individuals of which 24% have been already catalogued by the Blue World Institute (http://www.plavi-svijet.org/media/files/BWI_ZAVRNO_IZVJEE_2014.pdf).

Vivamar Society[12] did a research, not far from Cape Kamenjak, between 2003 and 2007. The authors (Ribarič and Herlec, 2008) note that Kamenjak is an important feeding habitat due to higher bio-productivity in the surrounding areas, as confirmed by the presence of other large predators, such as tuna. The publication points out that in order to properly manage species for the purpose of its preservation in the future in the northern Adriatic, Kamenjak is an important area for continuous monitoring, so we can better understand migration activities, including other biological and ecological characteristics of dolphin groups during field research.

The monk seal (*Monachus monachus*) is the only species of seal (order *Pinnipedia*) in the Adriatic Sea. Archaeological findings indicate that the animals were once numerous around the Greek Islands more than 6000 years ago, but by 1970 only twenty remained (Della Casa and Bass, 2001). *In situ* conservation efforts focus on the establishment of marine protected areas MPAs, zones for rescue and rehabilitation of orphaned and wounded seals, education and public awareness (Johnson and Lavigne, 1998). MPAs for the species have been established in Desertas Islands of Madeira; in the Northern Sporades Islands and northern Karpathos in Greece; on the Aegean and Mediterranean coasts of Turkey, and along the Côte des Phoques (Cabo Blanco) in the Western Sahara. Although, it is only a fraction of the areas the species need for growth and reproduction. It is believed that there are left about three to four individuals that are grouped around Cape Kamenjak (the southernmost part of the Istria peninsula), the western part of the island of Cres, but the sole individual confirmed to have used the area of the southern part of Istria for feeding and as shelter (caves) died in the summer of 2014, due chronic lung inflammation and heart failure[13].

One of the most typical fishing species on Kamenjak in second half of the 20th century occurring in large quantities in the waters around the southern part of Istria is the European spider crab (*Maja squinado*; Stevčić, 1964, 1971, 1980). This is why the village Premantura established gastro tourism revolving around this crab species. An event is helding when hunting season ends[14] for this species and intends to revive the memory of the old way of preparing crab on the pyre. Recently, crabs were no longer the main culinary theme due to an extremely bad hunting season and the scarcity of the crab. According to the local fishermen, the abundance of crab was most likely reduced due to predation by octopus, which that year was numerous in the waters of Kamenjak (Zrinščak-Šebelić, 2015). Many commercial fish species are present in area as well (sea bream, bass,

[12] An association founded with the idea of research of the common bottlenose dolphin (*Tursiops truncatus*) in the area of the Slovenian sea (Slovenia), Trieste Gulf (Italy) and off W Istria (Croatia).

[13] Doc. Ivana Conrado Šoštarić Zuckermanna, at Faculty of Veterinary Medicine (University of Zagreb).

[14] At the end of April and early May.

dentex, tunna).

Inner part of Medulin bay has been impacted on good hunting seasons many years before because it was health (productive) grounding and breeding area (Precali et al., 2013). There were several research on shellfish farming that only took place in the bay of Šćuza (north-western inner part of the Medulin bay; Hrs-Brenko and Filić, 1973).

Today, this inner area is surrounded by various human coastal infrastructure and catering facilities prevail mainly due to the greater attractiveness of employment since the summer season tourism (Plan, 2009). Marine waters are not used for fish farming yet, they acquired common European marine tourism. Municipality of Medulin (hereafter: MM) has expanded its diving offer (thus attract more "diving enthusiast"*)* by sinking (mining), well-preserved ship, built in 1956 in Uljanik (Pula), designed as a commanding ship of the former Yugoslavian Navy. There are 23 shipwrecks found around all the Istrian peninsula (Iveša et al., 2015).

Medulin is one of the largest municipalities in the County of Istria (by size) with rapid urbanization growth. Number of inhabitants has grown[15] since the second half of the 20th century and can be related to the development of tourism, which started relatively early, from the 60s (Plan, 2009).

Camping Stupice offers accommodation in mobile homes and campers located on the border (north) with the protected area of the Lower Kamenjak (Figure 5). It offers numerous tourist attractions and activities, both on the mainland (restaurants, sports content and children's playground) and also on the sea (diving, sailing, and surfing).

Figure 5. Camping Stupice (Source: Google Image Search)

From April onwards Camping Stupice offers an accommodation capacity, together with the campsite Runke (to the north), for more than 5000 campers (Plan, 2009). In the

[15] From year 1961 to 2011, number of inhabitants has raised by more than 200% (205,7%; Source: Settlements and population of the Republic of Croatia 1990-2001, State Statistical Bureau, 2005, http://www.infomedulin.com/hr/-opcina-medulin/67_0/8).

municipality of Medulin and Pula there are around thousand sports fishermen, a hundred permit holders for a small fishery (personal use), and about fifty professional fishermen (Plan, 2009). This gives an insight into the social and economic importance of Kamenjak for the local population.

2.2 *POSIDONIA* MEADOWS ON CAPE KAMENJAK

All bays of Kamenjak are vital areas for spawning, growth, and feeding economically important species of fish and other marine organisms in the region of Istria (Precali et al., 2013). Many economically significant migratory species of fish, crustaceans, and cephalopods are found seasonally in the area (Plan, 2009). Main fishing species are Sparidae (for example, sea bream *Sparus aurata*, saddled seabream *Oblada melanura*, common pandora *Pagellus erythrinus*, sharpsnout seabream *Diplodus puntazzo*, white seabream *Diplodus sargus*, common dentex, black seabream *Spondyliosoma cantharus* and others) flatfishes (for example, marbled electric ray *Torpedo marmorata*, common sole *Solea vulgaris*), cuttlefishes (*Sepia officinalis*) and squids (*Loligo vulgaris*; Plan, 2009; personal communication by local fishermen).

Little is known about the spread of *Posidonia* meadows in the Croatian part of the Adriatic because of the few research undertaken (Kružić, 2008). According to the available data (Precali et al., 2013). *P. oceanica* is found in the coastal zone of Brijuni Islands, near the village Banjole and the waters surrounding Cape Kamenjak. Authors point out that the data on the presence and size of the settlement of *Posidonia* for Istrian coast is sparse, therefore authors are proposing continued research mapping of *Posidonia* meadows in the area of Cape Kamenjak. Together with the Brijuni Islands these are the only areas in the Istria County in Croatia which are within the Natura 2000 network and are rich with *Posidonia* settlement, according to a preliminary study by the State Institute for Nature Protection (OG 80/2013, Regulation on the Ecological Network, Annex II).

Cape Kamenjak archipelago is defined as an important area for protection (priority 1) with the necessary continuous monitoring (once a year or every other year) with recognised influence of anchoring, as the main pressure (RAC/SPA - UNEP/MAP, 2014). In addition, southern part of Istria (Cape Kamenjak and Ližnjan archipelago) and Brijuni Islands are the only marine parts in Istria where *Posidonia* meadow have persisted; few decades before almost all Istrian coast was inhabitated by *Posidonia* meadows (Mikac and Žuljević, 2003).

2.3 NON-INDIGENOUS SPECIES ON CAPE KAMENJAK ARCHIPELAGO

The south and east side of the Cape is subject to the influence of bioinvasion due to the strong sea currents (Eastern Adriatic Current; Artegiani et al., 1997b, Zavatarelli et al., 2000), by providing transport of the larvae and juvenile forms of marine organisms, as indigenous and non-indigenous (foreign) species. Dulčić (2002) described new fish species

for the northern Adriatic, *Sphoeroides pachygaster*, Müller and Troschel (1848), found on Kamenjak which was then its most northern known location. On 22 November 2012, *S. pachygaster* was caught in Piran Bay (approx. one hundred kilometres north from Kamenjak; Lipej and Mavrič, 2013).

Non-indigenous[16] species *Caulerpa racemosa* (Forsskål) J. Agardh (1873), was found in the waters of Cape Marlera (eastern border waters of LKMA, http://www.istramet.com/caulerpa-racemosa-prijeti-jugu-istre/). Meadow was located on sandy and gravelly bottom stretched as three smaller meadows (about 1 m^2) and one of 50 m^2, separated from each other at about twenty metres of depth. There are no other scientific information on invasive types of species in Cape Kamenjak archipelago. More recently (summer 2016), divers have found a large area in outer Medulin bay (between the east coast and island Ceja) that is affected by the *C. racemosa* (communication with divers from KPA Medulin).

2.4 THE RESEARCH AREA AND WORKING METHODS

2.4.1 The state of *Posidonia* meadows

Background

Infralittoral is an area of coastal sea floor between the level of normal low tide and the depth to which still manage to survive seagrass species. Daily and seasonal fluctuations of the majority of the abiotic factors are substantial, supporting great diversity of habitats; the most diverse and productive area of the coastal sea (Bakran-Petricioli, 2011). Below there is circalittoral zone in which seagrasses and seaweeds fail to survive (Bakran-Petricioli, 2011). During field research the infralittoral and partly circalittoral zones were investigated.

Based on recent study on Kamenjak, Kružić (2014) states that marine area around Porer "*due to its remarkable beauty of marine life and great biodiversity of species, deserves a higher protection degree*". Meadows on Porer were categorised as "normal density meadow" (Pergent et al., 1995), while all other (7) sampling station as "low subnormal density". If we use classification according to Buia et al. (2004), only Porer has seabed in balance. Also, on Porer was recorded mäerl[17] (encrusting red algae; Figure 6).

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16 In the Adriatic is categorised as non-indigenous (Lipej and Dulčić, 2004).

17 Mäerl is characterized by the accumulation of the living and dead crumbly calcareous red algae (Rhodophyta), mostly Corallinaceae and Peyssonneliaceae. The habitat is analogous to the seagrasses due to similar complexity of habitat and because supports rich biodiversity. The European Habitats Directive now requires management of exploitation of two major European encrusted species of algae that form mäerl, *Phymatolithon calcareum* and *Lithothamnion corallioides*, classified in Appendix V. Although is not listed as habitat type according to the CORINE habitat classification, EUNIS supports revision of Annex I of the habitats in a way that mäerl is recognized as a priority habitat type. According to the Barcelona Convention and the requirements of SPABIM Protocol (from 1995) rhodolite communites and mäerl facies are involved as habitat type for the selection of areas of interest for protection.

Figure 6. Mäerl and *Posidonia* meadow near the island of Porer (Source: Kružić, 2014)

Because of that, I recognized area of Porer distinct and under less (human) pressure compared to other areas and bays, allowing me to incorporate background knowledge into variable in addition to this, as differences in the density of meadows belonging to two different situations/factors (impacted *vs* natural) in the two bathymetrical zones (shallow and deep, Figure 7). Used are sites variable according to the meadow size, depth and slope. Thus, at each location GPS data[18] was measured.

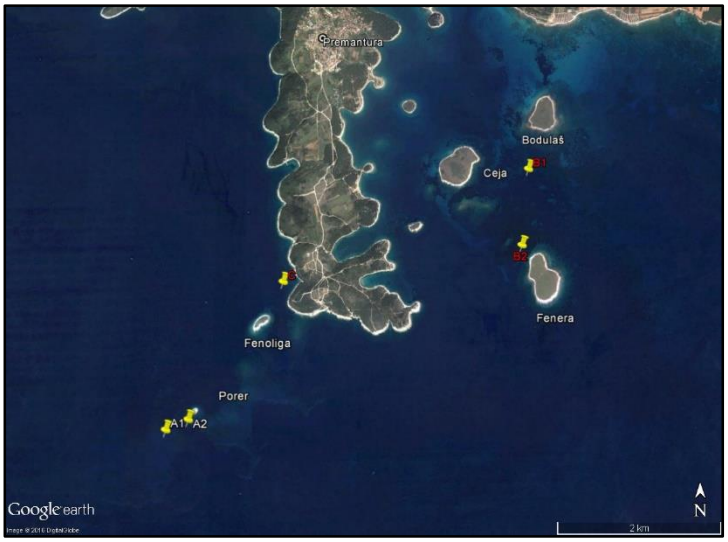

Figure 7. Study areas of determining the state of *Posidonia* meadow on Kamenjak

2.4.1.1 Meadow density

Since mechanical impacts (anchoring[19]) mostly affect the meadow structure, structural descriptors (i.e. shoot density and percentage cover) are considered to be the best variables to describe the state due to this kind of impact (Guala et al., 2012).

Research diving methods[20] for determine the state of *Posidonia* meadows (according to Pergent et al., 1995) are described in the field guide (RAC/SPA – UNEP/MAP, 2014). The

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18 A1 - 44°45'18.30" N, 13°53'10.21" S; A2 - 44°45'22.24" N, 13°53'22.70" S; B1 - 44°47'4.10" N, 13°56'41.21" S; B2 - 44°46'31.56" N, 13°56'35.29" S; C - 44°46'17.23" N, 13°54'15.61" S

19 Main pressure on Kamenjak (RAC/SPA - UNEP/MAP, 2014).

20 Field research has been done in accordance with the provisions of the maritime domain (OG, 158/03, 100/04, 141/06, 38/09), the Environmental Protection Act (OG, 80/13, 153/13, 78/15).

measuring is done by counting leaf shoots (rhizomes) within 40 cm x 40 cm quadrats randomly set; an area of 1600 cm^2 is considered the optimal sampling unit for estimating the density of *P. oceanica* (Panayotidis et al., 1981). The number of leaf shoots per (one) m^2 is one of the most often used descriptors to assess the status of *Posidonia oceanica* (Pergent-Martini et al., 2005) and gives information on the changes when measured on a pluriannual time scale (Buia et al., 2004). Quadrats were replicated randomly at a distance of at least one meter from other with a minimum three repetition (Pergent et al., 1995). Meadows can be categorized according to the depth and can be identified by four (Pergent et al., 1995) and five classes (UNEP-RAC/SPA, 2011, modified by Jakl et al., 2015). They are categorized by a function of the theoretical average density calculated for each depth (Pergent et al., 1995); it reflects the "*ecological conditions of the meadow*" (Buia et al., 2004; Figure 8 and 9).

Pergent *et al.* (1995)	abnormal density (AD)	low subnormal density (LSD)		normal density (ND)		high subnormal density (HSD)	
Buia *et al.* (2004)	very disturbed beds	disturbed beds		beds in equilibrium			
depth (m)							
1	↔	822	↔	934	↔	1158	↔
2	↔	646	↔	758	↔	982	↔
3	↔	543	↔	655	↔	879	↔
4	↔	470	↔	582	↔	806	↔
5	↔	413	↔	525	↔	749	↔
6	↔	367	↔	479	↔	703	↔
7	↔	327	↔	439	↔	663	↔
8	↔	294	↔	406	↔	630	↔
9	↔	264	↔	376	↔	600	↔
10	↔	237	↔	349	↔	573	↔
11	↔	213	↔	325	↔	549	↔
12	↔	191	↔	303	↔	527	↔
13	↔	170	↔	282	↔	506	↔
14	↔	151	↔	263	↔	487	↔
15	↔	134	↔	246	↔	470	↔
16	↔	117	↔	229	↔	453	↔
17	↔	102	↔	214	↔	438	↔
18	↔	88	↔	200	↔	424	↔
19	↔	74	↔	186	↔	410	↔
20	↔	61	↔	173	↔	397	↔

Figure 8. Classification of *Posidonia oceanica* meadows according to Pergent et al. (1995) and ecological significance (from Buia et al., 2004 modified by Guala et al., 2012)

depth (m)	High	Good	Moderate	Poor	Bad
1	> 1133	1133 to 930	930 to 727	727 to 524	< 524
2	> 1067	1067 to 863	863 to 659	659 to 456	< 456
3	> 1005	1005 to 808	808 to 612	612 to 415	< 415
4	> 947	947 to 757	757 to 567	567 to 377	< 377
5	> 892	892 to 709	709 to 526	526 to 343	< 343
6	> 841	841 to 665	665 to 489	489 to 312	< 312
7	> 792	792 to 623	623 to 454	454 to 284	< 284
8	> 746	746 to 584	584 to 421	421 to 259	< 259
9	> 703	703 to 547	547 to 391	391 to 235	< 235
10	> 662	662 to 513	513 to 364	364 to 214	< 214
11	> 624	624 to 481	481 to 338	338 to 195	< 195
12	> 588	588 to 451	451 to 314	314 to 177	< 177
13	> 554	554 to 423	423 to 292	292 to 161	< 161
14	> 522	522 to 397	397 to 272	272 to 147	< 147
15	> 492	492 to 372	372 to 253	253 to 134	< 134
16	> 463	463 to 349	349 to 236	236 to 122	< 122

Figure 9. Classification of *Posidonia oceanica* meadows according to Jakl et al. (2015), modified by Guala et al., (2012)

2.4.1.2 Percentage cover

The coverage is the surface of seabed, expressed as a percentage, covered with live plants of *P. oceanica* compared to that non-covered and consisting of sand, rock or dead matte (Buia et al., 2004). This variable provides information on both the macrostructure and the health of the meadows (Pergent-Martini et al., 2005; Montefalcone, 2009). Percentage cover was assessed using the Line Intercept Transect (LIT) technique (Montefalcone et al., 2007); ten meters marked line laid on the bottom along which the occurrence of live *P. oceanica* and the nature of the substrate (sand, rock and dead matte) are recorded. Four LITs, randomly positioned, were cross-set, i.e. "starting point" all four is the same, whose exact location (GPS position) is uploaded on the vessel[21]. In each LIT, the length of each key attribute[22] (Lx) is the distance occurring between two recorded intercepts, expressed as the percentage of the seabed occupied by living plants (Figure 10). Their percent cover (R %) along LIT is calculated using the following formula:

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

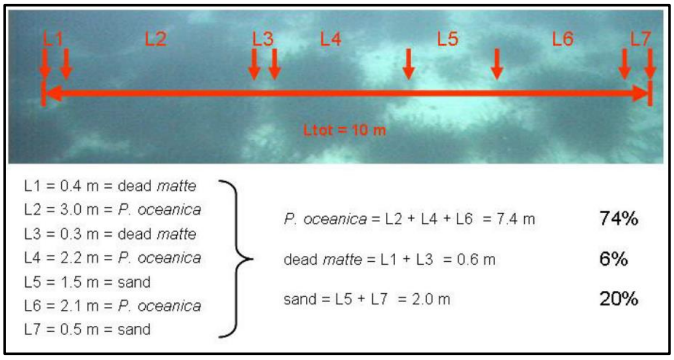

Figure 10. Scheme of LIT method for the assessment of percentage cover (R%).

Percentage cover allows to calculate, for each LIT, the Conservation Index (Moreno et al., 2001; Montefalcone et al., 2006). It 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:

CI =P/P+D,

P = % live *P. oceanica*, CI = 0 minimum state of conservation

D = % dead matte. CI = 1 maximum state of conservation

As needed (RAC/SPA – UNEP/MAP, 2014), lower limit, depth and sediment was recorded *on site*, but meadows have to be evaluated locally on multi-year time scale for good conservation status (Montefalcone et al., 2006 and Montefalcone, 2009).

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[21] Diving buoy mark is attached to the starting point if four LITs to record position while serving as a landmark for research under the sea.

[22] P – *Posidonia*, S – Sediment (rock, sand), D – Dead *Posidonia*

2.4.1.3 Data processing

Shoot density, percentage cover of live *Posidonia* meadow, as well as the Conservation Index (CI) were calculated for each station. Data were then classified/divided into two groups (reference and impacted) by a factor of human impact, an independent variable, in order to provide a common view of the general status of *Posidonia* meadows in the 5 investigated stations. To evaluate is there significant difference between average meadow densities in two groups, t-test[23] was carried out on both variable, shoot density and percentage cover. Significance level (α[24]) most commonly used in educational research and used in this study is 0.05.

2.4.2 Biocenoses and its threats

Recorded biocenoses were classified according to Nacional Classification System[25] (hereafter: NCS) and Natura 2000[26]. Biocenoses were determined using "Handbook for determining marine habitats in Croatia according to EU Habitats directive" (Bakran-Petricioli, 2011).

Main bays of Cape Kamenjak (Polje, Portić, Debeljak and Škokovica, see Figure 11) were inspected to find characteristic species and the general threats. Most of the marine habitats were analysed, mainly in the centre of the bays. Underwater pictures are made with a camera Canon G15 in Canon housing (by P. Kružić) summer 2014. Many species were easy to identify *in vivo*, while others that could not, are collected, preserved in 70% alcohol or 4% formalin and determined in the Laboratory of Marine Biology at the University of Zagreb.

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[23] T-test is any statistical hypothesis test in which the test statistic follows a Student's t-distribution under the null hypothesis. It can be used to determine if two sets of data are significantly different from each other.

[24] The terms "significance level" or "level of significance" refer to the likelihood that the random sample is not representative of the population.

[25] NCS is representative nomenclature signature for Croatian habitats since 2002, after Councile of Europe came to the conclusion that European classification is not sufficient to take into account total wealth and diversity of Croatian habitat types, especially for the marine habitats.

[26] Classification system for habitats (and species) under Habitats Directive (92/43/EEC).

Figure 11. Study areas for determine characteristic species and general threats

In Annex A, list of all identified species (inventory) in the waters of Kamenjak, is presented draft by the author; Kružić, 2012, 2014; Zahtila - unpublished paper. Species related to the settlement of *Posidonia* are specially labelled. The names of species are consistent with accepted names according to WORMS (World Register of Marine Species, http://www.marinespecies.org/).

2.4.2.1 The spread of *Caulerpa racemosa* in the south of the Cape Kamenjak

According to the diving instructor of diving centre Scuba Libre (Premantura) in the summer of 2012, *C. racemosa* began its expansion in a small bay Kolumbarica (south of the Cape Kamenjak). We examined meadow down to the area of the lower limit of its scope at a depth of 17 metres, on 3 October 2014. We did not record the GPS position.

Next summer (8 November 2015) mapping of *C. racemosa* meadows was conducted with four trained divers from diving club "KPA Medulin" in this area; used method is described by Vaugelas[27] et al. (1998). Given that we did not know exact location, we had to provide a method for the seabed survey: two teams of researchers surveyed the area using *zig-zag* method (Figure 12) About 750 m^2 of the seabed was reviewed. Teams moved parallel to each other, and each pair had made circular inspection of the seabed by means of a rope length of ten metres.

[27] Paper is based on a standard protocol for mapping of *Caulerpa taxifolia*, but in conversation with dr. sc. Ljiljana Iveša (CIM, Rovinj) method can be applied to *C. racemosa* because they have a similar way of spreading.

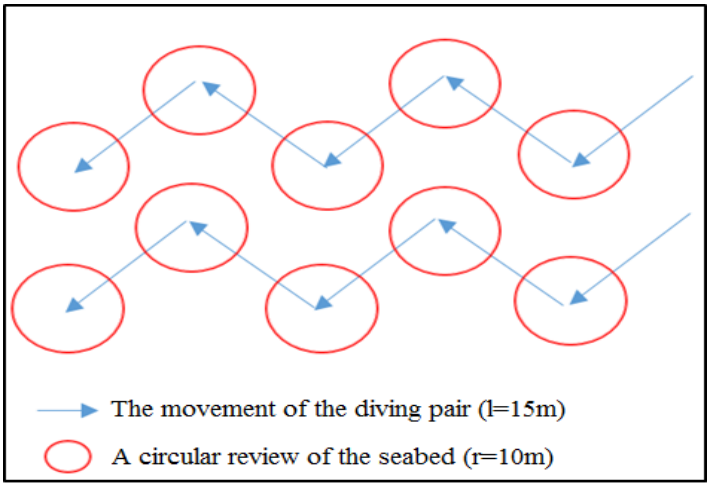


Figure 12. Scheme of the diver's movement during the mapping of *C. racemosa*.

Only meadow coverages 50 to 100% of the bottom was measured. Due to strong currents, accurate GPS position could not be obtained, so it is not listed in the Results.

2.4.3 Questionnaire for visitors of significant landscape LKMA

The attendance rate of local people and tourists in LKMA during the summer months is significant (Plan, 2009). The majority of revenues for the implementation of the annual programme by PI Kamenjak for the protection, maintenance, preservation, promotion and use is generated from billing the entrance to the protected area[28]; in the season 2013 (from June to October) no less than 130 000 vehicles was registered.

In summer of 2014, a questionnaire (Annex B) was distributed to visitors in order to obtain certain opinions (strengths, weaknesses, opportunities) and these data serve as a tool to identify what needs to be improved in tourist offer. The questionnaire is based on the document "*Guidelines for the preparation of the management plan*" (Ministry of Culture of RH, 2005) and aligned to the characteristics of the subject area and topic. Polls were available from 23 May to 30 August 2014 within the eco-centre "House of Nature Kamenjak" in agreement with the professional associate[29] of PI Kamenjak. Also, young (high school) volunteers have been carried out a survey on attractive beaches and places on Cape Kamenjak.

The questionnaires were written in four languages (Croatian, Italian, German and English) and had intension to get the following information:

- Attendance of significant landscape

- Accommodation of visitors

[28] Report on the implementation of protection programmes, maintenance of conservation, promotion and use of the area managed by the PI Kamenjak in year 2013.

[29] Nina Skoko, e-mail: nina.skoko@kamenjak.hr

- Expectation of visitors from the vacation on Kamenjak

- Source of information on Kamenjak

- The level of education of visitors and general interest for marine part

- The most attractive element on the Kamenjak

- Infrastructure of significant landscape that need to be improved

- Element of Kamenjak that presents a symbol of Kamenjak

Completed questionnaires were manually transcribed and translated into English. Answers were not ranked. Respondents had option in some questions to select one or more answers.

3 RESULTS

3.1 STATE OF *POSIDONIA* MEADOWS

There are several types of meadows in Mediterranean and the most usual is plain meadow; this type was determined in Kamenjak. It consists fairly continuous, horizontal or gently sloping meadow, broken by erosive and non-erosive structures (dead matte or dead leaves; Boudouresque et al., 2014).

Meadows at reference stations were more continuous than on other stations. They develop on hard substrate (sandy rock bottom), while on other stations bottom is mostly sandy. Lower and upper limit on Porer is sharp, characterized by the presence of circalittoral conditions on lower limit (depth>20m, low light intensity, hard substrate), while on upper limit due to the development of biocenoses of infralitoral algae (Figure 13).

Figure 13. Upper limit of *Posidonia* meadow on Porer (station A2).

In Medulin Bay (impacted stations) type of limit could not be identified due to more or less wide erosive structures (erosive intermatte, shifting intermatte) covered with sand or dead matte (Figure 14). Rhizomes and leaves were the biggest; leaves length were up to 3 times longer (more than a meter) which could be attributed to the resistance of being buried; they are capable of speeding up their growth (Boudouresque et al., 1985, Boudouresque et al., 1994b). Also, meadows have substantial portion of plagiotropic leaves indicating a potential for growth (Caye, 1980).

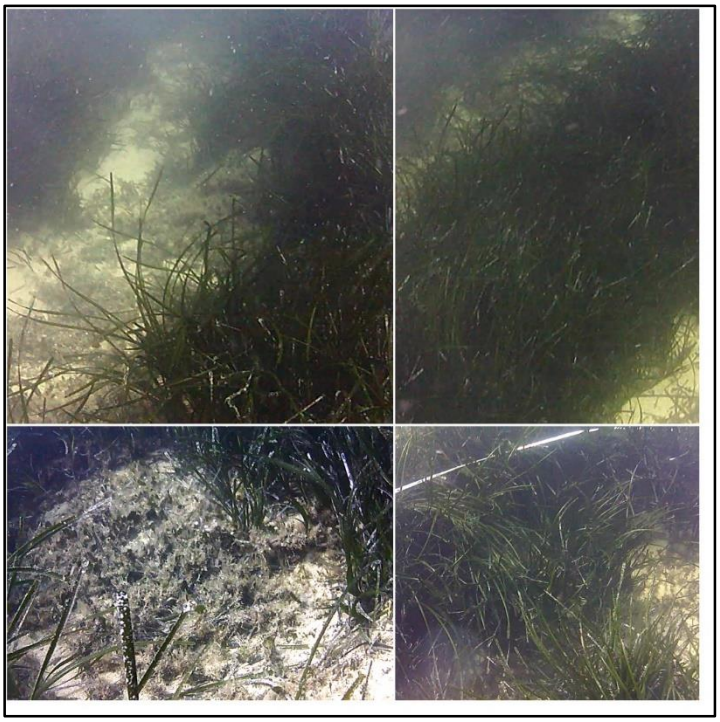


Figure 14. *Posidonia* meadow and erosive structures in Medulin Bay (station B1).

In the station B1 an area was detected where *Posidonia* has its regressive limit (Figure 15), characterized by the presence of dead matte and a few deeper sample shoots, indicating withdrawing meadow linked to an increase in the average turbidity of the water (Boudouresque et al., 2014).

Figure 15. Regressive limit of *Posidonia* meadow in Medulin Bay (station B1).

The most fragmented *Posidonia* meadow was at the bay of Radovica. Also, regressive type of meadow and islets of *Posidonia* with sharp edges was recored (Figure 16).

Figure 16. Limit of *Posidonia* meadow at the station C).

Turbidity and human pressure (anchoring, fishing) is substantial, therefore, it reflects on the quality of the meadow. Basal sheets (‘rhizomes’) had fewer leaves compared to other stations (4-5 per sheet); increased sedimentation clearly has an impact on lower production (Figure 17). *Posidonia* meadow intercept with biocenoses of muddy sands of the protected coasts.

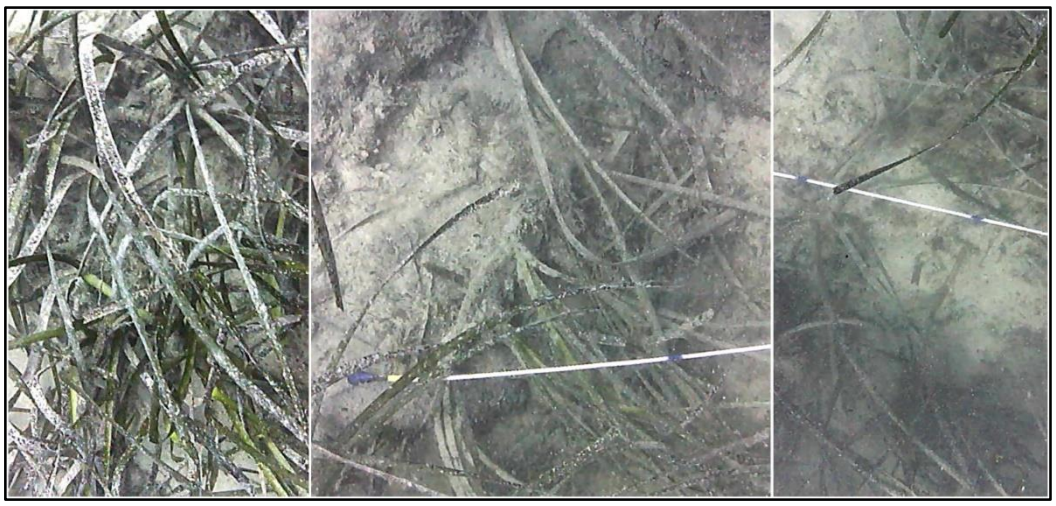


Figure 17. Unfavourable condition for seagrass species (*P. oceanica*) recorded at station C.

On the south of Cape Kamenjak two dives were conducted, at Small and Big Kolumbarica Bay), in order to determine the state of meadow. Unfortunately, due to its extreme fragmentation research was not possible. Also, meadow fragmentation can be attributable to rocky (solid) bottom that hinder the spread of seagrass meadow.

P. nobilis was recorded in all stations except A1, possibly due to optimal (shallow) conditions rich with organic matter (Figure 18).

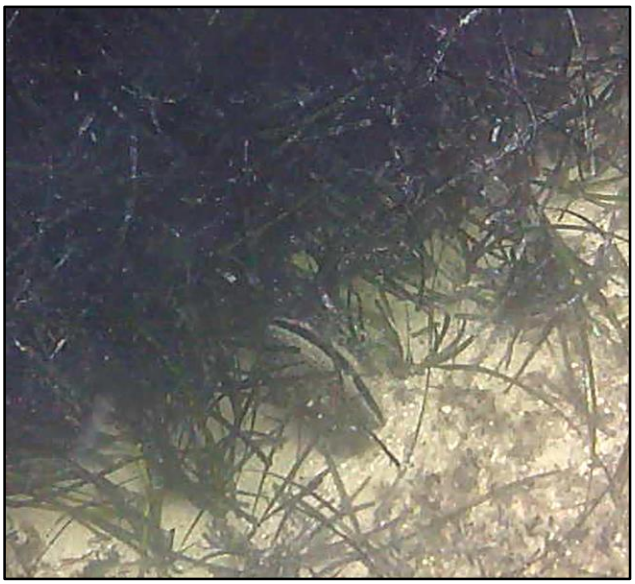


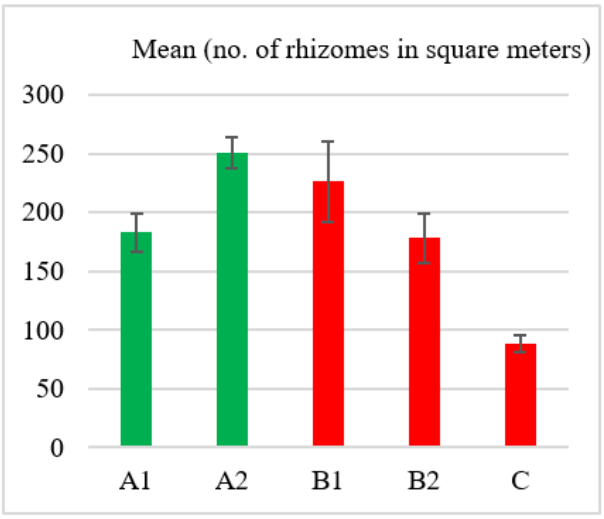
Figure 18. *P. nobilis* in *Posidonia* meadow at the station B1.

Altogether, 130 quadrats and 26 LITs were sampled in the five stations as indicated in Table 1; raw data are presented in Annex C.

Table 1. Sampling effort at Cape Kamenjak

Pressure	Stations	No. of quadrats	No. of LITs	Mean depth
Impacted	Medulin Bay (between the islands Bodulaš and Ceja (B1)	43	7	12.1
Impacted	Medulin Bay (northwest from the island Fenera) (B2)	24	6	8.5
Impacted	The bay of Radovica (C)	16	4	18.2
Reference	Southwestern part from the island Porer (A1)	17	4	18.8
Reference	Southern part from the island Porer (A2)	30	5	9.8
Total number	5	130	26	

The mean shoot density ranges from 88 ± 7 (mean ± standard error) to 251 ± 13 shoots per m^2 (Figure 19). Two stations (B2 and C) belong to the class AD (abnormal density), while all other is LSD (low subnormal density), according to Pergent et al. (1995). These values show that disturbance is present in all research areas (Buia et al., 2004). Then, using the classification of UNEP-RAC/SPA (2011), at stations A1, B1 and B2 meadows have had poor condition, station C bad condition, while only on station A2 moderate one.



	Mean density (m^2)	Mean depth (m)
A1	183	19
A2	251	10
B1	226	12
B2	177	9
C	87	18

Figure 19. Mean values and standard error of shoot density at each station.

Meadow density has varied greatly in impacted than in reference stations; standard error is highest in station B1 and lowest in station C (see Figure 19). Result of t-Test shows significant differences between impacted (185 ± 85 shoots/m^2) and references station (227 ± 55 shoots/m^2; Table 2).

Table 2. Results of a t-Test: Two-Sample Assuming Unequal Variances

	Reference	**Impacted**
Mean	226.73	185.62
Variance	3070.15	7293.95
Observations	47	83
Hypothesized Mean Difference	0	
df	126	
t Stat	3.32	
P(T<=t) one-tail	0	
t Critical one-tail	1.65	
P(T<=t) two-tail	0	
t Critical two-tail	1.97	

From the table above we can see that t Statistic value[30] is greater than the Critical value[31], while p value is <0.01 confirming significant difference in meadow density between reference and impacted stations. Although, if we remove the data of station C, t-Test does not show significant difference (Table 3); p value is bigger then 0.05, and t Statistic value is smaller than Critical value.

[30] Calculated difference represented in units of standard error. The greater the magnitude, the greater the evidence against the null hypothesis that there is no significant difference. The closer is to 0, the more likely there is not a significant difference.

[31] A point on the test distribution that is compared to the test statistic to determine whether to reject the null hypothesis. Critical values correspond to α, so their values become fixed when choosing the test's α

Table 3. t-Test: Two-Sample Assuming Unequal Variances (without C station)

	Reference	Impacted
Mean	226.73	208.95
Variance	3070.15	6117.69
Observations	47	67
Hypothesized Mean Difference	0	
df	112	
t Stat	1.42	
P(T<=t) one-tail	0.08	
t Critical one-tail	1.66	
P(T<=t) two-tail	0.16	
t Critical two-tail	1.98	

Meadows in reference station differ from the others because they form more constant meadow networked with plagiotropic roots. In Medulin Bay steams are more grouped and variable with consisteny. There are many erosion structures and gaps with sand or biocenoses of infralittoral algae; this can be seen on Figure 19 (in the stations B1 and B2 meadow density varied greatly whereas in the station A2 deviation is significantly lower (more than a half). In the station C, density varied from 9 to 21 rhizomes in 40x40 cm^2; in station B1 from 10 to 64.

The percentage cover of live Posidonia meadow ranges from 53% (station C) to 94% (station B2). There was no dead matte recorded at reference station, while the most of it was recorded at the station B1 (7%; Figure 20).

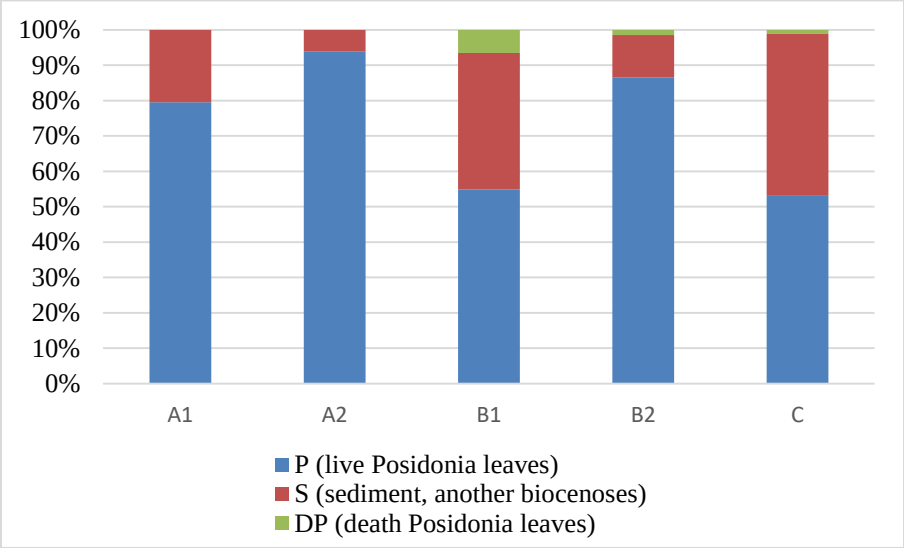


Figure 20. Percentage cover of live *Posidonia* in Kamenjak

The Conservation Index of the five meadows ranges from 0.89 to 1 (Figure 21). Like sad, on reference stations dead leaves were not recorded, while the most of it was observed at station B1.

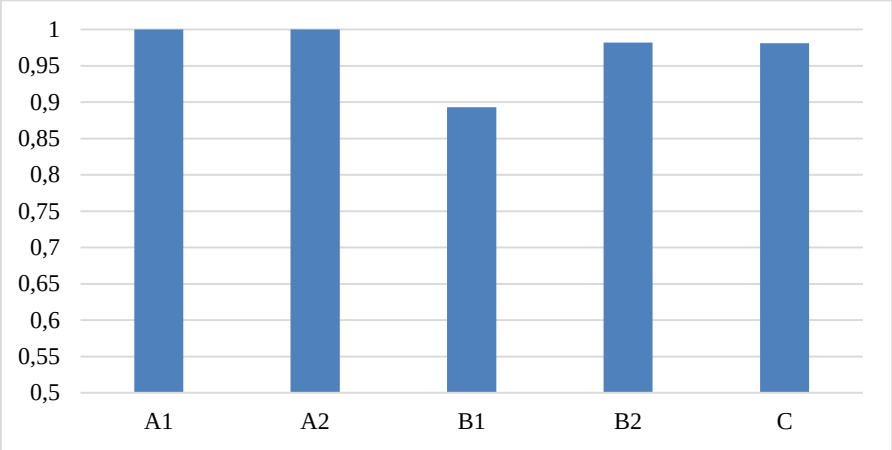


Figure 21. Conservation Index for each station in Kamenjak.

Data from the table above show that B1 has the lowest CI although it is clear from observations that meadow is on station C is the most endeared and under severe pressure. Reference stations have the highest value because there was not found dead leaves ("*matte*") like in others.

3.2 BIOCENOSES AND ITS THREATS

On the study areas were examined following living communities (biocenoses):

Benthic communities	**Code by NHC**	**Natura 2000**
Biocenoses of infralittoral gravel	G.3.4.1.	1110
Biocenoses of *Posidonia oceanica*	G.3.5.1. **	1120 *
Biocenoses of infralittoral algae	G.3.6.1. **	1170
Biocenoses of coastal detritus beds	G.4.2.2.	1110
Biocenoses of muddy sands of the protected coasts	G.3.2.3.	1160

* Priority habitat - habitats of interest to the entire EU; habitat conservation requires determining specially protected areas under the EU Habitats Directive (92/43 EEC)

** Endangered and/or rare habitat type that requires special protection measures under the Regulation OG, 07/2006 (NHC, OG, 07/2006)

In the bay of Polje and Portić on the rocky bottom biocenoses of the infralittoral algae (National Habitat Classification, NHC no. G.3.4.1.) has been found up to four metres of depth. Deeper is developing biocenosis of muddy sands of the protected coasts (NHC no. G.3.2.3.) where Posidonia islet bushes can be found, mostly present in the inner part of the bay on the sandy-rocky bottoms.

The bay of Portić has slightly developed living communities but the shallow zone (up to 3 metres) is the same as in Polje. After that zone appears the biocenoses of the coastal detrital bottoms (NHC no. G.4.2.2.) with developed seagrass *Zoostera nolti* settled with *Pinna nobilis*. In the depth between four and eight metres of depth appears the biocenoses

of muddy sands of the protected coasts with seagrass *Caulerpa nodosa* meadows has been found (Figure 22).

Figure 22. The noble pen shell (*Pinna nobilis*) in a meadow of seagrass *C. nodosa* in the bay of Portić (Source: Kružić)

The shallow part of the bay Debeljak was settled with the biocenoses of infralittoral algae, followed by the biocenoses of the coastal detrital bottoms with present bushes of *Posidonia* (Figure 23) on the sandy bottom. At the depth of four metres biocenoses of coastal muddy sands of the protected coasts has been found within which meadow *C. nodosa* is present at the central part of the bay. Below five meters sandy bottom is settled with well preserved and dense *Posidonia* meadow.

Figure 23. *Posidonia* meadow on the station Debeljak (Source: Kružić)

The list of characteristic species of flora and fauna (determined together with biologist scuba diver P. Kružić) is presented below in Table 4 and 5:

Table 4. Characteristic species of flora in the study areas

	Polje	**Portić**	**Debeljak**	**Škokovica**
Species				
Anadyomene stellata	x	x		x
Codium adhaerens			x	
Codium bursa		x		x

Codium vermilara				
Corallina officinalis			x	
Cymodocea nodosa		x	x	x
Cystoseira adriatica				x
Cystoseira barbata				x
Cystoseira spinosa		x		
Dasycladus vermicularis	x	x	x	x
Dictyota dichotoma		x		
Flabellia petiolata		x		x
Halimeda tuna	x		x	x
Jania rubens				x
Laurencia obtusa				x
Lithophyllum racemus			x	
Lithothamnion corallioides				
Padina pavonica	x	x		x
Palisada sp.	x			
Palmophyllum crassum	x			
Peyssonnelia rubra				x
Phymatolithon calcareum				
Posidonia oceanica	x		x	
Rytiphloea tinctoria			x	
Sargassum vulgare		x		
Ulva rigida		x		x
Valonia utricularis	x			
Zostera noltii		x		

Table 5. Characteristic species of fauna in the study areas

	Polje	**Portić**	**Debeljak**	**Škokovica**
Species				
Actinia equina	x	x		x
Aiptasia mutabilis			x	
Anemonia viridis	x		x	x
Antedon mediterranea				x
Aplysina aerophoba	x	x		
Arbacia lixula				x
Arca noae		x		
Astropecten aranciacus	x		x	x

Balanophyllia (*Balanophyllia*) *europaea*			x	x
Bispira mariae			x	x
Bittium reticulatum	x		x	x
Brissus unicolor				x
Calliactis parasitica	x			
Cereus pedunculatus			x	
Cerianthus membranaceus				x
Cerithium vulgatum				x
Chromis chromis	x		x	x
Cladocora caespitosa			x	x
Conus mediterraneus				x
Coris julis	x			
Coscinasterias tenuispina				x
Crambe crambe				
Cribrinopsis crassa				
Dicentrarchus labrax	x			
Echinaster sepositus	x			
Eudendrium racemosum				x
Halocynthia papillosa				
Hippospongia communis	x	x	x	
Holothuria tubulosa	x	x	x	x
Geodia gigas		x		
Glycymeris pilosa		x		
Gobius vittatus			x	
Lithophaga lithophaga				x
Marthasterias glacialis	x	x		
Microcosmus sabatieri			x	
Myxicola infundibulum		x	x	
Mytilus galloprovincialis	x			
Mullus surmuletus				
Notospermus geniculatus				
Oblada melanura				x
Ophioderma longicauda	x			
Ophiothrix fragilis	x			
Ostrea edulis		x		
Pagellus erythrinus				x
Pagurus prideaux	x			
Paranemonia cinerea				x

Parastichopus regalis	x	x	x	
Pecten jacobaeus		x		
Petrosia ficiformis			x	
Phallusia fumigata			x	
Phallusia mammillata		x	x	
Phymanthus pulcher			x	
Pinna nobilis	x	x	x	x
Protula tubularia	x			x
Sabella pavonina				
Sabella spallanzanii	x			
Sarpa salpa	x		x	x
Schizobrachiella sanguinea	x			x
Serpula concharum				x
Serranus hepatus			x	x
Serranus scriba		x	x	
Serpula vermicularis				x
Sphaerechinus granularis	x	x		
Spirastrella cunctatrix				x
Spongia (Spongia) officinalis		x		
Striarca lactea	x			
Venus verrucosa				x

This list of species reflects the following information:

- diversity of macroalgaes is the highest in the bay of Portić and Škokovica; possibly due to more diverse habitats and conditions; organic input from the drain – pollution, can be confirmed by the presence of green algae *Ulva rigida*

- fauna diversity among bays, (i.e. great number of fauna species) indicates great habitat diversity on Kamenjak

- endangered and/or rare species found on study area are: *Cymodocea nodosa, Posidonia oceanica, Zosteri noltii, Pinna nobilis, Lithophaga lithophaga, Spongia (Spongia) officinalis, Hippospongia communis.*

There are altogether 19 species of fauna which are strictly protected or protected under the NPA (OG, 80/13) and international conventions (Table 6) known to use marine area around Kamenjak full year or seasonal, determined by the Zahtila (unpublished article for PI Kamenjak) and Kružić (2012, 2014) inventory.

Table 6. Protected species in marine part of Cape Kamenjak

Species	**Barcelona**	**Bern**	**92/43/EEC**

	Convention	**Convention**[32]	
Axinella cannabina	Annex II	/	/
Axinella polypoides	Annex II	Appendix II	/
Caretta caretta	Annex II	Appendix I and II	Annex II and IV
Cymodocea nodosa	Annex II	Appendix I	/
Cystoseira corniculata	Annex II	/	/
Cystoseira corniculata var. laxior	Annex II	/	/
Fucus virsoides	Annex II	/	/
Hippocampus guttulatus	Annex II	Appendix II	/
Hippospongia communis	/	Appendix III	/
Homarus gammarus	Annex III[33]	Appendix III	/
Lithophaga lithophaga	Annex II	Appendix II	Annex IV
Luria lurida	Annex II	Appendix II	/
Maja squinado	Annex III	Appendix III	/
Monachus monachus	Annex II	Appendix I and II	Annex II and IV
Paracentrotus lividus	/	Appendix III	/
Pinna nobilis	Annex II	/	Annex IV
Posidonia oceanica	Annex II	Appendix I	Annex I
Scyllarides latus	/	Appendix III	Annex V
Spongia (Spongia) officinalis	Annex II	Appendix III	/
Tethya aurantium	Annex II	Appendix III	/
Tursiops truncatus	Annex II	Appendix I and II	Annex II and IV
Zosteri noltii	Annex II	/	

All (four) investigated bays of Cape Kamenjak are used as ports so human pressure is significant (see Figure 24).

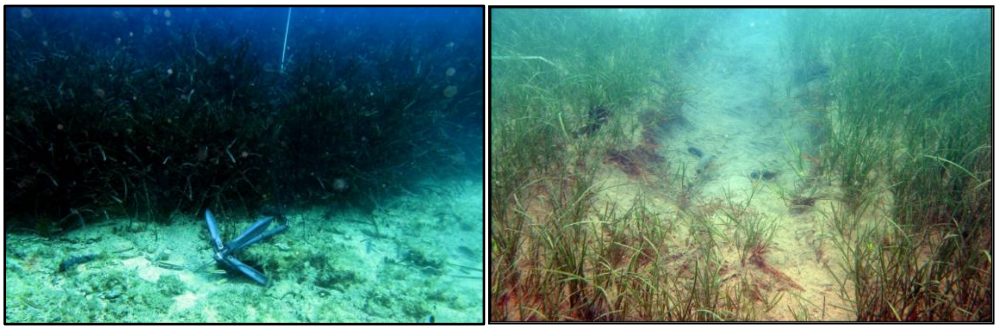


Figure 24. Anchoring in *Posidonia* meadow in the bay of Polje (left) and the footprint of the anchor on Portić

[32] Appendix I - strictly protected species of flora; Appendix II - strictly protected species of fauna, Annex III - protected species of fauna (http://conventions.coe.int/Treaty/en/Treaties/Html/104.htm).

[33] Annex III is a list of species whose overfishing must be regulated.

(right) (Source: Kružić)

Solid waste is recorded also (Figure 25). Although impact on *Posidonia* and other structural (habitat) species is considerably low in comparison to anchoring it does not have to be ignored; in many cases over time sessile organisms adopt to the environment and itself provides shelter and habitat for species, decomposing processes of solid waste can harm species on long term (DNA mutation).

Figure 25. Solid waste on the bay Škokovica (Source: Kružić)

Leaves of *Posidonia* were damaged due to increased feeding (bitten peaks of leaves sheets), especially at Porer (Figure 26), indicating the presence of herbivorous fish (primarily *Sarpa salpa*). Such damages are not detrimental for the *Posidonia* (Petar Kružić, personal communication).

Figure 26. Bitten leaves of *Posidonia* near the Porer (Source: Kružić)

Green algae *Ulva rigida* is a suitable indicator species used as indicator of eutrophication and increased organic substances (Brix et al., 1983). It is assumed that on the station Portić waste waters from the Municipality of Medulin were identified as a main cause of eutrophication. In most study areas the effect of shellfish extraction (*L. lithophaga*) has been noticed, discarded solid wastes (mainly various metal, glass and plastic items) from moored vessel and discarded fishing gear (that can do damage on seagrass meadows).

In Medulin Bay and Porer effect caused from anchoring was not recorded, while in the bay of Radovica damage caused by fishing tools and destroyed meadow, possibly by anchoring was detected together with. In communication with staff of PI Kamenjak (nature guardian), fishing activities are common in this area. Around the island Porer diving tourism is present, which contributes significantly to the endangerment of recorded coral species, tunicates, sponges and polychaete by divers that damage the colony with flippers and diving bottles.

The southern part of Cape Kamenjak is one of the most important places where negative impact reflects the most. Although this marine area does not serve as a port, it is a place where anchoring is common (especially in summer), because the excursion and other boats anchors; rocky coast is characterized by high canyons from which people jump in the sea.

Posidonia meadow was clearly well developed a few decades before. Nowadays, due to mechanical damage meadows are fragmented so research positions for this work were determined by the background knowledge of divers who gravitate on Kamenjak in order to successfully research meadow, not a "big patch".

3.2.1 Mapping of seaweed *C. racemosa* on the south of Cape Kamenjak

In the southern area of Kamenjak (bay of Kolumbarica) the expansion of *C. racemosa* has been detected at least in the last four years (Diving Center Scuba Libre, diving guide, personal communication). I can only assume that the possible cause of the *C. racemosa* spread in this area is from mooring. Location of initial spreading may be initiated from the largest meadow (34 m^2; Figure 27) because *Posidonia* meadow was on its edge. Three recorded meadows were extending in depth from 17.7 to 22.3 m.

Figure 27. Schematic view of *C. racemosa* meadows in the bay Kolumbarica (red polygon marks examined area)

The number of leaf shoots per m^2 on average reaches 60, considerably less than in other study areas. In this area biocenoses of muddy sands of the protected coasts is present. *Posidonia* islet bushes can also be found here, mostly in the inner part of the bay, on the sandy-rocky bottom. *C. racemosa* form denser meadow on macroalgae, while cross

networking with *Posidonia* islets.

3.3 RESULTS OF THE QUESTIONNAIRES

Altogether, 148 questionnaires were completed; 38 of them in Croatian, 44 in German, 43 in Italian and 23 in English. Some questionnaires have not been included in analysis due to poor handwriting, while some questions were not answered, so for every question number of respondents is mentioned.

Kamenjak is a site known in regional neighborhood countries, beside local (national) visitors who keep returning each year (summer season; Table 7). Croatian citizens were expected as a survey group which regularly returns on Kamenjak, or to the south of Istria (Municipality of Medulin). Surprisingly, foreign visitors also know well the Kamenjak area; more than a half of the foreign respondents already visited Kamenjak.

Table 7. Results on the question: "Is this your first visit of the cape Kamenjak?" (n^{34}=139)

	All visitors	Visitors from Croatia	Foreign visitors
Yes	51	10	41
No	88	29	59

Great number of visitors (21,14%) stay more than a week near the LKMA (Figure 28) having overnights in the nearby (Figure 29). Many visitors own or rent apartment/ house for one to three week in Premantura while other spend most days on the south of Istria before moving to other places.

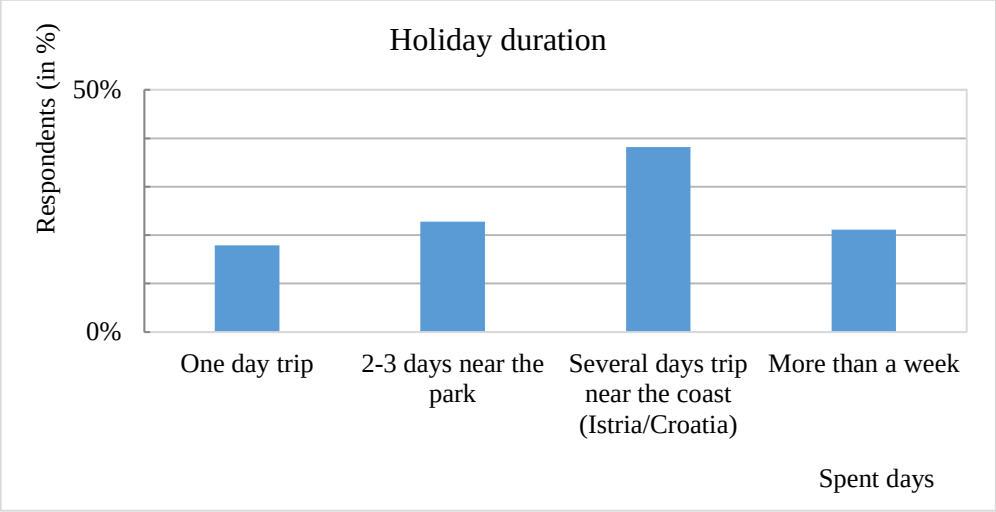


Figure 28. Results on the question: "Are you here on a day trip or spend here more than a day? (n=133).

[34] Number of respondents.

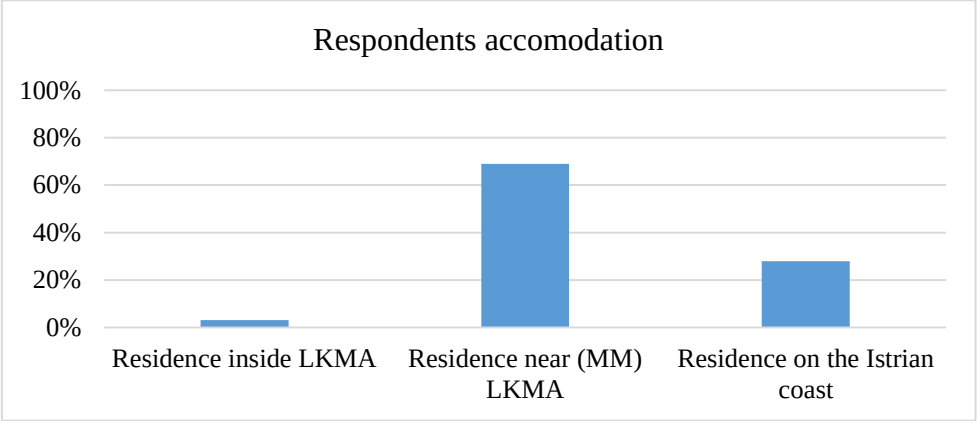


Figure 29. Results on the question: "If you stay longer than one day in this area, where are you accommodated?" (n=129)

Camping is restricted[35] in the area of LKMA. Many of the respondents stayed in the camp Stupice or camp Runke.

The majority of visitors came in the LKMA for rest and seek contacts with nature (Figure 30). Although many are looking for a simple holiday by the sea and nature, it is obvious that there is a group that recognizes Kamenjak in its high quality sports and/or adventurous content and outstanding natural and cultural heritage.

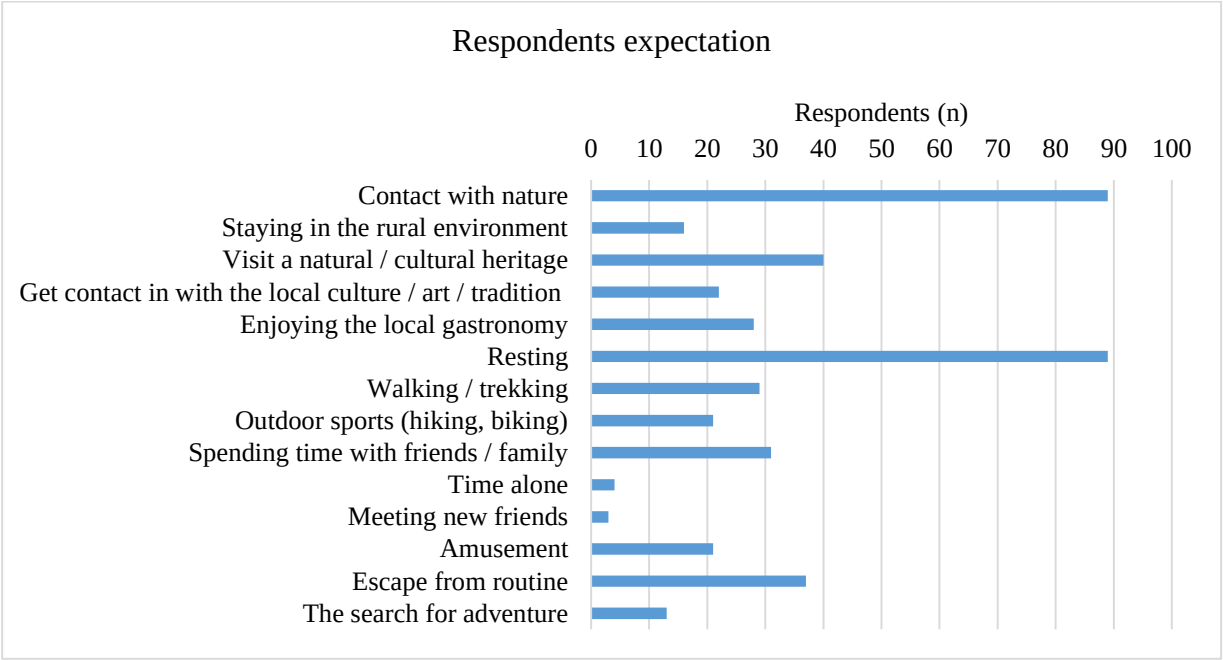


Figure 30. Results of the question: "What did you expect from your vacation prior to departure?" (n=147)

Most of the visitors have heard of Cape Kamenjak from relatives (Figure 31). Others were alerted by travel agencies and web pages.

35 OG 49/03, Revised text, Article 35, Paragraph 2.3.

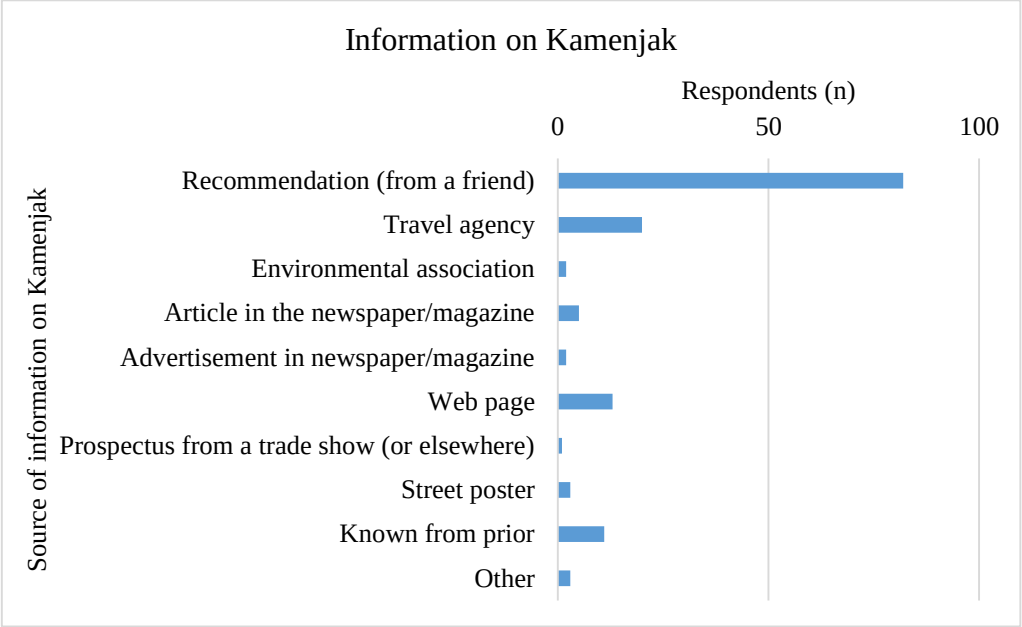


Figure 31. Results of the question: "Where did you hear for the Cape Kamenjak? What brings you here? (n=142)

It is obvious that many visitors have not learned much about wildlife and reasons for its protection (Figure 32).

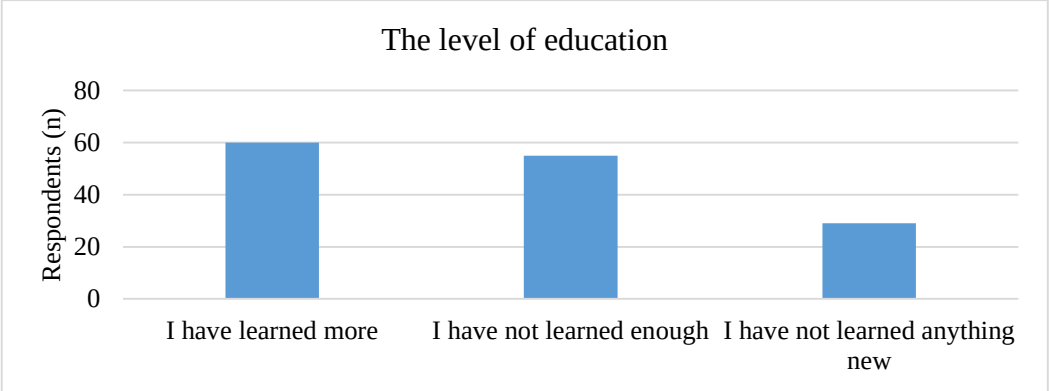


Figure 32. Results of the question: "Did you learn more about wildlife, as well as reasons for its protection within the park, from this visit? (n=144)

As part of the questions visitors were are able to indicate what new they have learned from the visit. Only 38 respondents gave a particular answer to this sub-question, and the answers were categorized into four main categories: "Water quality", "Species (land and sea)", "Dinosaur tracks" and "Habitat" (Figure 33).

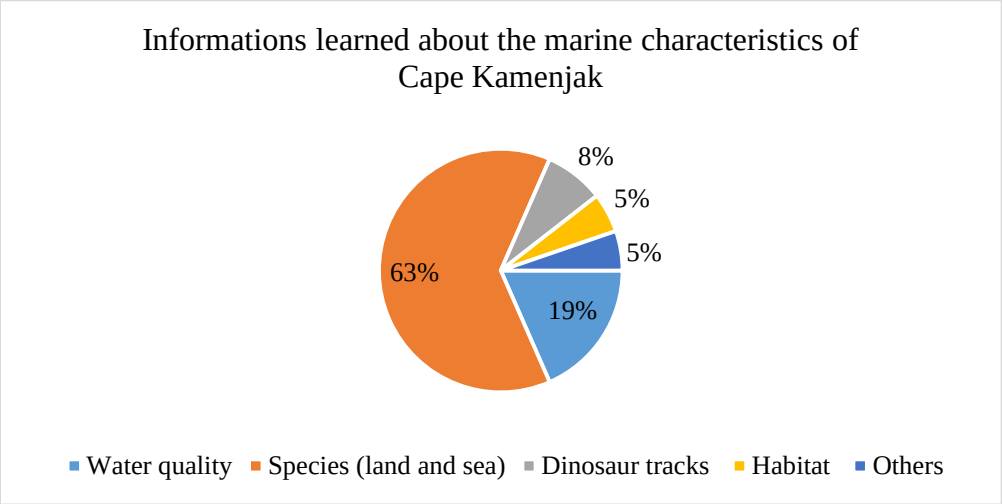


Figure 33. Results of the question: "Notify some information you learned about the marine characteristics of Cape Kamenjak; endangered species, key species for ecosystem sustainability, water quality, etc.)" (n=38)

As the protection of the Kamenjak is carried out exclusively on the mainland due to prominent flora (29 species of orchids (Vuković et al., 2011)), which is also the most frequent response, while the Mediterranean monk seal (*M. monachus*) was the most common response as an animal species representative of the sea.

One third of visitors showed a particular interest in diving educational program within diving course (CMAS R*) or diving excursions (Figure 34).

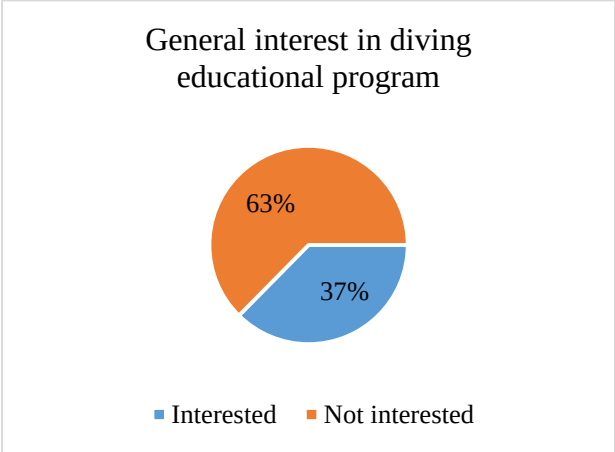


Figure 34. An interest in diving-educational program (n=131)

Respondents were asked to choose the most attractive element(s) of the Kamenjak. The majority of respondents (55%) think it is simple contact with nature, flora / fauna and untouched landscape (Figure 35). Other elements that can be distinguished as attractive are: natural and cultural heritage, outdoor sports, easy access to the park and the proportion of quality and price.

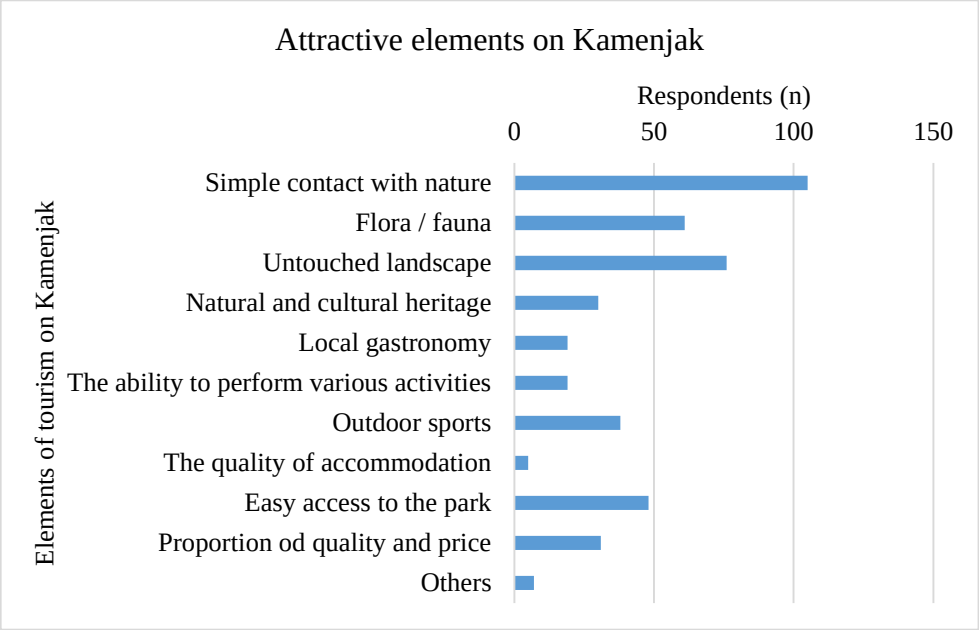


Figure 35. Results of the question: "What are the most attractive elements of tourism in this park, in your opinion? (n=147)

Traffic and cleanliness are the main issues (Figure 36) visitors would like to be improved in the year. Traffic inside the park has always been a problem because of the potholes and macadam on the road. This type of sandy road endanger pedestrians and cyclist/bikers due to dust lifted into the air by vehicles.

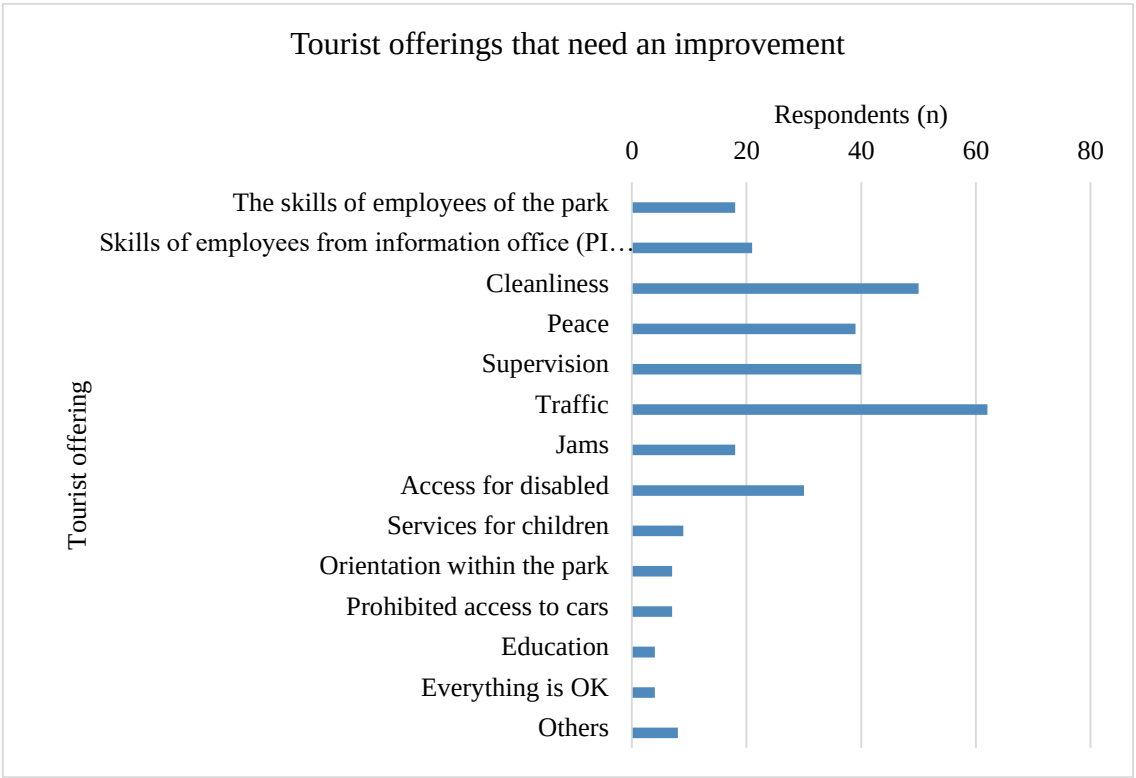


Figure 36. Results of the question: "What could improve tourist offerings in the park, in your opinion? (141)

According to the responses received infrastructure rods that link the park, roads inside the park and the parking spaces within the park (Figure 37) need improvement. Educational trail and walking path can also be taken into consideration.

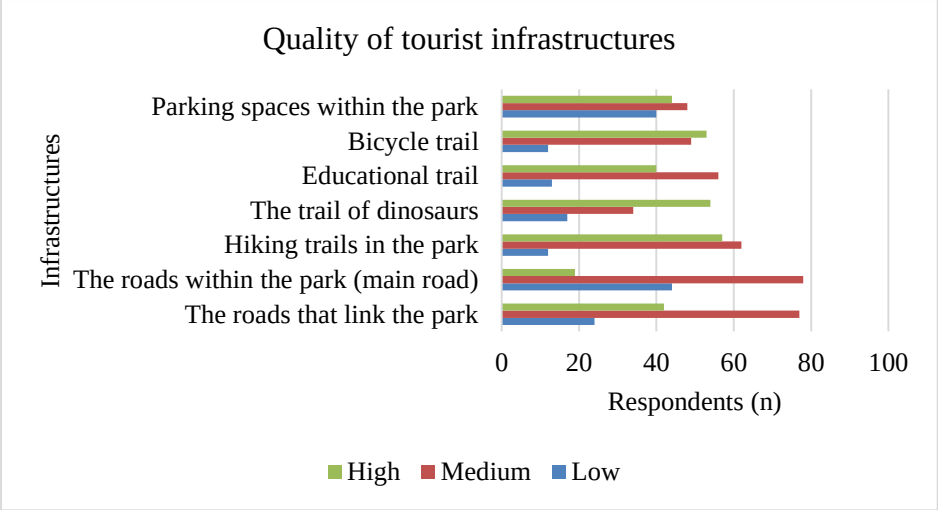


Figure 37. Results of the visitors opinion on the quality of seven main infrastructure on Kamenjak (n=145)

The last question was looking for the key feature that represents Kamenjak best (a symbol of Kamenjak). The majority of respondents think that landscape and fauna are the most important to Kamenjak (Figure 38).

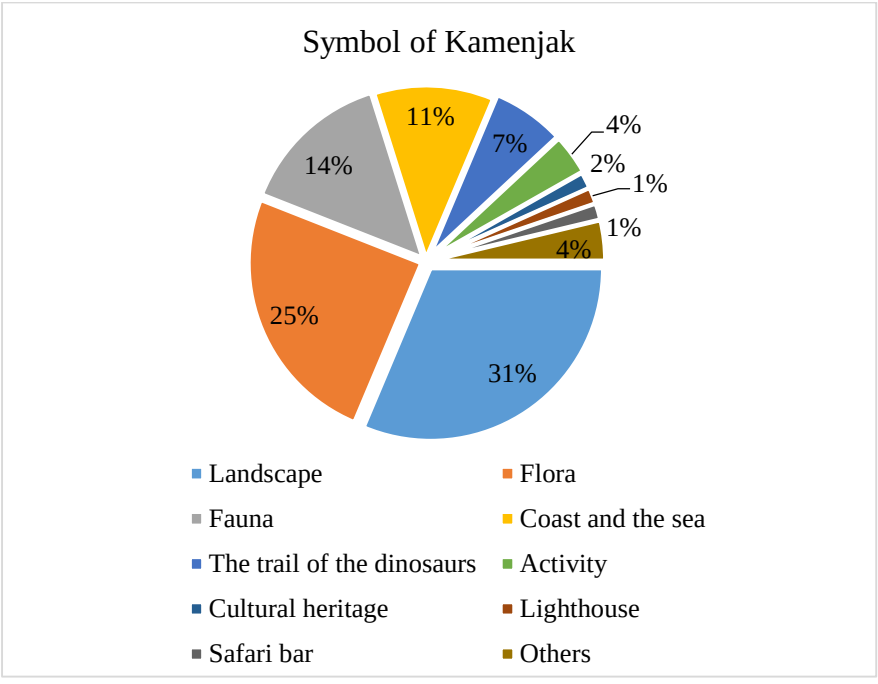


Figure 38. Results of the question: “Find one element (fauna, flora, landscape, cultural heritage or activity etc.) which can be used as a symbol of the park.” (n=127)

Some visitors gave the answer from the offered response, while responses from other visitors are categorized according to the particular group of elements, shown in the table below.

Table 8. List of written responses by respondents classified in 10 category

LANDSCAPE
The view of Kamenjak from the above; 4 responses (hereafter: R)
The nature
One lagoon in the sunset, without tourists
Landscape and the sea
The forest
Beautiful landscape with a view of the local flora / fauna
The lagoon with pine trees above her
FLORA
Orchids; 8 R
Broom ("Ginestra"); 2 R
Olive
Sage - the smell of herbs
Mediterranean maquis
Sage spring flowering with purple flowers
Maritime pines
Rosemary
FAUNA
Butterfly; 4 R
Mediterranean monk seal; 6 R
Donkey
Fishes
Black Widow
Cows and animals
Cormorant
COAST AND THE SEA
The sea; 6 R
The coast; 4 R
The beach; 3 R
Cliffs
The rocks, crystal clean water
The bay of Kolumbarica and rocks
TRAIL OF THE DINOSAURS

Dinosaurs; 4 R
Dinosaur trails; 4 R
Dinosaur path
ACTIVITY
Activity; 3 R
Active rest
Cycling
CULTURAL HERITAGE
Kažun - "stone house"
LIGHTHOUSE
Lighthouse; 2 R
SAFARI BAR
Safari bar; 2 R
OTHERS
Cape Kamenjak (unique in the world)
Everything is beautiful in its own way and should stay like it
The wind
I like the current symbol
Everything is so beautiful
Nothing

4 DISCUSSION

Protected areas cover only about 0.4% of a total marine area of the northern Adriatic (Turk and Odorico, 2009), which is far from the target which the Republic of Croatia should reach by 2020 in order to obtain a satisfactory quality status of the marine environment as an EU member and signatory to numerous conventions related to nature protection (RAC/SPA- UNEP/MAP, 2014).

There are many protected areas in the EU that are still in the process of planning level. Therefore, spatial documentation about particular area is adopted on regional/national level, but proposed (in the spatial document) management actions and measures necessary for protection goals are not always carried out. Kamenjak complete protection is facing the exact problem since 1973, where former assembly of Pula Municipality has failed to conduct decision on designation coastal area on the aerial line Pula-Medulin as natural reserve. At the end of 1994, Department for Urban Planning and Environmental Protection of the Istrian Region has send request (change of the Decision of the Act from 1973) on Kamanjak protection, including terrestrial and marine component. Mentioned request was granted only for the land part. The last governmental paper (seeking marine protection on Kamenjak from 2009 is spatial document of Lower Kamenjak and Medulin archipelago (OG of Istria County 2/09) made by Regional Planning Institute of Istria County. In the paper are designated two marine special reserves with total area of 406,9 ha (ANNEX C). It highlights the protection of *Posidonia* meadows and other underwater habitats relevant for seagrass meadows from any mechanical (anchoring, extraction), chemical (antifouling) or biological (introduction of alien species) disturbance method.

Human impact on marine area on Kamenjak was recorded in all four investigated bays and is present at least since 2003[36], mainly in the form of solid waste, fishing gear, and even explosives (military exercises). Many bays are facing mark of devastation due to shellfish extraction (*L. lithophaga*). The spread of invasive species *C. racemosa* was not recorded (cape Marlera, bay of Kolumbarica) during preparation of the spatial document, so potential problem of *Posidonia* meadows now, because of this request certain extensions of protection measures.

C. racemosa is widespread across the north-western Mediterranean and inhabits both pristine and degraded habitats (Ceccherelli et al., 2014). Competitive characteristics of the species is described in many works. An impact on changing the structure of the phyto- and zoobenthos community was noticed, because it has the ability to become the dominant species of the macrophyto[37] community (Ceccherelli et al., 2014), and therefore is categorized among the 100 worst invasive species in the Mediterranean (Streftaris and Zenetos, 2006). Species is overgrowing marine bottom to the extent by which coverage,

[36] Investigated were all bays of Cape Kamenjak, and areas around islands in Medulin archipelago, except Porer, Levan and Levanić (OG of Istria County 2/09).

[37] A macrophyte is an aquatic plant that grows in or near water and is either emergent, submergent, or floating.

numbers and diversity of other types of benthic species could not be sustained (Piazzi and Cinelli, 2003; Balata et al., 2004). Piazzi et al. (2001) demonstrated negative effects of spreading of *C. racemosa* on the seagrass meadow density; density of the shoots of *C. nodosa* was reduced by 50% (Ceccherelli and Campo, 2002). Dense *Posidonia* meadows prevents the spread of such invasive species, meaning it has high resistance on invasive expansion, respectively (Piazzi and Cinelli, 1999; Ceccherelli et al., 2000; Occhipinti-Ambrogi and Savini, 2003; Ruitton et al., 2005a; Infante et al., 2011). In addition, there is a way of "*natural regulation*" by grazing[38] (Ruitton et al., 2006). *Posidonia* meadows are important habitats for juvenile and adult herbivorous ichthyofauna (Bell and Harmelin-Vivien, 1982; Francour, 1997); the Damselfish (*Chromis chromis*) and Seabream (*Boops boops*) are playing an important role within the *Posidonia* being dominant in density and biomass (Kalogirou et al., 2010). If the spread of non-indigenous species in some marine area is "tricky" requires some action in regional policy and management decisions has to be made if the knowledge is science based (Galile, 2012).

4.1 HYPOTHESIS TESTING (1)

From the results we can see that all study bays are under certain anthropogenic influence while state of *Posidonia* meadows on impacted and reference station is similar to others in the Adriatic (Guala et al., 2012). Anchoring is the main pressure, especially for *Posidonia* as it is highlighted in this study. Due to strong currents anchoring is commonly placed where seagrass meadows are present, because the anchor holds better. Bays of Portić, Polje and Debeljak are the main mooring bays on Lower Kamenjak, so here the pressure is the most intense. Only at the island of Porer a sign of damage by anchoring was not detected: *Posidonia* meadow is well developed and due to presence of mäerl habitat, this area is more pristine and valuable than other study areas.

Illegal hunting on Kamenjak is present at least since 2003; results of shellfish extraction is recorded in more than a half of the investigated bays of the Lower Kamenjak during spatial document (OG of Istria County 2/09). Other threats to the communities include solid waste and the spread of non-indigenous species *C. racemosa* that only starts spreading at the edge of the meadow which is under a certain influence.

The spread of *C. racemosa* has been ongoing for many years. In the area of Sardinia is observed its expansion in the duration of about 15 years (Buller et al., 2011), spreading at the edge of the meadow which is under a certain influence and some authors (Carlton and Ruiz, 2005) conclude that anchoring is the main cause for invasion by algae species by anchoring. The sea current in the area concerned depends on the weather, (http://www.istra.hr/en/attractions-and-activities/natural-attractions/cape-kamenjak), but in general, current vector resultant is in the south-southwest direction (232 degrees; Plan, 2009). This situation favors the spread of *C. racemosa* from the bay of Kolumbarica to the

[38] Grazing is a method of feeding in which an herbivore feeds on plants such as grasses, or other multicellular organisms such as algae.

islands of Fenoliga and Porer, if the unadvisedly anchoring on the south of Kamenjak is continued. Is the settlement of species *C. racemosa* near Fenoliga and Porer islands possible problem for indigenous species on the south of Cape Kamenjak?

Hypothesis: "Use of LKMA marine area is not sustainable and as such could cause the gradual disappearance (local extinction) of *Posidonia* habitats," is confirmed considering that Kamenjak and Municipality of Medulin has growing tourist attendance rate during warm season and due to unregulated maritime activity on Kamenjak that damages *Posidonia* meadows. Literature data (Kružić, 2012, 2014; OG of Istria County 2/09) and personal data provided me an insight that generally all bays of Lower Kamenjak are long period of time under consistent pressure that has fragmented meadows irreversibly into "patches" and thus losing ecosystem functions as structural/habitat species (Boudouresque et al., 2012). Endangerment of *Posidonia* meadows in Medulin bay results from unregulated anchoring and expansion of *C. racemosa*, whose meadows has already been found in the summer of 2016. Personal research data show meadows discontinuity (especially in station B1) and the presence of dead *Posidonia* leaves which facilitate *Caulerpa* expansion, given that its expansion is evident mostly in the marginal and/or degraded parts of the *Posidonia* meadows (Ruitton et al., 2005a; Infante et al., 2011). *Posidonia* meadows around Porer is highlighted because no dead leaves were found and had little (natural only[39]) discontinuity, while in Medulin bay places of meadow discontinuity were not always natural; in most cases, places absent with *Posidonia* were stripped and flooded with sediment (sand), indicating a mechanical damage (anchor). Since *Caulerpa* meadows is recorded and mapped in the southern part of Lower Kamenjak near Porer, there exist real threat of its expansion in the *Posidonia* meadows with estimated best condition on Kamenjak.

If the anchoring on the marine area of Lower Kamenjak continues unregulated (without ecologic mooring system) it can speed up the spread of *C. racemosa* (Ceccherelli et al., 2000; Montefalcone et al., 2007). Area around Porer and Fenoliga can serve as natural regulator of the expansion of *C. racemosa*, due to its good preservation. Monitoring could provide information on expansion pattern of *C. racemosa*. For the effective management and conservation of the *Posidonia* meadows on Kamenjak I propose the measures that are outlined in 4.1.1 and 4.1.2.

4.1.1 Focused research on Kamenjak

In Croatia the research infrastructure is not fully developed (Operational Programme "Competitiveness and Cohesion", OPCC, 2014 – 2020). The fact that it is not fully developed limits the sector of research whether it's public or private, and does not give the opportunity to carry out in accordance international obligations.

I suggest preparation of the project at the national level which should identify the exact

[39] Marine bottom areas where seagrass meadow ends were settled by ifralittoral algae (dominated the *Padina pavonica*).

area of the *Posidonia* meadows in the area and the data will be used for future monitoring of the change to the (*baseline*[40]) state (Guala et al., 2012). The project should aim at mapping the settlement of the seagrass meadows in the waters of the Cape Kamenjak, "*real-time*" state and location, in order to precisely monitor future state changes. I propose the geo-referenced underwater filming from the surface of the sea. This technique was used in 2009 for mapping the habitats on the infralittoral zone in area of NP Kornati. This technique was promoted because of its precision, quality statistics, and low cost in comparison to the relation of the effectiveness and detection that cover the meadows (Schultz, 2008; Puhr et al., 2014, Schultz et al., 2015).

This method and direct (SCUBA), fixed plot methods are powerful enough to detect a loss of seagrass habitat in the scope of 10% accuracy (Schultz et al. 2015). It provides ground-truth[41] habitat classification models in which it is assumed that 100% accuracy in distinguishing live seagrass from algae, unvegetated surface, dead leaves, and exposed matte is reached (Schultz et al. 2015). The advantages of this method are high spatial and visual resolution, success at various depths[42], no destructiveness and quick data collection. Once the mapping has been done it is necessary to carry out consecutive surveys with scuba diving (on a year basis) at fixed location. Number of leaf shoots is accepted method for determining the state and possible degradation of the seagrass meadow (Díaz–Almela and Duarte, 2008).

4.1.1.1. Management of marine area and zonation

- most of marine area in the area concerd is settled with *Posidonia* meadows (priority habitat for protection),
- seven species were recorded that enjoy legal protection or demand regulation; all year round or seasonally the area is inhabited by 22 rare and/or endangered species of marine flora and fauna protected by many national and international regulations and Protocols (Kružić 2012, 2014; Zahtila, unpublished paper, Ribarič and Herlec, 2008)
- there is no service control for illegal marine activities during offseason, except the surveillance done by Harbour Authority of Pula ("Lučka Kapetanija"), which regulates marine activity of the whole County region; during summer marine vessel for public control and regulation of PI Kamenjak marine area only operate on randomless
- seabed is rich in both natural and hydro archeological places worth for preservation and promotion,
- in reference stations meadows were more dense than in impacted stations, as expected, but they are all important for conservation of Adriatic meadows

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40 Condition used as the basis for (future) comparison.

41 The accuracy of remotely sensed or mathematically calculated data based on data actually measured in the field.

42 GoPro camera can take up to four bars (4 atmosphere).

Additional human resources are needed to accommodate the needs for protection:

One expert should be trained for supervision of the area and supervisory service for monitoring priority species and habitats. Also, it is important to exchange experience through participation in national and international workshops and conferences (professional and scientific). In accordance with this, for a successful carry out of the plan, it is necessary to collect proper equipment:

- diving, informatics, office equipment, equipment for professional jobs of the supervision and performance.

Different strategies, especially in the context of MPAs are accepted, so the impact on seagrass could be reduced. The most used methods are (Milazzo et al., 2004):

- surveillance,
- limiting the number of mooring capacity,
- prohibition of anchoring in specific parts,
- waste supervision and its removal,
- supervision of non-indigenous species,
- education of local people and foreign visitors.

Furthermore, I suggest establishment of three defined areas with different terms of use and protection, shown in GIS representation of zoned marine areas (Figure 39), with defined list of activities that are compatible with the goals of protection (Table 8), to preserve and protect valuable marine habitats. The zoning of marine areas represents an “open-access system” for support in decision-making (Miolanen et al., 2005). It is one of the best method for spatial planning and also obligatory, according to some Protocols for nature protection (Merrifield et al., 2013; Precali et al., 2013; RAC/SPA- UNEP/MAP, 2014).

Table 8. Permitted activities by the zone of marine area

ACTIVITIES	ZONE OF STRICT PROTECTION	ZONE OF FOCUSED PROTECTION	ZONE OF COMMERCIAL USE
Scientific research	✓	✓	✓
Monitoring	✓	✓	✓
Diving - autonomous	R	R	✓
Sea bathing	R	R	✓
Small fishery	X	R	R
Anchoring	X	R	R
Sailing	R	R	✓
Bouy	X	R	✓
Kayakingn/ windsurfing / jet ski	R	R	✓

✓Allowed activities / X Restricted activities / R Permitted activities with regulation

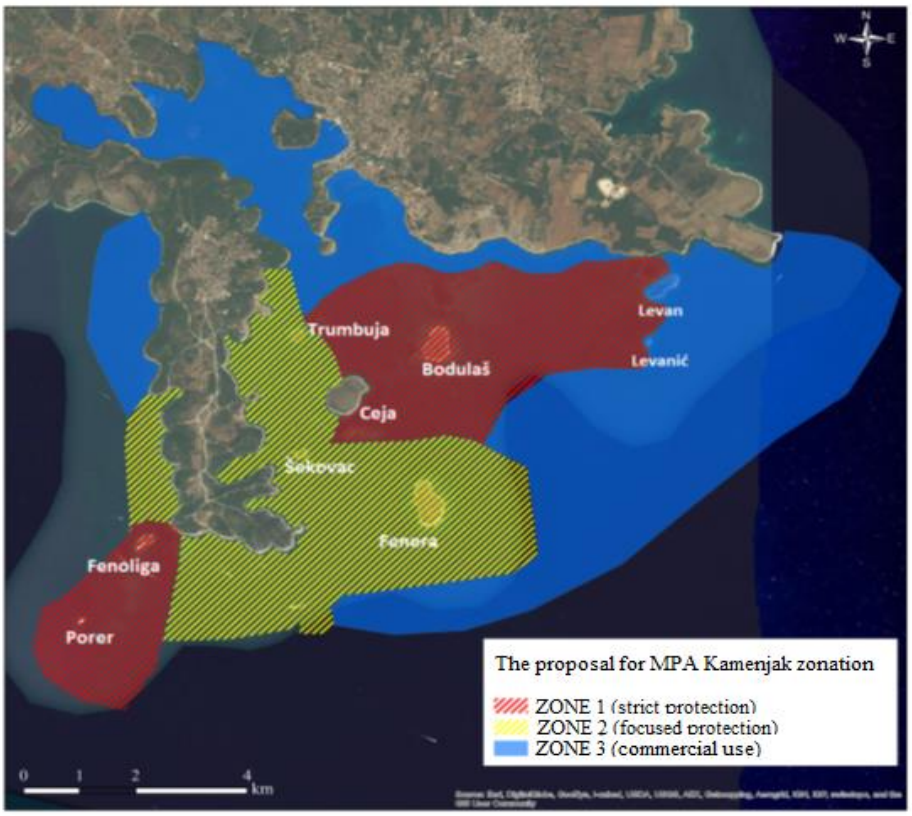

Figure 39. GIS representation of the possible MPA "Kamenjak"

Given that only bay of Debeljak enjoys active protection from anchoring during the summer months and that there is no supervision undertaken by legal entities over activities at sea near Kamenjak (boat excursions, diving tourism), protection of *Posidonia* meadows is not consistent, so it is required that:

- In the area of strict protection (ZONE 1) anchoring must be restricted and regulated. Several human activities must be regulated. Diving tourism needs to be prohibited in this location. Only diving for the purpose of scientific research is allowed. Area of strict protection (ZONE 1) can preserve *Posidonia* meadows habitats, while ZONE 2 with the upgraded mooring systems can serve as a tool to control marine activities.

- In the area of focused protection (ZONE 2) mooring system must be upgraded, especially in the bay of Polje and Portić should be set activities that include setting up concrete blocks and eco-buoys pontoons. Active protection is needed during summer time (tourist season). This applies to all the territory where the boats/yachts are usually anchoring (ZONE 1 and ZONE 2).

In order to monitor this area installation of three oceanographic buoys for *Posidonia*

meadows monitoring is recommended. They collect data from the water such as salinity, temperature, turbidity and from the weather as temperature, relative humidity, and rainfall (Sendra et al., 2015). Commercial zone (ZONE 3) is an area that provides for common exploitation or use for lagoon fish and shellfish farming (inner bay of Medulin archipelago).

Activities of PI Kamenjak that will improve management of MPA Kamenjak are as follows:

- Implementation of regular monitoring of the *Posidonia* meadows; preferable monitoring stations are in the bays of Školjić and Škokovica and the islands of Šekovac, Fenoliga and Porer.

- Implementation of regular monitoring of the non-indigenous expansion (*C. racemosa*) and their impact on indigenous species and habitats; in cooperation with the Institute Ruđer Bošković (Rovinj).

- Carry out the research related to sediment composition and the level of human impact by analyzing eco-toxic metal in sediment; in cooperation with the Institute Ruler Bošković (Rovinj).

- Production of info materials on the seagrass significance and its dissemination to local population and visitors

- Enhancement of cooperation with diving centers and clubs to obtain support of responsible diving (e.g. no diving in ZONE 1).

- Continuation of cooperation with the Institute “Blue World” in research of the northern Adriatic population of the dolphin (*T. Truncatus*; methods are mentioned briefly in Annex D).

It is required to conduct thematic workshops and meetings with all stakeholders and conduct a discussion on Management Plan. All local fishermen should be registered in PI Kamenjak. Their mooring areas should be in two main docks on Lower Kamenjak, bay of Polje and Portić. To stimulate cooperation with local fishermen, it is necessary to carry out the first few years into a survey of the fishermen data (Annex E, an example of one of these surveys).

Scientific contribution to the sustainability of fishery is well known, so monitoring of fisheries is very much based on size-age ration. Population regulates its own sexual maturity depending on the environmental conditions. If some species is overexploited it regulates its own sexual maturity and in this case it accelerates, since the reproduction delay would eventually lead to the collapse of the population (see Norse and Crowder, 2005, 238 p., Exploited Fishes). It seems that the only way to recover commercial species is reduced fishing effort (Myers et al., 1995) while knowing the structure of livestock can prevent the impoverishment of individual stock and set appropriate limits of its regulation

(see Norse and Crowder 2005).

Upgrading the infrastructure (tourist offer)

A great part of visitors stay on Kamenjak at least a week (Figure 28), allowing their engagement in implementation of education programmes on the marine component. Educational programmes encourage awareness of ecological issues, and therefore introduce visitors to the current situation in nature of the protected landscape through which they come in direct contact with nature, which ultimately visitors of Kamenjak expect from their visit (Figure 30). Given that more than a half of the respondents claim that they have not learned enough about the flora and fauna (Figure 32), more effort should be invested in education. The bicycle trail, trail of the dinosaurs and hiking trails are rated relatively well evaluated (Figure 37). It is recommended to undertake observations so as to see what is missing and/or what could be added within the same educational trail.

Advertising in order to attract new visitors requires some effort. For this purpose it is recommended to implement Facebook business platform (Gershon, 2013).

In Premantura, there are no official parking spaces in which visitors could leave their vehicles and use alternate transport within Kamenjak, so many visitors have outlined the need for better traffic infrastructure (Figure 37). I propose construction of one or two official parking spaces outside of the protected area at the very entrance of the park (Figure 40), with a total space occupation of 2 hectares.

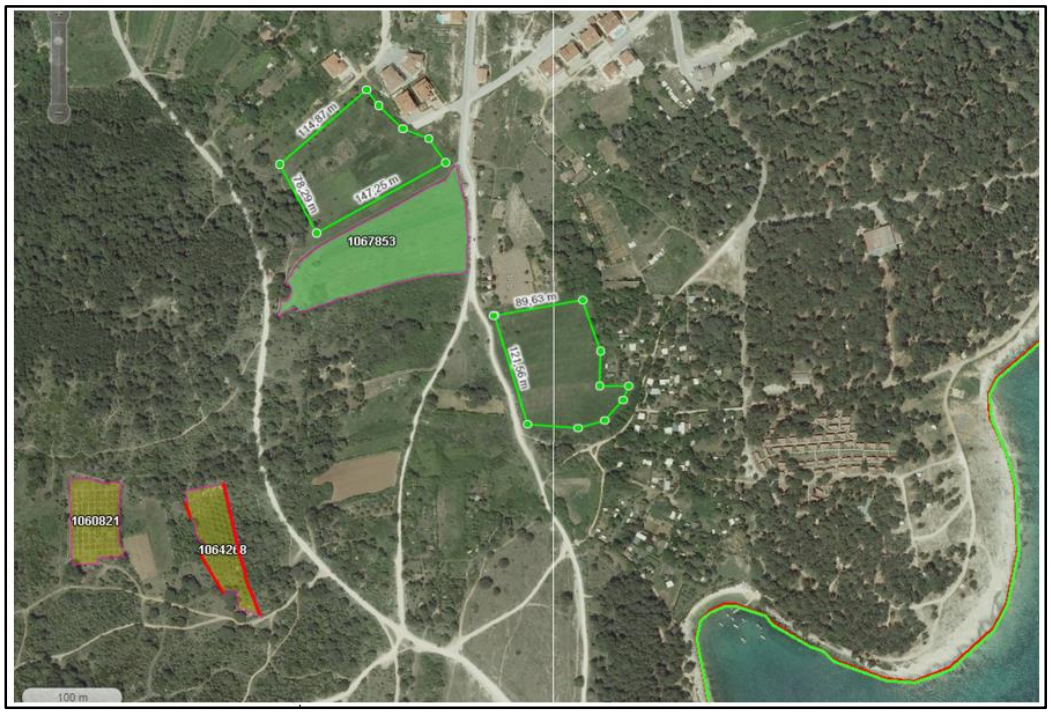

Figure 40. The proposed two parking spot (marked with green edges), surface of 1.18 and 1.16 hectares. (http://preglednik.arkod.hr)

Furthermore, I propose the implementation of “rent a bike” system where visitors could rent bikes and with the help of GPS receive a guided route within the park.

Development of a mobile application connected with the system of digital barcoding would give value to Kamenjak as PA, allowing visitors to have a more intimate approach in their contact with nature.

4.2 HYPOTHESIS TESTING (2)

By surveying the visitors of Kamenjak, an attempt was made to determine the interest for marine environment, as the general thoughts of LKMA tourist offer. In addition, it was recognised that many visitors know about the quality of the marine part and even a third of the visitors showed an interest for an educational diving programme.

Green tourism is a priority in many national tourism development strategies. It is known that "sea and sun" are dominant tourism products in coastal parts of Croatia. Diving tourism is recognised in this work as one of the key tourism activities with low environmental impact, if conducted according to the agreed standards.

On the southern part of Istria County there are ten diving centres and six diving clubs (Iveša et al., 2015). The diving made with a group of tourist must be conducted with minimal one diving instructor and diving guide if they are introduced with the conservation measures in the LKMA area.

Hypothesis: "Tourist infrastructure on Kamenjak is well developed and organised and has a good chance for managing sustainable tourism in near future related to the marine activity" can be confirmed if we take into account that PI Kamenjak is already trying to resolve issue about marine management jurisdiction with Municipality of Medulin (Annual program of PI Kamenjak, 2015). From the questionnaires, general picture of Kamenjak and its management can be prescribed to hypothesis following that:

- A great part of the visitors are interested in marine environment and marine education (Figure 34). This could serve as a tool to encourage the education of tourists, but also to monitor process at fixed locations,

- More than 20% of the visitors spend more than a week close to Kamenjak (Figure 28) and have highlighted contact with nature as the reason for their visit (Figure 30),

- Contact with nature, flora/fauna and pristine landscape are recognized as the most attractive elements of Kamenjak, so educational programs and activities on marine area seem as good way of managing sustainable tourism since many visitors stays at least a week and do not acquire enough new knowledge on key species and its habitats nowadays (Figure 32),

- Online promotion and marketing of Kamenjak with search engine on person activities and hobbies is good way to improve low promotion of Kamenjak and can effectively attract new (target) population (all year round). Low promotion is evident from following results:

- 63% of the respondents were not first time on Kamenjak,

- 57% of the respondents first have heard of Kamenjak from siblings and friends, only 10% from internet pages and 5% from some institute/organization for the environment and magazine/newspaper together,

- Parking space, roads and traffic inside the park are the main problematic infrastructures (Figure 36 and 37); solving that problem could improve visitor's movement and their supervisor (less chance of visitors entering restricted areas).

5 CONCLUSION

"*Being a country with large coastline and maritime area Croatia needs to protect and preserve the marine environment, prevent its deterioration, restore marine ecosystems … Planned future activities will be based on the Marine Environment and Coastal area Management Strategy (due end of 2016) and it will include set of priority measures and actions (so called "programmer of measures designed to achieve or maintain good environmental status in the Marine Environment by 2020")*", Operational Programme 2014 – 2020.

In the process of establishment of the protected area it is essential to collect and analyse data on the biodiversity, patterns of uses of natural resources, identify major threats to the area, species and habitats and to evaluate and raise support of the local communities and stakeholders to the creation of the MPA. As a first step, detailed analyses of the legal and special documents defining the area is needed. Marine area of LKMA is a place of prominent biological value and due its relatively small surface (1170 ha) and can be effectively managed by surveillance stuff of PI Kamenjak. Visitors of Kamenjak recognize the value of the marine area, thus declaring its protection might greatly enhance the quality of tourism on green promotion. Development of training programmes for surveillance, equipping PI Kamenjak with equipment for marine research and monitoring is a good start if it is based on a spatial document. Those documents provide a scheme for area management for a period of at least 10 years. Cooperation with stakeholders can provide active management of the MPA Kamenjak with the implementation of protection measures in order to act on the anchoring, main threat for living communities. Also, mapping invasive species is a good indication for reaching the specific objective "Improving framework for sustainable management of biodiversity (primarily Natura 2000), according to Operational Programme 2014 – 2020.

Marine area of Kamenjak is rare spot in Istria County coastal zone inhabited by *Posidonia* meadows under threat for losing its ecosystem functions. Without performed management measured mechanical damage (by anchor) will continuously produce the next possible area for *Caulerpa* expansion while unresponsible diving will endanger meadow by increased sedimentation. If acts on the key factors with proposed management further degradation of *Posidonia* meadows can be solved, so as the spread of *Caulerpa* to the new territories. Since the belonging protected land part is well known and has many visitors around the world that love and appreciate nature, focused tourism on Kamenjak can raise the bar in tourism while providing new and especially important knowledge of *Posidonia* meadows in Adriatic, since meadow characteristics in northern Adriatic differ from meadows investigated in most Mediterranean[43].

Perspective

[43] Doc. dr.sc. Bakran-Petricioli keynote on 5th Mediterranean Symposium on Marine Vegetation (Portorož, Slovenia 27-28 October 2014).

The increase in political, environmental and economic level of the local community can lead to a better future management of the environment, not only in protected areas, but also in other (unprotected). For the conservation of biodiversity at the time of the rapid human population expansion it is necessary to continue development of regional / local management system of protected areas and ecological networks. Raising public awareness, encouraging participation in the decision-making and changes in legal criteria for progress in inventory and evaluation process for biological diversity is the direction that should strive (SINP, 2008).

Istria has a natural predisposition, human resources and tradition for the development and improvement activities such as fishing, tourism, aquaculture, among others. The sea is among others, one of the most important natural resources crucial for traditional fishery and tourism (The County Development Strategy, 2011-2013). Detailed mapping of marine habitats in Istria County is planned through projects funded by the European Structural Funds in early 2017 (MedPAN, Monitoring Protocol for Croatia).

6 POVZETEK V SLOVENSKEM JEZIKU

ZAŠČITA SEVERNEGA JADRANA

V severnem Jadranu obstaja le dvanajst zaščitenih morskih območij (ZMO), ki zasedajo le 0,4% skupnega morskega območja. To je daleč od ciljev ohranjanja, ki jih je določila Republika Hrvaška kot odgovor na več mednarodnih konvencij in obveznosti, katerih cilj je zagotoviti ugodno stanje ohranjenosti morskega okolja.

Varstvo biotske raznovrstnosti na ravni Evropske skupnosti deluje predvsem z izvajanjem direktiv Evropske Unije (EC 79/409 in 92/43), imenovanih Direktiva o pticah in Direktiva o habitatih, ki države članice obvezujejo, da vzpostavijo zaščitena območja v znano omrežje kot je Natura 2000, eno od največjih mednarodnih omrežij zaščitenih območij. Morska komponenta omrežja Natura 2000 je sestavni del celotnega evropskega ekološkega omrežja in kot taka želi zaščititi habitate, opredeljene v Prilogi I in vrstah iz Priloge II. Direktiva o habitatih (92/43 EEC) vsebuje pravno podlago za ohranjanje naravnih habitatov in prosto živečih taksonov, tako da deluje kot zakonodajni instrument Skupnosti. Na teh območjih je treba opredeliti in izvajati ukrepe za upravljanje, ki bodo zagotovili ugodno stanje ohranjenosti habitatov in vrst, za katere so zaščiteni.

Ena od vrst z najvišje ohranitvene skrbi na Mediteranu je Posidonia oceanica (l.) Delile. Vrsta je endemična za Sredozemsko morje, navedena v Rdečem seznamu morske makroflore na Hrvaškem (Antolić in sodelavci, 2011). Formira velike podvodne travnike velikega ekološkega pomena, ki lahko trajajo tisoč let (Mateo in sodelavci, 1997) in katerih kolonizacija novega prostora se pojavi zelo počasi (Meinesz in Lefevre, 1984). Travniki Posidonije rastejo na območjih, kjer je pritisk človeških dejavnosti zelo visok, zato severni (jadranski) in srednji vzhodni del Sredozemlja kažeta izrazito regresijo (RAC/SPA - UNEP/MAP, 2014).

Predmetno področje se nahaja v najsevernejšem delu Sredozemskega morja, znanem kot severni Jadran. Nahaja se na jugu Istrskega polotoka (Hrvaška) kot del znatne pokrajine Spodnji Kamenjak in Medulinski arhipelag (v nadaljnjem besedilu: SKMA), zaščitenega leta 1996, na podlagi NZV (Uradni List Istrske Županije, 5/96). Zaščiten je samo kopenski del vključno z vsemi devetimi otoki med rtom Kamenjak in rtom Marlera (vzhodni del Medulinskega zaliva). Rt Kamenjak meji na globoko odprto morje severnega Jadrana, ki zagotavlja izmenjavo vodnih mas zaradi nenehnih in delno močnih (morskih) tokov, ki zagotavljajo prenos hranil, to pa je osnovni proces za primarno proizvodnjo morskega območja.

Po razpoložljivih podatkih (Precali in sodelavci, 2013), je prisotnost in velikost naselja Posidonje za Istrsko obalno območje redka, zato avtorji predlagajo nadaljnje raziskovalno kartiranje travnikov Posidonje na območju rta Kamenjak. Skupaj z Brijunskimi otoki so edina območja v Istrski županiji na Hrvaškem, ki so v omrežju Natura 2000 in bogato poseljena s Posidonijo po predhodni študiji Državnega zavoda za varstvo narave (Uradni list 80/2013, Pravilnik o Ekološkem omrežji, Priloga II).

IZZIV PREDMETNEGA PODROČJA

Poleg človekovih vplivov, ki puščajo madeže na morski habitat (sidrenje), je prisotno tudi širjenje invazivne vrste *Caulerpa racemosa* (Forsskål) J.Agardh 1873 (Caulepales, Chlophyta). V nedavni raziskavi, ki zajema zahodno istrsko obalo od rta Savudrije do rta Kamenjak, je določeno velikostno območje travnik *C. racemosa*, oziroma/ali *Caulerpa cylindracea* Sonder (Iveša in sodelavci, 2015). Ni bila izmerjena biomasa, velikost kolonij ali gostota, vendar "prizadeto območje" (Vaugelas in sodelavci, 1999); predstavlja kolonizirano območje in območje primerno za morebitno bodočo kolonizacijo. Vzorčenje je bilo napravljeno v obdobju september – december¸. Najbolj prizadeto območje in najprej kolonizirano mesto je pri Vrsarju (severno od Kamenjaka). Predvideno morsko dno, prizadeto s *C. cylindracea*, se je povečalo s 870 na 10000 m2 od leta 2004 do leta 2014 (Iveša in sodelavci, 2015). Širjenje na Kamenjaku je prisotno od leta 2012 na vzhodnem delu (v bližini rta Marleri). Avtorji pripisujejo kolonizacijo oddaljenih območij intenzivnemu prometu poleti z ladijami od leta 2010/2011. Propagule so verjetno odgovorne za kolonizacijo; *C. cylindracea* je najdena tudi na otoku Unije, ki se nahaja približno 30 km južno od rta Kamenjak.

NAMEN IN CILJI DELA, HIPOTEZE

Namen teze je predstaviti stanje travnikov Posidonije, ki merijo travno gostoto in preverjajo njeno kvaliteto (kategorijo) na dveh različnih področjih (referenčne in vplivne, po Pergent in sodelavci, 1995). Ta metoda mi bo dala podatke, ki so pomembni za zaščito. Predstavil bom aktualen popis morskih vrst, biocenoze in vrst, ki uživajo pravno varstvo, kot podlaga za upravljanje načrta MZO v morskem območju rta Kamenjak. Koncept dela si prizadeva, da se približimo prihodnjemu varstvu morskega območja, kakor je bilo že omenjeno (Požar-Domac in Bakran-Petricioli, 1996; Vučetić in Vučetić, 2000), na način, da postane del omrežja posebej zavarovanega območja z organiziranim in trajnostnim gospodarjenjem z okoljem, skupaj z zainteresiranimi stranmi, ki se temelji na informacijah prostornega načrta, in kjer so predlagana štirje posebni morski rezervati, ki bi izhajali iz pregleda travnika Posidonije.

Raziskava obiskovalcev rta Kamenjak bo zagotovila vpogled v to, katere so splošne šibkosti in prednosti pokrajine in možnosti za izvajanje zelenega turizma, ki bo spodbujal ekološko zavest morskega ekosistema. Informacije o turistični infrastrukturi in zmogljivostih na rtu Kamenjak in okolici bodo analizirani in omogočili splošen vpogled v smeri ohranjanja Posidonije in ukrepe za njeno upravljanje.

Cilji dela so:

- Predstaviti stanje travnikov Posidonije v morskem območju SKMA,

- Opredeliti ključne dejavnike, ki ogrožajo biocenozo Posidonije,

- Sestaviti popis vrst, biocenoz in karakterističnih (ogroženih) vrst,

- Določiti turistično infrastrukturo, ki jo je treba izboljšati, in zagotoviti načrt upravljanja, ki bo zagotovil boljše prihodnje upravljanje območja,

- Predstaviti režimsko podlago za zaščito in coniranje MZO Kamenjak.

Teza temelji na naslednjih dveh hipotezah:

(1) Uporaba morskega območja LKMA ni trajnostna in kot taka lahko povzroči postopno izginotje (lokalno izumrtje) posidonskih habitatov.

(2) Turistična infrastruktura na Kamenjaku je dobro razvita; z ustreznimi prihodnjimi ukrepi upravljanja v zvezi z morskimi dejavnostmi (npr. privezovalni sistem, sidrenje, ribolov, potapljanje) morskih območjih je treba zaščititi in sočasno podpirati zeleni turizem.

MATERIALI IN METODE

Podan je pregled trenutnega biološkega in sociološkega stanja pomembne krajine SKMA. Predstavljene so morske biocenoze in ključne vrste na Kamenjaku, problemi v zvezi z degradacijo habitata in turistično infrastrukturo južnega dela Istre (naselje Premantura).

V glavnih zalivih Spodnjeg Kamenjaka (Polje, Portić Debeljak in Škokovica) so potekale študije na terenu z biološkim biologom (Petar Kružić) v juniju in septembru, da bi se izognili povečanemu pomorskemu prometu, torej nesreči. Zapisane biocenoze so identificirane z uporabo "Priročnika za določanje morskih habitatov na Hrvaškem v skladu z direktivo EU o habitatih" (Bakran-Petricioli, 2011) in bodo podvržene klasifikaciji Nacionalnega klasifikacijskega sistema in Nature 2000.

Kružić (2014) je prepoznal, da je morsko območje okoli Porerja pomembno "*zaradi svoje izjemne lepote morskega življenja in velike biotske raznovrstnosti vrst, ki zaslužijo višjo stopnjo zaščite*". To znanje sem vključil v spremenljivki in pustil območje Porerja kot ločen ali nedotaknjen predel, medtem ko so notranji del zaliva Medulin in zalivi Spodnjega Kamenjaka kot prizadeta območja. Razlike v travni gostoti med Porerjem in prizadetimi območji so mi prikazale splošno stanje travnika Posidonije na morskem območju SKMA.

Razširjenost invazivne vrste *C. racemosa*, (*C. cylindracea*) je pomembna tudi za temo, tako da so pregledane vse (nove) informacije o njeni kolonizaciji.

Preiskave obiskovalcev (Sociološki vidiki)

Raziskava se bo nanašala tudi na obiskovalce te pomembne pokrajine, da bi dobil splošno sliko (prednosti, slabosti, priložnosti) in s tem lahko objektivno predlagal ukrepe, ki bi lahko izboljšali kakovost turistične ponudbe.

REZULTATI IN DISKUSIJA

Travniki na referenčnih postajah so bili bolj zvezni kot na drugih postajah. V Medulinskem

zalivu (prizadete postaje), vrste omejitve ni bilo mogoče določiti zaradi bolj ali manj širokih erozivnih objektov pokritih s peskom ali mrtvimi snovi (materiali). Tudi travniki imajo znaten del plagiotropskih listov, ki kažejo na potencial za rast (Caye, 1980). Travniki na referenčnih postajah se razlikujejo od drugih, ker tvorijo bolj konstantno travno mrežo, povezano s plagiotropnimi koreninami. V Medulinskem zalivu so korenke bolj združene in variabilne. Obstaja veliko erozijskih struktur in področij s peskom ali življenjske združbe infralitoralnih alg. Po klasifikaciji UNEP-RAC/SPA (2011), so na postajah A1, B1 in B2 travniki v slabem stanju, na postaji, medtem ko je samo na postaji A2 stanje zmerno.

Ogrožene in/ali redke vrste najdene na študijskem območju so: *Cymodocea nodosa*, *Posidonia oceanica*, *Zosteri noltii*, *Pinna nobilis*, *Lithophaga lithophaga*, *Spongia* (*Spongia*) *officinalis*, *Hippospongia communis*. Obstaja skupaj 19 živalskih vrst, ki so strogo zaščitene ali zaščitene v okviru NZV (UL, 80/13) in mednarodnih konvencij. Morsko območje okoli Kamenjaka se uporablja celoletno ali sezonsko, kar je določeil Elvis Zahtila (neobjavljeni članek za Javno Institucijo Kamenjak) in v inventarju Petra Kružića (2012). V južnem delu Kamenjaka (zaliv Kolumbarica) je širitev travnikov *C. racemose* opažena najmanj v zadnjih štiri letih. Zabeležena je na treh posnetih travnikih, ki se rastezajo na globini od 17.7 do 22.3 metra.

Skupaj je bilo zaključenih 148 vprašalnikov, 38 jih je bilo v hrvaščini, 44 v nemščini, 43 v italijanščini in 23 v angleščini. Na splošno so to obiskovalci, ki prihajajo že več let, iščejo počitek in stik za naravo, morske aktivnosti ter menijo da nekatere infrastrukture parkov zahtevajo prerazporeditev (predvsem cest in parkirišč).

Dela (npr. Kružić, 2012, 2014, OG Istrske županije 2/09) in osebni podatki mi dajejo vpogled v to, da so v glavnem vsi zalivi spodnjega Kamenjaka pod stalnim pritiskom že dolgo časa in so nepovratno razdrobili travnike na manjše dele. Rezultat tega je izguba funkcij ekosistema, kot strukturnih/habitatnih vrst (Boudouresque in sodelavci, 2012). Ogroženost travnikov Posidonije v Medulinskem zalivu je posledica nereguliranega sidrenja in širjenja kaulerpe, katere travnike so odkril žei poleti 2016. Osebni raziskovalni podatki kažejo na diskontinuiteto travnikov (zlasti na postaji B1) in na prisotnost mrtvih listov Posidonije. Lahko se olajša širjenje kaulerpe, saj je razvidna njena širitev predvsem na robnih in/ali (degradiranih) delih (Ruitton in sodelavci, 2005a; Infante in sodelavci, 2011).

Veliko obiskovalcev ostane na Kamenjaku vsaj en teden, kar omogoča njihovo vključevanje v izobraževalne programe na morski komponenti. Izobraževalni programi spodbujajo ozaveščenost o ekoloških vprašanjih in s tem predstavljajo obiskovalcem trenutno stanje v naravi, tako prihajajo v neposredni stik z naravo, kar obiskovalci Kamenjaka pričakujejo od svojega obiska. To bi lahko služilo kot orodje za spodbujanje izobraževanja turistov, pa tudi za spremljanje procesa na fiksnih lokacijah.

SKLEPI

Morsko območje Kamenjaka je redko mesto v obalni coni Istrske Županije, kjer so prisotni travniki Posidonije (ne le otoki), ampak so ogroženi zaradi izgube svojih ekosistemkih

funkcij. Osredotočen turizem na Kamenjaku lahko dvigne standard turizma in zagotavi novo in še posebej pomembno znanje o travnikih Posidonije na Jadranu. Saj se travniki v severnem Jadranu razlikujejo od travnikov raziskanih v večini Mediterana.

Za ohranjanje biotske raznovrstnosti v času hitrega razvoja človeške populacije je potrebno nadaljevati razvoj regionalnega/lokalnega sistema upravljanja zavarovanih območij in ekoloških omrežij. Ozaveščanje javnosti, spodbujanje udeležbe pri odločanju in sprememba pravnih meril za napredek pri inventuri in ocenjevanju biološke raznovrsnosti je smer, v kateri bi si morali prizadevati (Nacionalni Institut za Varstvo Narave RH, 2008).

7 REFERENCES

Agardy, T. S., 1994. Advances in marine conservation: the role of marine protected areas. Elsevier Science Ltd. Vol. 9, No. 7.

Agardy, T. S., 1997. Marine Protected Areas and Ocean Conservation. Austin, TX: R.G. Landes Company.

Alban, F., Appéré, G., Boncoeur, J., 2006. Economic Analysis of Marine Protected Areas. A Literature Review. EMPAFISH Project, 51 pp.

Andrade, G. S. M., Rhodes, J. R., 2012. Protected areas and local communities: an inevitable partnership toward successful conservation strategies? Ecology and Society 17(4): 14.

Annual program for protection, maintenance, preservation, promotion and use of protected areas of the Medulin municipality (significant landscape "Lower Kamenjak and Medulin archipelago", significant landscape Upper Kamenjak, Park "Brdo Soline" near Vinkuran, Park "Kašteja") for 2015. Premantura, 19 January 2015. http://www.kamenjak.hr/Dokumenti/godisnji_program_2015.pdf (18.2.2016)

Artegiani, A., Bregant, D., Paschini, E., Pinardi, N., Raicich, F., Russo, A., 1997b. The Adriatic Sea General Circulation. Part II: baroclinic circulation structure. J. Phys.Oceanogr. 27, 1515-1532.

Badalamenti, F., Ramos, A. A., Voultsiadou, E., Sánchez Lizaso, J. L., D'Anna, G., Pipitone, C., Mas, J., Ruiz Fernandez, J. A., Whitmarsh, D., Riggio, S., 2000. Cultural and socio-economic impacts of Mediterranean Marine Protected Areas. Environmental Conservation, 27, No.2, pp. 110-125.

Bakran-Petricioli, T., 2011. Handbook for determining marine habitats in Croatia according to EU Habitats directive. State Institute for Nature Protection. ISBN 978-953-7169-31-2.

Balata, D., Piazzi, L., Cinelli, F., 2004. A comparison among assemblages in areas invaded by *Caulerpa taxifolia* and *C. racemosa* on a subtidal Mediterranean rocky bottom. Marine Ecology, 25 (1): 1-13.

Bearzi, G., Fortuna, C. M., 2006. Common bottlenose dolphin (*Tursiops truncatus*). Mediterranean subpopulation. The status and distribution of cetaceans in the Black Sea and Mediterranean Sea, 137.

Bearzi, G., Fortuna, C. M., 2012. *Tursiops truncatus* (Mediterranean subpopulation). in: IUCN 2013 (Ed.). IUCN Red List of Threatened Species. Version 2013.2.

Bearzi, G., Fortuna, C. M., Reeves, R. R., 2008b. Ecology and conservation of common bottlenose dolphins *Tursiops truncatus* in the Mediterranean Sea. Mammal Review, 39, 92-123.

Bearzi, G., Holcer, D., Di Sciara, G. N., 2004. The role of historical dolphin takes and

habitat degradation in shaping the present status of northern Adriatic cetaceans. Aquatic Conservation, 14, 363-379.

Benović, A., Justić, D., Bender, A., 1987. Enigmatic changes in the hydromedusan fauna of the Northern Adriatic Sea. Nature, 326, 597-600.

Bell, J. D., Harmelin-Vivien M. L., 1982. Fish fauna of Frenc Mediterranean Posidonia oceanica seagrass meadow. 1. Comunity structure. Tethys, 10 (4): 337-347.

Belton, G. S., van Reine, W. F., Huisman, J. M., Draisma, S. G., D Gurgel, C. F., 2014. Resolving phenotypic plasticity and species designation in the morphologically challenging *Caulerpa racemosa-peltata* complex (Chlorophyta, Caulerpaceae). Journal of Phycology, 50: 32–54. doi:10.1111/jpy.12132

Beqiraj, S., Kashta, L., 2007. Te dhena paraprake per makrofaunen bentike shoqeruese te livadheve te *Posidonia oceanica* ne bregdetin shqiptar. Buletini i Shkencave Natyrore. Universiteti i Shkodres. 58, 107 – 121.

Beqiraj, S., Kashta, L., Kuci, M., Kasemi, D., Mato, X., Gace, A., 2008. Benthic macrofauna of *Posidonia oceanica* meadows in the Albanian coast. Natura Montenegrina, Podgorica, 7, 55-69.

Boudouresque, C. F., Mayot, N., Pergent, G., 2006. The outstanding traits of the functioning of the *Posidonia oceanica* seagrass ecosystem. Biol. Mar. Medit. 13, (4): 109-113.

Blue World Institute. Aqustic. http://www.plavi-svijet.org/hr/znanost/metode-istrazivanja/akustika/ (11.09.2016)

Blue World Institute. Fotoidentification. http://www.plavi-svijet.org/hr/znanost/metode-istrazivanja/fotoidentifikacija/ (11.09.2016)

Blue World Institute. Report on a research of Adriatic dolphin (January-December, 2014). prosinac). http://www.plavi-svijet.org/media/files/BWI_ZAVRNO_IZVJEE_2014.pdf (14.10.2016)

Boudouresque, C. F., Bernard, G., Bonhomme, P., Charbonnel, E., Diviacco, G., Meinesz, A., Pergent, G., Pergent-Martini, C., Ruitton, S., Tunesi, L., 2012. Protection and conservation of *Posidonia oceanica* meadows. Publikacija RAMOGE & RAC/SPA , Tunis: 1-202. ISBN: 2-905540-31-1.

Boyd, D. M., 2007. Why youth (heart) social network sites: The role of networked publics in teenage social life. In D. Buckingham (Ed.), Youth, identity, and digital media volume (pp. 119142). Cambridge, MA: MIT Press.

Breithaupt, H., 2003. Aliens on the shores. Biodiversity and national economies are being threatened by the invasion of non-native species. EMBO reports, 4 (6): 547-550.

Buia, M. C., Gambi, M. C., Dappiano, M., 2004. Seagrass systems. Biologia Marina Mediterranea 11 (suppl. 1), 133-183.

Bulleri, F., Alestra T., Ceccherelli, G., Tamburello, L., Pinna, S., Sechi, N., Benedetti-Cecchi, L., 2011. Determinants of *Caulerpa racemosa* distribution in the north-western Mediterranean. Marine Ecology Progress Series, Vol. 431, p. 55-67. ISSN 0171-8630.

Camuffo, D., Secco, C., Brimblecombe, P., Martin-Vide, J., 2000. Sea storms in the Adriatic Sea and the Western Mediterranean during the last millennium. Climatic Change. 46, 209-223.

Carlton, J. T., Ruiz, G. M., 2005. The Magnitude and Consequences of Bioinvasions in Marine Ecosystems: Implications for Conservation Biology. U: Norse, E. A., Crowder, L. B. (ur.) Marine conservation biology, Island press, Washington, p. 123 – 148.

Casale, P. 2015. *Caretta caretta* (Mediterranean subpopulation). The IUCN Red List of Threatened Species, 2015. e.T83644804A83646294. http://dx.doi.org/10.2305/IUCN.UK.2015-4.RLTS.T83644804A83646294.en (18.02.2016)

Casale, P., Affronte, M., Scaravelli, D., Lazar, B., Vallini, C., Luschi, P., 2012. Foraging grounds, movement patterns and habitat connectivity of juvenile loggerhead turtles (*Caretta caretta*) tracked from the Adriatic Sea. Marine Biology. 159 (7): 1527-1535.

Ceccherelli, A. G., Campo, D., 2002. Different effects of *Caulerpa racemosa* on two co-occurring seagrasses in the Mediterranean. Botanica Marina, 45: 71-76.

Ceccherelli, G., Piazzi, L., Cinelli, F., 2000. Response of non–indigenous *Caulerpa racemosa* (Forsskål) J. Agardh to the native seagrass *Posidonia oceanica* (L.) Delile: effect of density of shoots and orientation of edges of meadows. Journal of Experimental Marine Biology and Ecology, 243: 227–240.

Ceccherelli, G., Pinna, S., Cusseddu, V., Bulleri, F., 2014. The role of disturbance in promoting the spread of the invasive seaweed *Caulerpa racemosa* in seagrass meadows. Biological Invasions, 16 (12), 2737–2745. http://doi.org/10.1007/s10530-014-0700-7

Convention on Biological Diversity, 2011. Strategic Plan for Biodivesity 2011-2020 and the Aichi Targets. http://www.cbd.int/sp/targets/ (22.02.2016)

Council of Europe. Convention on the Conservation of European Wildlife and Natural Habitats. http://www.coe.int/en/web/conventions/full-list/-/conventions/treaty/104 (07.11.2015)

Deery, M., Leo, J., Liz, F., 2005. A framework for the development of social and socioeconomic indicators for sustainable tourism in communities. Tourism Review International, Volume 9, Number 1, (9): 69-77.

Degobbis, D., Precali, R., Ivancis, I., Smodlaka, N., Fuks, D., Kveder, S., 2000. Long-term changes in the northern Adriatic ecosystem related to anthropogenic eutrophication. International Journal of Environment and Pollution, 13: 495-533.

DG Environment, 2007. Guidance document on the strict protection of animal species of Community interest under the Habitats Directive 92/43/EEC.

Dixon, J. A., 1993. Marine resources conservation (Economic aspects). Oceanus, Woods Hole Oceanographic Institution, Magazine/Journal. ISSN: 0029-8182.

Dudley, N. (Ed.), 2008. Guidelines for Applying Protected Area Management Categories, Gland, Switzerland: IUCN. x + 86pp.

Dulčić, J., 2002. Northernmost occurrence of *Sphoeroides pachygaster* (Tetraodontidae) in the Adriatic Sea. Bulletin of Marine Science, 70, 133-139.

Dulčić, J., Grbec, B., Lipej, L., 1999. Information on the Adriatic ichthyofauna - effect ofb water warming? Acta Adriat. 40(2): 33-43.

Đakovac, T., 2006. Učestalost i uvjeti nastajanja cvjetanja mora, izrazite hipoksije i anoksije u sjevernom Jadranu. Doktorska disertacija, Sveučilište u Zagrebu, 139 pp.

Đakovac, T., Supić, N., Bernardi Aubry, F., Degobbis, D., Giani, M., 2015. Mechanisms of hypoxia frequency changes in the northern Adriatic Sea during the period 1972–2012. Journal of Marine Systems, *141*, 179–189. http://doi.org/10.1016/j.jmarsys.2014.08.001

Eagles, P. F. J., McCool, S. F., Haynes, C. D., 2002. Sustainable Tourism in Protected Areas: Guidelines for Planning and Management. IUCN Gland, Switzerland and Cambridge, UK. xv + 183pp.

EU Commission, Management Plan 2015. Ref. Ares(2015)3527314 - 26/08/2015

http://ec.europa.eu/atwork/synthesis/amp/doc/fisma_mp_en.pdf (19.3.2016)

Epstein, Y., 2014. The Habitats Directive and Bern Convention: Synergy and Dysfunction in Public International and EU law. Georgetown International Environmental Law Review, GIELR.

Ferraro, G., Bulgarelli, B., Meyer-Roux, S., Muellenhoff, O., Tarchi, D., Topouzelis, K., 2008. The use of satellite imagery from archives to monitor oil spills in the Mediterranean Sea. U: Barale, V., Gade, M. (ur.) Remote Sensing of the European Seas. Springer, Heidelberg, str. 371 – 382.

Francese, M., Zucca, P., Picciulin, M., Zuppa, F., Spoto, M., 1999. Cetaceans living in the North Adriatic Sea (Gulf of Trieste–Grado lagoon): intervention protocol for healthy and distressed animals. European Research on Cetaceans 13, 410-415.

Francour, P., 1997. Fish assemblages of Posidonia oceanica bed at Port Cros (France, NW Mediterranean): Assessment of composition and long-term fluctuations by visual cenzus. Marine Ecology. PSZNI, 18 (2): 157-173.

Frankić, A., 2004. Conservation and Sustainable Use of Biodiversity in the Dalmatian Coast through Greening Coastal Development, Progress Report, UNDP/GEF 'Coast' Project.

Gaines, S.D., White, C., Carr, M.H., Palumbi, S.R., 2010. Designing marine reserve networks for both conservation and fisheries management. Proceedings of the National Academy of Sciences 107: 18286–18293.

Gaspari, S., Holcer, D., Mackelworth, P., Fortuna, C., Frantzis, A., Genov, T., Vighi, M., Natali, C., Rako, N., Banchi, E., Chelazzi, G., Ciofi, C., 2015. Population genetic structure of common bottlenose dolphins (*Tursiops truncatus*) in the Adriatic Sea and contiguous regions: Implications for international conservation. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *25*(2), 212–222. http://doi.org/10.1002/aqc.2415

Gaspari, S., Natoli, A., 2012. *Grampus griseus* (Mediterranean subpopulation). in: IUCN 2013 (Ed.). IUCN Red List of Threatened Species.

Gershon, R. A., 2013. Facebook: A Business Perspective on the Power of Intelligent Networking and Social Media. Handbook of Social Media Management, 375-389. DOI 10.1007/978-3-642-28897-5_21

Glas Istre, 2013. http://www.glasistre.hr/vijesti/specijalna/kamenjakom-sve-vise-biciklom-i-pjesice-425705 (18.2.2016)

Gomerčić, H., Đuras Gomerčić, M., Gomerčić, T., Lucić, H., Škrtić, D., Ćurković, S., Vuković, S., Huber, Đ., Gomerčić, V., Bubić Špoljar, J., 2006b. Abundance and mortality of Risso's dolphins (*Grampus griseus*) in the last 15 years in the Croatian part of the Adriatic Sea. in: Bessendorfer, V., Klobučar, G.I.V. (Eds.). 9th Croatian Biological Congress. Croatian Biological Society, Rovinj, pp. 297-298.

Govan, H., 2011. Good coastal management practices in the Pacific: experiences from the field. – Apia, Samoa: SPREP, 42 p.

Guala, I., Di Carlo G., Jakl, Z., et al., 2012. Monitoring of Posidonia oceanica meadows in Croatian Protected Areas. Association Sunce Technical Report, January 2012, 40 pp. + Annexes.

Croatian Chamber of Economy, Division of Tourism, 2012. Main plan and strategy for the development of tourism. Ministry of Tourism of the Croatia Republic. The Institute for Tourism, Zagreb. Ur.br : 311-15-12-01.

Infante, E., Terrados, T., Orfila, A., 2011. Assessment of substratum effect on the distribution of two invasive *Caulerpa* (Chlorophyta) species. Estuarine, Coastal and Shelf Science, 91: 434–441.

Institute for Spatial Planning of the Istrian County, 2002. Spatial Plan of the Istria County. Official Gazette of the Istrian County 02/02.

Institute for Spatial Planning of the Istrian County, 2009. Spatial Plan of the special features of Lower Kamenjak and Medulin archipelago. Official Gazette of the Istrian County 2/09.

IMO, 2000-2004. Global Ballast Water Management Project: The Problem, http://globallast.imo.org/index.asp?page=problem.htm&menu=true (15.5.2016)

Istra. Official tourist website of Istria. Wrecks. http://www.istra.hr/hr/atrakcije-i-aktivnosti/sport/ronjenje/potonuli-brodovi (08.05.2016)

IstraMet. Caulerpa racemosa prijeti jugu Istre. http://www.istramet.com/caulerpa-racemosa-prijeti-jugu-istre/ (07.05.2015)

IUCN. 2015. IUCN Red List of Threatened Species. Version 2015. 2. http://www.iucnredlist.org/details/3897/0 (18.2.2015)

IUCN RedList. The IUCN Red List of Threatened Species (2016) http://www.iucnredlist.org/details/16369383/0 (11.09.2016)

IUCN - The World Conservation Union, 2002. Policy ecommendations Papers for Sixth meeting of the Conference of the Parties to the Convention on Biological Diversity (COP6). The Hague, Netherlands, 7-19 April 2002.

IUCN - The World Conservation Union, 2004. Report of the Seventh Meeting of the Conference of the Parties to the Convention on Biological Diversity (UNEP/CBD/COP/7/21). Gland, Switzerland: IUCN.

IUCN - WCPA, 2008. Establishing Resilient Marine Protected Area Networks - Making it Happen. Washington, DC: IUCNWCPA.

Iveša, N., Vojnić, N., Komšo, D., 2015. Istrian underwater story. Book. Kershoffset, Zagreb. ISBN 978-953-7001-33-9.

Jakl, Z., Šijan, M., Prvan, M., Sertić, M., Čavrak, V., Derezanin, L., Boi, S., Guala, I., 2015. Monitoring of *Posidonia oceanica* meadows in Telašćica Nature Park (Croatia). Forth Mediterranean Seagrass Workshop - Sardinia 2015, Oristano, Italy, 18th-22nd May 2015.

Javna Ustanova Kamenjak. http://www.kamenjak.hr/hr/ (04.02.2015)

Johnson, W. M., and D. M., Lavigne., 1998. The Mediterranean Monk Seal. Conservation Guidelines. Multilingual Edition. International Marine Mammal Association Inc., Guelph, Ontario, Canada. ISBN 0-9698171-4-2

Kovačević, Z., 2002. History and political ecology of the Adriatic Sea. Religion, Science and the Environment: Adriatic Sea Symposium. 8 pp. http://www.rsesymposia.org/themedia/File/1151678043-Kovacevic.pdf (02.06.2016)

Kružić, P., 2012. Mapping of marine habitats on the area of the Public Institution Kamenjak. NATURA - The Association for the Protection of Nature in Croatia, Report, Zagreb..

Kružić, P. 2014. Monitoring seagrass *Posidonia oceanica* on the area of the Public Institution Kamenjak. NATURA - The Association for the Protection of Nature in Croatia, Report, Zagreb.

Lazar, B., Margaritoulis, D., Tvrtkovic, N., 2004. Tag recoveries of the loggerhead sea

turtle *Caretta caretta* in the eastern Adriatic Sea: implications for conservation. Journal of the Marine Biological Association of the United Kingdom, (84): 475-480.

Lee, T. H., 2013. Influence analysis of community resident support for sustainable tourism development. Tourism Management. 34: 37-46

Lipej, L., Dulčić, J., 2004. The current status of the Adriatic fish biodiversity. In: Griffiths H.I. et al. (eds.): Balkan Biodiversity. Kluwer Academic Publishers. Dordrecht, Boston, London. 291-306.

Lipej, L., Mavrič, B., 2013. New northernmost record of the blunthead pufferfish, *Sphoeroides pachygaster* (Osteichthyes: tetraodontidae) in the Mediterranean sea. Annales. Series historia naturalis, 103-114.

Lotze, H. K., Lenihan, H. S., Bourque, B. J., Bradbury, R. H., Cooke, R. G., Kay, M. C., Kidwell, S. M., Kirby, M. X., Peterson, C. H., Jackson, J. B. C., 2006. Depletion, degradation, and recovery potential of estuaries and coastal seas. Science. 312: 1806-1809.

Norse, E. A., Crowder, L. B., 2005. Marine Conservation Biology: The science of maintaining the sea's biodiversity. Marine Conservation Biology Institut. Island Press, 1718 Connecticut Ave., Suite 300, NW, Washington, DC 20009. ISBN 1-55963-661-0

Nykjaer, L., 2009. Mediterranean Sea surface warming 1985-2006. European Commission, Joint Research Centre, Institute for Environment and Sustainability, Italy. (39): 11-17. DOI: 10.3354/cr00794

Massutí, E., Valls M., Ordines F., 2010. Changes in the western Mediterranean ichthyofauna: signs of tropicalisation and meridianizations. In: Golani, D., Appelbaum-Golani, B., (eds.): Fish invasions of the Mediterranean Sea: Change and renewal. Pensoft Publishers, Sofi-Moscow, p. 293–312.

Matijašić, R., 2012. Još jedan primjer fosiliziranoga antičkog krajolika u Istri: Rt Kamenjak (Premantura, Pula). Tabula 10, UDK 904:712.2/.4>(497.5-3Istra-13)«652«

Merrifield, M. S., McClintock, W., Burt, C., Fox, E., Serpa, P., Steinback, C., Gleason, M., 2013. MarineMap: A web-based platform for collaborative marine protected area planning. Ocean and Coastal Management. 74: 67-76.

Milazzo, M., Badalamenti, F., Ceccherelli, G., Chemello, R., 2004: Boat anchoring on *Posidonia oceanica* beds in a marine protected area (Italy, western Mediterranean): effect of anchor types in different anchoring stages. Journal of Experimental Marine Biology and Ecology, Volume 299, Issue 1, pp. 51-62.

Mikac, B., Žuljević, A., 2003. Audio / video recording. Save *Posidonia oceanica* meadows treasury of biological diveristy of the Adritic Sea. http://www.youtube.com/watch?v=ZgYY5rvz8yo (11.09.2016)

Moreno D., Aguilera P.A., Castro H., 2001. Assessment of the conservation status of

seagrass (*Posidonia oceanica*) meadows: implications for monitoring strategy and the decisionmaking process. Biological Conservation 102, 325-332.

MPAtlas. Atlas of Marine Protection. http://www.mpatlas.org (15.05.2015)

Myers, R. A., Barrowman, N. J., Hutchings, J. A., Rosenberg, A. A., 1995. Population dynamics of exploited fish stocks at low population levels. Science, New Series, Volume 269, Issue 5227, pp. 1106-1108.

Occhipinti-Ambrogi, A., 2007. Global change and marine communities: Alien species and climate change. Marine Pollution Bulletin. 55: 342-352.

Occhipinti–Ambrogi, A., Savini, D., 2003. Biological invasions as a component of global change in stressed marine ecosystems. Marine Pollution Bulletin, 46: 542–551.

Olsen, E. M., Johnson D., Weaver P., Goñi R., Ribeiro M. C., Rabaut M., Macpherson E., Pelletier D., Fonseca L., Katsanevakis S., Zaharia T., 2013. Achieving Ecologically Coherent MPA Networks in Europe: Science Needs and Priorities. Marine Board Position Paper 18. Larkin, K. E. i McDonough N. (Eds.). European Marine Board, Ostend, Belgium.

Operational Programme Competitiveness and Cohesion 2014 – 2020. http://www.strukturnifondovi.hr/UserDocsImages/Documents/OPKK_2014_20_FINALNI_NACRT_21_07_2014.pdf. (28.5.2016)

Ott, J. A., 1992. The Adriatic benthos: problems and perspectives. In: Colombo G, Ferrari I, Ceccherelli VD, Rossi R, editors. Marine Eutrophication and Population Dynamics: 25th European Marine Biology Symposium, Ferrara (Italy), 10–15 September 1990. International Symposium Series pp. 367–378.

Panayotidis, P., Boudouresque, C. F., Marcot-Coqueugniot., 1981. Microstructure de l'herbier de *Posidonia oceanica* (Linnaeus) Delile. Botanica Marina 24(3), 115-124.

Pergent, G., Pergent-Martini, C., Boudouresque, C.F., 1995. Utilisation de l'herbier à *Posidonia oceanica* comme indicateur biologique de la qualité du milieu littoral en Méditerranée: état des connaissances. Mésogée 54, 3-27.

Pfueller, S. L., Lee, D., Laing, J., 2011. Tourism Partnerships in Protected Areas: Exploring Contributions to Sustainability. Environmental Management. Volume 48, Issue (4): 734-749.

Precali, R., Iveša, Lj., Bihari, N., Travizi, A., Vrgoč, N., Dulčić, J., Peharda Uljević, M., Čikeš Keč, V., Isajlović, I., Deagičević, B., Ezgeta Balić, D., Zorica, B., 2013. Analysis of descriptors under the Regulation of establishing a framework for action of the Republic of Croatia in the field of the marine environmental protection, Annex I (OG, 136/11) for Region of Istria (ADUR-RI), Ruđer Bošković Institute, Center for Marine Research, Rovinj, 114pp.

Piazzi, L., Cinelli, F., 1999. Développement et dynamique saisonniére d'un peuplement méditerranéen de l'algue tropicale *Caulerpa racemosa* (Forsskål) J. Agardh.

Cryptogamie, Algologie, 20(4): 295–300.

Piazzi, L., Cinelli, F., 2003. Evaluation of benthic macroalgal invasion in a harbour area of the western Mediterranean Sea. European Journal of Phycology, 38: 223 -231.

Piazzi, L., Ceccherelli, G., Cinelli, F., 2001. Threat to macroalgal diversity: effects of the introduced green alga *Caulerpa racemosa* in the Mediterranean. Marine Ecology Progress Series. 210: 149–159.

Požar-Domac, A., Bakran-Petricioli, T., 1996. Protection, management and sustainable development of the Croatian costal zone. Partnership in Coastal zone Management, Samara Pulishing Limited, Cardigan, p. 73-77.

Puhr, K., Schultz, S., Pikelj, K., Petricioli, D., Bakran-Petricioli, T., 2014. The performance, application and integration of various seabed classification systems suitable for mapping *Posidonia oceanica* (L.) Delile meadows. Sci. Total Environ. 470-471: 364-78.

RAC/SPA - UNEP/MAP, 2014. Monitoring protocol for *Posidonia oceanica* beds. By Guala, I., Nikolić, V., Iveša, Lj., Di Carlo, G., Rajković Z., Rodić, P., Jelić, K., Ed. RAC/SPA - MedMPAnet Project, Tunis. 37 pages + annexes.

RAC/SPA – UNEP/MAP, 2014. Prvan M, Jakl Z, Guala I. Terenski vodič za praćenje stanja livada morske cvjetnice Posidonia oceanica (livade posidonije), RAC/SPA - MedMPAnet Projekt, Tunis : 16 p.

UNEP-MAP-RAC/SPA, 2015. Adriatic Sea: Important areas for conservation of cetaceans, sea turtles and giant devil rays. By Holcer, D., Fortuna, C. M., Mackelworth, P. C.. Ed. RAC/SPA, Tunis. 69 pp.

Ribarič, D., Herlec, T., 2008: Velika pliskavka (*Tursiops truncatus*) v morju pred rtom Kamenjak: prvo poročilo. Vpliv človekovih dejavnosti na morju, morskem obrežju in zalednju na biotsko raznovrstnost severnega Jadrana; Mednarodno strokovno srečanje, Piran, Slovenija.

Ricciardi, A., 2004. Assessing species invasions as a cause of extinction. Trends in Ecology and Evolution, 19 (12): 619.

Ruitton, S., Verlaque, M., Aubin, G., Boudouresque, C. F., 2006. Grazing of the invasive variety of Caulerpa racemosa (Caulerpales, Chlorophyta) in the Mediterranean Sea by herbivorous fish and sea urchins. Vie Milieu 56, 33-41.

Ruitton, S., Javel, F., Culioli, J. M., Meinesz, A., Pergent, G., Verlaque, M., 2005a. First assessment of the *Caulerpa racemosa* (Caulerpales, Chlorophyta) invasion along the French Mediterranean coast. Marine Pollution Bulletin, 50: 1061–1068.

Sanchirico, J. N., Cochran, K. A., Emerson, P. M., 2002. Marine Protected Areas: Economic and Social Implications. Resources for the Future, Discussion Paper 02-26. http://www.rff.org/documents/RFF-DP-02-26.pdf (09.07.2015)

Schultz, S., 2008: Seagrass monitoring by underwater videography: Disturbance regimes,

sampling design, and statistical power. Aquatic Botany (0304-3770) 88, 3: 228-238.

Schultz, S., Kruschel, C., Bakran-Petricioli, T., Petricioli, D., 2015: Error, Power and Blind Sentinels: The Statistics of Seagrass Monitoring. PLoSONE 10 (9): e0138378. doi:10.1371/journal.pone.0138378

Solidoro, C., Bastianini, M., Bandelj, V., Codermatz, R., Cossarini, G., Melaku Canu, D., Ravagnan, E., Salon, S., Trevisani, S., 2009. Current state, scales of variability and decadal trends of biogeochemical properties in the Northern Adriatic Sea. Journal of Geophysical Research. DOI: 10.1029/2008JC004838.

State Institute for Nature Protection, 2008: Report on the state of nature and nature conservation in the Republic of Croatia for the period 2000-2007. Zagreb.

State Institute for Nature Protection, 2014: Report on the state of nature in the Republic of Croatia for the period 2008-2012. Zagreb.

State Statistical Bureau of the Republic of Croatia, Settlements and population 1990-2001, 2005.

Stachowitsch, M., 1992. Benthic communities: eutrophication's „memory mode“. Sci. Total. Environ., Suppl: 1017-1028.

Stevčić, Z., 1964. Rakovica, “*Maja squinado*”, kao ribarstveni objekt. Acta Adriatica, 11 (35): 261-266

Stevčić, Z., 1971. Laboratory observation on the aggregations of the spiny spider crab (*M. squinado* Herbst). Animal Behaviour, 19: 18-25.

Stevčić, Z., 1980. Rakovica – najtipičniji ribolovni objekt Premanture. Prilozi o zavičaju (izd. Čakavski sabor) 2: 163-169.

Streftaris, N. and Zenetos, A., 2006. Alien Marine Species in the Mediterranean - the 100 ‘Worst Invasives’ and their Impact. Mediterranean Marine Science, 7(1): 87-118. DOI:10.12681/mms.180

Supić, N., Grbec, B, Vilibić, I., Ivančić, I., 2004. Long-term changes in hydrographic conditions in northern Adriatic and its relationship to hydrological and atmospheric processes. Annales Geophysicae, European Geosciences Union, 2004, 22 (3), pp.733-745.

Vaugelas, J., De, Meinesz, A., Antolić, B., Ballesteros, E., Belsher T., Cassar, N., Ceccherelli, G., Cinelli, F., Cottalorda, J., M., Orestano, C., Grau, A., M., Jaklin, A., Morucci, C., Relini, M., Sandullir, R., Span, A., Tripaldi, G., Klaveren, P., Van, Zavodnik, N., Žuljević A., 1998. Standardization proposal for the mapping of *Caulerpa taxifolia* expansion in the Mediterranean Sea. Oceanologica Acta (22): 85–94.

Vidas, D., 2009. Protection of the Adriatic. Schoolbook, Zagreb, 274 pp.

Vučetić, V., Vučetić, M., 2000. The role of climatic variations on the establishment of the

adriatic Marine parks. Periodicum biologorum, 102, (1): 489-498.

Vuković, N., Brana, S., Mitić, B., 2011. Orchid diversity of the cape of Kamenjak (Istria, Croatia). Acta Bot. Croat. 70(1), 23-40. DOI: 10.2478/v10184-010-0003-8

Tamburello, L., Benedetti-Cecchi, L., Masini, L., Bulleri, F., 2013. Habitat heterogeneity promotes the coexistence of exotic seaweeds. Oecologia 172 (2), 505-513.

The Nature Conservacy. http://www.nature.org (04.06.2015)

Turk, R., Odorico, R., 2009. Zaščitena morska območja v severnem Jadranu. Varstvo narave, 22: 33-45.

UNDP (ed. Vrgoč, N.), 2012. Marine fisheries: Situation and perspectives on the threshold of EU. Zagreb. ISBN 978-953-7429-39-3

UNEP, 2011. Sub-regional report on the "Identification of important ecosystem properties and assessment of ecological status and pressures to the Mediterranean marine and coastal biodiversity in the Adriatic Sea. in: WG.359/Inf.10, U.D.M. (Ed.). 10th Meeting of Focal Points for SPAs UNEP, Marseille, France, p. 63.

UNEP-RAC/SPA, 2011. Draft Guidelines for the Standardization of Mapping and Monitoring Methods of Marine Magnoliophyta in the Mediterranean. Tenth Meeting of Focal Points for SPAs Marseilles, France, 17-20 May 2011, RAC/SPA Publication, UNEP(DEPI)/MED WG 359/9. 1-63.

UNEP – WCMC, 2012: Aichi Target 11 - Reshaping the global agenda for MPAs. Policy brief. http://www.nature.org/newsfeatures/pressreleases/tnc-marine-policy-brief-2012.pdf (22.05.2016)

Vallarola, F., 2013. Protected Adriatic. The publication released as part of the project "AdriaPAN Secretariat", funded by the organizations MEDPAN, FFEM, MAVA Foundation and Foundation Prince Albert II of Monaco – 2. call 2012-2013. ISBN 978-1-291-56708-3.

Vivamar. An Ambassador of Dolphins between People. http://vivamar.org/ (25.10.2016)

Worms. World Register of Marine Species. 2016. http://www.marinespecies.org (21.09.2016)

WWF International; 2005. Marine protected areas: providing a future for fish and people. Gland, Switzerland, p. 20.

Zavatarelli, M., Baretta, J. W., Baretta-Bekker, J. G., Pinardi, N., 2000. The dynamics of the Adriatic Sea ecosystem: An idealized model study. Deep Sea Research Part I: Oceanographic Research Papers. 47: 937-970.

Zavodnik, N., Zavodnik, D., 1980. O biološkim karakteristikama morskog dna oko Premanture (on biological characteristcs of sea bottom around the cape Premantura). Reports on the homeland (ed. Parlament of Čakovec) 2: 171-177.

Zenetos, A., Gofas, S., Morri, C., Rosso, A., Violanti, D., García Raso, J. E., Çinar, Melih Ertan, Almogi-Labin, A., Ates, A. S., Azzurro, E., Ballesteros, E., Bianchi, C. N., Bilecenoglu, M., Gambi, M. C., Giangrande, A., Gravili, C., Hyams-Kaphzan, O., Karachle, P. K., Katsanevakis, S., Lipej, L., Mastrototaro, F., Mineur, F., Pancucci-Papadopoulou, Maria Antonietta, Ramos-Esplá, Alfonso A., Salas, C., San Martín Peral, Guillermo, Sfriso, A., Streftaris, N., Verlaque, M., 2012. Alien species in the Mediterranean Sea by 2012. A contribution to the application of European Union's Marine Strategy Framework Directive (MSFD). Part 2. Introduction trends and pathways. Biología Marina. Hellenic Centre for Marine Research. Mediterranean Marine Science. 2012, 13(2): 328-352. DOI:10.12681/mms.327

Zrinščak-Šebelić, J., 2015: Premanturska fešta od raki. Posted in RadioHRT, http://radio.hrt.hr/clanak/premanturska-festa-od-raki/92530/ (08.2.2016)

Excerpts of the Official Gazette, Official Journal of the Croatia

OG 30/94, National Protection Act

OG 72/94, National Protection Act

OG 70/05, National Protection Act

OG 139/08, National Protection Act

OG 57/11, National Protection Act

OG 80/13, National Protection Act

Annex A

Species inventory of the marine area of Lower Kamenjak and Medulin archipelago

List of species identified in the marine area of LKMA is gathered from documents by Zahtila, PhD (unpublished article for PI Kamenjak) and Prof. Kružića, PhD (Reports for PI Kamenjak 2012, 2014); red marked relates to the meadow of seagrass *Posidonia* (Kružić, 2014; Beqiraj et al., 2008; Beqiraj and Kashta, 2007).

LISCHENS

Verrucaria adriatica (Zahlbruckner, 1915)

Xanthoria parietina (L.) Beltr.

CYANOPHYTA

Rivularia atra (Roth ex Bornet et Flahault, 1886)

Rivularia mesenterica (Thuret ex Bomet et Flahault, 1886)

RHODOPHYTA

Amphiroa cryptarthrodia (Zanardini, 1844)

Amphiroa rigida (J.V. Lamouroux, 1816)

Botryocladia botryoides (Wulfen) Feldmann, 1941)

Catenella caespitosa (Withering) L.M. Irvine, 1976

Ceramium ciliatum (J. EIis) Ducluzeau, 1806

Ceramium diaphanum (Lightfoot) Roth, 1806

Ceramium virgatum (Roth, 1797)

Corallina officinalis (Linnaeus, 1758)

Dipterosiphonia rigens (Shousboe ex C. Agardh) Falkenberg, 1901

Ellisolandia elongata (J. EIis & Solander) K.R. Hind & G.W. Saunders, 2013

Gelidium spathulatum (Kützing) Bornet, 1892

Gelidium spinosum (S.G. Gmelin) P.C. Silva, 1996

Hydrolithon farinosum (J.V. Lamouroux) D. Penrose & Y.M.Chamberlain, 1993

Jania rubens (Linnaeus) J.V. Lamouroux, 1816

Laurencia obtusa (Hudson) J.V. Lamouroux, 1813

Lithophyllum racemus (Lamarck) Foslie, 1901

Lithothamnion corallioides (P.L. Crouan & H.M. Crouan, 1867)

Mesophyllum lichenoides (J. EIis) Me. Lemoine, 1928

Nemalion helminthoides (Velley) Batters, 1902

Osmundaria volubilis (Linnaeus) R.E. Norris, 1991

Peyssonnelia polymorpha (Zanardini) F. Schmitz, 1879

Peyssonnelia rubra (Greville) J. Agardh, 1851

Phymatolithon calcareum (Pallas) W.H. Adey & D.L. McKibbin, 1970

Phymatolithon lenormandii (Areschoug) W.H. Adey, 1966

Polysiphonia sp.

Pseudolythophyllum sp.

Pterothamnion plumula (J. Ellis) Nageli, 1855

Rytiphloea tinctoria (Clemente) C. Agardh, 1824

Sphaerococcus coronopifolius (Stackhouse, 1797)

Wrangelia penicillata (C. Agardh, 1828)

PHAEOPHYTA

Asperococcus bullosus (J.V. Lamouroux, 1813)

Colpomenia sinuosa (Mertens ex Roth) Derbes & Solier, 1851

Culteria multifida (Turner) Greville, 1830

Cystoseira barbata (C. Agardh, 1820)

Cystoseira corniculata (Turner) Zanardini, 1841

Cystoseira corniculata var. *laxior* Ercegovic

Cystoseira spinosa (Sauvageau, 1912)

Dictyota dichotoma (Hudson) J.V. Lamouroux, 1809

Dictyota implexa (Desfontaines) J.V. Lamouroux, 1809

Fucus virsoides (J. Agardh, 1868)

Giffordia sp.

Halopteris scoparia (Linnaeus) Sauvageau, 1904

Padina pavonica (Linnaeus) Thivy, 1960

Sargassum vulgare (C. Agardh, 1820)

Zanardinia typus (Nardo) P.C. Silva, 2000

CHLOROPHYTA

Acetabularia acetabulum (Linnaeus) P.C. Silva, 1952

Anadyomene stellata (Wulfen) C. Agardh, 1823

Cladophora coelothrix (Kützing, 1843)

Cladophora sp.

Codium adhaerens (C. Agardh, 1822)

Codium bursa (Olivi) C. Agardh, 1817

Codium vermilaria (Olivi) Delle Chiaje, 1829

Dasycladus vermicularis (Scopoli) Krasser, 1898

Flabellia petiolata (Turra) Nizamuddin, 1987

Halimeda tuna (J. Elis & Solander) J.V. Lamouroux, 1816

Ulva rigida (C. Agardh, 1823)

Valonia macrophysa (Kützing, 1843)

Valonia utricularis (Roth) C. Agardh, 1823

SPERMATOPHYTA

Cymodocea nodosa (Ucria) Ascherson, 1870

Posidonia oceanica (Linnaeus) Delile, 1813

Zostera noltii Hornemann

PHYLUM PORIFERA

Aplysina aerophoba (Nardo, 1833)

Chondrilla nucula (Schmidt, 1862)

Chondrosia reniformis (Nardo, 1847)

Clathrina clathrus (Schmidt, 1864)

Cliona celata (Grant, 1826)

Cliona viridis (Schmidt, 1862)

Crambe crambe (Schmidt, 1862)

Didemnum maculosum (Milne Edwards, 1841)

Geodia gigas (Schmidt, 1862)

Hemimycale columella (Bowerbank, 1874)

Hippospongia communis (Lamarck, 1814)

Ircinia dendroides (Schmidt, 1862)

Oscarella lobularis (Schmidt, 1862)

Petrosia ficiformis (Poiret, 1789)

Phorbas tenacior (Topsent, 1925)

Sarcotragus fasciculatus (Pallas, 1766)

Spirastrella cunctatrix (Schmidt, 1868)

*Spongia (*Spongia*) officinalis* (Linnaeus, 1759)

Tethya Sp.

PHYLUM CNIDARIA

SUBCLASS HEXACORALLIA

Actinia cari (Delle Chiaje, 1822)

Actinia equina (Linnaeus, 1758)

Aiptasia diaphana (Rapp, 1829)

Aiptasia mutabilis (Gravenhorst, 1831)

Anemonia sulcata (Pennant, 1777)

Anemonia viridis (Forskål 1775)

Astroides calycularis (Pallas, 1766)

Aulactinia verrucosa (Pennant, 1777)

Balanophylia (Balanophylia) *europaea* (Risso, 1826)

Bunodeopsis strumosa (Andrés, 1881)

Calliactis parasitica (Couch, 1842)

Caryophyllia (Caryophyllia) *inornata* (Duncan, 1878)

Cereus pedunculatum (Pennant, 1777)

Cerianthus membranaceus (Spallanzani, 1784)

Cladocera cespitosa (Linnaeus, 1767)

Condylactis aurantiaca (Delle Chiaje, 1825)

Cribrinopsis crassa (Andrés, 1881)

Paranemonia cinerea (Contarini, 1844)

Parazoanthus axinellae (Schmidt, 1862)

Phymanthus pulcher (Andrés, 1883)

CLASS HYDROZOA

Aglaophenia elongata (Meneghini, 1845)

Aglaophenia pluma (Linnaeus, 1758)

Antennella secundaria (Gmelin, 1791)

Clytia gracialis (Sars, 1850)

Dynamena disticha (Bosc, 1802)

Eudendrium racemosum (Cavolini, 1785)

Eudendrium ramosum (Linnaeus, 1758)

Halecium halecium (Linnaeus, 1758)

Obelia dichotoma (Linnaeus, 1758)

Plumularia setacea (Linnaeus, 1758)

CLASS SCYPHOZOA

Nausithoe punctata (Kölliker, 1853)

CLASS ANTHOZOA

Eunicella verrucosa (Pallas, 1766)

CLASS ECHIURIDEA

Bonellia viridis (Rolando, 1821)

CLASS SIPUNCULIDEA

Sipunculus nudus (Linnaeus, 1766)

PHYLUM MOLLUSCA

CLASS POLYPLACOPHORA

Acanthochitona fascicularis (Linnaeus, 1767)

Chiton (Rhyssoplax) *olivaceus* (Spengler, 1797)

Ischnochiton (Ischnochiton) *rissoi* (Payraudeau, 1826)

Lepidochitona (Lepidochitona) *caprearum* (Scacchi, 1836)

Leptochiton cancellatus (Sowerby, 1840)

CLASS GASTROPODA

Alvania beanii (Hanley in Thorpe, 1844)

Alvania cimex (Linnaeus, 1758)

Alvania discors (Allan, 1818)

Alvania lineata (Risso, 1826)

Anomia ephippium (Linnaeus, 1758)

Aplysia depilans (Gmelin, 1791)
Aplysia punctata (Cuvier, 1803)
Barleeia unifasciata (Montagu, 1803)
Berthella aurantiaca (Risso, 1818)
Bittium lateillii (Payraudeau, 1826)
Bittium reticulatum (da Costa, 1778)
Bolinus brandaris (Linnaeus, 1758)
Calliostoma conulus (Linnaeus, 1758)
Calliostoma laugieri (Payraudeau, 1826)
Calliostoma zizyphinum (Linnaeus, 1758)
Cardita calyculata (Linnaeus, 1758)
Cerastoderma edule (Linnaeus, 1758)
Cerihium vulgatum (Bruguiére, 1792)
Clanculus corallinus (Gmelin, 1791)
Clanculus cruciatus (Linnaeus, 1758)
Columbella rustica (Linnaeus, 1758)
Conus ventrihosus (Gmelin, 1791)
Diodora graeca (Linnaeus, 1758)
Felimare orsinii (Vérany, 1846)
Felimare tricolor (Cantraine, 1835)
Felimida luteorosea (Rapp, 1827)
Flabellina affinis (Gmelin, 1791)
Gibberula miliaria (Linnaeus, 1758)
Gibbula ardens (Salis Marschlins, 1793)
Gibbula divaricata (Linnaeus, 1758)
Gibbula magus (Linnaeus, 1758)
Gibbula varia (Linnaeus, 1758)
Haliotis tuberculata lamellose (Lamarck, 1822)
Haminoea hydatis (Linnaeus, 1758)
Hexaplex trunculus (Linnaeus, 1758)
Jujubinus exasperatus (Pennant, 1777)
Melarhaphe neritoides (Linnaeus, 1758)
Mitra cornicula (Linnaeus, 1758)
Muricopsis cristata (Brocchi, 1814)
Nassarius incrassatus (Støm, 1768)
Patella caeruela (Linnaeus, 1758)
Patella rustica (Linnaeus, 1758)
Peltodoris atromaculata (Bergh, 1880)
Phorcus articulatus (Lamarck, 1822)
Phorcus turbinatus (Born, 1778)
Pisania striata (Gmelin, 1791)

Rissoa variabilis (Megerle von Mühlfeldt, 1824)
Rissoina bruguieri (Payraudeau, 1826)
Thuridilla hopei (Vérany, 1853)
Thylacodes arenarius (Linnaeus, 1758)
Tricolia speciose (Megerle von Mühfeld, 1824)
Tylodina perverse (Gmelin, 1791)
Vermetus sp.
Vermetus triquetrus (Bivona-Bernardi, 1832)
Vexillum (Pusiolina) tricolor (Gmelin, 1791)
CLASS BIVALVIA
Abra alba (W. Wood, 1802)
Acanthocardia tuberculata (Linnaeus, 1758)
Arca noae (Linnaeus, 1758)
Barbatia barbata (Linnaeus, 1758)
Callista chione (Linnaeus, 1758)
Cerastoderma glaucum (Brugiére, 1798)
Chama gryphoides (Linnaeus, 1758)
Corbula gibba (Olivi, 1792)
Ctena decussate (O.G. Costa, 1829)
Flexopecten glaber (Linnaeus, 1758)
Gari depressa (Pennant, 1777)
Gastrana fragilis (Linnaeus, 1758)
Glycymeris glycymeris (Linnaeus, 1758)
Glycymeris pilosa (Linnaeus, 1767)
Hiatella arctica (Linnaeus, 1767)
Limaria hians (Gmelin, 1791)
Lithophaga lithophaga (Linnaeus, 1758)
Manupecten pesfelis (Linnaeus, 1758)
Mimachlymis varia (Linnaeus, 1758)
Moliodus barbatus (Linnaeus, 1758)
Musculus costulatus (Risso, 1826)
Mytilaster minimus (Poli, 1975)
Mytillus galloprovincialis (Lamarck, 1819)
Ostrea edulis (Linnaeus, 1758)
Pecten jacobaeus (Linnaeus, 1758)
Pinna nobilis (Linnaeus, 1758)
Pitar rudis (Poli, 1795)
Rocellaria dubia (Pennant, 1777)
Ruditapes decussatus (Linnaeus, 1758)
Spondylus gaederopus (Linnaeus, 1758)
Striarca lacteal (Linnaeus, 1758)
Talochlamys multistriata (Poli, 1795)

Tellina tenuis (da Costa, 1778)

Teredo navalis (Linnaeus, 1758)

Venerupis corrugate (Gmelin, 1791)

Venerupis decussata (Linnaeus, 1758)

Venus verrucosa (Linnaeus, 1758)

CLASS CEPHALOPODA

Loligo vulgaris (Lamarck, 1798)

Octopus vulgaris (Cuvier, 1797)

Sepia officinalis (Linnaeus, 1758)

CLASS POLYCHAETA

Alitta succinea (Leuckart, 1847)

Amphicteis gunneri (M. Sars, 1835)

Arabella geniculata (Claparède, 1868)

Bispira mariae (Lo Bianco, 1893)

Branchiomma lucullanum (Delle Chiaje, 1828)

Ceratonereis costae (Grube, 1840)

Chaetopterus variopedatus (Renier, 1804)

Chaetozone setosa (Malmgren, 1867)

Chone duneri (Malmgren, 1867)

Dasybranchus caducus (Grube, 1846)

Dasybranchus gajolae (Eisig, 1887)

Drilonereis filum (Claparède, 1868)

Euclymene lombricoides (Quatrefages, 1866)

Eunice aphroditois (Pallas, 1788)

Eunice vittata (Della Chiaje, 1828)

Eunoe nodosa (M. Sars, 1861)

Eupolymnia nebulosi (Montagu, 1818)

Eusyllis blomstrandi (Malmgren, 1867)

Ficopomatus enigmaticus (Fauvel, 1923)

Fimbriosthenelais minor (Pruvot & Racovitza, 1895)

Glycera tridactyla (Schmarda, 1861)

Glycera unicomis (Lamarck, 1818)

Harmothoe extenuate (Grube, 1840)

Hilbigneris gracialis (Ehlers, 1868)

Hyalinoecia brementi (Fauvel, 1916)

Hydroides norvegicus (Gunnerus, 1768)

Hydroides pseudouncinatus pseudouncinatus (Zibrowius, 1791)

Janua pagenstecheri (Quatrefages, 1866)

Jasmineira candela (Grube, 1863)

Jasmineira elegans (Saint-Joseph, 1894)

Laenereis glauca (Claparède, 1870)

Laetmonice hystrix (Savigny in Lamarck, 1818)

Lagis koreni (Malmgren, 1866)

Leodice harassii (Audouin & Milne Edwards, 1833)

Lumbrineris coccinea (Renier, 1804)

Lumbrineris latrelli (Audouin & Milne Edwards, 1834)

Lysidice ninetta (Audouin & Milne Edwards, 1833)

Marphysa fallax (Marion & Bobretzky, 1875)

Megalomma seciculosum (Montagu, 1815)

Melinna palmate (Grube, 1870)

Myriochele heeri (Malmgren, 1867)

Mysta picta (Quatrefages, 1866)

Myxiola infundibulum (Montagu, 1808)

Nephtys hombergii (Savigny in Lamarck, 1818)

Nephtys hystricis (MyIntosh, 1900)

Nephtys incisa (Malmgren, 1865)

Nereis fucata (Savigny in Lamarck, 1818)

Nereis lamellose (Ehlers, 1864)

Notomastus latericeus (Sars, 1851)

Orbinia sertulata (Savigny, 1822)

Owenia fusiformis (Delle Chiaje, 1844)

Pherusa monilifera (Delle Chiaje, 1841)

Piromis eruca (Claparède, 1869)

Polycirrus aurantiacus (Grube, 1860)

Praxillella gracilis (M. Sars, 1861)

Protula intestinum (Lamarck, 1818)

Protula tubularia (Montagu, 1803)

Sabella pavonina (Savigny, 1822)

Sabella spallanzanii (Gmelin, 1791)

Serpula concharum (Langerhans, 1880)

Serpula vermicularis (Linnaeus, 1767)

Sige macroceros (Grube, 1860)

Spirobranchus polytrema (Philippi, 1844)

Spirobranchus triqueter (Linnaeus, 1758)

Spirorbis sp.

Sthenelais boa (Johnston, 1833)

Syllis cornuta (Rathke, 1843)

Syllis krohni (Ehlers, 1864)

Tharyx marioni (Saint-Joseph, 1894)

Thelepus cincinnatus (Fabricius, 1780)

CLASS NEMERTEA

Notospermus geniculatus (Della Chiaje, 1828)

SUBCLASS CRUSTACEA

INFRACLASS CIRRIPEDIA

Chthamalus montagui (Southward, 1976)

Chthamalus stellatus (Poli, 1791)

Euraphia depressa (Poli, 1791)

Perforatus perforates (Bruguiérin, 1829)

ORDER DECAPODA

Acanthonyx lunulatus (Risso, 1816)

Alpheus dentipes (Guérin, 1829)

Athanas nitescens (Leach, 1813)

Carcinus aestuarii (Nardo, 1847)

Clibanarius erythropus (Latreille, 1818)

Dromia personata (Linnaeus, 1758)

Eriphia verrucosa (Forskål, 1775)

Galathea sp.

Galathea squamifera (Leach, 1814)

Galathea strigose (Linnaeus, 1761)

Homarus gammarus (Linnaeus, 1758)

Lissa chiragra (Fabricius, 1775)

Maja crispate (Risso, 1827)

Maja squinado (Herbst, 1788)

Pachygrapsus marmoratus (Fabricius, 1787)

Pagurus prideaux (Leach, 1815)

Palaemon elegans (Rathke, 1837)

Periclimenes amethysteus (Risso, 1827)

Pilumnus hirtellus (Linnaeus, 1761)

Pisidia longimana (Risso, 1816)

Processa edulis edulis (Risso, 1816)

Processa sp.

Scyllarides latus (Latreille, 1803)

ORDER ISOPODA

Ligia italica (Fabricius, 1798)

PHYLUM BRYOZOA

Aetea sica (Couch, 1844)

Aetea truncata (Landsborough, 1852)

Calpensia nobilis (Esper, 1796)

Cellepora pumicosa (Pallas, 1766)

Cradoscrupocellaria reptans (Linnaeus, 1758)

Electra posidoniae (Gautier, 1954)

Frondipora verrucosa (Lamouroux, 1821)

Hornera frondiculata (Lamarck, 1816)

Margaretta cereoides (Ellis & Solander, 1786)

Myriapora truncata (Pallas, 1766)

Reptadeonella violacea (Johnston, 1847)

Reteporella beaniana (King, 1846)

Reteporella feuerbornii (Hass, 1948)

Reteporella grimaldii (Julien, 1903)

Schizobranchiella sanguinea (Norman, 1868)

Scrupocellaria scrupea (Busk, 1852)

Smittina cervicornis (Pallas, 1766)

PHYLUM ECHINODERMATA

ORDER CRINOIDEA

Antedon mediterranea (Lamarck, 1816)

ORDER OPHIURIDA

Amphipholis squamata (Delle Chiaje, 1828)

Ophioderma longicauda (Bruzelius, 1805)

Ophiothrix fragilis (O.F. Müller, 1789)

Ophiura albida (Forbes, 1839)

ORDER ECHINOIDEA

Arbacia lixula (Linnaeus, 1758)

Brissus unicolor (Leske, 1778)

Echinocyamus pusillus (O.F. Müller, 1776)

Gracilechinus acutus (Lamarck, 1816)

Paracentrotus lividus (Lamarck, 1816)

Psammechinus microtuberculatus (Blainville, 1825)

Spatangus purpureus (O.F. Müller, 1776)

Sphaerechinus granularis (Lamarck, 1816)

ORDER ASTEROIDEA

Asterina gibbosa (Pennant, 1777)

Astropecten aranciacus (Linnaeus, 1758)

Astropecten spinulosus (Philippi, 1837)

Costinasterias tenuispina (Lamarck, 1816)

Echinaster sepositus (Retzius, 1783)

Luidia ciliaris (Philippi, 1837)

Marthasterias glacialis (Linnaeus, 1758)

ORDER HOLOTHUROIDEA

Holothuria poli (Delle Chiaje, 1824)

Holothuria (Panningothuria) *forskali* (Delle Chiaje, 1823)

Holothuria tubulosa (Gmelin, 1791)

Parastichopus regalis (Cuvier, 1817)

ORDER ASCIDIACEA

Aplidium conicum (Olivi, 1792)

Aplidium elegans (Giard, 1872)

Aplidium proliferum (Milne Edwards, 1841)

Ciona intestinalis (Linnaeus, 1767)

Diplosoma listerianum (Milne Edwards, 1841)

Halocynthia papilosa (Linnaeus, 1767)

Microcosmus sabatieri (Roule, 1885)

Microcosmus vulgaris (Heller, 1877)

Phallusia fumigata (Grube, 1864)

Phallusia mammillata (Cuvier, 1815)

SUBPHYLUM VERTEBRATA

Boops boops (Linnaeus, 1758)

Chromis chromis (Linnaeus, 1758)

Coris julis (Linnaeus, 1758)

Dentex dentex (Linnaeus, 1758)

Dicentrarchus labrax (Linnaeus, 1758)

Diplecogaster bimaculata (Bonnaterre, 1788)

Diplodus puntazzo (Cetti, 1777)

Diplodus sargus (Linnaeus, 1758)

Diplodus vulgaris (Geoffroy Saint-Hilaire, 1817)

Glycera unicornis (Lamarck, 1818)

Gobius bucchichi (Steindachner, 1870)

Gobius cruentatus (Gmelin, 1789)

Gobius vittatus (Vinciguerra, 1883)

Hippocampus guttulatus (Cuvier, 1829)

Labrus merula (Linnaeus, 1758)

Lepadogaster sp.

Lichia amia (Linnaeus, 1758)

Mullus surmuletus (Linnaeus, 1758)

Oblada melanura (Linnaeus, 1758)

Pagellus erythrinus (Linnaeus, 1758)

Parablennius rouxi (Cocco, 1833)

Salaria pavo (Risso, 1810)

Sarpa salpa (Linnaeus, 1758)

Scorpaena notate (Rafinesque, 1810)

Serranus cabrilla (Linnaeus, 1758)

Serranus hepatus (Linnaeus, 1758)

Serranus scriba (Linnaeus, 1758)

Sparus aurata (Linnaeus, 1758)

Sphoeroides pachygaster (Müller & Troschel, 1848)

Spicara maena (Linnaeus, 1758)

Spondyliosoma cantharus (Linnaeus, 1758)

Symphodus mediterraneus (Linnaeus, 1758)

Symphodus rostratus (Bloch, 1791)

Symphodus tinca (Linnaeus, 1758)

Thorogubius ephoppiatus (Lowe, 1839)

Torpedo marmorata (Risso, 1810)

Trachinus draco (Linnaeus, 1758)

Trigloporus lastoviza (Bonnaterre, 1788)

Tripterygion tripteronotum (Risso, 1810)

Zeus faber (Linnaeus, 1758)

Annex B

QUESTIONNAIRE FOR VISITORS OF SIGNIFICANT LANDSCAPE "CAPE KAMENJAK AND MEDULIN ARCHIPELAGO"

I am a graduate student of the Faculty of Mathematics, Natural Sciences and Information Technology at University of Primorska in Koper (SLO). Study program is called „Protection of nature“(*Conservation of Nature)*. For my graduate thesis I chose Cape Kamenjak, as an area of extraordinary beauty, of cultural significance for Istria and Croatia, with rich terrestrial and marine flora and fauna.

These few initial questions will help me in making graduate scripts but still can greatly benefit to the public institution (PI) Kamenjak in understanding what visitors are looking for and expecting from the staff and which activities within the promotion of nature protection.

The questionnaire is anonymous.

THANK YOU FOR YOUR SUPPORT!!!

DATE OF FILLING _____

Basic information of visitor

IS THIS YOUR FIRST VISIT OF the CAPE KAMENJAK? Yes No

DOES YOUR MAIN GOAL OF VACATION WAS VISITING CAPE KAMENJAK?

Yes No

Place the 'x' in the square

1. ARE YOU HERE ON A DAY TRIP OR SPEND HERE MORE THAN A DAY? (please select only one answer)

   ☐ Day trip

   ☐ 2-3 days stays in the park and the surrounding area

   ☐ More than 3 days visiting the region (Istria)

   ☐ The journey of several days along the coast (Istria / Croatia)

☐ Other, please specify_____

2. IF YOU STAY LONGER THAN ONE DAY IN THIS AREA, WHERE ARE YOU ACCOMMODATED? (Please choose only one answer)

☐ Accommodation in the park

☐ Accommodation nearby the park

☐ Accommodation on the coast

3. WHAT DID YOU EXPECT FROM YOUR VACATION PRIOR TO DEPARTURE? (Please do not choose more than 3 responses)

☐ Search for adventure

☐ Escape from the routine

☐ Amusement

☐ Meeting new friends

☐ Time alone

☐ Spending time with friends / relatives

☐ Outdoor sports (hiking, biking)

☐ Walking / trekking

☐ Resting

☐ Enjoying the local gastronomy

☐ Get into contact with the local culture / art / tradition

☐ Visiting natural / cultural heritage

☐ Staying in the rural environment

☐ Contact with nature

4. WHERE DID YOU HEAR FOR CAPE KAMENJAK? WHAT BRINGS YOU HERE? (Please choose only one answer)

☐ Recommendation of friends / relatives

☐ Travel agency

☐ Institution for the environment, etc.

☐ Article in newspaper / magazine

☐ Advertisement in newspaper / magazine

☐ Website

☐ Prospectus from the trade show (or elsewhere)

☐ Street posters

☐ Other (please fulfill _____

5. DID YOU LEARN MORE ABOUT WILDLIFE, AS WELL AS REASONS FOR ITS PROTECTION WITHIN THE PARK, FROM THIS VISIT? (please circle the answer):

a. I have learned more
b. I have not learned enough
c. I have not learned anything new

If you have encircled a.

NOTIFY SOME INFORMATION YOU LEARNED ABOUT THE MARINE CHARACTERISTICS OF CAPE KAMENJAK; Endangered species, key species for ecosystem sustainability, water quality, etc.)

_____

_____

_____

WOULD YOU BE ATTRACTED BY FIVE DAYS LONG DIVING-EDUCATIONAL PROGRAM WITHIN DIVING COURSE (CMAS R*) OR DIVING EXCURSIONS, WHERE YOU MEET WITH THE MAIN CHARACTERISTICS OF BIOCENOSIS (*biological community, ecological community*) AND THEIR RECOGNITION IN A FUN AND ATTRACTIVE WAY?

Yes No

6. WHAT ARE THE MOST ATTRACTIVE ELEMENTS OF TOURISM IN THIS PARK, IN YOUR OPINION? (you can choose multiple options)

☐ Simple contact with nature

☐ Flora / fauna

☐ Untouched landscape

☐ Natural / cultural heritage

☐ Local gastronomy

☐ The ability to perform a various activities

☐ Outdoor sports

☐ The quality of accommodation

☐ Easy access to the park

☐ The proportion of quality / price

☐ Other; please fulfill _____

7. WHAT COULD IMPROVE TOURIST OFFERINGS IN THE PARK, IN YOUR OPINION? (You can choose multiple options)

☐ Park staff (*worker*) skills

☐ Skills of staff at information office (public institution "Kamenjak")

☐ Cleanliness

☐ Peace

☐ Supervision

☐ Traffic

☐ Crowds

☐ Access for disabled people

☐ Services for children

☐ Other, please fulfill _____

8. IDENTIFY THE QUALITY OF MOBILE INFRASTRUCTURE IN THE PARK /

NEAR PARK (put 'x' in the appropriate category)

	LOW	MEDIUM	HIGH
• The roads that link the park			
• The roads inside the park (Main Road)			
• Walking routes inside the park			
• Dinosaur trail			
• Educational trail			
• Bicycle path			
• Parking spaces in the park			

9. FIND ONE ELEMENT (fauna, flora, landscape, cultural heritage or activity etc.) WHICH CAN BE USED AS A SYMBOL OF THE PARK.

Annex C

Spatial Plan of the County of Istria – protected areas and special reserves on a scale 1:100 000

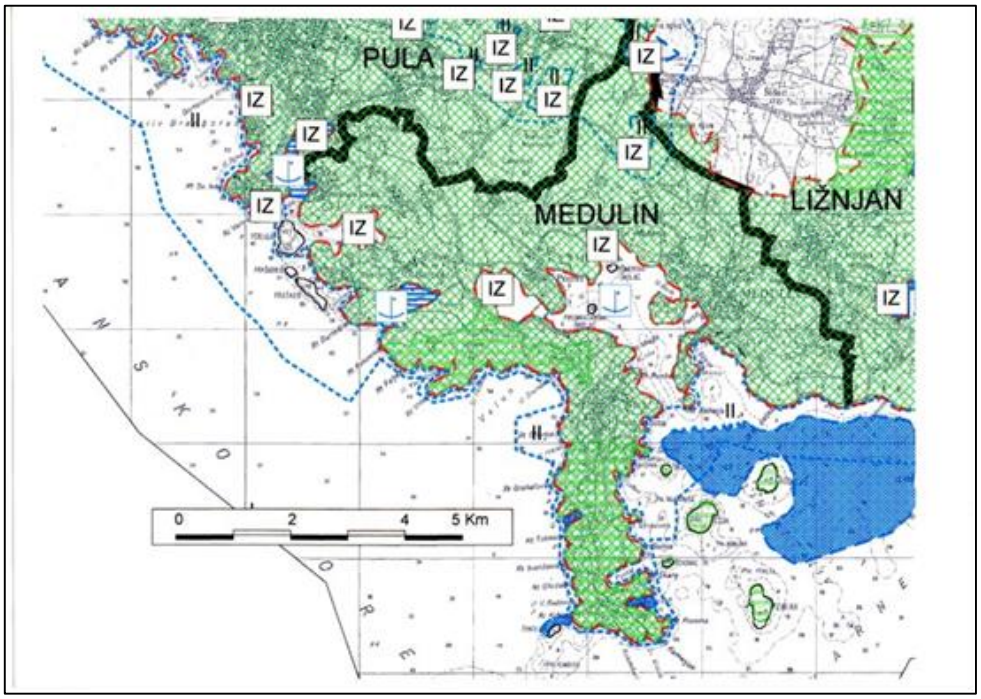

Figure. Spatial Plan of the County of Istria – original scale 1: 100 000 (Areas of special use restrictions); blue polygon represent protected area)

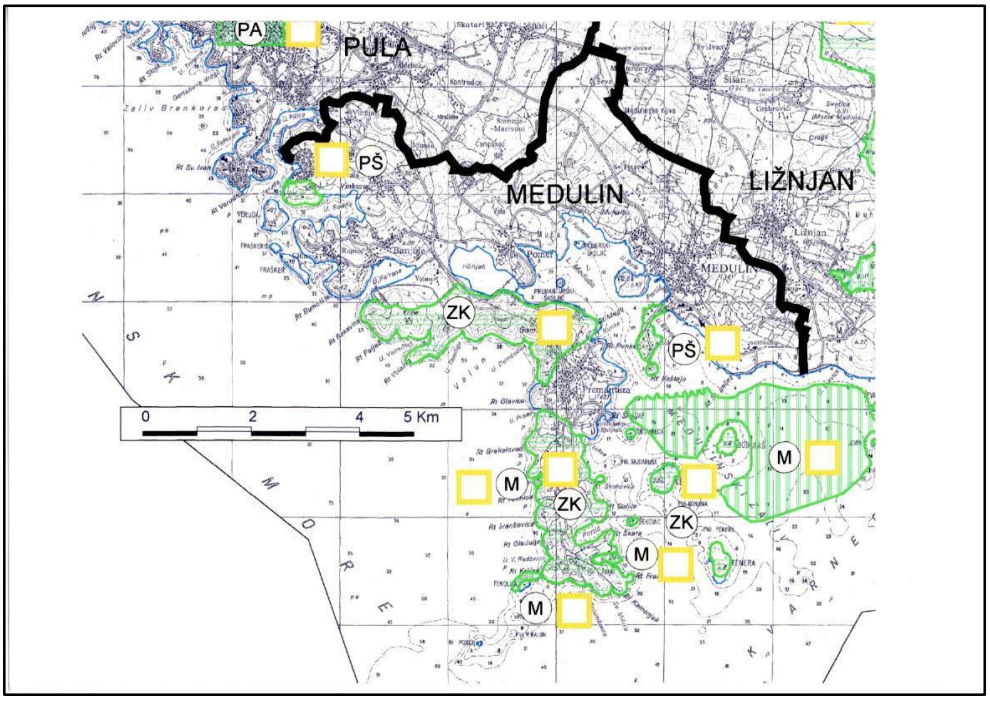

Figure. Spatial Plan of the County of Istria – original scale 1: 100 000 (Protection of natural heritage); green polygon represent special reserve)

Annex D

The study of the bottlenose dolphin (*Tursiops truncates*)

The most important method is photoidentification by which can be identified individuals form the HQ image shoots of the dorsal fins (http://www.plavi-svijet.org/hr/znanost/metode-istrazivanja/fotoidentifikacija/). After the field work, images are imported into a database where they are compared with others in order to determine is this individual new one or already known and then the data is entered into a GIS. Obtained data serve to analyse the frequency of occurrence of dolphins, belonging to a certain area, size of the area in which they reside, their number, distribution, social ecology, patterns of movement, population size, reproductive status and / or social organization. In doing so we can determine areas of great importance for dolphins, such as feeding and nursery habitats or habitats where they are just resting / basking.

During the photoidentification is recording a group of dolphins, their initial behavior and response (behavior change) for the presence of the research vessel. Blue World Institute research shows that 92% of the negative reactions of dolphins are caused by recreational vessels (http://www.plavi-svijet.org/hr/znanost/studije-ponasanja/). Also, recorded are patterns of behavior in order to determine how much time (a day) is certain pattern occurring the form that appears, because in this way it can be determined how much time dolphins are spending for certain activity.

The last method is recording sounds produced by dolphins for better insight into their habits and habitats in which they live. On the basis of these sounds can be concluded if they are currently hunting fish, traveling / migrating or socializing (http://www.plavi-svijet.org/en/science/methods-research/acoustics/