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POST-2020 SAP BIO

SLOVENIA
CONSERVATION OF MEDITERRANEAN MARINE AND COASTAL BIODIVERSITY BY 2030 AND BEYOND

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Ecological Status, Pressures, Impacts, their Drivers and Priority Response Fields

POST-2020
SAP BIO

Strategic Action Programme
for the **Conservation** of **Biodiversity**
and **Sustainable Management**
of **Natural Resources**
in the **Mediterranean Region**

United Nations Environment Programme
Mediterranean Action Plan
Specially Protected Areas Regional Activity Centre (SPA/RAC)
Boulevard du Leader Yasser Arafat
B.P.337
1080 Tunis Cedex – TUNISIA
car-asp@spa-rac.org

The original version of this document was prepared for the Specially Protected Areas Regional Activity Centre (SPA/RAC) in the framework of the Post-2020 SAPBIO elaboration by Mr. Lovrenc Lipej - National Institute of Biology, Marine Biology Station as National consultant for Slovenia, guided and supervised by Mr Robert Turk National SAPBIO Correspondent and Focal Point for SPAs

For bibliographic purposes, this document may be cited as:
UNEP/MAP-SPA/RAC, 2021. Slovenia Conservation of Mediterranean marine and coastal biodiversity by 2030 and beyond. By L. Lipej . Ed. SPA/RAC, Tunis

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This publication has been prepared with the financial support of the MAVA foundation.

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List of Acronyms

CBD	Convention on Biological Diversity
DOPPS	Društvo za opazovanje in proučevanje ptic (Slovenian Ornithological Association)
EBSA	Ecologically and Biologically Significant Areas
FAO	Food and Agriculture Organisation
HAB	harmful algal blooms
IPCC	the Intergovernmental Panel on Climate change
IUCN	International Union for Conservation of Nature
LP	Landscape Park
MBS	Marine Biology Station
MFA	marine fisheries act
MoU	memorandum of understanding
MPA	marine protected area
MSP	Maritime Spatial Plan
N2k	Natura 2000
NCA	nature conservation act
NAP	national action plan
NGO	nongovernmental organisation
NIB	National institute of Biology
NIS	non indigenous species
NM	natural monument
NR	nature reserve
OECM	other effective area-based conservation measures
PA	protected area
RSLR	relative sea level rise
SAR	Species Area Relationship
SSF	Small Scale Fishery

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Executive Summary

On the basis of the available published data the marine biodiversity of the Slovenian coastal Sea, which comprises a very small portion of the Adriatic Sea, could be considered as a rather rich portion of the Adriatic Sea. The checklist of the Slovenian marine biodiversity is based on records of at least 2260 different species. The main factors, which affect the high diversity of the area, are probable related to the diversity of habitat types, to the increased research effort, to the presence of marine and coastal protected areas and probably also to the geographical, geomorphological and oceanographical specificity of the area. Less than 18% of the coastline is still present as natural. In order to assure the conservation of the most important elements of biodiversity, a number of protected areas – marine and coastal, were declared from the 1990 until today. Three marine protected areas were established up to now in the Slovenian sea, two landscape parks and one natural monument.

Although the Slovenian coastal sea is very shallow in depth, the habitat diversity of the area is rather diverse. Among important habitat types seagrass meadows of *Posidonia oceanica* and *Cymodocea nodosa* should be mentioned. In Slovenian Sea there are present also biogenic formations, which are peculiar habitat types, characterized by an outstanding biodiversity. Among other important habitats precoralligen is well developed and host a diverse assemblage of benthic invertebrates and coastal fish fauna.

The key impacts and pressures to the Slovenian coastal and marine area are habitat degradation, mainly due to urbanization, maritime transport (sediment resuspension, noise) and leisure boating (anchoring, noise) cannot be neglected. Recent events in the Mediterranean areas, related to bioinvasion and tropicalisation have also some consequences on the marine biota. However, it is not yet clear what pressures and possible impacts the alien species have to the natiove environment and biodiversity. Some cases are linked to the climate change phenomena. Owing to the rising temperatures, cases of coral bleaching of the Mediterranean stony coral were recorded. Recent discoveries predict habitat changes due to the rise of sea level in Slovenian coastal wetlands and some studies revealed that in certain lagoons cases of sea water intrusion could change the local biodiversity, adapted to euryhaline and eurytherm environmental conditions. It seems that also the extirpation of the Adriatic endemic brown algae *Fucus virsoides* from the Slovenian sea in 2015 could be related to climate change phenomena. The algal belts of *Cystoseira barbata*, an important building element of the biocoenosis of photophyllic algae, were shrinked to some extension or even disappeared in various part of the Slovenian coastline. The same is true for seagrass meadows of *Cymodocea nodosa* Recently, cases of Noble pen shell (*Pinna nobilis*) mortality was recorded in the Slovenian part of the Adriatic Sea

To this end, some research initiatives are ongoing to reduce the disappearance of the mentioned marine plants and vegetation, and the Noble pen shell. Based on the present knowledge of the state of marine biodiversity in the Slovenian sea and threats, a number of recommendations could be put forward. It would be imperative to protect the remaining natural coastline and give up new interventions on the urbanized part of the coastline. At the national and sub-regional level would be imperative to increase the common effort in terms of species inventories and habitat mapping in the entire Gulf of Trieste, to identify the key elements of biodiversity and to agree on the needed conservation measures.

1.

Reference documents and information consulted

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1.1. Documents provided by SPA/RAC and international consultants

Bellan-Santini, D., G. Bellan, G. Bitar, J.-G. Harmelin & G. Pergent (2002): Handbook for interpreting types of marine habitat for the selection of sites to be included in the national inventories of natural sites of conservation interest. UNEP, Action Plan for the Mediterranean. Regional Activity Centre for Specially Protected Areas, 217 pp.

1.2. National documents and publications identified and available

- Endangered species and habitat types in the Slovenian Sea (2006)
- Book authored by Lovrenc Lipej, Robert Turk & Tihomir Makovec. Besides listing the endangered species and endangered habitat types, monograph gives the basic information on the Adriatic and on the Slovenian Sea as well as on the main causes of degradation of the marine environment, including among others the unsustainable use of resources, pollution, climate change and bio invasion. It includes also general information on the state of marine biodiversity and on the main tools for its conservation.
- Marine protected areas in the Northern Adriatic (2009)
- Paper by Robert Turk and Roberto Odorico presenting the situation of MPAs in the Northern Adriatic.
- How far are we from the 2012/2020 target? (2011)
- Paper from Barbara Vidmar and Robert Turk that deals with the state of art of Slovenian MPAs in terms of representativeness and management efficiency.
- The state of art of alien fauna and flora (2012)
- A scientific paper published by Lipej, L., Mavrič, B. Orlando-Bonaca, M. and A. Malej, This paper represent the first survey of marine alien biodiversity in Slovenia and discuss the main pathways and vectors of introduction.
- Biogenic formations in the Slovenian Sea (2016)
- A scientific monograph published by Lipej, L., B. Mavrič and M. Orlando-Bonaca. The monograph described the peculiar habitat types of biogenic origin and their importanc for biodiveristy. The monograph was completely financed by the SPA/RAC.

- Mapping of marine habitat types Natura 2000 (2018)

- A report realized by Lipej, L., B. Mavrič, M. Šiško, D. Trkov and M. Orlando-Bonaca. A topographic material of Natura 2000 sites in Slovenian coastal sea together with basic data on the biodiversity related to the mentioned sites.

- Mapping and description of benthic habitat types in Slovenian sea (2018)

- A report realized by Lipej, L., B. Mavrič, M. Šiško and M. Orlando-Bonaca. Habitat types occurring in the Slovenian coastal sea were described and mapped. Most probable pressures on habitat types in the area were analysed.

- Key elements of biodiversity of the Slovenian Sea (2019)

- Paper by Tina Centrih Genov, Borut Mavrič, Robert Turk, Lovrenc Lipej. It gives a first assessment of the key elements of marine biodiversity of the Slovenian Sea and indicates the main threats. It points out the absence of systemic studies and monitoring of biodiversity as well as studies on and monitoring of the impact of human activities on biodiversity.

- Decree on the Marine Environment Management Plan (Official Gazette of the Republic of Slovenia, No. 41/17)

- Natura 2000 Management programme for Slovenia for the period 2014-2020.

1.3. Other documents identified

Fisheries. Key features for the general public (2019). Document by Aleš Bolje edit., Ministry of Agriculture, Forestry and Food.

Document edited by Aleš Bolje, fisheries expert, explaining the main features and characteristics of the Slovenian fisheries sector. In Slovenian.

1.4. Quality and comprehensiveness of available information documents

The mentioned monographs, scientific papers and scientific reports represent basic data and arguments for preparing proper conservation measures. Since the first two categories were passing through the revision process, they were critically assessed and properly implemented by competent referees.

2.

Marine and coastal ecosystem status

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The Slovenian sea is part of the North Adriatic Ecologically and Biologically Significant Area (EBSA). The north Adriatic EBSA hosts mobile sandy bottoms, seagrass meadows, hard bottom associations and unique rocky outcrops called "trezze" and "tegnue". The area is important for several threatened species. It hosts a population of the highest density of bottlenose dolphin (*Tursiops truncatus*) in the Mediterranean, it is one of the most important feeding grounds in the Mediterranean of the loggerhead turtle (*Caretta caretta*) and it is a nursery area for a number of vulnerable species (blue shark, *Prionace glauca*, sandbar shark, *Carcharinus plumbeus*, thresher shark, *Alopias vulpinus*, etc., Lipej *et al*., 2004). In the last thirty years long period the area became also an important feeding and roosting ground for the Mediterranean Shag (*Phalacrocorax aristotelis desmaresti*) (Koce, 2018). The area hosts an outstanding diversity of benthic and pelagic habitats due to an important gradient of environmental factors from its western portion to its eastern coasts. It is also one of the most productive areas in the Mediterranean Sea.

2.1. Biological characteristics

2.1.1 Description of water column biological communities

2.1.1.1. Phytoplankton production

The Slovenian coastal Sea is characterized by two seasonal peaks of phytoplankton biomass, the first occurring during the late spring and the second in autumn with average values up to 1.3 µg/dm3. During the last decades, the Slovenian part of the Adriatic Sea faced a significant decrease in phytoplankton biomass (in terms of Chl *a*). Among the factors which cause the decrease, the reduction of nutrient concentrations, especially phosphates were identified (Mozetič *et al*., 2010, 2012). The euphotic zone in the Slovenian Sea greatly exceeds the depth of the upper mixed layer (Talaber *et al.* 2014) with the exception of the winter months. Annual primary production for the years 2010 and 2011, characterized by different nutrient availability especially during summer, was estimated at 87.4 and 60.2 g C m−2, respectively (Talaber *et al*., 2018). According to the classification of Nixon (1995) the area should be thus classified as oligotrophic.

2.1.1.2. Microzooplankton grazing

Microzooplankton ecology in the Slovenian coastal sea deserved only poor attention. There are some data available on the microzooplankton structure in the period from 1989-1992. Tintinnid ciliates were studied in term of density, species richness and seasonal occurrence (Lipej, 1992). From the adjacent area of the northern part of the Gulf of Trieste some evidences were accumulated which proved that microzooplankton population controlled heterotrophic nano flagellate biomass very efficiently (Fonda Umani & Beran, 2003). In addition, the food of microzooplankton consists of cyanobacteria and heterotrophic bacteria, as well (Fonda Umani *et al*., 2005).

2.1.2. Information on invertebrate bottom fauna, macro-algae and angiosperms including species composition, biomass and annual/seasonal variability

Up to date, approximately 2260 species were recorded (reported) in the Slovenian part of the Adriatic Sea, which represent almost 1% of all reported species in seas and oceans (Lipej & Mavrič, 2019). The great majority of Slovenian marine fauna is bottom dwelling, such as epifauna and infauna. No endemism has been till yet described in the Slovenian part of the Adriatic Sea. Many endangered habitats and endangered marine species were up to date recorded in the Slovenian part of the Adriatic Sea (Lipej *et al.*, 2006, 2018).

Angiosperms

In the Slovenian waters four native species of seagrass are present: *Posidonia oceanica* (Linnaeus) Delile, *Cymodocea nodosa* (Ucria) Ascherson, *Zostera marina* Linnaeus and *Zostera noltei* Hornemann (Borum and Greve, 2004). The first and the second one are forming extensive seagrass meadows, while the latter two are present only in the form of small islets. Seagrass *Ruppia cirrhosa* is present in euryhaline and eurytherm biotopes such as lagoons, salt marsh and isolated channels.

Macroalgae

According to all published data on macroalgae recorded in the Slovenian part of the Adriatic Sea, altogether 166 red algae, 61 brown algae and 59 green algae were recorded (*sensu* Lipej & Orlando Bonaca, 2011).

For the northern Adriatic Sea nine *Cystoseira* taxa were currently reported (Orlando-Bonaca & Rotter, 2018):

- *(C. amentacea)* var. *stricta* Montagne, (Montagne, 1846)
- *(C. barbata)* (Stackhouse) C. Agardh, (1820)
- *(C. compressa)* (Esper) Gerloff & Nizamuddin, (1975)
- *(C. compressa)* subsp. *pustulata* (Ercegović) Verlaque, (in Thibaut *et al.* 2015)
- *(Cystoseira corniculata)* (Turner) Zanardini, (1841)
- *(Cystoseira crinita)* Duby, (1830)
- *(Cystoseira crinitophylla)* Ercegović, (1952)
- *(Cystoseira foeniculacea* f. *schiffneri)* (Hamel) Gómez Garreta, Barceló, Ribera & Rull Lluch, (2001)
- *(Cystoseira montagnei* var. *compressa)* (Ercegović) M. Verlaque, A. Blanfuné, C.F. Boudouresque, T. Thibaut & L.N. Sellam. (2017)

Among other macroalgae *Fucus virsoides* J. Agardh deserved to be mentioned. It is an endemic species to the Adriatic Sea and is considered to be a glacial relict. In recent decades, *F. virsoides* was patchily distributed on the hard substrata of the northern Adriatic mediolittoral belt (Orlando-Bonaca *et al.*, 2013), The macroalgal community was poorly investigated in the Slovenian part of the Adriatic Sea. The majority of works are dealing only with species composition. Recently, some works were done on other issues such as ecological evaluation in accordance to EU Water Framework directive (Orlando Bonaca *et al.*, 2008) and long term trend evolution (Orlando Bonaca & Rotter, 2018).

Habitat structuring species

Among species which are facing certain threats and are thus considered as endangered species is also the Mediterranean stony coral (*Cladocora caespitosa*), which is an important habitat building species. The biggest colonies in Slovenia with approximately 70 cm of length may according to the prediction based on SAR (species area relationship model) host a total of 130 invertebrate taxa (95 % confidence intervals: 105-162), among them 39 taxa of molluscs (95 % confidence intervals: 29-53) and 61 (95% confidence intervals: 43-85) taxa of polychaetes (Pitacco, 2016).

Reefs are formed also by an alien colonial polychaete *Ficopomatus enigmaticus,* which may form even bigger colonies than *C. caespitosa*. However, since it inhabits eurytherm and euryhaline environments with high oscillations of temperature and salinities, it hosts only a small number of epibionts.

Species of known sharp reduction along last decades

Fucus virsoides J. Agardh is an endemic brown algal species to the Adriatic Sea and is considered to be a glacial relict. In recent decades, *F. virsoides* was widespread, distributed on the hard bottom in the Slovenian Sea and in the northern Adriatic mediolittoral belt (Orlando-Bonaca *et al.*, 2013). A significant decline in *F. virsoides* populations was observed from 2010 to 2015, and Battelli (2016) reported the total disappearance of this species from Slovenian coastal waters in August 2015. Among invertebrates no such cases were detected. The problem may be related to the fact that many invertebrates group are not monitored regularly, so the trends of their populations are not clear.

2.1.3. Information on vertebrates other than fish

Marine mammals

The bottlenose dolphin (*Tursiops truncatus*) is the only cetacean species regularly observed in the Northern Adriatic Sea in recent times (Kryštufek & Lipej 1993; Notarbartolo di Sciara *et al.*, 1993; Bearzi & Notarbartolo di Sciara 1995, Bearzi *et al.* 2004). This species is regularly present in Slovenian territorial and adjacent waters, where it has been the focus of a long-term study by Morigenos, Slovenian Marine Mammal Society since 2002. The full extent of the habitat for this population is not yet known, but it includes the entire Gulf of Trieste and part of Croatian Istria (Genov *et al.*, 2008; 2009). Dolphins can be seen in Slovenian territorial watres area year-round. Re-sighting rates within and between years suggest that at least some individuals are resident in the area. Observations of feeding behaviour and mother-calf pairs suggest that the area is used for feeding, breeding and

nursing (Genov *et al*., 2008). To date, the most robust estimate of population size based on the mark-recapture method is 74 animals (95% CI = 57–90), although the number of animals using this area varies between years (Genov, 2011). For example, in 2013, around 150 specimens (Morigenos, *unpublished data*) were recorded in Slovenian waters.

Based on data collected in 2018, the estimated total number of animals using the area of Slovenian national waters in 2018 was 158 animals (95% confidence interval: 111–224, CV = 0.18). Based on a study done in 2018 by Morigenos (2019) the estimated population size of the bottlenose dolphin population in Slovenian waters was 111–224 animals (^= 158, 95% CI = 111–224, CV = 0.18). This figure is relatively accurate (CV = 0.18) and at the same time relatively comparable to past estimates (Genov *et al*., 2008; Genov, 2011). However, it should be noted that direct comparisons can be problematic, as the 2018 estimate is limited to waters under the jurisdiction of the Republic of Slovenia throughout the year, and past estimates are based on the wider Gulf of Trieste and surrounding waters. Given the size of the area and the time period mentioned, the number of animals in this area is relatively high and thus probably favorable, but a population of less than 250 sexually mature specimens can be considered Endangered under IUCN Criterion D (IUCN, 2012). The most robust estimate of the number of animals in the area is 158, and the number 250 does not even exceed the upper limit of 95% of the confidence interval (224). Current data suggest that this local population is demographically (Genov *et al*., 2009) and genetically (Gaspari *et al*., 2015) separate from the rest of the Adriatic.

Threats and pressures of human activities in the marine environment directly affect the conservation of the species. The bottlenose dolphin is considered as a coastal species and is therefore most likely affected by human interactions at sea and on the coast. Slovenian waters, as well as other parts of the Gulf of Trieste and the Northern Adriatic Sea, are under great pressure from human activities such as maritime traffic (Ferraro *et al*., 2007; Perkovič *et al*., 2013), tourism and recreational maritime transport. (Codarin *et al*., 2008; Genov *et al*., 2008; Picciulin *et al*., 2010), underwater noise (Picciulin *et al*., 2008; Codarin *et al*., 2009b), intensive fishing (Pranovi *et al*., 2000; Casale *et al*., 2004; Coll *et al*., 2007; Genov *et al*., 2008, 2019a), mariculture (France & Mozetič, 2006; Grego *et al*., 2009b), urbanization and chemical and physical pollution (Horvat *et al*., 1999; Malačič *et al*., 2000; Faganeli *et al*., 2003; Mozetič *et al*., 2008; Genov *et al*., 2019b). The arrival and introduction of non-native species (David & Perkovič, 2004; David *et al*., 2007; Lipej *et al*., 2012) represents a potential threat to the species. All these factors directly or indirectly affect the bottlenose dolphin, mainly through the following mechanisms:

a) overfishing leading to a lack of prey;

b) by-catch (unplanned catch) or entanglement of dolphins in fishing nets leading to immediate mortality;

c) chemical pollution affecting the increase in disease, increased adult and juvenile mortality and reduced fertility;

d) physical pollution which may lead to injuries or ingestion of dangerous objects;

e) underwater noise causing disturbance, changes in behavior, difficulties to search for prey, difficulties for communication between individuals, increased energy loss, loss of habitat and potential hearing impairment;

f) collisions with high-speed vessels and related injuries or death.

Due to their migratory nature, bottlenose dolphins do not recognize state borders and jurisdictions. Therefore, any conservation effort requires transboundary cooperation. Long-term conservation and ensuring the favorable status of marine mammal populations and their habitats in Slovenian waters contributes to their long-term protection in the Adriatic Sea, and indirectly helps to ensure the favorable status of other species in the marine ecosystem and thus marine biodiversity conservation.

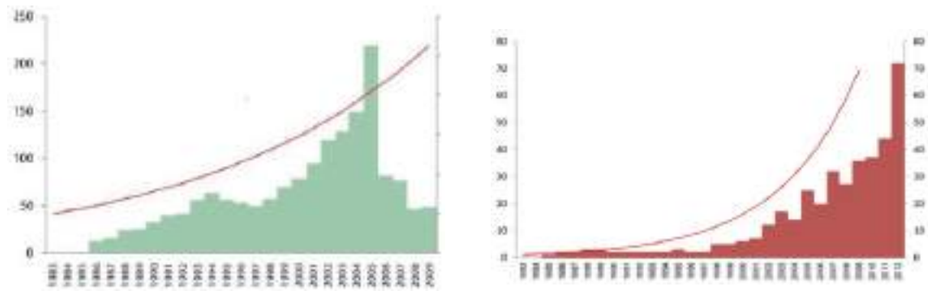
Marine birds

Among the piscivorous marine birds in the area the main predators are the Great cormorant (*Phalacrocorax carbo*) and the Mediterranean shag (*Phalacrocorax aristotelis desmaresti*). The cormorant is a wintering bird, which can reach some hundreds of specimens in the area of Sečovlje salina. It is a diurnal bird, resting at mariculture facilities for culturing mussels. Mediterranean shag is a common bird species in Slovenian Sea, however, it does not nest in the area. The nearest breeding grounds are present in the Brijuni archipelago along the Istrian peninsula. In the Slovenian part of the Adriatic Sea at least 2000 specimens are present outside the breeding season, which represent 11% of its whole population (Koce, 2017). They are occurring mainly at three roosting sites. In Slovenia the main threat represents the bycatch, however, no published records exists on this matter (Koce, 2017).

Among gulls the Yellow legged gulls (*Larus michahellis*) is a regular breeder at Sečovlje salina which is a Ramsar site. It began to nest only in 1983. The same site is the most important Slovenian breeding area which represent more than 85% of all breeding pairs (Figure 1) (Škornik, 2012).

Figure 1

The breeding pair number of the Yellow-legged gull (green bars) and the Little Tern (red bars) in the Sečovlje salina in the period from 1983 to app. 2010 (modified from Škornik, 2012).



The maximum number of Yellow legged gull in the coastal area may in certain periods increase to almost 15.000 specimens (Škornik, 2012). Among terns, two species are regularly breeding. The common tern (*Sterna hirundo*) started to breed in 1986, where first (eleven) pairs were

were recorded. Since then the breeding population drastically increase, especially in the Sečovlje salina (Škornik, 2012). However, the breeding success seems to be rather low,

which could be a consequence of stochastic events in the salina such as huge storms and low temperatures (Škornik *et al.,* 1995). The Little tern (*Sternula albifrons*) started to breed in Slovenia in 1985 (Škornik, 1985) (Figure 1). Nowadays the breeding population is present with more than 70 pairs. Among other marine birds, present in the area, they are neither breeders nor are present in huge numbers.

Sea turtles

The Slovenian territorial waters are part of the Northern Adriatic shelf area, one of the most significant feeding and wintering area for the Loggerhead sea turtle (*Caretta caretta*) mainly those nesting in Greece and Turkey. More so, the Northern Adriatic shelf area is suspected to be an important nursery area for juvenile animals (Fortuna *et al*., 2015). Aerial surveys (Fortuna *et al*., 2010; 2015; ACCOBAMS (ASI 2018)) conducted in the area of the Northern Adriatic Sea have shown that high numbers of loggerheads are present in Slovenian waters. However, since no long-term systematic data collection regarding loggerhead presence in Slovenian territorial waters is available, at present, it is not possible to estimate or predict a possible trend in population size on the basis of publicly available data, so it is not possible to identify a possible increase or decrease in the population. We can only emphasis that the Slovenian territorial waters represent a part of the important Northern Adriatic shelf area and therefore can be seen as important Loggerhead sea turtle habitat in the Adriatic Sea. As the loggerhead sea turtle is a highly mobile species a systematic data collection program, ensuring long term data collection of sea turtle presence in the waters of the Northern Adriatic Sea as a whole, for conservation purposes, are needed.

The threats to loggerheads in Slovenian territorial waters are the same as those for the Northern Adriatic Sea in general. These include incidental capture in fishing gear, particularly with bottom set-nets (gillnets and trammel nets), and, in the smaller extension, bottom trawls. Other sources of mortality include boat strikes and ingestion of plastics. A survey carried out in the north-eastern Adriatic conservatively estimated loggerhead bycatch of Slovenian gillnet fleet at 70 captures/year, with Bycatch Per Unit Effort (BPUE) of 2.81 turtles/year/vessel and direct mortality of 74.7%. If this BPUE is extrapolated to multifunctional vessels, a potential gillnet bycatch may be as high as about 270 captures/year. Though most of multifunctional vessels use gillnets, their fishing effort is probably lower than of the exclusive gillnetters, most likely resulting in lower BPUE and lower bycatch rates. Bycatch in bottom trawls is certainly much lower, due to the small fleet size and the absence of loggerheads from Slovenian waters during the winter as the peak season of trawl bycatch in the Adriatic (Life Euroturtles, 2019).

The conservation of *Caretta caretta* as a migratory species requires efforts extending beyond national borders. Due to the migratory features of the species, it does not recognize state borders and jurisdictions. Therefore, any effective conservation effort requires transboundary cooperation.

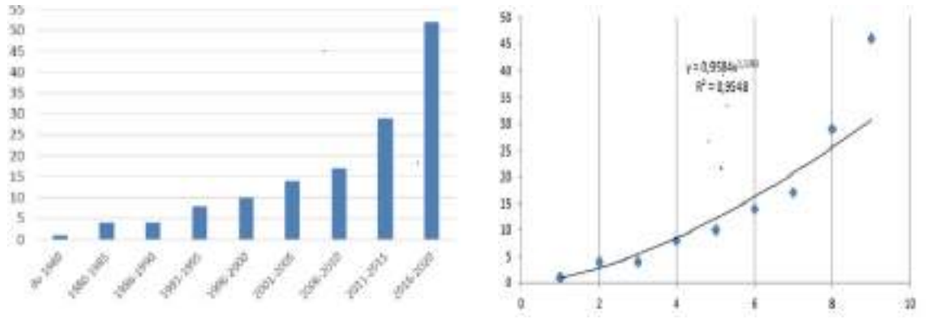
2.1.4 Inventory of the temporal occurrence, abundance and spatial distribution of non-indigenous, including invasive, species

2.1.4.1. Inventory

Up to date at least 52 non indigenous species (NIS) were reported in marine waters of Slovenia (Orlando Bonaca *et al.,* 2020) (Figure 2). The majority of NIS are already established in the area, while cryptogenic, invasive and casual NIS represents smaller shares (Figure 2).

Figure 2

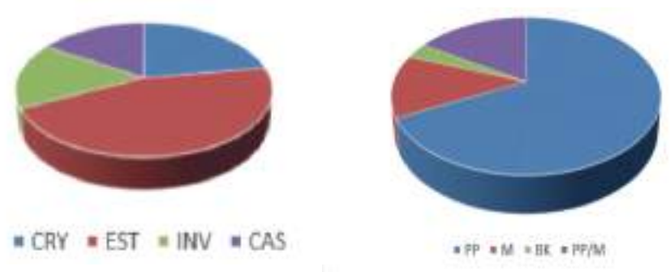
Trends of marine NIS introduction/detection in Slovenia: the cumulative number of NIS in five years intervals reported in the period from 1980 to 2020 (according to Orlando Bonaca et al., 2019).



As in other regions, the vectors of introduction are various, comprising Lessepsian migration, aquaculture, biocontrol, aquaristics and shipping (Figure 3. left). The far most important vector of introduction is the maritime traffic (Figure 3. right). Aquaculture and biocontrol are less important in spreading NIS. There are also cases of deliberate release of certain aquarium pet fish.

Figure 3

The characterization of NIS up to date reported for Slovenia (according to Orlando Bonaca *et al.,* 2020). Legend: CRY – cryptogenic, EST – established, INV – invasive, CAS – casual, PP – maritime traffic, PP/M - maritime traffic and/or mariculture, M – mariculture and BK – biocontrol.



The recorded invasive species up to date reported in Slovenian marine waters are *Haloa japonica, Arcuatula senhousia, Magallana gigas, Mnemiopisis leidyi* and *Pseudodiaptomus marinus*. There are also many cryptogenic species with uncertain biogeographical affiliation.

They are mainly found among cirripeds (*Balanus trigonus, Amphibalanus amphitrite*), bryozoans (*Bugula neritina* and *Amathia verticillata*) and tunicates (*Styela plicata, Bottrylus schlosseri*). Cryptogenic species are found mainly in harbors, ports and marinas as part of fouling community.

The majority of NIS were firstly reported only after 2000 (Lipej *et al*., 2012). The obtained numbers are much lower in comparison to adjacent areas (Trieste and Venice Gulfs), which could be explained by various reasons. The first is related to the size of the studied area, which covers only a small portion of the Gulf of Trieste and less than 50 km of coastline. The second reason could be related to the fact that in the area there are only few substantially devastated environments, where non-indigenous species could settle down at first. Finally, we cannot neglect the low winter temperatures in the studied area which might have an important impact on the survival of newcomers. According to the trend of discoveries, the number of NIS in Slovenian waters we can certainly expect the number to increase in the future (Figure 2).

2.1.4.2. Spatial distribution

According to the survey of NIS in Slovenia, the great majority of all species was found

a) in ports, harbors and marinas,

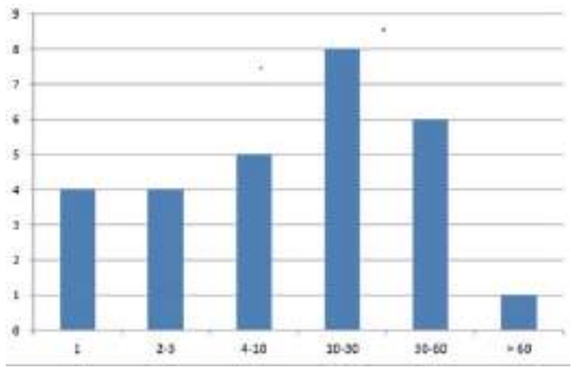
b) coastal wetlands and

c) aquaculture facilities (fish farms, *Mytilus galloprovincialis* cultures and buoys).

Harbors and marinas are considered as susceptible environments for bioinvasion and they act as recipients of newly introduced alien species. Such environments are characterized as disturbed areas with numerous oscillations of abiotic factors such as temperature and salinity (due to freshwater inflow) and are often subject of pollution.

Figure 4

The number of marine NIS (Y axis) per number of localities (X axis) in Slovenia (according to Orlando Bonaca et al., 2019).



One of the most important sites is within the coastal lagoon, the Nature Reserve Škocjan Inlet.

This area, characterized by brackish waters, seems to be a recipient for NIS mollusks, suitable for colonization, due to the connection of the lagoon with the harbor of Koper.

The majority of NIS was found at higher number of localities (Figure 4). Only 4 species were found only once and at a single locality.

The bulk of recorded NIS were found in two biocenoses: the biocenosis of the lower mediolittoral rock and the euryhaline and eurytherm biocenosis. As all reported species are considered opportunistic, with a broader ecological valence (Mizzan, 1999) they could tolerate great oscillations of temperature and salinity, typical conditions of the eurytherm and euryhaline biocenosis. Such living communities are found mainly in coastal lagoons and estuaries, typical environments where NIS species are the most successful from the aspect of colonization (Paavola *et al*., 2005).

2.1.5. Information on species of commercial interest for fishing (fish, mollusk and shellfish)

Commercial fishing in Slovenia can be almost exclusively defined as Small Scale Fishery SSF). The data for the year 2016 show that 87% of all the fishing boats were devoted to SSF. Due to the small size of the fishing boats the fishing activity is mainly limited to the territorial sea, which is part of the 37.2.1. FAO fishing Division. In spite of the fact that the impact of Slovenian fishery on Adriatic fish stocks is almost negligible it nevertheless suffers from the impact of intensive fishing activity, resulting in lower yields and higher fishing effort.

Around 120 species of fish and other organisms are represented in the catches of the Slovenian fishermen. Pilchard and anchovy used to be the top two species before 2012, with catches reaching 400 t for pilchard in 2009 and 2010 and for anchovy in 2005 – 2007. After the decommissioning of the last two vessels with midwater trawl and the almost complete omission of the purse seine fishery, the catches for both species experienced a drastic fall. As a consequence, in the following years the main species of commercial interest were and still are: Whiting (*Merlangius merlangus*), Gilthead seabream (*Sparus aurata*), Musky octopus (*Eledona moschata*), European squid (*Loligo vulgaris*), Common sole (*Solea solea*), Red mullet (*Mullus barbatus*), Common cuttlefish (*Sepia officinalis*), grey mullets (*Chelon labrosus, Liza aurata, Mugil cephalus*), Annular seabream (*Diplodus annularis*), Blackspotted smooth-hound (*Mustelus punctulatus)*, Smooth-hound, *Mustelus mustelus*).

The fishing activity does not impact the species listed in Annex II, as for the species in Annex III, the exploitation of Smooth-hound and Blackspotted smooth-hound is still not regulated. The common lobster on the other hand is protected by the governmental Decree on protected wild animal species, it is however the target of scuba divers that take advantage of poor surveillance (Lipej, *personal observation*).

The approximate values in terms of catches for the top five in 2017 are shown in the table below (Table 1).

Table 1.
Catches of the most important fish species in Slovenia (in tonnes).

Species	Catch (t)
Whiting (*Merlangius merlangus*)	20
Gilthead seabream *(Sparus aurata)*	18
Common sole *(Solea solea)*	13
Musky octopus *(Eledona moschata)*	10
grey mullets *(Chelon labrosus,Liza aurata, Mugil cephalus)*	6
European squid *(Loligo vulgaris)*	6

2.2. Main Habitat types

The Gulf of Trieste is a shallow semi-enclosed embayment located in the northernmost part of the Adriatic Sea, which extends from Cape Savudrija (Croatia) to Grado (Italy). The southern part of the Gulf represents the Slovenian territorial waters. The Slovenian part of the Adriatic Sea is predominantly shallow with the maximum depth of the 33m in waters off Piran. The coastal morphology of the study area varies from steep rocky cliffs to gradual sloping beaches consisting of gravel and pebbles (Ogorelec *et al.*, 1991). The rocky substratum of the Slovenian coast is made of Eocene flysch layers, with alternating solid sandstone and soft marl (Ogorelec *et al.*, 1997). Only a smaller part of the coastline (1/5) is not yet urbanised. During past decades the Slovenian coastal sea suffered from many anthropogenic impacts such as intensive fishing, sewage outfalls and aquaculture (Mozetič *et al.*, 2008). Table 2 presents the data about the bionomic categories (biocoenoses) in Slovenain aprt of the Adriatic Sea.

2.2.1. Supralittoral rocks

Supralittoral rocks are present only locally, since only 18% of the Slovenian coastline is still present in its natural form. The biocenosis of supralittoral rocks (I.4.1.) is therefore present only in few locations. No supralittoral rock pools could be found in Slovenia.

Table 2.
The broader habitat types and their surface in Slovenia (according to Lipej et al., 2018b).

Habitat type	EUNIS (2016)	Surface (km²)
Littoral rocks	*MA1*	*0.37*
Littoral sediment	*MA3, MA4, MA5, MA6*	*0.52*
Infralittoral rocky bottom	*MB1*	*0.68*
Infralittoral sand and muds	*MB5, MB6*	*4.38*
Circalittoral biogenic formations	*MC2*	*0.05*
Circalittoral coarse sediment & sands	*MC3, MC5*	*81.08*
Circalittoral muds	*MC6*	*126.34*

2.2.2. Supralittoral muds and sands

Even more rare are natural areas with supralittoral natural sediments. A special habitat type was found in two localities in the eastern part of the Slovenian coast, made of dead leaves of *Cymodocea nodosa*, which have been washed ashore (1.2.1.5. Facies of phanerogams which have been washed ashore).

2.2.3. Mediolittoral rocks

The biocoenoses of the upper (II. 4.1.) and lower mediolittoral rocks (II.4.2.) are found in its pristine form only in less than 1/5 of Slovenian coastline.

2.2.4. Mediolittoral sands and muds (II.3.1)

One among the most important biocoenosis for many marine invertebrates, but also the wintering and breeding bird fauna, are mediolittoral sands and muds. Some of them were in the past anthropogenically modified in salt pans (facies of saltworks) and are nowadays important from the aspect of specific hypersaline fauna, halophytic vegetation and important resting ground for many wintering and migrating birds.

2.2.5. Photophilic algal communities (III.6.1)

The widespread canopy-forming species of the genus *Cystoseira* are known to form the so-called brown algal forests (III.6.1.16) in the infralittoral, which represent the final stage of the succession of photophilic algal communities on hard substrata in the Mediterranean Sea (Pérès & Picard, 1964). The vegetation of *Cystoseira* is present only in the form of restricted algal belts on rocky bottom, formed by *Cystoseira barbata* (Figure 5) and *Cystoseira compressa* mainly in the depth range from 1 to 5 m. A map with the distributional data on *Cystoseira* habitat types is not yet available, however, it is a part of the research project activities in 2020. Many of the algal patches of *Cystoseira* spec. are present inside the MPAs Cape Madona Natural monument, Debeli rtič Landscape Park and Strunjan Nature reserve.

Figure 5

The vegetation cover made by the arborescent algae Cystoseira barbata is one among the most important habitat types in term of species richness in Slovenian waters. During last years this habitat is facing drastic changes in coverage reduction.

2.2.6. Euryhaline and eurytherm biocoenosis (III.1.1.)

The euryhaline and eurytherm biocoenosis is developed mainly in lagoons, estuaries, salinas, isolated channels and other similar biotopes. The northern Adriatic Sea is characterized by many lagoons, which are present in Italy. In Slovenia, however, only two lagoons are present and both of them are anthropogenic in origin. Both lagoons, Stjuža (Strunjan)(Figure 6) and Škocjan lagoon (Koper) hosts certain lagoon faunistic elements and are parts of protected coastal wetlands. This shallow areas are known to host great oscillations in salinity and temperature and other harsh ecological mconditions.

Figure 6

The lagoon Stjuža (right) with its transient part (in the middle) and the Strunjan salina (left).

2.2.7 Seagrass meadows

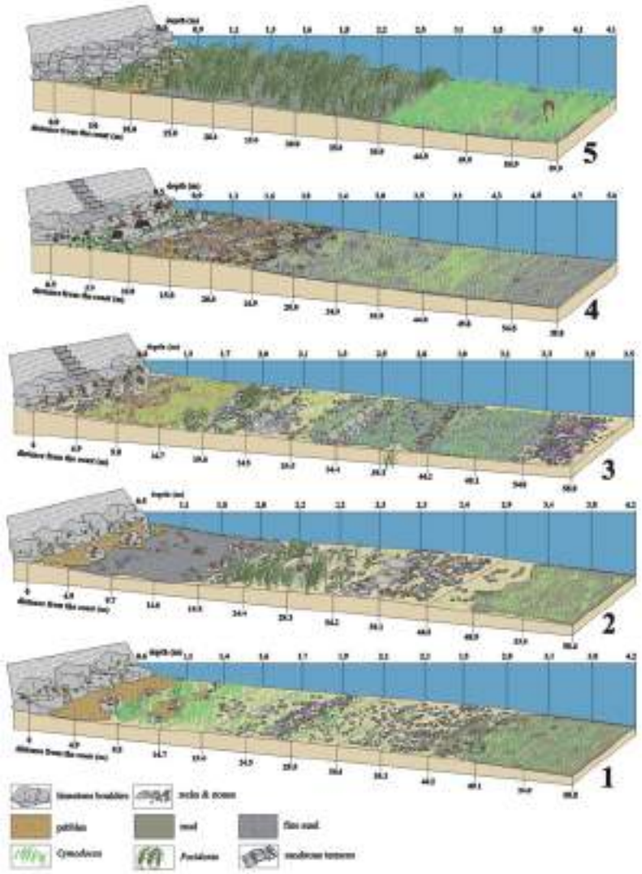
Posidonia oceanica seagrass meadow (III.5.) is restricted in size (0.64 ha; Turk and Vukovič, 1998) (Figures 7 and 8), whereas *Cymodocea nodosa* covered different habitat types such as exposed areas, protected embayment's and coastal lagoons (*sensu* Lipej *et al.*, 2006).

Figure 7

Seagrass meadows of Posidonia oceanica, distributed in the area between Izola a nd Koper. Seagrass meadows are present in forms of big fragments (I-V), normally embraced by seagrass meadows of Cymodocea nodosa.

Figure 8

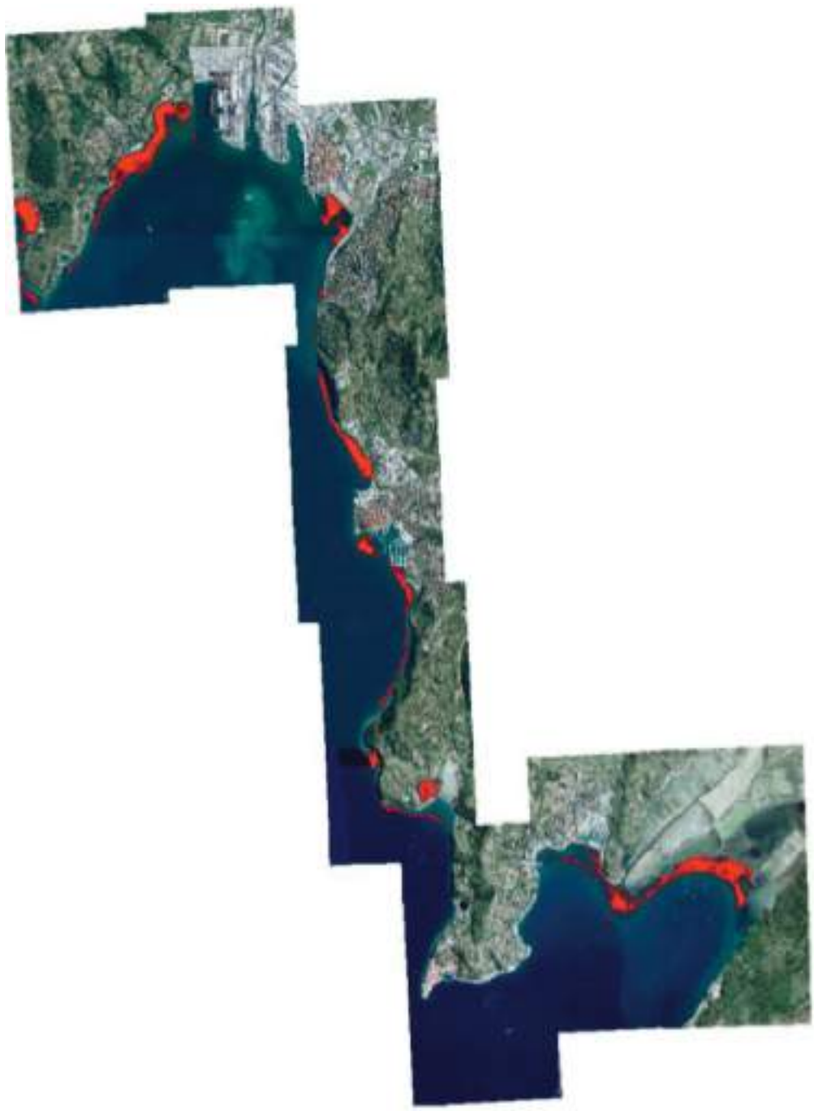
Topographical survey of Posidonia oceanica islets, embraced by seagrass meadows of Cymodocea nodosa at five stations between Žusterna and Moleto (Koper) in the mediolittoral and infralittoral stages.



Seagrass meadows of *C. nodosa* are present in three different biocenoses (Figure 9). A restricted seagrass meadow which is characterized as a euryhaline and eurytherm biocenosis (III.1.1.) is present in the lagoon Stjuža in Strunjan. The majority of *Cymodocea* meadows are found in the biocenosis of superficial muddy sands in sheltered waters (III. 2. 3. 4. Association with *Cymodocea nodosa* on superficial muddy sands in sheltered waters) and some of them also in the biocenosis of well sorted fine sands (III. 2. 2. 1. Association with *Cymodocea nodosa* on well sorted fine sands)

Figure 9

Seagrass meadow distribution in the territorial waters of Slovenia in 2018 (from Lipej *et al.*, 2018b). The great majority of seagrass meadows is covered by Cymodocea nodosa.

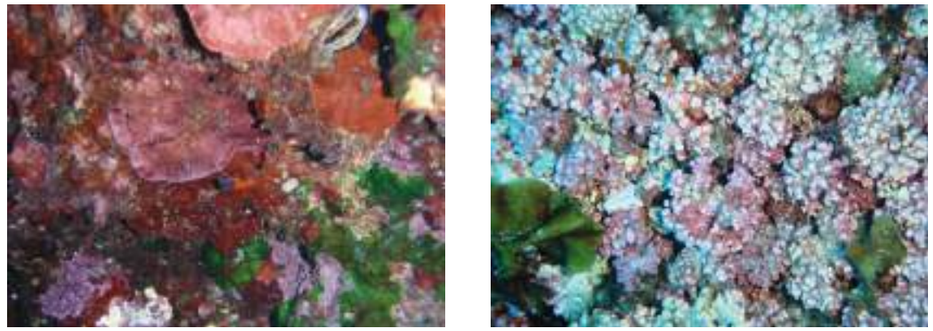


2.2.8. Precoralligenous stage of coralligenous biocoenosis

In certain areas of the Slovenian sea a precoralligenous stage of coralligenous biocoenosis is well developed (Figure 10). To be pointed out the area between Strunjan and Piran in the depth range from 5 to 14 m. Such areas are characterized by high spatial heterogeneity, which resulted in outstanding diversity of microhabitats (caves, cavities, crevices, burrows, holes and others) and benthic invertebrate fauna: The coastal fish assemblage, which inhabit such habitat type is rich, as well.

Figure 10

Coralligenous algae are the building elements of the precoralligen.
Legend: Left: Peyssonnelia spp., Right: Lithophyllum spp..



2.2.9. Biogenic formations

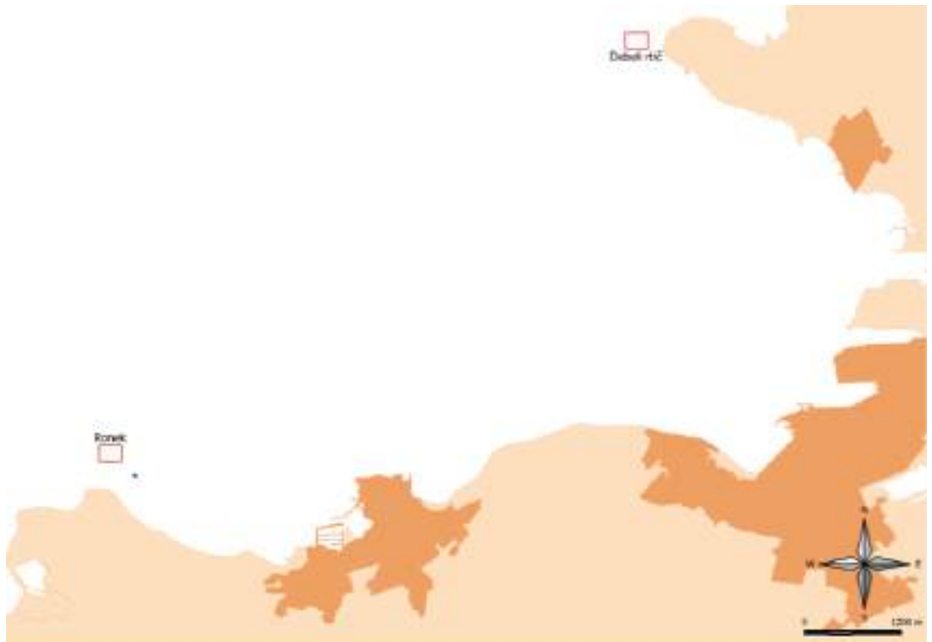
Two biogenic formations made of dead corallites (Figure 11) of the Mediterranean stony coral *Cladocora caespitosa* were discovered in the Slovenian coastal sea (Lipej *et al.*, 2016). One is located in front of the NR Strunjan (cape Ronek) in the Strunjan Landscape Park and the other within the newly established Debeli Rtič Landscape Park (Figure 12).

Figure 11

The biogenic formation in front of the Cape Ronek is a peculiar habitat type of the secondary hard bottom (left). It is made completely of dead corallites of the Mediterranean stony coral (right).
At the very same time the area hosts the highest density of living colonies of the stony Coral

Figure 12

The distribution of biogenic formations in the Slovenian Sea.



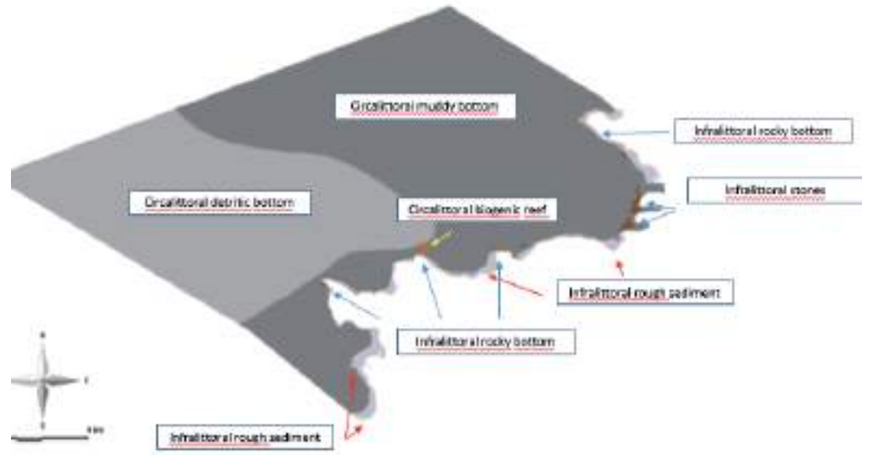
The dead corallites built a secondary hard bottom, which is increasing the spatial heterogeneity and attracting merozooplankton larvae to settle down and develop in adult benthic organisms (Lipej *et al*., 2016). As a consequence, the area is considered very rich in species number and abundance of benthic epifauna as well as nectobenthic and epibenthic fish fauna. At the very same time the biogenic formation is densely overgrown with colonies of *C. caespitosa*.

2.2.10. Others

The great portion of the Slovenian sea is characterized by the circalittoral muddy bottom and the circalittoral detritic bottom (IV.2.2.) (Figure 13). The latter is hosting more diverse invertebrate epifaunal community. Some biogenic formations in the circalittoral stage were also recently discovered and studied (Lipej *et al*., 2016). The infralittoral rocky bottom is present mainly in exposed areas, especially in MPA such as NM Cape Madona, NM Debeli rtič and NR Strunjan.

Figure 13

Topographical survey of macrohabitat types in the Slovenian Sea (modified frim Lipej et al., 2018).



2.3. Singular habitats in the country

The northern Adriatic Sea is characterized by rocky outcrops. In the Italian part of the northern Adriatic Sea they are known as *trezze*, formations made of biogenic carbonates, which are islands of secondary hard bottom on a muddy-sandy sediment. They provide space for settlement of planktonic larvae of many benthic invertebrates and at the same time attract many fish species. Two giant rocky outcrops, made of dead corallites of the Mediterranean stony coral are present in waters of Slovenia, which represents an oasis of biodiversity. SPA/RAC recognized the importance of such megahabitats for biodiversity and financed the publishing of a scientific monograph on biogenic formations in 2016 (Lipej *et al*., 2016).

2.4. Transboundary issues

Since the Slovenian territorial waters comprised only a small portion of the Adriatic Sea the efficiency of its conservation measures is strongly dependent on the marine conservation policy of the bordering countries.

Good cooperation is established between the research communities covering the Gulf of Trieste. Many common projects were carried out within different national (National Research Agency) and international (Interreg, LIFE) financial programmes.

There is however very little collaboration targeting marine and coastal biodiversity conservation. This is most critical in two ways. One concerns the conservation of highly mobile species as well as the ecological representativity and connectivity of MPAs in the area. The other issue that certainly depend on transboundary collaboration are the human impacts on the marine ecosystems – how to monitor them and more important, how to reduce their negative impacts and at the same time increase the resilience of the marine environment.

2.5. Identification of the country's marine and coastal biodiversity gaps needed for scientifically sound based conservation

The knowledge of the Slovenian marine biodiversity in general could be to our opinion considered as rather good. However, there are still some gaps which should be filled in the nearby future.

1 _ There are no recently done overall checklist of marine fauna and flora in the area. Few such studies are available, such as is the monograph of opisthobranch fauna of Slovenia (Lipej *et al.*, 2018) which pointed out some impressive data. At least 141 species were up to date reported which represent a huge portion of Mediterranean opisthobranch fauna. To this end, it would be an important task to understand which species are resident, migrants, occasional and sporadic species.

2 _ One of the most important actions which should be done in nearby future is the preparation for the red book on marine fish fauna, marine flora and marine fauna, at least in term of the studied taxonomical groups which deserved scientific attention. The knowledge on the status of species in the area (according to the IUCN standardisation), especially in term of marine vertebrates will elucidate the needs to maintain such biodiversity in the area also in the future.

3 _ One of the important gaps in terms of inventories and habitat mapping is the absence of a detailed cartography of the circalittoral habitat types with the emphasis on the detritic bottom.

4 _ Another gap is related to food web, which is described as networks of feeding interactions between consumers and their food. In fact, this topic, which is one of the descriptors of Marine Strategy Framework directive, was up to date only poorly investigated in Slovenia (Orlando Bonaca *et al.*, 2019).

5 _ Besides the above, a long - term systematic monitoring of the key elements of biodiversity of the Slovenian sea.

6 _ Studies on factors which affect the biodiversity in the area are not yet studied properly. Macrohabitat and microhabitat diversity and availability studies in the area were performed only recently. Since biodiversity is closely related to the diversity of habitats and the spatial heterogeneity, such factors should deserve proper scientific investigation from the aspect of conservation.

7 _ The shallow Slovenian part of the Adriatic and the adjacent Gulf of Trieste is known as nursery area for many elasmobranch species. Since many of those species are facing the danger of extirpation, it would be very important to prepare measures in order to reduce the mortality of sharks and rays in the area.

8 _ According to our opinion an ultimate task would be also to assess the present vulnerability of the Slovenian coastline in term of (recent) pressures and impacts (Figure 14).

Figure 14

The natural coastline of Slovenia, indicated in pink. Other parts of the coastline are already anthropogenically modified (from Orlando Bonaca et al., 2019)

3.

Pressures and impacts

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3.1. Biological disturbance

3.1.1. Bioinvasion

Up to date there is no evidence which would point to pressures and possible impacts of NIS in the Slovenian sea. Even in the case of *Mnemiopsis leidyi,* a study which dealt with the possible impact of this invasive species to the local biota, did not show any impact on the fish eggs and larvae (Mavrič *et al*., 2019). No comprehensive studies were up to date performed on other invasive species and NIS in general.

3.1.2. Impact of non-native biota on fisheries and aquaculture

Recently, some species such as the Blue fish (*Pomatomus saltatrix*) were recorded in higher numbers in the Slovenian coastal sea. There are no published data regarding any impact of this species on local fish fauna, the only sporadic records were published in local newspapers regarding substantial landings of this species in fishing ports. However, in the close vicinity of the Croatian Tar Cove (not distant from the Slovenian border), there are scientific reports on substantial captures of the Blue Fish. The catch in the estuarine habitat of the Tar cove near the river Mirna estuary is related to feeding migrations of Blue fish in estuarine habitats where they prey on shoals of mullets or other fishes destroying numbers apparently far in excess of feeding requirements (Collette, 2003).

In 2018 the traditional winter fishing event in Tar Cove was characterized by a massive capture of blue fish (1.5 tonnes), which represented almost all fished specimens. There are some evidences of NIS tunicates such as *Clavellina oblonga* (Figure 15). In the neighbouring Croatian mariculture facilities this tunicate causes a huge economic damage, since it overgrown the cultured bivalves.

Figure 15.

A colonial ascidian Clavellina oblonga is causing seasonal problems to mariculture by overgrowing the cultured mussels. Left: Fouling community with C. oblonga, Right: a close-up photo of a zoid. Photo: A. Fortič.

3.1.3. Other stressors

In the finalization of the present report the first cases of infestation with the parasite *Haplosporidium pinnae*, which affected almost whole Mediterranean Sea, were recorded also in the Slovenian marine waters. In August 2020 only isolated cases were noticed, whereas in the September we witnessed the massive mortality of *Pinna nobilis* in different localities along the Slovenian coast.

3.2. Vulnerable marine ecosystems

3.2.1. Seagrass meadows

Seagrass meadows are amongst the most valuable coastal ecosystems in the marine environment, since they provide many important ecosystem services. Since coastal areas are nowadays subjected to intense anthropogenic pressures (turbidity, modified nutrient cycles, physical damage to the sea bottom. pollution), a rapid and widespread decline of seagrass meadows has been reported from many areas (Figure 16).

Figure 16.
The trend of disappearance of Cymodocea nodosa seagrass meadows druing the last decade (2009-2019) in the area of Strunjan Bay and Strunjan lagoon (modified from Lipej et al., 2018).

In recent years seagrass meadows are facing a decline of coverage due to anthropogenic stressors and natural factors also in the territorial waters of Slovenia.

During the last decade certain seagrass meadows of *Cymodocea nodosa* experienced important regression disappeared (Figures 16 and 17). In the area of Strunjan the seagrass meadow completely disappeared from the innermost part of the gulf in 2018.

Among the factors responsible for its disappearance, deposition of suspended material is certainly the first in line. Increased deposition in the last years was on one hand the consequence of reconstruction works that were carried out on the small fishermen port and on the banks of the Roja stream. On the other hand, in the same years two major events of hard rainfall and high tide caused flooding and massive discharge of silt in the gulf. As a consequence, some areas were affected also by hypoxia (Lipej *et al.,* 2018). In certain areas and inside some MPA such as the Debeli rtič Landscape Park and adjacent areas as well as some parts of the Nature Reserve of Strunjan, the seagrass meadows and its macrofauna (such as *Pinna nobilis*) are being heavily damaged by anchoring (Lipej *et al*., 2016).

Figure 17
Disappearance of seagrass meadow of Cymodocea nodosa in front of the Marine biology station in Piran. Left: the end of a pipeline in still present seagrass meadow in 2017; Right: A photo on the very same position in 2018 shows the complete disappearance of Cymodocea nodosa. Photo: T. Makovec.

3.2.2. Photophilic algal communities

3.2.2.1.Cystoseira algal belts

Scientists identified increased temperature, sedimentation rates, urbanization and changes in water quality (summarized in Giani *et al*., 2020) as some of the most critical stressors for algal forests. A global regression of *Cystoseira* brown forests was signalized for the northern Adriatic in the period 1970-1990. Two major stressors were documented, the first being related to high eutrophication levels (Iveša *et al.,* 2016), and the second characterized by overgrazing by sea urchins (*Paracentrotus lividus)* (Vukovič, 1976). Sea urchins experienced a population explosion which caused the consumption of almost all the macroalgal cover and its total devastation in the Slovenian coastal Sea.

The recovery of algal belt made of species of genus *Cystoseira* was recorded along the Croatian Istrian Peninsula, suggesting that these species never completely disappeared from the basin, and that some patches probably persisted during the regression period, forming the potential for the subsequent recovery during the period of favourable conditions (Iveša *et al*., 2016). Also, along the Slovenian coastline a slight recovery in the proportion of canopy-forming algae (*Cystoseira* spp. and *Halopithys incurva*) was reported from 2016 (Orlando-Bonaca & Rotter, 2018).

3.3. Emerging issues such as climatic change effects and open sea including deep-sea ecosystem concerns

In the last few decades, we have been faced with certain processes in the Slovenian part of the Adriatic Sea that can be in one way or another linked to global warming / climate change. Three main processes were recorded and described throughout scientific studies: tropicalisation, coral bleaching and sea level rise.

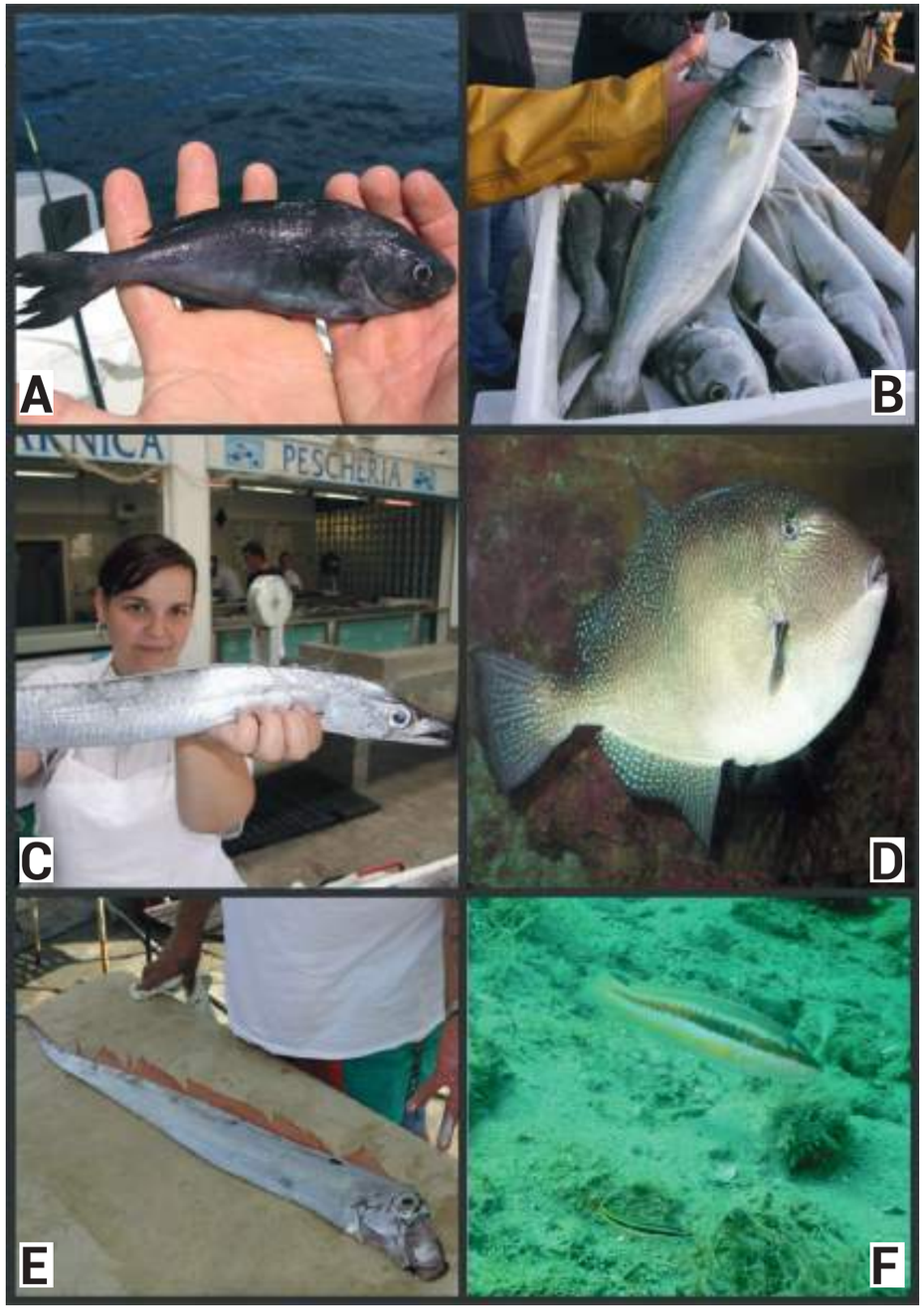
3.3.1. Tropicalisation

Tropicalisation is a process of northward spreading of southern thermophilous species (Francour *et al.*, 1994).

Northward spreading of thermophilus species was confirmed in many animal taxa, although especially fish proved to be particularly good indicators, given that they are incapable of regulating their own body temperature (Stebbing *et al*., 2001), with the monitoring of their distribution being a relatively simple task. In fact, many fish species of southern origin were recently documented in the northernmost part of the Adriatic and in the territorial waters of Slovenia (Figure 18).

In the last few decades, the ecological barriers that used to prevent species spreading northwards have also fallen in the northern parts of the Mediterranean Sea as a result of higher temperatures. Owing to the rising temperatures, certain species that are otherwise characteristic of the Mediterranean Sea's southern parts began to occur in the Adriatic (Dulčić *et al*., 1999) and, in the final phase, in the Gulf of Trieste as well (Lipej *et al*., 2009).

Figure 18:
Fish species related to the process of northward spreading of southern species recorded in the Slovenian sea. Legend: A – Centrolophus niger, B – Pomatomus saltator, C. Lepidopus caudatus, D. Balistes



3.3.2. Coral bleaching

The other phenomenon is coral bleaching, which occurs when endosymbiotic zooxanthellae leave the polyps due to their physiological stress (Figure 19). This is triggered largely by high temperatures, but also owing to the intensive solar radiation or certain diseases. One of the anthozoan species that is known to be good indicator of climate change is the Mediterranean colonial stony coral (*Cladocora caespitosa)* (see e.g., Rodolfo-Metalpa *et al.,* 2008), which is present in the Slovenian sea as well.

Figure 19

Polyps of the Mediterranean stony coral (Cladocora caespitosa). Legend : A – normal situation = all polyps alive and colored), B – bleached polyps and C – dead polyps.

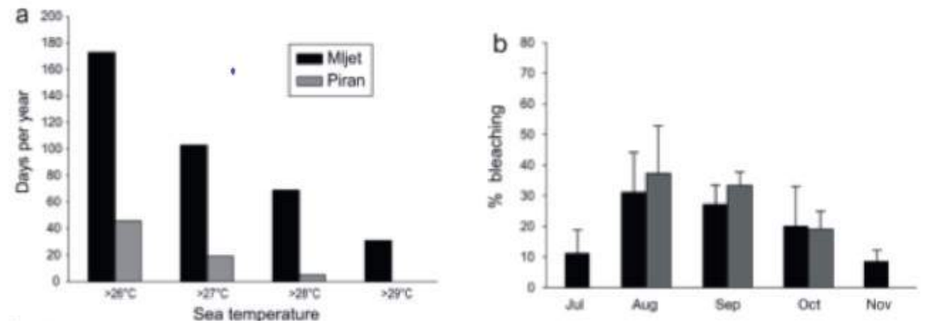
In the summer/autumn period of the 2011 the shallow-water populations of *C. caespitosa* were clearly decimated in Piran and Strunjan area, with mortality rates similar to those reported for tropical seas (Figure 20) (Kružić *et al.,* 2014). The bleaching event was caused by thermal stress, characterized by temperatures of 26–27°C, which can be considered the threshold temperature for triggering *C. caespitosa* bleaching (Kružić *et al.,* 2014).

3.3.3. Sea level rise

Climate change is expected to result in an acceleration of current rates of sea level rise, inundating many low-lying coastal and intertidal landscapes. In Slovenia, coastal wetlands are exposed to climate-change induced sea level rise. The predicted sea level rise in the fore coming decades will affect certain marine and coastal species, especially some species of birds. Many nesting marine species and waders are building their nests preferentially at low elevations above sea level (< 20cm) (Valle and Scarton, 1999), as is the case of *Sternula albifrons, Sterna hirundo* and *Charadrius alexandrinus*.

Figure 20.

Days per year with temperatures above 26, 27, 28 and 29°C in 2011 and (b) percentage of bleached polyps per colony (mean + SE) detected in Mljet National Park (Croatia) and Piran (Slovenia) (Kružić et al., 2014).

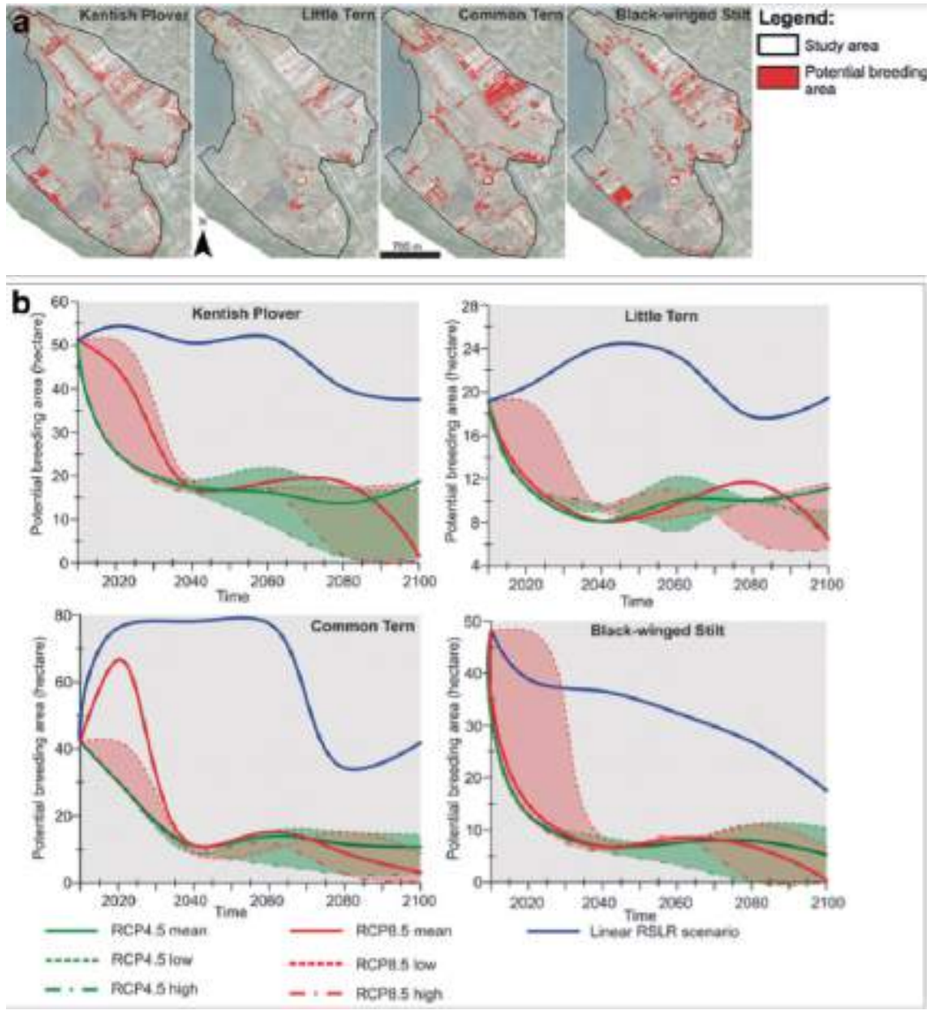


A study dealing with the fate of four rare and endangered breeding birds in the Sečovlje Salina (SW Slovenia) such as *Sternula albifrons, Sterna hirundo, Himantopus himantopus* and *Charadrius alexandrinus* suggests that sea level rise will result in the loss of habitats which are essential breeding sites for all four of these bird species, which will subsequently decrease their breeding success (Figure 21) (Ivajnšič *et al*., 2017).

All four species are endangered, since they inhabit low-lying areas known to be very vulnerable to inundation, cause a decrease of suitable breeding areas but also in the the availability of foraging habitats for shorebirds. Climate change also results in increased storminess. The most vulnerable to such floods and heavy precipitation are the *S. albifrons* and the *S. hirundo* (Škornik, 2012).

The sea level rise will affect also coastal lagoons. In fact, due to climate change the Slovenian coastal lagoons are susceptible to seawater intrusion, which will facilitate the colonization of marine faunistic elements in lagoons.

Figure 21.
Bird breeding suitability maps in Sečovlje Salina (a) and predicted changes in potential breeding area for the Kentish Plover (Charadrius alexandrines), the Little Tern (Sternula albifrons), the Common Tern (Sterna hirundo) and the Black-winged Stilt (Himantopus himantopus), considering linear and IPCC AR5 RSLR scenarios (RCP4.5 and RCP8.5) (Ivajnšić et al., 2017).



4.

Current response measures

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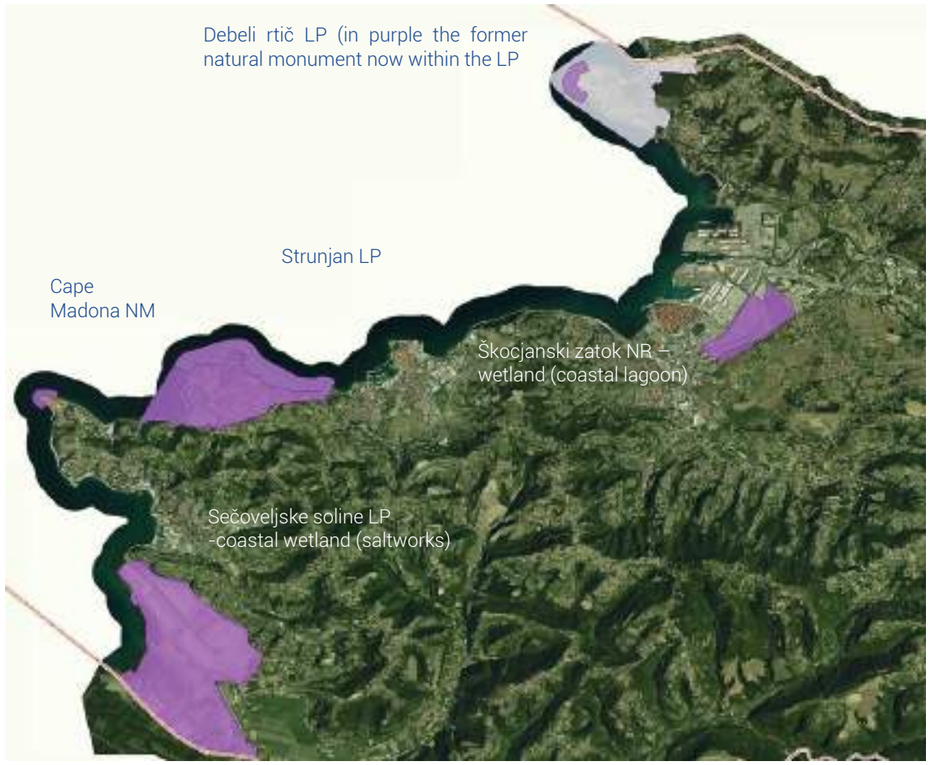
4.1. Marine protected areas and other area-based conservation measures

Three marine protected areas (Figure 22) were established up to now in the Slovenian sea, two landscape parks and one natural monument. Both landscape parks (Strunjan, Debeli rtič) encompass a marine and a terrestrial part while the natural monument (Cape Madona) is only marine. The marine area covered by the three areas is roughly 3.7 km2 which represent 1.85% of the Slovenian sea. The main data on their surface, establishment and management as well as on their respective objectives are summed in the next paragraphs.

Figure 22.
Slovenian marine and coastal MPAs



4.1.1. Strunjan Landscape Park

The Strunjan Landscape Park was established in 1990 (decree by the two municipalities of Izola and Piran). In 2004 the municipal ordinance was replaced by a government decree, which includes provisions concerning the management and the establishment of two nature reserves within the park (Strunjan Nature Reserve and Strunjan – Stjuža Nature Reserve). Half of the total surface of the marine area, which is roughly 2 km2, is included in the Strunjan Nature reserve. The MPA is managed by a public institute, established by the government. The main nature conservation objectives of the MPA as they are stated in the legal act are:

- the protection of natural values[1],
- the conservation of biodiversity,
- the conservation of populations of rare, threatened nationally and internationally protected species,
- assuring the good conservation status of the Natura 2000 habitat types and species,
- the conservation of landscape diversity of the area and the ecological characteristics of the salt-works, the coastal lagoon and the coastline, including the natural processes running between supra, - medio and infralittoral.

4.1.2. Debeli rtič Landscape Park

The Debeli rtič Landscape Park was established in 2018 as an important upgrade in terms of surface, conservation measures and management of the former protected area, the Natural Monument of Debeli rtič, established in 1991. The surface of the marine area covers 1.6 km2 and is divided into three zones with different conservation measures, the former natural monument being the core zone of the area. The MPA is managed by the local community and the main conservation objectives for the marine and coastal environment stated in the legal act are as follows:

- the protection of natural values, the conservation biological and landscape diversity,
- the conservation of populations of rare, threatened nationally and internationally protected species,
- assuring the good conservation status of the Natura 2000 habitat types and species.

4.1.3. Cape Madona Natural Monument

The Cape Madona Natural Monument was established by a municipal ordinance in 1990 under the former Law on Natural and Cultural Heritage. As such no in-field management was foreseen. It is a very small area in front of the city of Piran with a surface around 12 hectares. Its primary conservation objective is the conservation of marine biodiversity.

1 According to the Nature Conservation Act natural values include all natural heritage in the territory of the Republic of Slovenia. In addition to rare, valuable or famous natural phenomenon, a natural value shall be any other valuable phenomenon, any biotic or abiotic component of the natural environment, pristine nature area or part thereof, an ecosystem, a distinct landscape or urban park.

4.1.4. NR Škocjanski zatok

The area of Škocjanski zatok is a coastal wetland, connected with the sea by a channel, going to the sea through the area of the Port of Koper. The Škocjanski zatok Nature reserve was established in 1998 by the Slovenian Parliament and later replaced by a governmental decree in 2014. The management of the area is entrusted to the NGO DOPPS – BirdLife Slovenia.

The combination of brackish and freshwater habitats makes Škocjanski zatok a very diverse environment, regardless its small size. Out of its 122 hectares nearly three quarters are covered by the brackish lagoon – its nesting islands, saltmarshes and mudflats are a home to a range of rare animal and plant species. The freshwater part of the nature reserve was artificially created during the reserve restoration in 2006-07 as a substitute habitat for the wetlands lost nearby Koper through the intensive urbanization processes. It consists of wet meadows, reedbed and deep-water areas which are all important breeding and feeding grounds for birds. The reserve hosts more than 250 species and the number is still increasing. This is over 60% of all bird species observed in Slovenia. The diversity of bird's species is a direct positive result of the carefully planned and implemented restoration as well as management of the reserve.

The conservation objectives, as stated in the legal act are:

- the conservation of brackish and freshwater habitat types,
- protection of bird species that nest, overwinter and stop here on their migration routes,
- protection of habitats of other native wildlife and plant species,
- rising public awareness and carry out educational programs.

4.1.5. Sečovlje salina

The Sečovlje Salina Landscape Park was established in 1990 by the Municipality of Piran. The designation was later upgraded by a governmental decree in 2001. It covers 750 ha and consists of two parts, the northern part, known as Lera, where salt is still being harvested and the southern part, called Fontanigge. Together with the Strunjan salt-works, they are the northernmost and still active salt-works in the Mediterranean and amongst the very few, where salt is still produced in compliance with several centuries' old procedures. The Sečovlje Salina is exceptional in the great diversity of its fauna, flora and habitats.

In 1993, the Sečovlje salt-pans were inscribed on the Ramsar List of wetlands of international importance. There are halophyte meadows, reeds, halophyte islets in the basins, overgrown and bare levees and mudflats. The great diversity of animal and plant species made the area famous far beyond the national boundaries. Apart from the exceptional biodiversity, the Sečovlje salt-works are also an example of exceptional but also endangered Mediterranean landscape, as well as of the most valuable cultural heritage based on centuries-old culture of salt harvesting.

The basic purpose of the designation of the protected area is the conservation of the biodiversity. More specifically, the conservation objectives could be summed as follows:

- the protection of natural values,
- the conservation of biodiversity,
- the conservation of populations of rare, threatened nationally and internationally protected species,
- assuring the good conservation status of the Natura 2000 habitat types and species,
- the conservation of landscape diversity of the area and the ecological characteristics as well as cultural heritage of the salt-works.

Based on the definition of other area-based conservation measures (OECM, CBD Decision 14/8) three types of areas could be taken on board in the Slovenian marine environment, the Natura 2000 sites (they almost completely overlap with the MPAs), the natural values (with minor exceptions they overlap with MPAs and/or Natura 2000 sites) and the fishing reserves. In terms of marine environment, the Natura 2000 sites are designated to achieve the good conservation status of the following habitat types and species: 1110 – Sandbanks which are slightly covered by sea water all the time, 1120 – Posidonia beds *(Posidonion oceanicae)*, 1130 – Estuaries, 1140 – Mudflats and sandflats not covered by seawater at low tide, 1150 – Coastal lagoons, 1170 – Reefs, A392 – Mediterranean shag (*Phalacrocorax aristotelis desmarestii*), A176 – Mediterranean gull (*Larus melanocephalus*), A459 – Caspian gull (*L. cachinnans*), A191 – Sandwich tern (*Sterna sandwicensis*), A195 – Little tern (*S. albifrons*), A193 – Common tern (*S. hirundo*), A002 – Black-throated loon (*Gavia arctica*).

According to the Marine Fisheries Act (Official Gazette of the republic of Slovenia, No. 115/0676/15 and 69/17, there are two fishing reserves - the Strunjan fishing reserve, within the borders of the landscape park Strunjan and the Portorož fishing reserve in the inner part of the Piran Bay that is set within one of the Natura 2000 sites. All commercial and leisure fishing is prohibited with the exception of the harvest of winter shoals of mullets (species of the family Mugilidae) on the basis of a special permit and leisure fishing from the coast.

4.2. Legal and institutional frameworks governing the conservation and sustainable use of marine and coastal biodiversity

The institutional actors related to marine and coastal biodiversity are acting at different levels. The Ministry of the Environment and spatial planning is responsible for the overall nature conservation policy, which is then being implemented through different procedures and protocols by a number of actors. First in line, the Institute of the Republic of Slovenia for Nature Conservation. The institute is involved in the spatial planning process as well as in all kind of concrete interventions (constructions etc) and plans for the use of natural resources with nature conservation guidelines, permits and consents. To mention also proposals of new PAs and other conservation measures, expert opinions in the field of nature conservation and the supervision of the conservation measures implemented by the PA management. Besides, the Institute has the right and duty to represent the interests of biodiversity conservation and protection of natural values in all administrative and judicial proceedings, the subject of which are components of biodiversity, natural values or protected areas.

An important player in the Slovenian legal and institutional framework of nature conservation are the PA management bodies. Three different legal statuses of management bodies are foreseen in the Environmental Protection Act. The management of a PA can be entrusted to a public body (the case of the LP Strunjan), it can be implemented by the local community that established the PA (the case of LP Debeli rtič) or given through concession to an NGO (the case of the NR Škocjanski zatok) or even a business company (the case of the LP Sečoveljske soline).

Environmental Protection Act (Official Gazette of the Republic of Slovenia, No. 39/06 - official consolidated text, 49/06 - ZMetD, 66/06 - US decision, 33/07 - ZPNačrt, 57/08 - ZFO-1A, 70/08 , 108/09 , 108/09 -ZPNačrt- 48/12 , 57/12 , 92/13 , 56/15 , 102/15 , 30/16 , 61/17 - GZ, 21/18 - ZNOrg in 84 / 18 - ZIURKOE)

The EPA is the overall legal act dealing with environmental issues. It has no special marine section; its provisions however do apply also to the marine and coastal environment.

Nature Conservation Act (Official Gazette of the Republic of Slovenia, No. 96/04 - official consolidated text, 61/06 - ZDru-1, 8/10 - ZSKZ-B, 46/14 , 21/18 - ZNOrg and 31/18)

Same as above, the NCA has no special marine section. It determines measures for the conservation of biodiversity and the system of protection of natural values in order to contribute to the conservation of nature. It also defines that the measures for the conservation of biodiversity and the system of protection of natural values under this Act shall be included in spatial planning and the use and exploitation of natural resources, as well as measures for the protection of cultural heritage. Apart its general provisions, the main chapters of the NCA are dealing with biodiversity conservation (plant and animal species, genetic material, ecosystems – ecologically important areas, Natura 2000 sites), protection of natural values (measures of protection, protected areas – including MPAs, endangered species), guidance and authorization (nature protection guidelines, permits and consents), monitoring and organization, which includes provisions on the

establishment of the Institute for Nature Conservation, the management of protected areas and the NGOs working in the public interest.

Decree on ecologically important areas (Official Gazette of the Republic of Slovenia, no., 33/13, 99/13 and 47/18)

This Regulation lays down ecologically important areas and protection guidelines for the maintenance or achievement of a favorable status of habitat types and of wild plant and animal species and their habitats in those areas. An ecologically important area is defined as an area of a habitat type, part of a habitat type or a larger ecosystem unit that makes an important contribution to the conservation of biodiversity. According to the regulation the Slovenian sea and its coastal belt is designated as ecological important area. However, apart from very general provisions on biodiversity conservation and endangered species protection, the regulation does not impose concrete conservation measures as well as no nature conservation consents and/or permits.

Rules on the determination and protection of natural values (Official Gazette of the Republic of Slovenia, No. 111/04, 70/06, 58/09, 93/10, 23/15 and 7/19)

These Rules determine the parts of nature which, due to their properties, are recognized as natural values, classify them into natural values of national and natural values of local importance and regulate more detailed protection and development policies and other mandatory rules of conduct for their protection. They include a list of natural values and their classification into values of national and local importance. The natural values designated in the marine and coastal environment represent mainly coastal wetlands, cliffs with important geological, geomorphological and botanical features and areas with important benthic communities such as seagrass meadows, reefs and algal associations.

Decree on Special Protection Areas (Natura 2000 sites) (Official Gazette of the Republic of Slovenia, No. 49/04, 110/04, 59/07, 43/08, 8/12, 33/13, 35/13 - amended, 39 / 13- US decisions, 3/14, 21/16 and 47/18)

This Regulation lays down specific protection areas (Natura 2000 sites) and protection objectives in those areas, as well as protection guidelines for maintaining or achieving a favorable status of wild plant and animal species, their habitats and habitat types whose conservation is in the interest of the European Union and other rules of conduct for the conservation of these areas.

Decree on protected wild animal species (Official Gazette of the Republic of Slovenia no. 46/04, 109/04, 84/05, 115/07, 32/08 – decision US, 96/8, 36/9, 102/11, 15/14, 64/16 and 62/19 & Decree on protected wild plant species (Official Gazette of the Republic of Slovenia, No. 46/04, 110/04, 115/07, 36/09 and 15”.”

Both regulations deal with protected endangered species, prescribe rules of conduct, special protection regime and protection measures as well as guidelines for the conservation of habitats of species, in order to maintain their favorable status of conservation.

Marine Fisheries Act (ZMR-2, Official Gazette of the republic of Slovenia, No. 115/0676/15 and 69/17)

According to the MFA, fish, as well as other marine organisms are natural resource under special protection of the state. It imposes sustainable use of fish and establishes the two fishing reserves. It defines commercial and non-commercial (scientific and research work, leisure) fishing, defines the licensing procedures for both and includes provisions concerning cultivation and collection of marine organisms.

Decree on the Strunjan Landscape Park (Official Gazette of the Republic of Slovenia, No. 114/04 - amended, 83/06, 71/08, 77/10 and 46/14 - ZON-C).

Ordinance on the Debeli rtič Landscape Park (Official Gazette of the Republic of Slovenia, No. 48/18).

Municipal Ordinance on the Cape Madona Natural Monument (Official Announcements of the Municipality of Piran No. 5/90).

Decree on the Sečovlje Salina Landscape Park (Official Gazette of the Republic of Slovenia, No. 29/01, 46/14 - ZON-C and 48/18).

Decree on the Škocjanski zatok Nature Reserve (Official Gazette of the Republic of Slovenia, No. 75/13 and 46/14 - ZON-C).

Natura 2000 sites management program (2015-2020)

The management plan that was adopted by the Slovenian government lists all the Slovenian Natura 2000 sites and all the conservation measures foreseen for each habitat type or species for which a single site was designated (see 4.1.). The implementation of the measures is, depending on the nature of the measure, assigned to different stakeholders, from local communities to national authorities.

The Natura 2000 MP defines a set of measures with the aim of reaching and maintaining the good conservation status of Natura 2000 species and habitat types. Among them the regulation of anchoring on vulnerable habitats, habitat's mapping, awareness activities, setting nature conservation guidelines in the spatial planning process including the Maritime Spatial Planning.

Decree on the Marine Environment Management Plan (NUMO, Official gazette of the Republic of Slovenia, No. 41/17)

The plan, adopted according the **EU Marine Strategy Framework Directive,** determines the environmental starting points for the management of the marine environment in accordance with the regulations governing environmental protection. A program of measures is the implementing part of the plan that is supposed to ensure the achievement and maintenance of a good state of the marine environment until 2020. The definitions for descriptors D1 and D2 are given below.

Good environmental status in relation to the quality descriptor Biodiversity (D1) - groups of species of birds, reptiles, mammals, fish and cephalopods are achieved when: (1) the species-specific mortality rate due to unintentional by-catches is below species-threatening levels, that their long-term viability is assured, (2) anthropogenic pressures do not adversely affect the abundance of fish species so that their long-term viability is assured, (3) the demographic characteristics of commercial and cephalopod populations exploited for commercial purposes are characterized by for a healthy population and, (4) the range of species is consistent with the prevailing physiographic, geographical and climatic conditions.

The good environmental status of the pelagic habitat is achieved when the physical, chemical and hydrological conditions in the water column allow the undisturbed development of pelagic communities and species that need access to the pelagic habitat for the life cycle closure. The movements of the water masses and organisms must be also undisturbed. The Good status of the marine environment for pelagic habitat in relation to the quality descriptor D1 is achieved when the values relevant for the assessment defined for the relevant elements and parameters in other descriptors (if available) are reached. These values also represent environmental goals. If values for assessing the achievement of the good status are not available, an expert judgement of the achievement of the good status of the marine environment is given.

The good environmental status for Non-indigenous species resulting from human activities descriptor D2 is achieved when the presence of non-native species does not affect the ecosystem, namely: the number of newly introduced alien species in the environment, from human activity for a particular impact assessment period, measured from the reference level, modified to a minimum; when the abundance and spatial distribution of inhabited alien species, especially invasive ones, which have significant adverse effects on species in the EUNIS2 habitat type is limited; when the percentage of species or spatial range of the EUNIS2 habitat type that has adverse effects on non-native species, in particular, invasive ones is negligible.

Concerning the other activities undertaken by Slovenia within the framework of the Marine Strategy Framework Directive, an important three – year project on NIS (descriptor II) that just started has to be pointed out, while a long-term systematic monitoring programme concerning biodiversity (descriptor I) has not been addressed properly yet.

Slovenian Maritime Spatial Plan

According to the EU Directive on MSP the national maritime spatial plan should be adopted in 2021. In the draft that is currently being elaborated, the areas relevant for marine and coastal biodiversity conservation were identified and should play an important role in the final development of the plan.

Slovenia is party to a number of relevant international agreements dealing with marine and coastal biodiversity, both on a global and regional level. Taking into account the purpose of the present national report the following ones should be mentioned:

- Convention on Biological Diversity, ratified in 1996,
- Ramsar Convention on Wetlands of International Importance especially as Waterfowl Habitat, notified in 1992,
- Convention on the Conservation of European Wildlife and Natural Habitats, ratified in 1998,
- Convention for the protection of the marine environment and the coastal region of the Mediterranean (Barcelona convention & protocols), ratified 2002,
- Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic area (ACCOBAMS), ratified in 2006.
- Act on Ratification of the Agreement on the Conservation of African-Eurasian Migratory Waterbirds (Official Gazette of the Republic of Slovenia - International Treaties, ratified in 2003.

4.3. Transboundary issues and existing, planned or needed coordination / harmonisation at sub regional or regional level

There is a MoU between the Institute of the Republic of Slovenia for Nature Conservation and the Miramare MPA while the Strunjan Landscape Park was involved in the SPAMI Twinning programme. Two out of three Slovenian MPAs (Strunjan LP and Debeli rtič LP) are members of the MedPAN association and they were both involved in the currently ongoing Interreg Med project MPA Networks.

As already stated under point 2.4, there is no governmental collaboration targeting marine and coastal biodiversity conservation at national level and the same goes for the sub regional level. Taking into account that whatever level is taken on board – Gulf of Trieste, Northern Adriatic, Adriatic Sea or Adriatic-Ionian basin, we're dealing with one single water body. Consequently, all the solutions concerning pressures and impacts, monitoring as well as conservation measures, should be the result of a coordinated action between the riverine countries.

5.

Assessment of the marine and coastal status and pressures on marine and coastal areas

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5.1. Marine and coastal status and pressures relevant for national marine and coastal areas

The Slovenian coast – 46 kilometres in length, presents itself in two distinctive types – the abrasive and the accumulative type. The abrasive type is characterised by flysch cliffs, a great part of them still in their natural state. The accumulative type of the coast, present in the mouths of valleys and rivers, is distinctively flat. While most of the flysch cliffs kept their natural state, the coastal plains were turned firstly into salt-works, and later most of them on to agricultural land, settlements and yacht harbours. However, the remaining salt-works, with their great variety of plant and animal life, are among the most important elements of Slovenian coastal biodiversity.

Coastal and transitional ecosystems of Slovenia are subjected to a variety of local stressors that are occurring globally and global stressors with local impacts. The first group of stressors comprises different forms of water pollution (*e.g.,* pollution by heavy metals and organic compounds), and habitat degradation, alteration and destruction, with consequent biodiversity loss (Orlando-Bonaca *et al*., 2012). The ever-increasing levels of chemical pollutants have significant adverse effects on organisms and ecosystem services, especially in coastal areas.

The over-enrichment of sea water by nutrients (mainly nitrogen and phosphorus), defined as eutrophication, leads to different problems in coastal environments, like increasing hypoxia and harmful algal blooms (HABs) events. A gradual increase of eutrophication impacts occurred in the northern Adriatic Sea in the period 1970-1990, with a following reversal trend that was especially marked in the years after 2000. This decreasing eutrophication trend was ascribed to a reduction of some anthropogenic impacts (*i.e.* phosphorus loads, and climate changes that led to declining atmospheric precipitations with a consequent lower runoff) (Giani *et al*., 2012).

Also, the hydro morphological degradation of habitats along the Slovenian coastline is being pronounced in recent decades. It is related to increasing urbanisation and industrial development and coastal modification.

Although shallow, with a short coastline and urbanised, the Slovenian sea plays an important role in terms of biodiversity. A number of habitat types are present, including coralligenous biocoenosis, associations with different *Cystoseira* species and seagrass meadows. In order to assure the conservation of the most important elements of biodiversity, a number of protected areas – marine and coastal, were declared from the 1990 until today.

The key impacts and pressures to the Slovenian coastal and marine area could be grouped into few clusters. The first and the most important one is habitat degradation, mainly due to urbanization, although maritime transport (sediment resuspension, noise) and leisure boating (anchoring, noise) cannot be neglected. As a result, approximately only 20 % of the Slovenian coast is still in its natural state, but at the same time it is very fragmented and therefore more sensitive to further degradation. In spite of that there are still tendencies of local authorities for beach enlargements, new maritime infrastructure and even artificial islands.

The second cluster concerns environmental pollution. There are however few concrete data on direct or indirect impacts on biodiversity, especially on the actual changes in fauna and flora. During the very scarce investigations carried out so far, data have been obtained on the Hg and Cd content in the flesh of Mediterranean mussel (*Mytilus galloprovincialis*) and common pandora (*Pagellus erythrinus*) as well as on golden grey mullet (*Liza aurata*) and European conger (*Conger conger*). Maritime traffic and leisure boating represent an important source of noise pollution; however, no systematic investigation was carried out yet.

Although very limited in size and quantities, fishery and aquaculture could be listed as the third cluster. The numbers of professional fishermen and larger fishing vessels have greatly decreased, especially after 2012. As a consequence, the negative impacts on biodiversity of the Slovenian sea are today incomparably less damaging than in the past. The greatest threat has thus become the by-catch, with sometimes important impacts on loggerhead turtles, stingrays, eagle rays, sharks, seabirds and less frequently, the bottlenose dolphins (*Tursiops truncatus*) (Lipej, *pers observations*).

The fourth cluster gathers processes concerning the spreading of non-indigenous species (NIS). Some of them are linked to climate change, with tropicalization and bio invasion, enabled by the increasing water temperature, being the main vectors. In the last thirty years, more than 30 new fish species have been documented in the Adriatic Sea, the majority of which can be specified as migrants towards the north. For the time being, there are no data on the actual impact of the species associated with tropicalization on native species and habitat types. Maritime traffic linked to the three ports of Koper, Trieste and Monfalcone, could be most certainly listed as an important vector of NIS introduction in the waters of the Gulf of Trieste both, through ballast waters and through epigrowth.

5.2. Critical impacts and effects on marine and coastal biodiversity

Due to the oceanographic features of the Slovenian coast and sea, coupled with intensive urbanization, the space available for the main littoral and infralittoral habitat types is very limited. While the rocky bottom on average extends some 50 – 80 meters from the coast, the lower limit of seagrass meadows that follow is between 8- and 10-meters depth, which is approximately 150 meters from the coast. This is why any human intervention on the coast can be critical, especially if no mitigation measures (silt curtains and other) are implemented. The same goes for human activities in the sea. Massive presence of leisure boats, concentrated mainly in pristine areas, during summer season, is detrimental for species and structures of both, the rocky bottom and seagrass meadows. In the area of Debeli rtič in some localities (some of them also inside the MPA) from 14.3 to 31.1% noble pen shells (*Pinna nobilis*) were pulled out or devastated because of anchoring (Lipej *et al*., 2016). In certain localities the anchoring together with dredging is causing devastation on the Mediterranean stony coral (*Cladocora caespitosa*), which is according to IUCN an endangered species.

6. Assessment of national priority needs and response actions

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6.1. Needs

The following needs were listed within the national consultation process:

I. Research and monitoring on climate change related issues:

a) sea water intrusion into lagoons, saltworks and coastal wetlands and the addressing issue of marinisation of such habitats;

b) the possible impact of alien species and species related to tropicalization and their northward spreading to native biota.

In fact, a recent pan-Mediterranean study pointed out the phenomenon of rapid northward spreading of some thermophilous fish species. Some of them are known to have caused substantial problems in local fisheries (Azzurro *et al*., 2019), which is especially true for the Blue fish (*Pomatomus saltatrix*).

II. Research and monitoring related to the conservation of endangered species and habitat types:

a) Cartography and monitoring of *Zostera marina* and *Z. noltii*,

b) Cartography of the circalittoral detritic bottom,

c) Study on no-anchoring areas outside MPAs,

d) monitoring the populations of certain habitat building and endangered species in Slovenia (*Cladocora caespitosa*),

e) importance of different habitat types (in and outside MPAs) as nursery and/or spawning grounds.

III. Transboundary actions

a) a study on coralligenous biocenosis in the Gulf of Trieste, with special reference to rocky outcrops,

b) monitoring of highly mobile species,

c) inventory of biodiversity hot spots in the Gulf of Trieste,

d) inventory of impacts of the main maritime sectors on marine biodiversity.

e) based on the above - agreement on conservation measures, including MPAs and OECMs should be defined and implemented.

IV. The effectiveness of Slovenian marine protected areas in achieving their biodiversity conservation goals through a comparison with areas outside MPAs.

V. Public awareness campaign on marine and coastal biodiversity its importance and vulnerability as well as on the presence and possible impacts of non-indigenous biota in the Slovenian Sea (lectures, brochures, web site).

VI. Targeted awareness campaigns for the relevant marine sectors (maritime transport, leisure boating, small scale fisheries, aquaculture, recreational fisheries) based on Pharos4MPA results on their impacts on marine biodiversity.

VII. Adequate, stable financial resources for the three MPAs as well as for the systematic, long-term monitoring of marine and coastal biodiversity and its response to human pressures.

VIII. National SAP for marine biodiversity & NAPs for cetaceans, Mediterranean stony coral (Cladocora caespitosa), turtles, marine vegetation, chondrichthyans, coralligenous.

6.2. Urgent actions proposed

- Drafting the proposal to include in the legislation dealing with construction works on the coast and in the sea, measures that prevent sediment resuspension and spreading the suspended material outside the construction area.
- Banning or regulating anchoring on vulnerable infralittoral habitats (rocky bottom with stony coral, sponges, pre-coralligenous, sand and mud bottoms with seagrass meadows).
- Moving the NE limit of the Port of Koper anchoring area away from the MPA Debeli rtič.
- Limiting maritime traffic in front of the Westernmost part of the MPA Debeli rtič.
- Mapping and monitoring of Noble pen shell *Pinna nobilis* populations with measures to prevent or reduce the possible infestation with *Haplosporidium pinnae.*
- Investigation on the possible techniques for recolonization of the endemic Mediterranean stony coral (*Cladocora caespitosa*), which is facing mortality events due to the increase of temperature,
- The study on the techniques of repopulation of endangered algae of the genus *Cystoseira*,
- The study on the techniques of repopulation of endangered algal species Fucus virosides,
- Protection of the *Posidonia oceanica* seagrass meadow and of the remaining sites with *Zostera marina* and *Zosterella noltii*,
- New legal act on the protection of the Cape Madona NM (enlargement of the PA & new conservation measures),
- Enlargement of the Strunjan Landscape Park (inclusion of the bordering N2k areas).

7.

Funding problems and opportunities

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7.1. Regular national sources, potential co-financing for international funding

The Slovenian research agency offers the possibility for obtaining research funds regularly, however, due to high competition with many Slovenian institutes only a small percentage of the proposing institutes are successful.

Sporadically (non-regular annual funding), some funds are obtained from the Ministry of the Environment and Spatial Planning for the implementation of the Water Framework Directive and the Marine Strategy Framework Directive. Projects addressing fisheries through marine biodiversity conservation can be funded through EMMF, while projects dealing with priority marine Natura 2000 species and habitat types are taking advantage of the LIFE funds.

7.2. Other sources (private, public, partnership)

An important part in obtaining funds or financial contributions is deriving from specific research projects, offered by certain companies (Luka Koper/Port of Koper) or managing institutions of protected areas (Regional Park Strunjan). Certain small fund projects for studying biodiversity are coastal municipalities of Slovenia (Izola, Koper, Ankaran and Piran).

7.3. International funds, projects, programmes, national eligibility for international programmes/funds (e.g., green funds) identified.

Research projects, achieved from many funding opportunities such as Interreg Project (Interreg Slovenia – Italy, Interreg Mediterranean, Interreg Adrion), Horizon 2020, DG Environment, and others are the basis for investigating different biodiversity issues. For example, the main funding sources for the research and studies for marine biodiversity research performed by the Marine Biology Station (National institute of biology), which is the leading Slovenian institute dealing with the regular and continuous research on marine biodiversity, is obtained by the Slovenian research agency (app. 54%). Some research projects on biodiversity were obtained from international financial sources (various projects such as Interreg, COST, Adrion, etc.) (app. 14%) and others financed from local and national enterprises/companies (17%).

8.

Conclusions and recommendations

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According to the available published data the marine biodiversity of the Slovenian coastal Sea could be considered as a rather rich portion of the Adriatic Sea. The checklist of the Slovenian marine biodiversity, which is from our opinion far of being complete, is based on records of at least 2260 different species. The main factors, which affect the high diversity of the area, are probable related to the diversity of habitat types, to the increased research effort, to the presence of marine and coastal protected areas and probably also to the geographical, geomorphological and oceanographical specificity of the area. In order to assure the conservation of the most important elements of biodiversity, a number of protected areas – marine and coastal, were declared from the 1990 until today. Three marine protected areas were established up to now in the Slovenian sea, two landscape parks and one natural monument. Both landscape parks (Strunjan, Debeli rtič) encompass a marine and a terrestrial part while the natural monument (Cape Madona) is only marine. The marine area covered by the three areas is roughly 3.7 km2 which represent 1.85% of the Slovenian sea.

Due to the oceanographic features of the Slovenian coast and sea, coupled with intensive urbanization, the space available for the main littoral and infralittoral habitat types is very limited. Less than 18% of the coastline is still present as natural. The key impacts and pressures to the Slovenian coastal and marine area could be grouped into few clusters. The first and the most important one is habitat degradation, mainly due to urbanization, although maritime transport (sediment resuspension, noise) and leisure boating (anchoring, noise) cannot be neglected.

Although the Slovenian coastal sea rarely exceeds more than 30 m in depth, the habitat diversity of the area is rather diverse. Among important habitat types seagrass meadows of *Posidonia oceanica* and *Cymodocea nodosa* should be mentioned. In Slovenian Sea there are present also biogenic formations, which are peculiar habitat types, characterized by an outstanding biodiversity. Among other important habitats precoralligen is well developed and host a diverse assemblage of benthic invertebrates and coastal fish fauna. The area is also known as a nursery area for many elasmobranch species and is very important for certain endangered species such as the loggerhead turtle (*Caretta caretta*), bottlenose dolphin (*Tursiops truncatus*) and the Mediterranean shag (*Phalacrocorax arisotelis desmaresti*).

The recent events in the Mediterranean areas, such as the processes of bioinvasion and tropicalisation have been noticed also in the Slovenian part of the Adriatic Sea. At least 52 NIS were up to date reported in the area. Up to date there is no evidence which would point to pressures and possible impacts of NIS in the Slovenian sea. The only ascertained evidence was the case of the tunicate *Clavellina oblonga* which overgrown the cultured mussels and caused in the summer period a decreased growth of mussels. Even in the case of *Mnemiopsis leidyi,* a study which dealt with the possible impact of this invasive species to the local biota, did not show any impact on the fish eggs and larvae.

There are also many thermophilic species, related to the increase of temperature which were registered in the area. Owing to the rising temperatures, such species that are otherwise characteristic of the Mediterranean Sea's southern parts began to occur in the northern Adriatic and in Slovenian waters. Some of them are already caused some problems in neighbouring areas, such as is the case of Blue fish (*Pomatomus saltatrix*).

Another event, which is also related to the climate change, is coral bleaching. Although this phenomenon is in cases, when high temperature does not persist in the area for longer period of time, reversible, many events on coral mortality were reported in Slovenian Sea. There is also an evidence of the sea level models of relative sea level rise in the nearby future, which predict the fate of the most important breeding birds in the Ramsar site Sečovlje salina. Slovenian coastal wetlands, especially coastal lagoons, are already susceptible to seawater intrusion, which will facilitate the colonization of marine faunistic elements in lagoons and the disappearance of the lagoon faunistic elements.

Although it was not yet thoroughly analysed, the disappearance of the Adriatic endemic brown algae *Fucus virsoides* from the Slovenian sea in 2015, may be attributed to the climate change and related oceanographic oscillations phenomena. Some other marine plants witness shrinkage in their vegetation coverage. The algal belts of *Cystoseira barbata*, an important building element of the biocoenosis of photophyllic algae, were shrunk to some extension or even disappeared in various part of the Slovenian coastline. The same is true for seagrass meadows of *Cymodocea nodosa*, which is otherwise considered as a relatively tolerant phanerogam. Substantial decrease was recorded during the last few years. Recently, cases of Noble pen shell (*Pinna nobilis*) mortality were recorded in the Slovenian part of the Adriatic Sea

To this end, some research initiatives are ongoing to reduce the disappearance of the mentioned marine plants and vegetation. These are dealing mainly with the pioneer experiments of culturing propagules of *Cystoseira* plants. Such studies are planned in future also to restore the population of *Fucus virsoideus* in the area and to mitigate the shrinkage of seagrass meadows of *Cymodocea nodosa*. Similar initiatives are planned also to investigate the possible techniques for recolonization of the endemic Mediterranean stony coral (*Cladocora caespitosa*), which is facing mortality events due to the increase of temperature. Among the important initiatives to be done in nearby future is the mapping and monitoring of Noble penshell *Pinna nobilis* populations with measures to prevent or reduce the possible infestation with *Haplosporidium pinnae*.

Based on the present knowledge of the state of marine biodiversity in the Slovenian sea and at the same time in the Gulf of Trieste and of the threats coming from human activities and climate change as well as taking into account the foreseen development of the main maritime sectors, a number of recommendations could be put forward. They are basically linked to the listed needs and urgent actions.

Nevertheless, two main recommendations should be pointed out. The first one applies to the national level. It would be imperative to protect (PA and/or OECM) the remaining natural coastline and give up new interventions on the urbanized part of the coastline (artificial islands, enlargement of beaches and of the existing leisure boats harbours, …). Concrete proposals on this line are already part of the spatial planning process of the local municipalities as well as of the maritime spatial plan that is being drafted.

The second recommendation, which should be taken on board on national and sub-regional level would be to increase the common effort in terms of species inventories and habitat mapping in the entire Gulf of Trieste, to identify the key elements of biodiversity in the gulf and to agree on the needed conservation measures, including the possible redefinition of the development plans for the main maritime sectors operating in the area. This is in line with the CBD EBSA's process as well as with one of the main goals of the MSP process that is to apply an ecosystem-based approach with the aim of ensuring that the collective pressure of all activities is kept within levels compatible with the achievement of good environmental status and that the capacity of marine ecosystems to respond to human-induced changes is not compromised.

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http://www.medtrends.org/ - 6/8/2020

SPA/RAC WORKING AREAS

*SPA/ RAC, the UNEP/ MAP **Specially Protected Areas Regional Activity Centre**, was created in 1985 to assist the Contracting Parties to the Barcelona Convention (21 Mediterranean contries and the European Union) in implementing the Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean (SPA/BD Protocol).*

POST-2020 SAPBIO

Strategic Action Programme for the **Conservation** of **Biodiversity** and **Sustainable Management** of **Natural Resources** in the **Mediterranean Region**

SPAMI

Specially Protected Areas of **Mediterranean Importance**

Marine turtles

Cetaceans

Specially Protected Areas

Monitoring

Mediterranean Monk Seal

Cartilaginous fishes
(Chondrichtyans)

Coralligenous and other calcareous bio-concretions

Marine vegetation

Marine and coastal bird species

Listed in Annex II of the Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean

Dark Habitats

Habitats and species associated with seamounts, underwater caves and canyons, aphotic hard beds and chemo-synthetic phenomena

Species introduction and invasive species

POST-2020 SAP BIO

Strategic Action Programme
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Specially Protected Areas Regional Activity Centre (SPA/RAC)
Boulevard du Leader Yasser Arafet
B.P. 337 - 1080 - Tunis Cedex - Tunisia
+216 71 206 649 / +216 71 206 485
car-asp@spa-rac.org
www.spa-rac.org

MAVA FONDATION POUR LA NATURE

This publication has been prepared
with the financial support of the MAVA foundation