Study on Integrating an Eco-system-based Approach into Maritime Spatial Planning

Valuation case study:

Assessing and valuing ecosystem services in the Northern Adriatic

Final report

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Study on Integrating an Eco-system-based Approach into Maritime Spatial Planning

Task 4: Elaboration of MSP cases studies using an EBA

Assessing and valuing ecosystem services in the Northern Adriatic

Final report

European Climate, Infrastructure and Environment Executive Agency

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1 Introduction

European seas face **many challenges in relation to the health of marine ecosystems**. Degraded marine and coastal ecosystems can be found in all European seas, as a result of many anthropic pressures, such as pollution (including organic, chemical, plastic and noise pollution), morphological alterations, and unsustainable extraction of marine resources. High population densities along Europe's coasts, tourism developments, fishing, agricultural and industrial developments, shipping, and renewable energy infrastructures are among the sectors that impact European seas[1]. The significant development of economic activities expected at sea in the coming decades heightens the need for sustainable blue activities and for a sustainable sharing of marine space that accounts for marine ecosystem protection priorities.

To respond to these challenges, the European Union (EU) adopted its **Marine Strategy Framework Directive (MSFD)** in 2008 (2008/56/EC)[2], which aims to achieve Good Environmental Status (GES) of the EU's marine waters by 2020 while protecting the resource base on which marine-related socioeconomic activities depend. The Directive builds on different key management principles and promotes an **ecosystem approach** to the management of human activities with an impact on the marine environment. The MSFD was complemented in 2014 by the Maritime Spatial Planning (MSP) Directive (2014/89/EU), which aims to promote 'sustainable growth of maritime economies, sustainable development of marine areas and sustainable use of marine resources' (Article 1(1)). In preparing and implementing their plans, Member States should apply 'an ecosystem-based approach' (Article 5(1)) that adequately accounts for the functioning of ecosystems and biodiversity.

Today, experiences in the practical application of **ecosystem-based approaches** (EBA) in MSP are growing but as yet are not well documented or are limited to the scientific literature. The European Climate, Infrastructure and Environment Executive Agency (CINEA, formerly EASME), on behalf of the European Commission Directorate-General for Maritime Affairs and Fisheries (DG MARE), has set a service contract for a study on the concrete application of EBA in MSP. Its main objective is to assess the current state of play in the practical application of EBA in MSP, and to develop a practical method or toolbox to support EBA applications, monitoring and evaluation. Building on different case studies developed in different European regional seas, the study seeks to address specific aspects of EBA. In line with the importance given to understanding the functioning and dynamics of the socio-ecological system and the role the assessment of ecosystem services can play in supporting MSP in general, and EBA in MSP in particular, a specific case study was launched in the **transboundary Northern Adriatic Sea** (NAS) to apply different methods and techniques for identifying, quantifying and providing monetary values for the services delivered by coastal and marine ecosystems.

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[1] https://www.eea.europa.eu/themes/water/europes-seas-and-coasts/europes-seas-and-coasts/#interesting-facts

[2] https://ec.europa.eu/environment/marine/eu-coast-and-marine-policy/marine-strategy-framework-directive/index_en.htm

2 Overview of the Northern Adriatic case study

2.1 Objectives of the case study

The main aim of the case study carried out in the Northern Adriatic is to illustrate the potential role of the assessment and valuation of services provided by marine ecosystems in supporting MSP.

More specifically, the case study addresses the following questions:

- Q1 – What are the **main characteristics of NAS marine ecosystems**? What are the main habitats that these ecosystems host, and the pressures imposed on these ecosystems by socioeconomic activities?
- Q2 – **What services are provided by marine ecosystems** in the NAS? What is the status of these services and some of the key threats they are facing? What is the spatial extent of the ecosystem services delivered, in terms of the marine area(s) that produce the services and the area(s) where beneficiaries of these services are located?
- Q3 – How **important are the services delivered by NAS marine ecosystems**? What activities and sectors benefit from these services? In particular, what value(s) do these services provide to specific activities and to society as a whole, including monetary values when these can be assessed? Is there a significant difference in the importance and values of these services, and of healthy marine ecosystems in general, between the three countries bordering the NAS (Italy, Slovenia, Croatia)?
- Q4 – How can the characterisation and valuation of services provided by marine ecosystems **support the MSP process and decisions**? What challenges and limitations are faced in quantifying and valuing ecosystem services, and what solution(s) are there for addressing these challenges and limitations?

2.2 Methodology

Building on the review of the different categorisation of ecosystem services in the literature[3], the study used the Common International Classification of Ecosystem Services (CICES; see categorisation in Annex I). It also included supporting services derived from ecosystem structures and functions. The ecosystem services analysed are presented in Table 1, addressing use and non-use values of these services.

Table 1: Ecosystem services considered in the Northern Adriatic case study

Type	List of ecosystem services considered
Supporting services	Habitat provisioning and biodiversity
Provisioning services	Food, sand/gravel, water, salt, ornamental products
Regulating services	Nutrient regulation and water quality, coastal protection, climate regulation
Cultural services	Tourism and recreation, scientific knowledge research and education

The methodology aimed to reconstruct the flow of ecosystem services by: i) qualitatively describing the provisioning mechanisms of each service, focusing on the ecosystem

[3] See, for example, https://norden.diva-portal.org/smash/get/diva2:920382/FULLTEXT01.pdf for a review of the different systems.

structures and functions and identifying potential pressures that might affect the capacity of the ecosystems to provide services; ii) quantifying the effective or potential delivery of services to beneficiaries, identifying the benefit area; and iii) assessing, in monetary terms, the benefits delivered by these services. The analysis built on an extensive review of the available literature, complemented by the collection of available data and information in different **(public) databases, including general statistics**, and by **semi-structured interviews** with representatives from sectors for which data and information were not readily available.

Depending on the ecosystem services, different methods were used to assess their monetary values building on market data when these are available (e.g. for fisheries or sea salt extraction), the assessment of avoided cost (e.g. in relation to the benefits from reduce climate risk) or data obtained via a dedicated **willingness to pay (WTP) survey** for ecosystem services for which markets do not exist. For the latter, a dedicated survey was carried out in the three countries bordering the NAS, building on the choice-experiment framework that helps in assessing monetary values for different attributes (ecosystem services). In total, the views and perceptions of 1,000 inhabitants from Italy, Slovenia and Croatia (a representative sample of 333 respondents per country) were collected via an online survey. Annex V of the report provides the distribution of the sample among the three countries according to some basic characteristics (age, income, gender, etc.). The general structure of the questionnaire applied in the survey is presented in Box 1.

Box 1: Focus of the questionnaire

In line with typical practice in WTP surveys, the questionnaire used in the Northern Adriatic survey included the following sections:

- An introduction - presenting the focus of the survey;
- Part 1 - questions related to the priority societal challenges faced by respondents, and their connection(s) to the NAS, including in terms of uses and practices related to personal or professional activities;
- Part 2 - challenges faced by marine ecosystems in the NAS and their familiarity to respondents;
- Part 3 - respondents were presented with choice cards presenting different scenarios in terms of the health of marine ecosystems, their level of biodiversity/water quality/possibility to carry out recreational activities and payment level, and asked to choose among scenarios. This was central to the WTP questionnaire;
- Part 4 - a series of questions aiming to understand respondents' reasons for choosing scenarios and being willing (or not) to pay for improvements in the health of marine ecosystems in the NAS;
- Part 5 – collected basic socioeconomic characteristics of respondents' households.

The results of the survey were **statistically analysed**. Descriptive statistics were complemented by an econometric analysis using a probit model (see Annexes VI, VIII for detail of the analysis, the regression model and results table) to identify key variables that might explain respondents' WTP, their choices in terms of scenarios, and the relative importance of the three attributes in this choice. The limited resources allocated to the case study similarly limited the econometric analysis carried out: additional econometric models and relationships will be investigated after the end of the study.

All results obtained for the characterisation and valuation of ecosystem services were **summarised in synthetic tabular and schematic formats**, combining qualitative, quantitative and monetary information, and characterising the main uncertainties in assessment. Preliminary results of the study were briefly presented at a workshop on 10 March 2021 as part of the study addressing ecosystem service assessment and valuation for MSP.

2.3 Structure of the report

This report presents the main results of the case study and is structured as follows:

- The **context** of the EBA and MSP study that hosts the Northern Adriatic case study, the **objectives** of the case study, the **ecosystem services considered,** and the **methodology** applied for their quantification and valuation are summarised in Chapters 1 and 2.
- Chapter 3 presents the main **characteristics of the Northern Adriatic case study**, in terms of its boundaries, the main maritime activities that are present in the NAS, as well as its environmental conditions (current status of marine ecosystems and main threats to these ecosystems). It distinguishes between the context and situation for each of the three neighbouring countries (Italy, Slovenia, Croatia).
- Chapter 4 describes the different **ecosystem services provided by the NAS**, building on qualitative, quantitative and monetary information to characterise supporting, provisioning, regulating and cultural ecosystem services.
- Chapter 5 presents the main results of the **WTP survey.**
- Chapter 6 provides **an overview of the assessment results** and the case study **conclusions,** providing synthetic tables and figures on all ecosystem services analysed. It discusses the relevance of ecosystem service assessment and valuation for MSP and identifies areas that require further work beyond the scope of the present study.

3 Northern Adriatic case study

3.1 Case study definition and geographical scope

The Adriatic Sea is bordered by Italy to the west, and Slovenia, Croatia, Montenegro, Bosnia and Herzegovina and Albania to the east. The assessment of ecosystem services carried out under the EBA and MSP project was limited to the NAS, marked by Ancona on the western coast, and by Zadar on the eastern coast, as shown in Figure 1.

Figure 1: Map of the case study's geographical extent

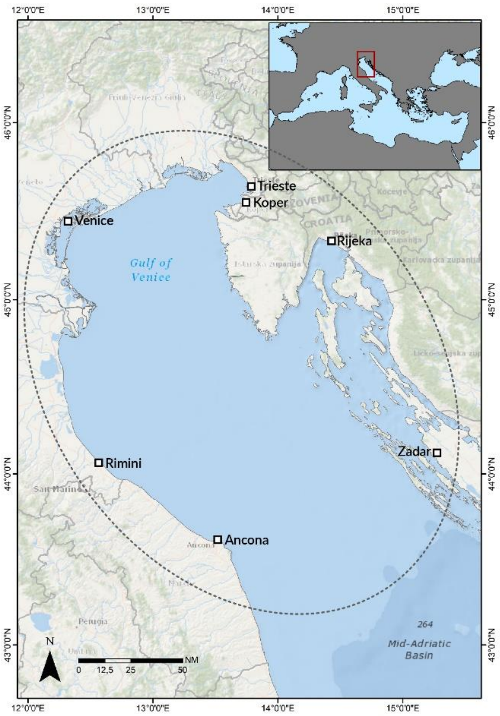


Table 2 presents some of the basis statistics of the case study area that highlight its importance.

Table 2: Basic characteristics of the area considered for the Northern Adriatic case study

Country	Italy	Slovenia	Croatia
Population density (inhabitants/sq. km) Source: Worldometers (2021)	**206**	103	73 (97 in the coastal area (HR ESA,2019))
Total coastline (km)	7,500	47	1,880 + 4,398 for the islands
Administrative divisions considered in the case study.	Emilia-Romagna; Veneto; Friuli-Venezia Giulia regions	" Coastal–Karst"	Istria; Primorje-Gorski Kotar; Lika Senj; Zadar counties
Approx. coastline length for North Adriatic case study (km) (based on GIS shapefiles)	351	47	753
Total marine waters of the country (km²) Source: https://water.europa.eu/marine	587,155	214	55,492
Approximate area of marine waters for the North Adriatic case study (km²)	16,670	214	17,770

3.2 Main characteristics of the NAS - maritime activities, impacts and trends

The following section presents a general overview of the main maritime activities taking place in the NAS, based on results from the MedTrends Project report (Randone, 2015), and the PHAROS4MPAs project's reports recommendations on cruise ships and tour boats (Caric et. al., 2019; Petit et. al., 2019).

The strategic geographical location of the NAS connects the core of Europe to the sea, making it a hotspot for **commercial shipping activities** and thus substantial amounts of cargo traffic. The North Adriatic Port Association comprises the major ports of Venice, Trieste, Rijeka and Koper, with the latter having the largest share (Randone et al., 2015). In 2014, one-third of the total cargo handled by Koper Port was for Austria, traditionally Koper's most important market (Luka Koper, 2021). The Mediterranean Sea is the second largest market globally for **cruise shipping**, with the Adriatic being the second most-visited sea in the Mediterranean. Venice port's passenger share of cruise ships was 31.7% in 2016. Other important cruise ports in the NAS are Ancona, Ravenna, Trieste, Rijeka and Zadar. Besides the tourist-oriented cruise sector, the NAS is an important sea passenger traffic hub. Here again, Venice plays a significant role, but the Croatian side also hosts heavy passenger traffic, particularly the ports of Zadar and Rijeka. Impacts of the shipping and maritime transport sectors on the marine environment include marine pollution, oil spills, littering, noise pollution, light pollution, ballast water and transport invasive species and collision with marine mammals/sea turtles, among others.

Adriatic Sea **oil and gas production** represents 9% of the total Mediterranean region (Plan bleu, 2014). In the Northern Adriatic, Italy and Croatia are active in the industry. In Croatia, for example, extraction is carried at Istria height to three hydrocarbon exploitation fields (Izabela, North Adriatic, Marca), with 19 gas excavation voids and one compressor of 51 excavation wells. Annual production is around 1.2 billion m^3 gas (ESA HR, 2019). Impacts on the marine environment from oil production activities result from potential accidents such as spills and leakages, as well as damage to the seafloor from drilling and cable laying, pollution from chemicals, noise, light, and air pollution from rigs.

The **fisheries sector** in the Adriatic is largely composed of small-scale fisheries, on which many national economies (notably Italy and Croatia) rely. Based on numbers from 2014, Italy has the largest fishing fleet in the Adriatic, followed by Croatia. Slovenia's fleet is negligible in comparison. Trends show a decrease in the number of fishing vessels in Italy and an increase in Croatia. Over 80% of the fleet in the Adriatic consists of small vessels (<12 metres), making the role of **small scale/artisanal and recreational fisheries** particularly important. The Adriatic's geomorphological features make it suitable for trawl fisheries and dredgers. Small scale/artisanal fisheries that reach up to 50km from the shore or 200m depth play a key role in Croatia in particular. Impacts of the fisheries sector on the marine environment stem from trawling activities (which have detrimental impacts on the seabed), overfishing and by-catch (which affect the ecosystem and fish stocks) and ghost nets (which cause injuries and suffocation to several species).

The Adriatic Sea constitutes 3-5% of total Mediterranean production value and Gross Value Added (GVA) of the **aquaculture sector** (Plan bleu, 2014)**.** Italy is by far the largest producer in the NAS, followed by Croatia. Growth in the Adriatic has not been as significant as in other parts of the Mediterranean - most of the western coast hosts shellfish farms, while the eastern coast is more dedicated to fish farms. The NAS area contains both types of farms, concentrated mainly within the Venice lagoon.

Impacts of aquaculture on the marine environment result from infrastructure, such as seabed damage from anchoring. Impacts also stem from operational activities leading to eutrophication and oxygen depletion due to unmanaged effluent discharges. Changes in benthic community structure are linked to overfeeding, in addition to potential transfer of diseases, parasites and non-indigenous species due to unintentional release of farmed organisms into the environment. Finally, marine litter is increased by abandoned cages, for example.

The Adriatic is an important **tourism destination** in the Mediterranean, hosting 6% of the regional tourism in the region, with 9% of international overnight visitors. Over two-thirds of total arrivals are registered in coastal areas. Italy and Croatia together account for 90% of the Adriatic sea's revenue from tourism. The three main categories are coastal tourism, nautical tourism and cruise tourism, and they are highly seasonal, peaking during summer (Plan bleu, 2014). Impacts of tourism on the marine environment include damage to benthic communities from diving and anchoring activities, marine pollution from motorised vessels and solid waste, and wastewater management issues due to seasonal pressures.

Marine mining is still in its exploratory stages in the Adriatic Sea. However, **dredging** is relatively common, especially in the North. Italy is leading in this sector, with dredged material mostly used for beach nourishment of coastal zones affected by erosion. In Slovenia, regular dredging is required to ensure maritime navigability within the Port of Koper. Sand extraction may have several impacts on natural resources and ecosystem services, such as the modification of benthic populations (Simonini et al., 2007), alteration of suspended particles along the water column and potential contaminants in solutions, and morphological modifications of the substrate (SUPREME, 2017). Mining activities can have impacts for human activities such as fishing, and more generally on activities that rely on high water quality. Climate change and sea level rise will potentially exacerbate coastal erosion, with increased coastal vulnerability to sea flooding, especially during intense storms (SUPREME, 2018).

Military activities related to research, demining, rescue at sea, control of migration and borders, international exercises, and shooting areas are sporadic and mainly involve practice areas for submarines and military shooting, as well as dumping areas. Impacts of military activities on the marine environment come from unexploded ordinances (i.e. from World War II and the Kosovo war) that pollute the marine environment, underwater explosions causing physical damage to habitats such as Posidonia meadows, and noise pollution from sonar that affects marine mammals' orientation abilities.

According to the 2015 MedTrends report on the Adriatic Sea (covering Italian, Croatian and Slovenian waters), most traditional sectors (tourism, shipping, aquaculture, offshore oil and gas extraction, marine mining.) are **expected to grow** (Piante and Ody, 2015). As fish stocks reveal a low recovery rate, some decreasing trends in the fisheries sector are noted, particularly in Italy. An emerging economic interest relates to the development of renewable energy infrastructure, with new wind farms proposed in the Adriatic.

3.3 Environmental characteristics: status and threats

The Adriatic Sea is a semi-enclosed basin that communicates with the Ionian Sea through the Otranto Strait. Its coastline is characterized by diverse geomorphological features: wetlands, dunes, lagoons, cliffed and rocky coasts, coastal plains, deltas, which make the basin highly heterogeneous. Circulation in the Adriatic Sea is complex and composed of different currents, gyres and jets, which alter their spatial variability with the seasons. The general circulation presents a northerly flow along the eastern coast that drops south along the West coast (reverse clockwise motion), with currents more intense along the eastern shore in winter and along the western shore in summer (Orlic et al., 1992). It is powered by the inflow of fresh water (especially Italy's Po River in the northwest), which causes lower salinity, heat losses, and surplus of water (Coll et al., 2007). Transversal currents are oriented mainly from the eastern to the western coast. Wind and heat have significant impacts on surface waters and can create deep (dense) waters in the Northern Adriatic, which influence the seasonality of the circulation (Artegiani et al., 1997).

Overall, the Adriatic Sea hosts substantial biodiversity and provides a wide range of natural resources of great economic value for people. Several protected areas were established to conserve these key ecosystems on which human rely. The following map illustrates the different types of protected areas within the NAS *(Map under preparation).*

Table 3: List of RAMSAR sites within the NAS study area

Country	Region	RAMSAR site
Italy	Friuli-Venezia Giulia	Valle Cavanata
		Laguna Di Marano: Foci Dello Stella
	Veneto	Laguna Di Venezia: Valle Averto
	Emilia Romagna	Pialassa Della Baiona E Risega
		Valle Bertuzzi
		Valle Di Gorino
		Sacca Di Bellocchio
		Valli Residue Del Comprensorio Di Comacchio
		Punte Alberete
		Ortazzo E Ortazzino
		Saline Di Cervia
Slovenia	Piran	Secovlje Salt Pans
Croatia	Dalmatia	Vransko Lake

Source: RAMSAR (2021).

Due to its large shelf area, smooth coastal area and gentle sloping bottom, the northern area of the Adriatic Sea is a hotspot for commercially valuable fish and shellfish species. The NAS attracts a wide variety of marine mammals, and its shallow areas and wetlands offer shelter for several species of seabirds. It is also one of the main feeding and wintering areas for three species of sea turtles: green sea turtle (*Chelonia mydas*), leatherback sea turtle (*Dermochelys coriacea*) and loggerhead turtle (*Caretta caretta*), which is the only permanent resident of the Adriatic. Its strategic location at the core of Europe made it particularly vulnerable to exploitation by human activities and it has been recognised as one of the marine areas most affected by multiple pressures in the Mediterranean Sea (Gissi et al., 2017).

3.3.1 Italy

The Italian Northern Adriatic coast is relatively low, smooth and regular. Deltas and narrow coastal plains, generally occupied by wetlands and lagoons, define the landscape of the northwestern coastal area. The seabed sediments are predominantly sandy–muddy.

Among the habitats that characterise the northern area of the Italian Adriatic coast, **seagrass meadows** are recognised for their fundamental ecological role as a habitat of nursery, protection and foraging for several marine organisms. This habitat contributes to stabilising and protecting the coastline, as well as being a long-term carbon sink and contributing to the abatement of atmospheric CO_2 (Howard et al., 2018). Two types of **seagrass** are present in the area: *Posidonia oceanica* and *Cymodocea spp.* The Gulf of Trieste represents the northernmost distributional boundary of *Posidonia oceanica* of the Mediterranean Sea. The more extensive meadow of *Posidonia oceanica* is located near Capodistria, on the Slovenian coast of the Gulf of Trieste, while on the Italian side it has been defined as sparse and limited since 1938 (Benacchio, 1938; Simonetti, 1968). At the end of the 1960s, it had strongly reduced. At present, *Posidonia oceanica* along the Italian coast (total area covered around 5 ha) is in a limited area in front of the Grado Lagoon, between 3 m and 4.5 m depth (SUPREME, 2011). These formations do not have Posidonia meadow status because they are isolated and of limited dimensions (Cainer, 1993-94).

Located in the same area, *Cymodocea nodosa* creates dense meadows. Seagrasses require high light levels to provide enough oxygen to their tissues through photosynthesis, and for this reason they are vulnerable to changes in light availability due to changes in sediment loading, eutrophication or epiphyte cover on seagrass leaves (Najdek et al., 2020). Although *Cymodocea nodosa* shows large phenotypic plasticity and capability of adaptation to stressors, it has registered a severe decline during the last few decades in the coastal areas of the Northern Adriatic (Najdek et al., 2020). In Italy, the seagrass areas are subjected to high sedimentation and hydrodynamic conditions that disturb the habitat (SUPREME, 2017). The potential land-based pollution and organic inputs increase the level of stress on the habitat.

Other important benthic habitats are the **rocky outcrops - *tegnùe* or *trezze*** (local calcareous sediments cemented by seeping methane) - widely distributed on the muddy-detritic bottom of the Northern Adriatic between the Po Delta and the Gulf of Trieste. These bioconstructions represent biodiversity hotspots and display great morphological heterogeneity, depending on the environmental conditions and the associated communities (Falace et al., 2015). Indeed, they can present a distance from the coast, ranging between 0.5 km and 21 km and a depth range corresponding to 7-25 m. They are usually associated with reef or coralligenous in habitat classification methods (Habitats Directive, MSFD, and EUNIS classification), but in reality they have peculiar distinguishing characteristics. More than one thousand taxa inhabit these Northern Adriatic sublittoral biogenic outcrops. The main groups are molluscs, coralline algae (e.g. *Peyssonneliaceae*), polychaetes, crustaceans, sponges, and fish. A high variability in the number of species and their coverage has been recorded on the different outcrops. This variability relates to depth and coastal-related processes, such as river inflows, hydrodynamism, and diverse human-derived pressures (Falace et al., 2015). The hydrodynamic connectivity at the base of propagules recruitment processes was recently recognised as an important driver of habitat heterogeneity (Bandelj et al., 2020). These habitats are affected by diverse local stressors, such as fishing, dredging and anchoring, as well as mucilage and dystrophic crisis that can be due to nutrient unbalance events (Falace et al., 2015; Bandelj et al., 2020), driven by both terrestrial run-off and changes in environmental factors. The current state of these bioconstruction is unknown, but with an increase in the intensity of anthropogenic pressures and climate change, their exposure level to multiple stressors could increase in the future.

The **maërl bed** is another specific type of representative calcareous bio-constructed habitat with high ecological importance that is present in the North Adriatic. The maërl is formed by an accumulation of unattached calcareous red algae (*Rhodophyta*) growing in a superficial living layer on sediments within the photic zone (Barberà et al., 2003). The maërl beds are ecologically fragile due to growth rates of approximately 1 mm per year. The Habitats Directive mandates the conservation of two of the main maërl-forming species, *Phymatolithon calcareum* and *Lithothamnion corallioides*. The distribution of this habitat ranges between 9 m and 24 m depth and between Venice and the Grado lagoon, where both fossil and living thalli are present. For both tegnùe and maërl beds the main threats are trawling, artisanal and recreational fishing, anchoring, invasive species, global warming, wastewater discharges, aquaculture, changes in land use, coastal infrastructure construction and urbanisation, recreational activities (e.g. scuba diving), non-indigenous mucilaginous, and filamentous algal aggregates (SUPREME North Adriatic case study, 2018).

The endemic **mollusc species** *Pinna nobilis* (fan mussel) is a priority for conservation under the Habitats Directive. It occurs in coastal areas, between 0.5 m and 60 m depth, principally on soft sediment colonised by seagrass meadows, but also on bare sand, mud, maërl beds, pebbly bottoms or among boulders. Fan mussels usually have a patchy distribution. Diverse stressors affect the species, such as boat anchoring, habitat degradation, trawling, dredging, illegal extraction, coastal construction, sewage discharges, and other pollution factors, global warming, acidification and food-web alterations, and it is now experiencing a mass mortality event and is in severe decline (Öndes et al., 2020).

The Italian area of the case study hosts also diverse pelagic species identified to be of priority for conservation. These include:

- **Cetaceans**: *Tursiops truncatus* (bottlenose dolphin) is present with a numerous population and with a distribution hotspot situated off the Po River Delta (Bonizzoni et al., 2020). Other cetaceans can be encountered in the area, such as the striped dolphin (*Stenella coeruleoalba*), the fin whale (*Balaenoptera physalus*), the sperm whale (*Physeter macrocephalus*), Risso's dolphin (*Grampus griseus*), Cuvier’s beaked whale *(Ziphius cavirostris)* and the long-finned pilot whale (*Globicephala melas*). Individuals of these species are rare visitors, however. In the past, individuals of the species *Delphinus delphis*, (short-beaked common dolphin) were also abundant, but the last 40 years saw the species became extinct (Fortuna et al., 2015). Bottlenose dolphins in the area are mainly affected by marine environmental degradation and prey depletion through fishing (particularly bottom trawling), with other pressures being climate change, pollution, drilling, geo-seismic prospecting and maritime traffic (Bonizzoni et al., 2020).
- **Reptiles**: The area is one of the most important Mediterranean feeding grounds of the loggerhead turtle (*Caretta caretta*) (Pulcinella et al., 2019). The loggerhead turtle movements in the Adriatic Sea include adult breeding migration from foraging (e.g. the Po Delta area in spring and summer) to breeding grounds (e.g. Croatian islands) and vice-versa (Casale et al., 2012). Genetic diversity indexes indicate that the Adriatic Sea area receives individuals mostly from the Greek rookeries, followed by western Turkey, and Crete, Cyprus and eastern Turkey rookeries. This species is highly impacted by bycatch due to mid-water and bottom trawlers in the North Adriatic, especially the nearby Po Delta, which is the main foraging ground in the area, and in the central part of the Northern Adriatic (Pulcinella et al., 2019).
- **Fish**: The Italian North Adriatic has a high density of essential fish habitats (EFH), important spawning grounds for diverse species of great economic value for the entire Adriatic Sea. These are anchovies, pilchards, mullets, sole and pelagic sharks, and invertebrate species (e.g. crustaceans, molluscs). Fish stocks are far from sustainable fishing levels and the target of exploiting stocks at maximum sustainable yield (MSY) by 2020, according to the assessment carried out within the Italian National Triennial Fishing and Aquaculture Programme 2017-2019. For instance, the spawning and recruitment stock biomass of anchovies (*Engraulis encrasicolus*) shows a descending trend, with periodic fluctuations but a constant decrease. The landing trend of sardines (*Sardina pilchardus*) has declined during the last six years. Scarcella et al. (2014) reported overfishing of the common sole (*Solea solea*). The juveniles of this species aggregate inshore along the Italian coast, mostly in the area close to the Po River mouth, while individuals older than one year gradually migrate offshore and adults are concentrated in deepest waters (South West offshore Istria).
- **Cephalopods**: Common cuttlefish (*Sepia officinalis*) mainly aggregate in the Northern Adriatic, accomplishing seasonal migration, spawning in shallow waters between April and July, and laying their eggs on seagrasses and algal canopies (e.g. in the Venice lagoon). After a strong decrease between 2003 and 2013, this species biomass recovered, although it is still below estimated biomass maximum sustainable yields (BMSY).
- **Birds**: The seabird Mediterranean shag (*Phalacrocorax aristotelis desmarestii*) is widely distributed in the Italian coast of the North Adriatic. Their breeding areas are located in Croatia. However, other seabird species breed along the Italian coast. In 2008-2014, wader and seabird nesting pairs were counted along the Veneto and Friuli-Venezia Giulia regions’ coastlines. The whole population of these seabird species was found to have increased. Their main nesting habitats are semi-natural (such as fish farms) and man-made sites (dredge islands), saltmarsh islets and the beach zones. The major threats affecting seabirds in the area are coastal erosion, uncontrolled exploitation of beaches for tourism, increasing frequency of saltmarsh submersion by high tides, and strong fluctuations of water levels inside fish farms (Scarton et al., 2018).

3.3.2 Slovenia

The portion of the NAS in Slovenian marine waters lies in the Gulf of Trieste. The Gulf has an average depth of 21 m, reaching a maximum depth of 35 m in its southeastern part. The Slovenian coast primarily has steep slopes and is gradual only between Koper and Ankaran, and Portorož and Sečovlje, at the mouths of the Rižana and Dragonja rivers. Elsewhere, **flysch cliffs, made of sandstone and marl,** are common. The area is heavily affected by meteorological phenomena due to the semi-closed shape of the Gulf and its shallow depth (Raicich et al., 2013). Littoral sediment, littoral rocks and biogenic reefs are unevenly distributed along the Slovenian coast and are covered by angiosperms, algae and cyanobacteria in brackish waters of inlets, shoals, abandoned salt facilities and estuaries. The extension of the habitats is declining due to new constructions along the coastline.

At least 30 km of coastline is covered by **littoral rocks,** which present biocenosis of upper and lower mediolittoral. The biodiversity in this belt is low due to high natural stress, and the associated biocenosis is decreasing due to new constructions along the coastline. Overall, these habitats have been assessed as in a poor state, primarily due to urbanisation of the coast, tourism pressure, changes in water and sedimentation regimes and illegal extraction of species used as fish bait (SUPREME, 2017).

The shallow sublittoral rock and **biogenic reef** with photophilic algae, dominated by species of the brown algae of the genus *Cystoseira* is distributed at a depth range of 1m to 5 m, and with precoralligenous formations (depth from 4 m to 12 m). The precoralligenous is the initial stage of the coralligenous biocoenosis, and in Slovenia, its formations are present in Fiesa and within the Rt Madona Natural Monument. This type of habitat covers approximately 10 km of coastline and has been assessed as being in a good state (SUPREME, 2017). However, key impacts affecting this habitat are fishing, coastal urbanisation and consequent changes in water and sedimentation regimes, and land run-off.

The shallow sublittoral mixed sediments are composed of mud, sand and detritus, and host seagrass meadows of *Cymodocea nodosa*, which forms large meadows wherever there is a sedimentary bottom at a depth ranging from 0.5 m to 10 m, and *Posidonia oceanica*. In the Gulf of Trieste, only one meadow of *Posidonia oceanica* is present, near the road that leads from Žusterna (Koper) towards Izola. According to old records, the **Posidonia meadows** were largely distributed in many areas in the Gulf of Trieste. After the 1960s, there was extensive degradation and today the species covers an area of approximately 0.64 hectares. Recently, a mild spread of this meadow was observed, and the species was assessed as being in a good status. Overall, the status of this habitat is assessed as variable, depending on the area, with main impact sources being anchoring, bottom trawling, sedimentation regime modifications and land-based pollution (SUPREME, 2017).

The Mediterranean **stony coral** *Cladocora caespitosa* occurs in the coastal zone as individual colonies, between 3 m and 8 m depth. Near Rt Ronek, the colonies appear below 14 m of depth in the form of a reef. The distribution of this species is driven by the presence of hard substrata and appropriate hydrographic conditions. It is also influenced by water transparency, as solar light is necessary for endosymbiontic zooxanthellae. Being zooxanthellate, *Cladocora caespitosa* can be affected by bleaching events. The status of the species has not been assessed. Its main pressures derive from fishing (mainly demersal net), anchoring and urbanisation, which increase the rate of sediment resuspension and sedimentation (SUPREME, 2017).

The area also hosts**:**

- Different **fish** species, such as the European anchovy *(Engraulis encrasicolus*), European pilchard *(Sardina pilchardus)* and the common sole (*Solea solea),* which have substantial economic value. They present altered populations due to overfishing (SUPREME, 2017). Overall, bony fish are represented by more than

200 species, including Gobiidae, Blenniidae, Sparidae, Labridae, Serranidae and Mullidae. The highest biodiversity of fish is present in association with *Cystoseira spp* and the rocky bottom. This macroalgae forms the most important habitat for the species of Labridae. Coastal species of fish are impacted by habitat loss due to urbanisation and pollution.

- **Cartilaginous fish -** 34 species of cartilaginous fish have been identified, including 20 sharks and 14 rays. The basking shark (*Cetorhinus maximus*), the grey shark (*Carcharhinus plumbeus*), blackspotted smooth-hound shark (*Mustelus punctulatus*), the pelagic stingray *Pteroplatytrigon violacea*, the bull ray (*Pteromylaeus bovinus*), and the marbled electric ray (*Torpedo marmorata*) have occasionally been recorded. These are species that, worldwide, show a decline; however, there are no data on their distribution and status in Slovenian waters.

3.3.3 Croatia

The coastline of Croatia includes 1,244 islands, islets and rocks (78 islands, 524 islets, 642 rocks and reefs). The seabed morphology is mainly sedimentary in nature, with deposits of organic and inorganic origin brought by Adriatic-basin streams – Neretva, Cetina, Krka and Zrmanja. Abrasive processes affect the coastline and the seabed is mainly sandy. The infralittoral rocky bottom is present and reaches up to 35 m depth, hosting abundant photophilic algal communities. The most exposed sites in the upper boundary present *Cystoseira* amentacea var. *Spicata* coverage, while below *C. compressa, C. crinitophylla, C. crinita, C. barbata, C. Agardh, C. spinosa,* and C. *foeniculacea* are present. In the upper infralittoral - the habitat mainly affected by anthropogenic sources of contamination - a macroalgal community represented by individuals of the genera *Ulva* and *Enteromorpha* (green algae), *Pterocladia* and *Gigartina* (red algae), and *Dictyota* and *Phylitis* (brown algae) is present. P. *oceanica* and C. *nodosa* meadows distributional range is 5 m to 35 m depth. They develop on sedimentary and solid seabeds.

Most of the area is characterised by very good or good condition of the macroalgal benthic communities. The **Posidonia meadows** have good or very good ecological status, with the exception of isolated sites that are directly influenced by human activities (SUPREME, 2017). Recently, however, a severe decline has been registered in seagrasses in certain coastal areas (Najdek et al., 2020). Key impacts affecting this species in the area are anchoring, changes in oxygen content and concentrations of nutrients, changes in sedimentation regime, changes in granulometric composition, redox potential and nutrient content of sediments (SUPREME, 2017).

The **coralligenous** is widely distributed in the Croatian part of the Adriatic. It is a calcareous bio-construction principally constituted by coralline red algae and develops under stable current, temperature, salinity, and dim light conditions (Ballesteros, 2006). It is considered a key habitat because of its role in hosting a high biodiversity and contributing to carbon regulation processes and ocean acidification mitigation (Rastelli et al., 2020; Costanzo et al., 2020). Data scarcity limits the knowledge on its distribution to small areas and up to 70 m depth. The main impacts affecting this habitat are fishing, changes in sedimentation regimes and pollution (marine litter). *Corallium rubrum is* a characteristic coralligenous species, listed in Annex V of the Habitats Directive. It has great economic value and for this reason is commercially exploited. Normally, its distribution range falls between 15 m and 130 m, although deeper records have been reported (up to 180-200 m depth). Although there is no information on its distribution and status, it has significantly decreased in recent decades due to over-harvesting and illegal harvesting.

Among the benthic species of priority for conservation, the fan **mussel** (*Pinna nobilis)* is historically widely distributed along the Croatian coast. However, a recent study carried out at the Nature Park Telašćica and Elaphiti islands reported the species to be experiencing a mass mortality event that has spread from the western Mediterranean to the entire Adriatic Sea (Čižmek et al., 2020). The date mussel (*Litophaga litophaga)* (illegally) and two sponges - *Spongia officinalis* and *Spongia lamella* – are both of commercial interest and are harvested.

The presence of submerged features, such as Rogoznica Lake, anhialine speleological features and **sea caves,** in shallow areas deserve to be mentioned. Formations of submerged karst are part of the Croatian heritage, as records of past climatic conditions and sea-level changes. Submerged karst springs, marine lakes, submerged river canyons and strongly karstified submerged areas are reservoirs of biodiversity and have substantial paleo-environmental significance.

Different species present in the area include:

- **Marine mammals**: Diverse marine mammals can occur in Croatian waters, including the Mediterranean monk seal (*Monachus monachus*), bottlenose dolphin (*Tursiops truncatus*), Cuvier's beaked whale (*Ziphius cavirostris*), false killer whale (*Pseudorca crassidens*), fin whale (*Balaenoptera physalus*), Minke whale (*Balaenoptera acutorostrata*), North Atlantic right whale (*Eubalaena glacialis*), northern bottlenose whale (*Hyperoodon ampullatus*), Risso's dolphin (*Grampus griseus*), short-beaked common dolphin (*Delphinus delphis*), sperm whale (*Physeter macrocephalus*) and striped dolphin (*Stenella coeruleoalba*). The bottlenose dolphin is the only permanent marine mammal in the Adriatic Sea, with most individuals observed at a depth of 150-200 m. The status of bottlenose dolphin populations is not fully known, although it is known that their numbers have halved in the second half of the 20th century due to hunting, degradation of habitats and prey overfishing. *Stenella coeruleoalba* is mainly present in the southern Adriatic at depths greater than 200 m. Occasionally, smaller groups appear in the Central and North Adriatic areas. According to the Croatian Red List of Mammals (2006), the Mediterranean monk seal was then considered extinct in Croatia. In recent years, sightings are increasing, however, with regular spotting in different parts of the Adriatic, especially along the eastern coast of Istria and the west coast of Cres and Lošinj. The main sources of impact on this species are bycatch, marine litter and pollution.
- **Fish:** Fish diversity is high, and decreasing northward (Jardas, 1996). According to the Institute of Oceanography and Fisheries[4] the biomass of commercially important species has decreased in recent years, especially in open sea areas, mainly due to excessive fishing effort. The worst situation is in the extraterritorial waters of the Adriatic Sea, where fishing effort is most intense and the most important nursery and spawning areas for a large number of economically important species are located (IZOR, 2012). The largest decrease in abundance was recorded at depths of 50 m to 200 m, where the main fishing areas are located (Jakl, 2015). However, the coastal stocks along the eastern Adriatic are also largely depleted and some areas are in state of overfishing (Kornati, wider area of cities and some islands off the mainland, Malostonski Bay and others) (SUPREME, 2017). The most important small pelagic stocks of commercial value are sardines (*sardina pilchardus*) and anchovies (*engraulis encrasicolus*), while among the demersal species are European hake (*Merluccius Merluccius*), Norway lobster (*Nephrops norvegicus*), common sole (*Solea solea*), red mullet (*Mullus barbatus*) and deepwater rose shrimp (*Parapenaeus longirostris*).
- **Cephalopods**: Curled octopus (*Eledone cirrhosa*) primarily inhabits the middle Adriatic, at depth greater than 100 m, while the musky octopus (*Eledone mmoschata*) generally inhabits the shallow areas. The largest population density is along the western coast of Istria (MZOIP, 2012). According to the Institute of Oceanography and Fisheries, all cephalopod stocks show high fluctuation in biomass and catch (mainly due to the fluctuation in recruitments). Croatia is experiencing an increase in the number of new species, primarily due to aquaculture

[4] http://baltazar.izor.hr/azopub/bindex

activities and shipping, and species coming from other Mediterranean subregions. A checklist of introduced species in Croatian waters contains 113 species (15 phytoplankton, 16 zooplankton, 16 macroalgae, 44 zoobenthic, 22 fish species), of which 61 species are alien and 52 introduced (Pečarević et al., 2013).

- **Birds**: In the Croatian part of the Adriatic, there are several important seabird populations, although with a relatively small number. Scopoli's shearwater (*Calonectris diomedea*) nesting areas are the offshore islands of the South Adriatic: Sv. Andrija, Kamnik, Palagruža and several islands of the Lastovo archipelago. This species counts 700-1,250 nesting pairs. These islands are also the breeding sites of the species *Falco eleonorae*, which counts 65-100 nesting pairs. Mediterranean shearwater (*Puffinus yelkouan*) has three breeding sites in Croatia: the Lastovo Archipelago and islands Svetac and Kamnik, and its population counts 300-400 nesting pairs. *Larus audoinii* has an estimated population of 60-70 nesting pairs in the area of the islands of Korčula, Mljet, Lastovo and Pelješac peninsula. The Mediterranean shag population (*Phalacrocorax aristotelis desmaresti*) nests on small islands along the entire Adriatic and numbers 1,600-2,000 nesting pairs. More than 30% of the birds' populations nest in the mid-Adriatic, as part of the ecological network and the Special Protection Area (SPA) in the northern part of the Zadar archipelago. The griffon vulture populations (*Gyps fulvus*) are mainly present in the large northern Adriatic islands. Over the last 15 years, its population has risen, likely due to active protection measures. Nonetheless, marine birds in Croatia are endangered due to the increased pressure of commercial fishing in feeding areas and the impact of invasive organisms (rats) in their nesting areas (SUPREME, 2017).

4 Ecosystem services in the Northern Adriatic Sea

This chapter presents the different ecosystem services supplied by the marine ecosystems of the NAS, combining qualitative, quantitative and monetary information. Where monetary data are not available from the NAS case study area, estimates are provided, based on information available for other marine ecosystems/sea basins.

4.1 Supporting ecosystem services: habitat provisioning and biodiversity

Supporting ecosystem services represent the array of ecological processes and functions that allows the delivery of all such services to humans (MA, 2005; Costanza et al., 2017; Manea et al., 2019). Their consideration is essential to enable sustainable management of marine resources, yet they are rarely considered in conservation planning because of the difficulty in assigning them a monetary value. The North Adriatic is an area of great ecological value because of the high level of multiple supporting ecosystem services it provides (Manea et al., 2019). Unfortunately, it has few sites of conservation and these are scattered and of limited size, mainly belonging to the Natura 2000 network and only partially managed and protected (Claudet et al., 2020). In addition, these protected areas are largely coastal. The exclusion of offshore waters and their limited extension in the marine space means they do not capture all important habitats of priority for conservation (Manea et al., 2020). One new protected offshore area is under development in front of the Italian coast shared between the Veneto and Emilia Romagna regions, in front of the Po River Delta, intended to protect cetaceans, primarily bottlenose dolphins.

Beyond the limited protection tools present in the area, the North Adriatic has been designated an Ecologically or Biologically Significant Area (EBSA) (SCBD, 2021), recognising that it is one of the most productive areas in the entire Mediterranean Sea at several trophic levels, from phytoplankton to fish (Fonda Umani, 1996), and that it houses important biodiversity, unique habitats and several threatened species.

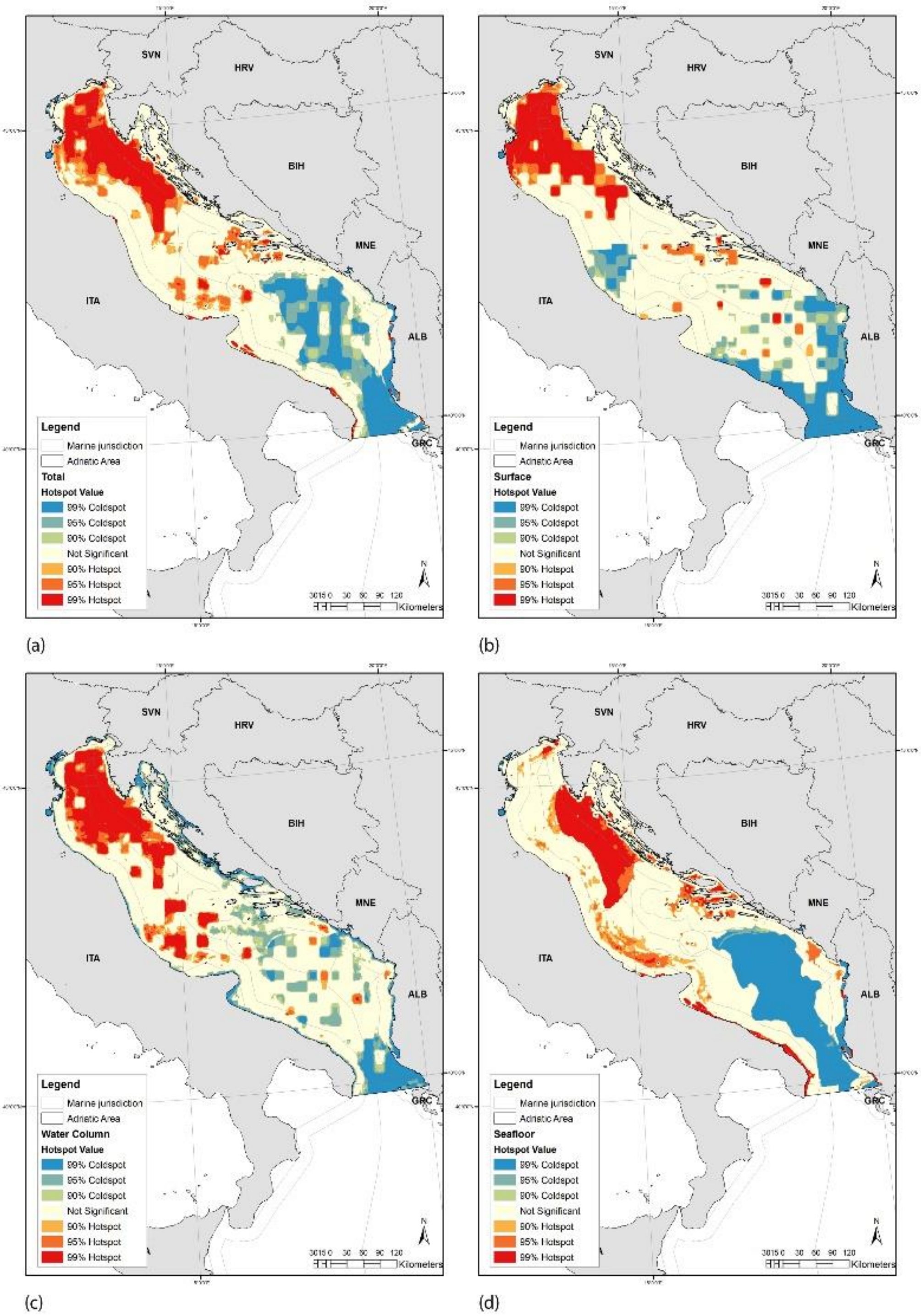
The area includes a diversity of **bottom habitats**: mobile, sandy and muddy, seagrass meadows (including *Posidonia oceanica*, *Cymodocea nodosa*, *Zostera marina* and *Zostera noltii),* **hard bottom** associations (such as coralligenous formations, maërl beds) and **unique rocky outcrops** called 'trezze' and 'tegnùe', which exist only in this marine area. These outcrops in the Northern Adriatic play an extraordinary ecological role because they are the only hard substrates located offshore and able to offer shelter, breeding and feeding sites for numerous fish and invertebrate species (Falace et al., 2015), and is one of the densest populations of bottlenose dolphin (*Tursiops truncatus*) in the Mediterranean. In fact, the Cres-Lošinj Archipelago (Kvarnerić area) hosts a resident sub-population of bottlenose dolphin (Jones et al., 2011), which cross the entire North Adriatic, feeding on its western side (in front of the Po River Delta) (Bonizzoni et al., 2020). This Archipelago is a key area for Mediterranean shags (*Phalacrocorax aristotelis desmarestii*). Large aggregations of shags forage in the area in late summer and autumn, with average counts of 2,000−4,000 individuals (highs of 10,000), exceeding half of the entire breeding population in the Adriatic. This area is also important for the common tern (*Sterna hirundo*), which nests on little islands in the North Adriatic area, and is the most northern natural population of griffon vultures (*Gyps fulvus*) in the Mediterranean (SCBD, 2021). The area is one of the most important feeding grounds in the Mediterranean for the loggerhead turtle (*Caretta caretta*) and is a nursery area for a number of vulnerable species, such as the blue shark (*Prionace glauca*), and the sandbar shark (*Carcharinus plumbeus*), as well as species of great commercial value, such as anchovies (*Engraulis encrasicolus*), sardines (*Sardina pilchardus*) and common sole (*Solea solea*).

Recently, Manea et al. (2019) assessed and mapped the supporting ecosystem services delivery in the Adriatic Sea and identified several suitable indicators for developing the supporting ecosystem services assessment: marine mammals, seabirds, giant devil rays, loggerhead turtles, primary producers, seabed habitats, and areas suitable to provide nursery grounds. Each was assigned the capability of provide diverse supporting ecosystem services, including:

- **Nutrient cycling -** the flow of nutrients in nature that support biodiversity;
- **Biodiversity maintenance** - support key ecosystem processes affecting the maintenance of ecosystem functioning;
- **Habitat provision** - availability and status of habitats that enable the presence of biodiversity.
- **Primary production** - fundamental to supporting marine life in both benthic and pelagic environments, it includes nutrient production of both photosynthetic and chemosynthetic origin.

The North Adriatic was found to be a hotspot of multiple overlapping supporting ecosystem services delivery (Manea et al., 2019). This was particularly true for the marine components (marine mammals, giant devil rays, loggerhead turtles, and primary producers) living in the pelagic habitats of the North Adriatic. When focusing on the seabed habitats, some hotspot areas were found, chiefly aligned with the coralligenous outcrops, trezze and tegnùe, and some areas suitable to host nursery habitats (Figure 2).

Figure 2: Identified hotspots (red areas) and cold spots (blue areas)

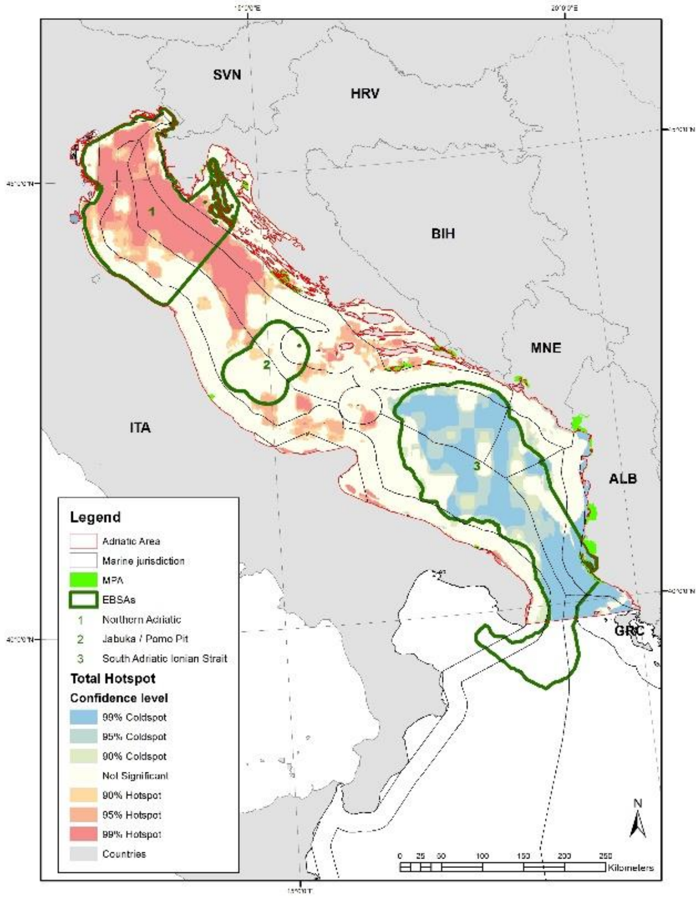


Notes: (a) Total hot and cold spot areas not distinguishing the marine domains; map (b) Surface hot and cold spot areas; map (c) Water Column hot and cold spot areas; map (d) Seabed hot and cold spot areas.

Source: Manea et al. (2019).

The hotspot identified in the North Adriatic overlaps with the North Adriatic EBSA (Figure 3).

Figure 3: Spatial coincidence between hot and cold spot areas, not distinguishing the marine domains, and MPAs and EBSAs in the study area



Source: Manea et al. (2019).

Looking to the threats and pressures impacting the delivery of these supporting ecosystem services in the North Adriatic, all excessive and uncontrolled human activities in the area represent a source of impact. Fishing, coastal and maritime tourism, coastal urbanisation and run-off, land-based and maritime-based pollution, oil and gas exploration/extraction and seismic activities, maritime transport, pipelines and cable installations, are all activities that can deteriorate the coastal and marine environment and have an impact on all marine life (species and habitats). Climate change, global warming and extreme events (e.g. extraordinary high tide events) have already begun to alter the state of the marine environment and its organisms. These multiple stressors together are changing the capacity of delivering supporting ecosystem services in the North Adriatic. Indeed, the North Adriatic has been listed as one of the main impacted areas in the Mediterranean Sea due to anthropogenic activities (Micheli et al., 2013), and its level of naturalness (criterion 7 of the EBSA definition process) was defined as low.

Estimated monetary values of the *Posidonia* meadows' contribution to supporting ecosystem services are presented in Table 4.

Table 4: Ecosystem services considered in the Northern Adriatic case study

	Italy	Slovenia	Croatia
Area of NAS covered by Posidonia meadows in ha (Telascica, 2015)	Negligible	9 ha (2004)	31,437 ha (2010)
Value of supporting ecosystem services provided by Posidonia Oceanica in the Mediterannean (EUR/ha/year) (Campagne et. al., 2015) Considering two supporting ecosystem services	Water purification: 60 EUR/ha/year Fisheries contribution (habitat provisioning): 27-35 EUR/ha/year >> Total contribution: 87-95 EUR/ha/year (2014)		
Total value of supporting ecosystem services provided by Posidonia Oceanica in NAS (approx.) (EUR/year)	Between 2,735,802 and 2,987,370 EUR/year.		
Value of supporting ecosystem services provided by Posidonia Oceanica in the Med (Vasallo et al., 2013) Considering 25 ecosystem services	Between 283 and 513 EUR/ha/year		
Total value of supporting ecosystem services provided by Posidonia Oceanica in NAS (approx.) (EUR/year)	Between 8,899,218 and 16,131,798 EUR/year		

Source: Telascica (2015); Campagne et. al. (2015); Vassallo et al. (2013); Plan Bleu (2014).

This example reveals how important the Croatian ***Posidonia* meadows** are in providing supporting ecosystem services for the entire NAS area, and how important it is to account for all ecosystem services. The value differed dramatically depending on the number of ecosystem services considered. Building on the values presented in Table 4, the total value of supporting ecosystem services provided by *Posidonia Oceanica* in the NAS could **range from EUR 8.9 million to EUR 16.1 million per year.**

4.2 Provisioning ecosystem services

Provisioning ecosystem services refers to the benefits people obtain and extract directly from nature (MA, 2005). Along with food, other services are provided by the marine environment, such as water, sand, salt and energy. The use and subsequent transformation of ecosystems for the purpose of meeting human food needs is something that, historically, has always been done.

The capture and farming of fish and shellfish, **both from marine and freshwater environments,** contributes significantly to humans' protein supply. In addition, the fishing sector provides important incomes and employment opportunities, as well as aquaculture, which already provides important amounts of fish worldwide and is continuing to grow[5]. The main source of food extracted from the Adriatic Sea as a provisioning service is from pelagic and small pelagic fish species, molluscs, crustaceans and cephalopods captured through fishing (wild capture) or farming in aquaculture facilities. The North Adriatic corresponds to geographical sub-area 17 (GSA17) and it is known as an

[5] http://www.fao.org

area where fishing effort greatly exceeds MSY of most species of commercial interest (Bastardie et al., 2017). In generally, professional fishing and harvesting activities are usually located inside the national water limits but also extend into international waters.

The target fish stocks are often shared between Italy, Slovenia and Croatia, creating substantial competition at transboundary level. The state of fish resources is not only linked to fishing effort but also to the quality of the marine environment. Any type of stressors potentially altering environmental conditions can strongly affect the capacity of the marine environment to provide food sources.

In the Adriatic Sea, fish products represent income in respect of both the national market and for export. The following sections will provide an overview of both the wild capture and farmed seafood sectors, the main species of commercial importance, their quantities, value and contributions to the national economy. Each section will be divided by country for readability. A summary table is provided at the end, together with an illustration of the import origin and export destination of seafood products, to help to understand the geographical extent of the ecosystem services.

4.2.1 Food – wild capture

This section presents the key features of the fisheries sector in the three countries, describing: fishing techniques and methods, main target fish species and the status of fish stocks, per capita fish consumption, landing volumes (per region, if relevant, and per species), along with the economic importance of the sector for employment and economic value (potentially disaggregated by region and species).

The fishing sector in the North Adriatic recorded a steady decrease in the period 2010-2015, which has stabilised in recent years. That decreasing trend was in line with trends registered at EU level. Over the coming years, a further reduction in industrial fishing capacity is expected. This means that the provisioning service of seafood directly captured through fishing is severely over-exploited and the capability of this particular marine environment to deliver ecosystem services is decreasing to a worrying degree.

Italy

In Italy, the fisheries sector depends on various **fishing techniques** that target diverse marine species and are distributed differently in the case study area. Bottom otter trawling (OTB), pelagic pair trawl (PTM), Rapido trawl, purse seining and hydraulic dredging are among the main techniques used, especially in GSA17.

Small-scale fishing refers to vessels smaller than 12 m, with the use of set gears. It is characterised by high seasonality, depending on the ecology of the target species. It **is concentrated within 6-7 nautical miles (nm) for all set gears**. The exception is some forms of fishing using gillnets, hydraulic dredging for clams, and purse seining off the coast of Emilia-Romagna and Friuli. This small-scale fishing represents the most important sector in terms of numbers of fishing vessels, with over 600 units in GSA17 (MIPAAF National Programme Data Collection 2016, North Adriatic case study, SUPREME, 2018). The most commonly fished species are sole, mantis shrimps, turbot (*Scophthalmus maximus*), cuttlefish (*Sepia officinalis*) and sea snails (*Tritia mutabilis*).

Commercial OTB for demersal species is legal off 3 nm and the main targets are mantis shrimp, cuttlefish, and red mullet (MIPAAF National Programme Data Collection 2016, North Adriatic case study, SUPREME, 2018). PTM for small pelagic species is practised off 3 nm from the coast and targets anchovies and sardines. The distribution of both bottom and pelagic trawling effort is diverse in the study area (North Adriatic case study, SUPREME, 2018). OTB covers the whole study area beyond 3 nm, presenting greater intensity between 10 and 14 nm and in international waters.

Rapido trawl has greater intensity outside 6 nm between Venice, Chioggia and the Po River Delta, in the southern part of the Emilia-Romagna coasts and in international waters offshore the Po River Delta. PTM is distributed over the entire study area off 3 nm, with greater intensity between 3 nm and 6 nm in front of the Veneto region and in the southern part of the Emilia Romagna.

The Italian National Triennial Fishing and Aquaculture Programme 2017-2019 confirmed **excessive fishing exploitation** in the Adriatic, although the situation is not homogeneous in all GSAs. In GSA17, the fish species' European hake (*Merluccius merluccius),* red mullet (*Mullus barbatus),* and sole (*Solea solea)* are in a state of overexploitation. The mantis shrimp (*Squilla mantis*) fishing effort has slight exceeded in recent years and is now overexploited too. The small pelagic species', anchovy (*Engraulis encrasicolus*) and European pilchard (*Sardina pilchardus*) are strongly overfished.

Employment in the fisheries sector in Italy in 2017 was estimated at 20,268 (STECF, 2019a). Employment in the fish processing industry in Italy was 4,568 in 2017 (STECF, 2019b).

According to Martin (2008), numbers from 2005 revealed that the NAS region (mainly Veneto and Emilia Romagna) accounted for 7% of total employment in fisheries, or around 1,420 employees, in the NAS region. According to Martin (2008), the Veneto region alone accounted for 12% of total employment in the sector, some 550 employees in the NAS region in Italy.

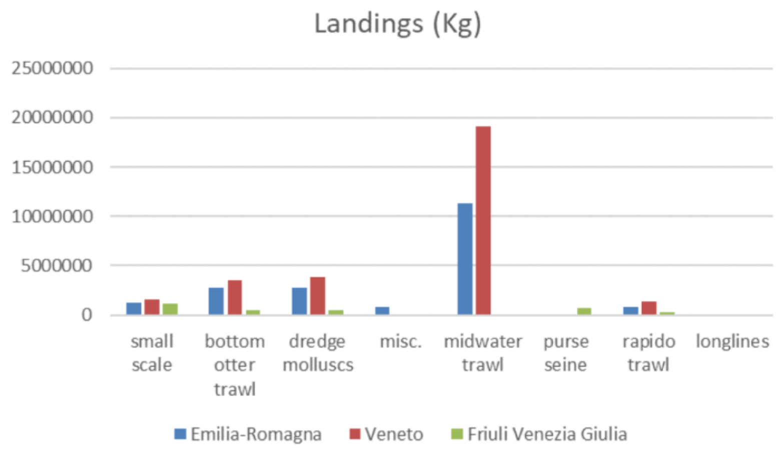
In terms of quantities, the main landed species in Italy in 2012 are anchovies (~22%) sardines (~10%), mussels/clams (~10%) hake (~5%) and deepwater rose shrimp (~5%) (Statista; FAO). In 2018, in the GSA17, Italy landed 1,852 tonnes of European hake, 1,763.2 tonnes of sole, 2,517.1 tonnes of red mullet, 1,476 tonnes of cuttlefish, 3,169 tonnes of mantis shrimp and 835 tonnes of deep-water rose shrimp (STECF, 2019).

Looking at fishing activities and values, the most important fishing in the Italian North Adriatic is the midwater trawl (EUR 38,693,000), followed by OTB (EUR 16,776,000) and dredging for molluscs (EUR 15,200,000) (2016 data, North Adriatic case study, SUPREME, 2017).

In terms of geographical distribution, the Veneto region presented the highest abundances (kg) and economic incomes value (EUR) in 2016, followed by the Emilia-Romagna and Friuli-Venezia-Giulia regions (EUR 71,997,028.72, EUR 46,259,430.59 and EUR 18,503,741.79, respectively) (Figures 1 and 2, North Adriatic case study, SUPREME, 2018). While in Friuli-Venezia-Giulia, the most productive fishing activity is small-scale fishing (EUR 9,256,614.81), in the other regions, both pelagic and bottom trawling activities (bottom, midwater and rapido) are more productive. In Emilia-Romagna, the biggest income is from the catch of mantis shrimp (EUR 10,545,695), followed by Venus clams (*Chamelea gallina)*, sardine, anchovy and sole. In Veneto, the most important incomes are those from anchovies (EUR 10,969,847), followed by cuttlefish, sole, sardine and Venus clams (*Chamelea gallina)*. In Friuli-Venezia-Giulia, the species that provides the highest revenue is cuttlefish (EUR 2,216,540), followed by gilthead (sea) bream, smooth clam (*Callista chione*), European bass and sole. In terms of value, **hake is still the most valuable species:** at EUR 86.1 million, it accounts for 7.9% of the total value of domestic landings[6].

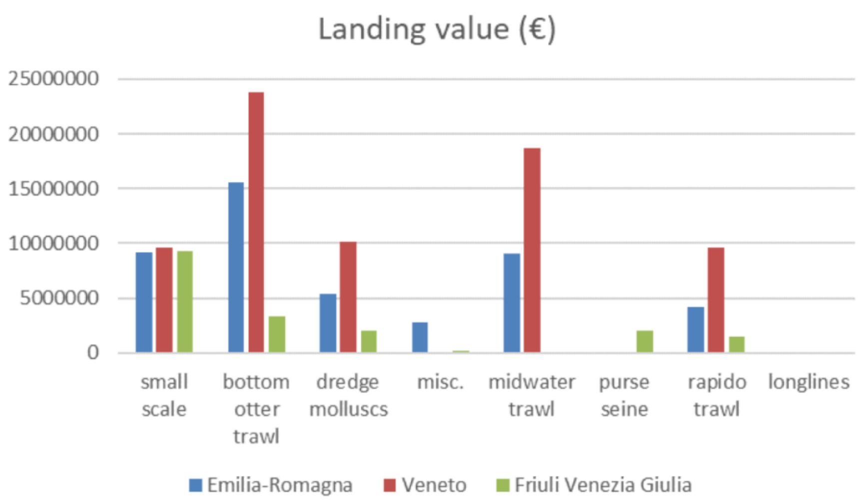
[6] http://www.fao.org/fishery/facp/ITA/en

Figure 4: Weight landing value of each region, by type of fishing activity, 2016



Source: North Adriatic case study, SUPREME (2017).

Figure 5: Economic landing value of each region, by type of fishing activity, 2016.



Source: North Adriatic case study, SUPREME (2017).

Slovenia

In **Slovenia**, unlike in Italy and Croatia, the fisheries sector is not a leading sector. There are three fishing ports, Koper, Izola and Piran, and the fishing fleet consists mostly of vessels of up to 12 m in length (91%), which primarily fish along the coast. In 2018, Slovenia had 134 active fishing vessels. The main targeted species are whiting (*Merlangius merlangus*), musky octopus (*Eledone moschata*), gilthead sea bream (*Sparus aurata*), the common sole, European squid (*Loligo vulgaris*) and European sea bass (*Dicentrarchus labrax)*, which are fished using standing nets (FAO, 2019). The average seafood consumption is 10.8 kg/capita (EUMOFA, 2014).

In 2018, 28 tonnes of whiting, 20 tonnes of musky octopus, 15 tonnes of gilthead sea bream, 10 tonnes of sole, 8 tonnes of European squid, 6 tonnes of red mullet, 4 tonnes of European bass and common Pandora, 1.6 tonnes of cuttlefish, 1 tonne of mantis shrimp and 28 tonnes of other species were landed, with a total landing of 126 tonnes (FAO, 2019; STECF, 2019).

According to the Economic and Social Analysis (ESA) of the MSFD carried out for Slovenia, 171 fishing vessels were registered in 2016 (Ministry of Agriculture, Forestry Food). The production value in 2019 was estimated at EUR 2,016,280 and added value at EUR 547,360. Fish and shellfish processing had a production value of EUR 4,278,004 and an added value of EUR 1,808,688 (ESA SI, 2019). Over the years, there has been a decline in catch landed (SUPREME, 2017), a trend that has also been observed for recreational fishing activity.

In 2017, **employment** in the fisheries sector was 63 (STECF, 2019a), with 130 employed in processing (STECF, 2019b). While these numbers vary according to sources and the nature of the employment (seasonal or full-time equivalent (FTE)), they are nevertheless representative of the importance of the processing industry for the sector.

Croatia

In Croatia, the fisheries sector is an important economic income and participates significantly in the export of food products. A positive foreign trade balance of the sector is maintained. The species of greatest commercial interest are sardines and anchovies, followed by mackerel, European horse mackerel, red mullet and hake. The role of recreational and sport fishing is growing, especially after Croatia's accession to the EU (SUPREME, 2017). In 2019, Croatia counted 7,536 vessels (FAO, 2019).

Estimates of the value of **direct production** from the fishing, fish farming and processing sectors varies between 0.2% and 0.7% of total Gross Domestic Product (GDP). When the value of associated assets is included, the contribution to the national GDP exceeds 1%. In addition, the fisheries sector is significant in the export of Croatia's food products. Approximately **14,000 people** (fishermen, employees in fisheries companies, farming and processing) are **directly employed** in the sector, with a further 11,000 indirectly employed.

The **total landing** in 2016 was 72,003 tonnes, chiefly sardines and anchovies, followed by red mullet and hake (SUPREME, 2017), while in 2017 the total landings decreased to 68,875 tonnes, which included 48,333 tonnes of sardines, 10,880 tonnes of anchovies, 1.981 tonnes of mackerel, 1,000 tonnes of red mullet, 928 tonnes of European hake, 841,5 tonnes of red mullet, 89 tonnes of cuttlefish, 13.1 tonnes of mantis shrimp and 912.49 tonnes of deepwater rose shrimp (FAO, 2019; STECF, 2019).

The average total catch of sea fisheries in the period 2012-2017 were 72,545 tonnes, of which 90.8% were blue fish (sardines, anchovies, tuna, bluefin tuna, horse mackerel and others), 5.5% other fish (hake, red mullet, mullet, common sole, gilthead sea bream and others), 1.7% molluscs (squid, cuttle fish, octopus, muccap and other), 1.1% crustaceans (Norway lobsters, crawfish and others) and 0.9% oysters, mussels and other bivalve molluscs. The biggest single species' were sardines, with a share of almost 75%, and anchovies, at almost 15%.

The average total value of annual catch by **commercial fisheries** during the period 2014-2017 was estimated to be less than HRK 440 million per year, or just below EUR 60 million per year. Parallel annual revenue from fishing activities in the coastal areas exceeded HRK 10 million in 2016 and 2017 (around EUR 1,318,000) (ESA HR, 2019). For **recreational fisheries**, assuming that there are around 10,000 recreational liners (only those previously active in small-scale fishing for their own use) and that each fishes 5 kg of fish per day and catches every third day, the total potential catch volume is 9,000 tonnes per year or around 10% of the volume of catch from commercial fishing (ESA HR, 2019).

In 2017, **employment** in the fisheries sector in Croatia was 1,665 (STECF, 2019a) and in processing it was 1,672 (STECF, 2019b). **Sport fishing** activity has grown in recent years, with over 78,000 permits issued in 2011. Production and trading of vessels, equipment and tools for sport and recreational fisheries provide jobs for over 3,000 people (SUPREME, 2017). In terms of **trade**, fisheries represent 7% of total export of agricultural products. Croatia is a net exporter of fish and seafood products, with about EUR 50 million surplus in 2017. Japan is the most important destination for Croatian tuna, while within the EU, Italy, Slovenia and Spain are the main export destinations for fresh and salted fisheries products. Demersal fish and cephalopods are exported fresh to Italy. Export of fish and seafood in 2017 amounted to EUR 208.1 million and 62,000 tonnes (eurofish (Croatia)).

4.2.2 Food – farmed seafood

In addition to the food resources that are directly captured and extracted from the marine environment, the cultivation of fish and shellfish (i.e. aquaculture) represents a key sector in the blue economy scenario in the North Adriatic. While the fishing sector marked a steady decrease between 2010-2015 and many species are suffering from overexploitation, the ecosystem services linked to the food provided by the marine environment and cultivated in **aquaculture** facilities in the North Adriatic is gaining importance.

Italy

In **Italy**, national aquaculture production was 140,846 tonnes in 2013, with a total value of around EUR 393 million, equivalent to 33% of the total seafood sector. Mussel production accounted for 63% in weight and 44% in value (FAO, 2015). The Northern Adriatic, particularly Emilia-Romagna, Veneto and Friuli-Venezia-Giulia are the most productive regions for shellfish and finfish in Italy (MIPAAF, 2015; SUPREME, 2017). The aquaculture in the Emilia-Romagna and Veneto regions is primarily based on shellfish production, while in Friuli-Venezia-Giulia, it centres on finfish production. The Emilia-Romagna and Veneto regions contribute 66% of the national production of shellfish (45.7% and 20.6%, respectively), in particular clams (*Tapes philippinarum)* in transitional waters and Mediterranean mussels (*Mytilus galloprovincialis)* in marine waters. In Emilia-Romagna, production areas are concentrated along the coast, while in Veneto, the mussel farms are located along the coast from Chioggia to Venice, and out of the Po Delta. The mussel farms in Friuli-Venezia-Giulia are mainly located in the Gulf of Trieste. The Emilia-Romagna and Veneto regions represent the highest shellfish production in Italy, particularly for clams (*Tapes philippinarum*) and mussels (*Mytilus galloprovincialis*).

Emilia-Romagna produces 40,000 tonnes/year, followed by Veneto, with 18,000 tonnes/year, of shellfish. In Veneto, the production of mussels in the Po Delta accounts for almost 88% of the regional total. Friuli-Venezia-Giulia is mainly based on finfish aquaculture (trout farming), with an average of 14,000 tonnes produced per year, or 26% of national production. This region also produces 4,000 tonnes/year of shellfish (2013 data from MIPAAF, 2015; North Adriatic case study, SUPREME, 2018). In 2015, 16 companies and 42 employees were involved in mussel farming in Trieste.

The **occupational trend** in aquaculture in Italy showed an increase between 2002 and 2011, with 79% in the shellfish sector, 12% in marine aquaculture and 9% in freshwater (FAO, 2015).

In 2016, **employment** in the aquaculture sector in Italy was 3,289 (STECF, 2018). According to Martin (2008), the Emilia-Romagna region accounted for 25% of employment in aquaculture, while the Veneto region was around 16%. In total, this would amount to around 1,350 employees in the aquaculture sector in the NAS region in Italy. Some statistics reveal that FTEs are only 60% of total employees in the sector, reflecting high seasonality (Eurofish (Italy).

Despite the growing demand for fish and shellfish products, the Italian side of the study area observed a general **decrease** in production from 2002 to 2015. Indeed, production decreased from more than 180,000 tonnes in 2003 to 140,000 tonnes in 2015. This was due to an intense storm between 5 and 8 February 2015, characterised by waves higher than 7 m that destroyed most of the rows of the longline facilities offshore, causing 10,000 tonnes of product loss. Aquaculture and food provisioning can therefore demonstrably be strongly affected by extreme climate events.

Looking at **future trends** in aquaculture, substantial stability can be expected for clam farming, alongside an increase in mussel farming in the whole area (North Adriatic case study, SUPREME, 2018).

Molluscs, cephalopods, sea bass and sea bream are commonly consumed products. Fresh fish is the most frequently consumed product (84%). This share is significantly higher than the EU average (68%) (Eurofish (Italy)).

Slovenia

In **Slovenia**, the predominantly cultivated organisms are European sea bass (*Dicentrarchus labrax*) and Mediterranean mussels (*Mytilus galloprovincialis).* This activity is dominated by small family-run businesses, with few workers, with an objective limit to growth, given the limited space available for this activity (SUPREME, 2017). In 2016, around 20 persons were **employed** in the aquaculture sector (STECF, 2018).

The annual average aquaculture production in the period between 2005 and 2010 was 213 tonnes of mussels and 37.7 tonnes of sea bass. The sector is expected to grow over time, as it is recognised that the demand for sea products will not be able to be met by fishing. However, the opportunity for production increase is limited by the current size of officially designated mariculture areas (Slovenian case study, SUPREME, 2018).

In terms of species and quantities, the Mediterranean mussel (*Mytilus galloprovincialis*) consitutes around 83% of total mariculture production in Slovenia, while the European sea bass (*Dicentrarchus labrax*) is around 17% of total production (FAO, 2021).

In 2016, the total production value amounted to EUR 4,976,000 (Ministry of Agriculture, Forestry and Food, 2016), and around EUR 3,705,508 in 2019 (ESA SI, 2019).

Table 5: Exports and imports of fish and fish products in Slovenia, 2010-2016

Export and import	2010	2011	2012	2013	2014	2015	2016
Exports (net weight in 1,000 kg)	3,166	3,534	3,186	3,251	4,247	3,871	4,789
Imports (net weight in 1,000 kg)	15,845	16,166	14,911	14,718	15,816	15,724	17,285
Exports (EUR 1,000)	13,886	16,061	16,646	17,982	24,082	22,324	26,071
Imports (EUR 1,000)	55,679	64,363	63,501	64,872	69,456	75,249	90,407

Source: SURS (2017), from ESA SI (2019).

In terms of value, the two most valuable species are sole (18.59 EUR/kg, sea bass (14.47 EUR/kg), squid (12.87 EUR/kg) and sea bream (12.78 EUR/kg). These are followed by mullet, which show a radical decrease (4.08 EUR/kg), whiting (3.67 EUR/kg) and musky octopus (3.44 EUR/kg). The species with the lowest value are sardines (1.97 EUR/kg) and anchovies (2.84 EUR/kg). These values represent the purchase price in 2016, based on average on values or quantities of landing in the period 2010-2016 (ZZRS, 2018, in ESA SI, 2019).

Table 6: Average quantities and average values of landings of Slovenian fishing vessels, by species, 2010-2016

Type	Landings (tonnes)		Value of landings (EUR)	
	Average Quantity (tonnes)	Average Share (% of total landings)	Average value (EUR)	Average share (% of total value of landings)
Sardine	129.4	34.1	198,877	13.4
Anchovy	60.8	16.1	124,653	8.4
Whiting	44.2	11.7	140,039	9.4
Musky octopus	18.0	4.8	62,669	4.2
Squid	13.7	3.6	166,200	11.2
Sea bream	13.5	3.6	148,963	10.0
Mullet	13.1	3.5	33,126	2.2
Sole	12.0	3.2	184,067	12.4
Golden grey mullet	7.0	1.8	19,911	1.3
Pandora	6.4	1.7	47,623	3.2
Cuttlefish	6.3	1.7	39,010	2.6
Horse mackerel	4.8	1.3	10,932	0.7
Sprat	4.8	1.3	8,154	0.5
Flounder	4.8	1.3	21,651	1.5
Salps	3.9	1.0	9,615	0.6
Red mullet	3.3	0.9	11,636	0.8
Sea bass	3.1	0.8	49,934	3.4
Mackerel	2.4	0.6	16,337	1.1
Sea bream	2.0	0.5	4,713	0.3
Mantis shrimp	2.0	0.5	12,138	0.8
Other species	23.5	6.2	174,089	11.7
Total landings	**379.0**	**100**	**1,484,339**	**100**

Source: SURS (2017), from ESA SI (2019).

Croatia

In **Croatia**, the mariculture industry includes both fish and shellfish farming (SUPREME, 2017). European sea bass *(Dicentrarchus labrax),* gilthead (sea) bream (*Sparus aurata)* and Atlantic bluefin tuna (T*hunnus thynnus)* are the main species bred. Shellfish are mostly produced in the area along Pelješac peninsula near the Mali Ston. There are also some shellfish farms along the west Istrian coast and in Velebit channel, Novigrad sea and the mouth of Krka River. Other areas along the Croatian coastline are devoted to aquaculture, such as Zadar County, Šibenik-Knin County, and the area of Malostonski Bay and Malo More in Dubrovnik-Neretva County. The aquaculture sector is important to Croatia’s growing export market. In 2013, there were a total of 148 registered farmers (117 shellfish farmers and 30 fish farmers). The total production in mariculture in 2015 was 12,043 tonnes. Mariculture activities in Croatia are recording steady growth that is likely to last into the future: the share of aquaculture in total fish production in Croatia is only around 20% therefore (especially given limitations on fishing quotas), the development of this sector is very important to supply the fish market (SUPREME, 2017).

Fish consumption in Croatia amounts to 110 EUR/year of fish on average, or 8kg/capita (Soullard and Bencetic, 2016). The total annual income of Croatian aquaculture in the marine environment of the coastal area represented an average of HRK 691 million, or around EUR 91 million. The average annual newly created value was about HRK 200 million (ESA HR, 2019). According to these sources, the defined NAS area accounts for over 90% of total aquaculture production in Croatia.

148 breeders were registered in 2013, with up to a maximum of (117) shellfish farmers, 30 white fish growers, and 4 tuna growers. Production was carried out in 330 locations,

45 for white fish, white fish and shellfish in polyculture at 10 sites, tuna in 14 sites and 4 sites for white fish hatcheries (MP, 2015). Approximately half of this number was employed by Cromaris d.d. (established and operated for processing and sorting fish in Zadar and Istria) (ESA HR, 2019).

Employment in Croatia in aquaculture (in 2016) was 1,625 (STECF, 2018). The annual average total newly created value of the fish/shellfish processing industry over the period 2012-2017 was about HRK 170 million, or around EUR 22 million. A significant trend has been observed towards shifting activities from the narrower coast down to its hinterland (ESA HR, 2019).

4.2.3 Food: summary of fisheries products

Table 6 combines values gathered from multiple sources, including some estimations for the NAS region.

Table 7: Summarising the fisheries and aquaculture sectors' economic valuation in the NAS

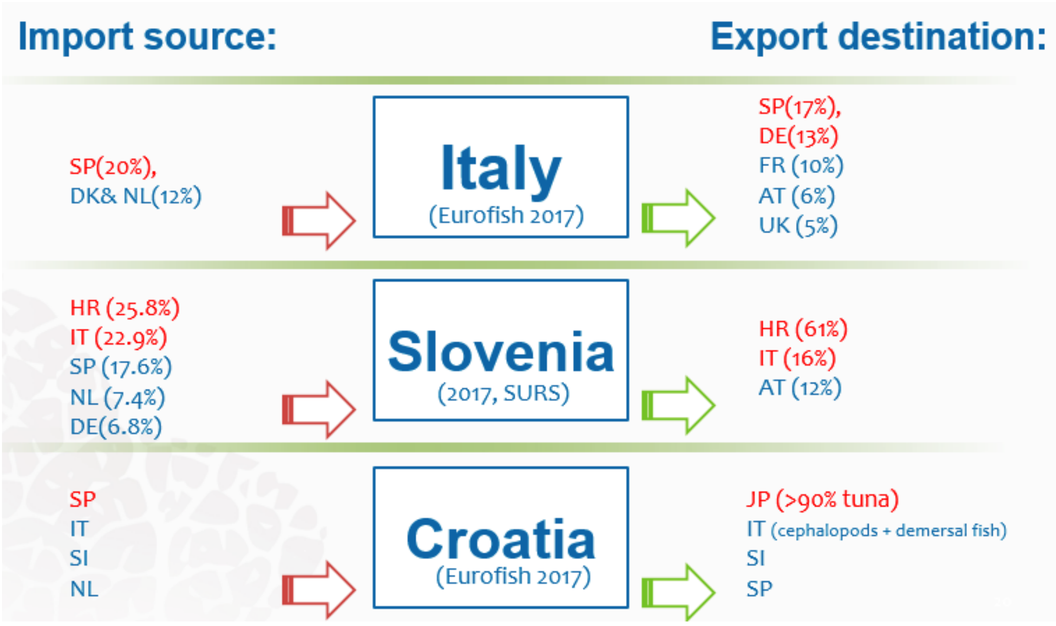
	Italy	Slovenia	Croatia	NAS (approx.)
Consumption	28.4 kg/capita	11 kg/capita	8kg/capita	~ 15 kg/capita
Import value (2017)	EUR 6,000 million (2017, Trade Data Monitor)	EUR 64.5 million (2017, SURS)	EUR 145.5 million (Eurostat, 2017)	~ EUR 6,210 million
Export value (2017)	EUR 792 million (2017, Trade Data Monitor)	EUR 8.76 million (2017, SURS)	EUR 208.1 million (Eurostat, 2017)	~ EUR 1,008 million
Trade balance (2017)	(-)5,208,000,000	(-)64,336,000	(+)62,600,000	~ (-) EUR 5,210 million
Employment in fisheries in 2017 (FTE)	20,268 >> 1,420 in NAS	63	1,665 >> ~ 1,500 in NAS	~ 2,983
Employment in Aquaculture in 2016 (FTE)	3,289 >> ~ 1,350 in NAS	20	1625 >>~1,465 in NAS	~ 2,835
Employment in processing in 2017 (FTE)	4,568 >> ~ 550 in NAS	130	1,672 >> ~ 1,500 in NAS	~ 2,180
Production value (EUR) fisheries	EUR 951 million (2018) (Statista) >> ~ EUR 220 million in NAS (~23%)	EUR 4,976,000 (2016)	~ EUR 60 million/year (based on 2014-2017 ESA HR)	~ EUR 285 million/year
Production value (EUR) aquaculture	EUR 393 million (2013) >> ~ EUR 250 million in NAS (~65)	EUR 3.98 million (2015, ESA SI)	~ EUR 92 million (2017) (ESA HR, 2019)	~ EUR 346 million/year

Overall:

- Per capita consumption varies significantly between the three countries and is also reflected in their import/export trade balance (Italy is the largest consumer and the largest importer).
- Italy and Slovenia have a negative trade balance, unlike Croatia, whose exports exceed its imports by over EUR 60 million. However, the general NAS trade remains negative.
- The sector's economic role is highly important in Italy and Croatia, although not in Slovenia. This can be linked to the limited spatial extent of the Slovenian marine waters, thus the limited fishing grounds and fish resources.
- The relative importance of the NAS for the fisheries and aquaculture sectors is primarily evident in Italy. While the NAS part of Italy represents only 3% of its entire marine area and 5% of its coastline, it contributes to around 23% of its national production value, and around 63% of its national aquaculture values.
- The fish processing industry is almost as important as the fisheries sector and the aquaculture sector in both employment and value.
- The **total production value of fisheries** in NAS amounts to around **EUR 285 million per year** (values varied 2014-2017). This can be compared to a total value for the Mediterranean of around EUR 3.2 billion in 2008 (Plan Bleu, 2014), the NAS value representing around 9% of the Mediterranean value.
- The total **production value of aquaculture** in the NAS amounts to **EUR 346 million per year** (values varied 2013-2017) versus around EUR 2.6 billion for the Mediterranean in 2011 (Plan Bleu, 2014). The NAS represents around 13% of the total aquaculture production value of the Mediterranean Sea.

Note: there are gaps and discrepancies in the data collected - some outdated information, some with blurry definition of the values included. For instance, the fish processing industry, which contributes considerably to GVA, is not always or not clearly accounted for in calculations.

Figure 6: Import origin and export destination for fish and seafood products in the NAS, 2017



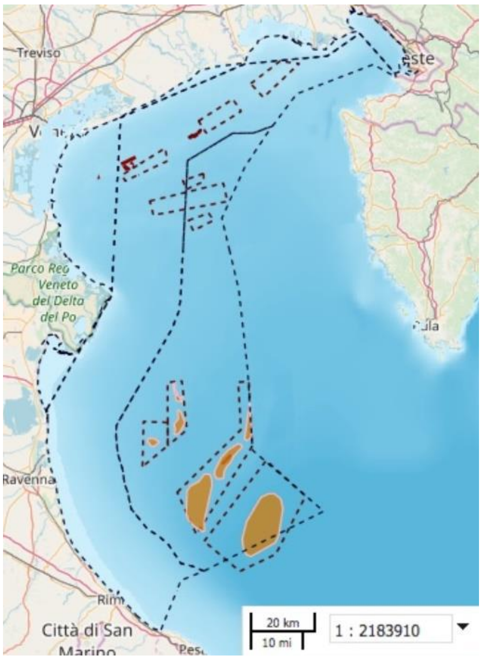
4.2.4 Sand and gravel extraction

In the NAS, **especially along the Italian coast,** there are long stretches of coastline and wide coastal areas under erosion and risk of flooding, particularly in the Emilia-Romagna and Veneto regions (SUPREME, 2017). Beach retreat in the Italian Northern Adriatic sandy beaches is driven by the following factors: a scarcity of natural sediment supply by rivers, natural and anthropogenic subsidence, and strong urbanisation of the coastal zone (Grottoli et al., 2020). Currently, the set of preventive actions includes so-called soft defence works, e.g. interventions realised through the reshaping of sedimentary deposits or the addition of new sediments that may/may not come from the same coastal area (beach nourishments, creation or reconstruction of coastal dunes) (MATTM-Regioni, 2018). The reduction in the use of infrastructure is enabled by the increased use of artificial sand nourishment as an integrated system to protect coasts.

In the recent past, sediment used for nourishment works came mainly from coastal accumulations and dredging activities at ports and river mouths, according to their environmental quality (SUPREME, 2017). Coastal sediment accumulations are mainly used for the so-called ordinary maintenance of beaches and coastal areas. Relict sand deposits dredged offshore are used for extraordinary maintenance, e.g. structural restoration of coasts (ICZM Guidelines, 2005; Barbanti et al., 2017).

In the Northern Adriatic, sands accumulated in these offshore deposits, called **relict sands** (Figure 7), derive from ancient beaches (8,000-11,000 years ago) formed during the marine transgression phase following the last Ice Age, then submerged after the sea-level rise (Simonini et al., 2005; SUPREME, 2018). These deposits are an important strategic resource for **beach nourishmen**t as their composition is similar to that of current beaches. For instance, analysing the long-term effects of sand extraction on macrozoobenthic communities in an offshore area in the NAS characterised by relict sands in front of Emilia Romagna Region, Simonini et al. (2007) found 'a rapid initial recolonisation phase by the dominant taxa present before dredging, which took place 6–12 months after sand extraction, and a slower recovery phase, that ended 30 months after the operations, when the composition and structure of the communities were similar in the dredged and reference areas' (p. 574) (SUPREME, 2017).

Figure 7: Relict sand deposits of Veneto Region (in brown) and of Emilia Romagna Region (in orange), and potential requests of concessions for extraction (hatched areas)



Source: SUPREME (2017).

In **Italy**, due to the nature of the coast of the North Adriatic (which presents a morphology largely characterised by sandy beaches with minor slope), sand deposits have been assessed to quantify the potential availability of sand to manage the effects of ongoing erosion. The volume of dredged sand in the NAS in the period 1997-2017 amounted to 10,511,005 m^3 (Annex II). The National Guidelines on Coastal Defence identified the origin and destination sites of dredged sediment (Annex III), representing the flow of the provisioning service related to sand extraction.

- Several compatible sand deposits have been detected in the Italian Northern Adriatic (SUPREME, 2017). Regional Decree 505 of 28 December 2017 authorised the dredging of 7,600,000 m3 from the RV_H[7] sand deposit[8].
- **Beach nourishment** has taken place in Emilia Romagna and Veneto. About 8.3 million m3 of sand taken from offshore deposits have been used for beach accretion (Consorzio Venezia Nuova, 2000; Correggiari et al., 1996a, in Correggiari et. al., 2002). The costs per cubic metre are particularly low (6 EUR/m3) when the source of borrowed material is from dredging an adjacent estuary or port. For the remainder, the unit costs typically vary between 10 and 20 EUR/m^3 (Valloni and Barsanti, 2007).

In **Slovenia**, there is no extraction of sand and gravel (SUPREME, 2017). However, sand dredging is a regular activity within the Koper Port harbour to facilitate navigation of vessels in and out of the port. Around 80,000 m^3 of muddy sediment is removed annually, with the sediment often reused for port structure and service facilities construction (Randone, 2015).

[7] Spatial reference for the sand deposit RV_H is the following: Vertex (Lat WGS 84, Long WGS 84) A (45.178302, 12.909594), B (B 45.178302, 12.935257), C (45.169151, 12.935231), D (45.169154, 12.909782).

[8] https://www.regione.veneto.it/web/ambiente-e-territorio/difesa-dei-litorali

In **Croatia,** there are very small reserves of fine sand deposits for **sand extraction** from the seabed in the northern part of the territorial waters (SUPREME, 2017). The sand and gravel are used for beach nourishment. Current exploitation of sand and gravel from the seabed is carried out in extraction fields *Crvene stijene* (1.01 ha), *Vidiskala-Zigovac* (0.73 ha), *Krklant* (0.84 ha) and *Samotorac* (0.64 ha), all close to the Island of Rab in Primorje-Gorski Kotar County (data from the Croatian Ministry of Economy, mining sector, 2012, according to the Mining Act, Officiai Gazette 75/09 and 49/11). Extraction is minimal (about 2,000 m3/year) with very low economic profitability (SUPREME, 2017).

Minerals extraction, mainly in coastal areas (sand, clay, gravel, architectural stone) is valued at HRK 200 million/year (2012-2017), or around EUR 23,800,000 each year. This revenue is mainly from the construction sector, representing 0.5% of total Croatian Adriatic employment (ESA HR, 2019).

Table 8: Summarising sand and mineral extraction values in the NAS

	Italy	Slovenia	Croatia
Quantities of sand extracted (m^3 per year)	~ 525,550 m^3/year (1997-2017)	80,000 m^3/year	2,000 m^3/year
Average cost of sand extraction and beach nourishment per m^3 (EUR/m^3)	10-20 EUR/m^3 (Valloni and Barsanti, 2007)	N/A	N/A
Average cost of sand extraction and beach nourishment (EUR/year)	~ EUR 5,255,500 – EUR 10,511,000	EUR 800,000 – EUR 1,600,000	EUR 20,000 – EUR 40,000
Total cost of sand extraction for beach nourishment in the NAS (EUR/year)	EUR 6,075,500 – EUR 12,151,000 per year		

The differences in costs and needs for beach nourishment in the NAS reflect the biophysical nature of the NAS countries (Italy's dominant muddy bottoms and sandy beaches, as opposed to Croatia's rocky outcrops and karstic caves). The estimated **total costs of extraction of sand for beach nourishment** in the NAS range from **EUR 6.1 million to EUR 12.2 million per year**.

4.2.5 Water

The demand for different sources of water supply is especially urgent in the coastal islands of Croatia and in Slovenia. Water supply is a major problem in the Adriatic islands of Croatia, especially during the summer tourism season, and represents a limiting factor to the islands' economic development (Vlahovic and Munda, 2012). Marine water may be a solution to the increasing water demand for drinking or other uses. There are examples of desalinisation plants in the Mediterranean, such as those in Spain (e.g. Capò et al., 2020; Palomar and Losada, 2008). However, desalinisation can cause potential harm to marine coastal ecosystems. The high salinity can affect aquatic plants, altering the rate of germination, growth and photosynthesis (Parihar et al., 2015). For instance, hypersaline water spills reduce the growth of *Posidonia oceanica* (Capò et al., 2020), which provides several ecosystem services.

At present, **Italy** has no programme to construct desalination plants in the Northern Adriatic, though in Veneto and Emilia-Romagna, there are all favorable conditions for developing the production of desalinated water, relieving pressure on traditional sources (SUPREME, 2017).

Abstraction of sea water for human use is regulated in **Slovenia**. Geographically, this activity is distributed along the Slovenian coast (SUPREME, 2017). Abstraction of sea water can be detrimental to both ecosystem services provision and natural ecosystem functioning. However, due to heavily regulated usage of water abstraction in Slovenia, ecosystem level impacts remain negligible. The water is used for a variety of economically profitable sectors (tourism, energy production, technology), thus sea water abstraction is seen as beneficial to human society, supporting jobs and recreational activities (SUPREME, 2017).

Water abstraction is regulated through permits and the granting of rights for the use of sea water, which is under the jurisdiction of the Slovenian Water Agency and monitored by the Environmental Agency of Slovenia. In 2015, 31 permits for the use of sea water were approved (SUPREME, 2017), for four different activities: pool bathing areas, other uses (e.g. fire water), water for production of heat, and water for technological uses. The maximum approved annual extraction is 3,630,544 m^3, with a maximum momentary extraction of 1,266.42 L/s (Table 8). The use of sea water for technological, heat production, and bathing activities is linked to different economic sectors, such as energy production, tourism and industry.

Table 9 Number of water abstraction permits and users for four different activities, with maximum yearly and momentary extractions of water

Activity	No. of water permits	No. of users	Maximum yearly extraction allowed	Maximum momentary extraction allowed
Pool bathing areas	18	13	265,540 m3/leto	339.2 L/s
Other uses	3	2	15,964 m3/leto	422.2 L/s
Production of heat	3	2	1,067,000 m3/leto	80 L/s
Technological uses	7	3	2,282,040 m3/leto	425.02 L

Source: SUPREME (2017).

In **Croatia**, Vlahovic and Munda (2008) explained that the **Croatian islands** are 'built predominantly of karstic carbonate rock with the surface hydrographical network poorly developed. In such terrains, due to increasing karstification, major water quantities infiltrate and flow underground. The freshwater systems on the islands are also limited due to the wide, open influence zone of the sea, which causes large freshwater quantities to flow diffusely into the sea' (p. 6211). The zone of explicit saltwater impacts on coastal aquifers covers most of the Istria coast and significant parts of coasts of Croatia in the Northern Adriatic that are part of the Dinaric karst belt (Vlahovic and Munda, 2008; Figure 8).

Extraction of sea water in **Croatia** is carried out exclusively by desalination processes, and the most developed systems are located on the islands of Mljet and Lastovo (SUPREME, 2017). Both desalination systems work according to the principle of reverse osmotic desalination of water droplets, and the potable water obtained is used as water supply for the island population. The water produced in Lastovo had a very high cost (EUR 2.05 per m^3) (Sambrailo, 2005). Desalinisation technology has been assessed for its capacity to potentially respond to the water supply demand on small and distant islands. Of 66 permanently inhabited Croatian islands, 10 have secured their water supply partially or completely from their own resources (Borovic et al., 2019).

Figure 8: Geographical location of the coastal areas in Croatia in the Dinaric karst belt characterised by potential risk of saltwater impact on coastal karstic aquifers

Source: Vlahovic and Munda (2008).

Long-term sustainable water supply must be ensured, in light of demand, existing desalination practices, and connection of water supply system to the mainland, as well as water availability in the context of climate change (Borovic et al., 2019). The Silba island of Croatia is considering using solar power to turn sea water into drinking water[9]. A desalinisation system powered by photovoltaics was proposed for Silba in a pre-investment study produced within the PROSEU project, funded by the EU. The small Adriatic island in Croatia is struggling with its external drinking water supply and a solar power plant could be the solution. Excess electricity could then be delivered to the grid or stored.

In general, studies show that over the years, desalination costs in the Mediterranean have decreased to around 0.5 USD/m^3, or around 0.45 EUR/m^3 (Verdier and Viollet, 2015).

Table 10: Average value of water extraction and desalination in the NAS region

	Italy	Slovenia	Croatia
Volume of water extracted from the sea (m^3/year)	N/A	Maximum approved annual extraction is 3,630,544 m^3/year (SUPREME,2017)	N/A
Volume of fresh water produced (m^3/year)	N/A		54,000 m^3/year (Lastovo)
Cost of water desalination (EUR/m^3) (Verdier and Viollet, 2015)	**Estimated at 0.45 EUR/m^3**		
Average total cost (EUR/year)	N/A	EUR 1,633,745	EUR 24,300

[9] balkangreenenergynews

Accounting for the available information, the **value of water extracted from the NAS is at least EUR 1.7 million per year,** estimated on the basis of desalination costs and data on volumes extracted. Despite the absence of comparable numbers, the available data reveal an increased need for water extraction from the sea for both domestic or commercial purposes. In Croatia with many islands, in particular, there is a particular need to ensure access to water for residents. Another issue to be addressed is the adverse effects from brine water discharge in coastal fields or marine ecosystems.

4.2.6 Salt

Of the multiple areas for the extraction of salt previously available in the Northern Adriatic, very few remain. Since prehistoric times, the Northern Adriatic coast was characterised by the presence of saltworks, such as those of Aquilea, Chioggia, Grado, Padua, Venice, Cervia, Comacchio, Cesenatico, and Ravenna[10], facilitated by low clay coasts that naturally lent themselves to receive sea water at high tide and expose it to evaporation in summertime. The Gulf of Trieste and Istria had several smaller and larger pans, such as at Muggia, Koper and Izola, in addition to the Old Piran salt pans at Sečovlje, Lucija and Strunjan (KPSS, 2011).

In **Italy**, the saltworks of Cervia and Comacchio in Emilia-Romagna are the sole remaining witnesses of the practice of salt production, but only the saltworks of Cervia are still active. **The saltworks of Cervia** extend for 827 hectares, in a natural park at the southern gate of the Po Delta Park[11]. The saline of Cervia is made up of over 50 basins, surrounded by a channel of over 16 km, which allows the water of the Adriatic Sea to enter and exit the salt pan. The saltworks are part of a natural population and nesting reserve for many animal and plant species. The saltworks' activities and production are managed by the *Parco della Salina di Cervia* company, established in 2002 by a partnership of local authorities. The company is responsible for environmental and ecological management, cultural and leisure activity enhancement, and for tourism and ecological purposes.

The saltworks of Comacchio is a protected area located in Emilia-Romagna, in the province of Ferrara. It protects about 600 ha of saltworks, which were last used to produce salt in 1984. Due to the high number of bird species, such as the greater flamingo (*Phoenicopterus roseus*) and the black-necked grebe or eared grebe (*Podiceps nigricollis*), the Comacchio saltworks are parts of the Emilia-Romagna Po Delta Regional Park[12].

In **Slovenia**, the Sečovlje and Strunjan saltpans are the only ones in that part of the Adriatic still producing salt and where the traditional method of daily gathering has been preserved. The extraction of salt is carried out in a traditional, sustainable way, developed in the 15th century. Annually, 2,000-4,000 tonnes of salt are produced, with the potential to produce more, should there be higher demand (SUPREME, 2017). Sečovlje and Strunjan saltworks are both protected nationally, as part of landscape parks and under international policies and conventions, including the Ramsar Convention, the Birds and Habitats Directives and the Barcelona Convention, and are also part of the Natura 2000 network. The salt extraction activity employed 117 people in eight different companies in 2015 (SUPREME, 2017). The trends between 2002 and 2009 showed a general increase in the value added in products and in numbers of employees, but employment began to decrease from 2012, while the number of companies have grown (SUPREME, 2017).

In **Croatia**, sea salt extraction has developed in three locations: solana Pag, solana Nin and solana Ston (the latter being outside the NAS study area). Salt production is of local

[10] www.arpae.it
[11] salinadicervia
[12] Salinadicomacchio

and regional economic significance. Considered part of cultural heritage by the government, the saltworks host a series of recreational activities and visits, showcasing the heritage value of traditional activities (ESA HR, 2019). The average annual production is around 19,000 tonnes of salt, of which nearly 18,000 tonnes are from solana Pag production[13]. Only 0.01% of the total number of employees in Croatia are employed in the salt production sector (SUPREME, 2017). Additional sources indicate that total annual production can reach 25,000 tonnes (ESA HR, 2019).

Table 11: Salt production economic value in the NAS region

	Italy	Slovenia	Croatia
Employment	N/A	108 FTE (2019) 117 (2015)	0.01% of total employment
Salt production company	Cervia/ Comacchio: Il sale dei Longobardi	Piranske sol/ Secovlje salina	Solana pag
Total production (tonnes)	N/A	2,000–4,000 tonnes (SUPREME, 2017)	solana pag: 19,000 tonnes/year
Approx. market value (EUR/g)	N/A	PiranSelGris: 26 USD/214g; 11 USD/78g; 7 USD/31g Piranske sol: 29 USD/250g; 12 USD/70g; 19 USD/125g.	solana Pag: 8.09 EUR/150g or 10.12 EUR/150g depending on type of salt
Approx. value of 100g (EUR)	According to the various prices available for the three salinas, the price per 100g sold in shops (as souvenirs for tourists) varies between EUR 6 and EUR 10		
Total production value (EUR/year)	NA	~ 12 million EUR/year (ESA SI, 2019)	Around 72 million EUR/year, using the estimates for Slovenia as basis for calculation

In the NAS, salt production is often linked to traditional practices, taking place within natural protected areas such as RAMSAR sites (wetlands, salt marshes, etc.). These sites also offer shelter to several species, therefore their value encompasses several ecosystem services. **Total salt production is 2,000 to 4,000 tonness/year and 18,000 tonnes/year for Slovenia and Croatia**, respectively, with an estimated **sale value of EUR 84 million/year** for the two countries.

4.2.7 Ornamental products

Croatia produces other non-food goods with direct economic value, that are provided and collected from the marine environment (SUPREME, 2017). **Red coral** (*Corallium rubrum)* is collected traditionally on the island of Zlarin in Šibenik. The first records of such activity date from the 13th century. In 2010, the Croatian Tourist Board proclaimed the Adriatic red coral on stone the best souvenir of the year (Elitetravel, 2021). **Sea sponges** are collected traditionally, especially on the island of Krapanj in the Šibenik aquatorium. Sea sponge collection is also carried out in Istria, around Kornati, and in Dubrovnik aquatorium with sea sponge habitats being today endangered as a result of excessive collection.

Red coral is reportedly valued at about USD 1,000 per gramme, compared to between USD 250 and USD 300 five years ago. Scognamiglio also reports that 90% of their

[13] Solana Pag dates as far back as 999 CE and produces two-thirds of Croatia's total salt production (link).

clientele is Chinese (Sidell, 2015). Red coral product value can be valued through online shopping platforms for red coral accessories: 10ml bottles of raw branches of red coral USD 15.38, 48 cm necklace USD 65.51, 18 cm bracelet, 10.35 grams, USD 121.79 (ETSY shop).

Both sea sponges and coral hunting are recognised as a tourism product of Croatia, thus can be considered part of the cultural ecosystem services. While the exact value that these products create is not available, Chinese market demand appears to play a major role in the extraction of red coral.

4.3 Regulating ecosystem services

Thanks to the species and habitats they host, ecosystems provide key regulating services that help to maintain GES. These are diverse and, in the marine environment, relate mainly to water quality, local and global climate regulation (e.g. carbon storage, moderation of extreme events, protection from erosion) and biological control to avoid proliferation of pathogens and parasites (MA, 2005).

4.3.1 Nutrient regulation and water quality

River inputs in the North Adriatic basin play a fundamental role in modulating its biogeochemistry. In **Italy**, the Po River is the major source of freshwater and nutrient inputs in the basin, carrying 47 $km^3 yr^{-1}$ of water, $6x10^6$ t yr^{-1} of solid transport, $255x10^3$ t C yr^{-1} of Total Organic Carbon (TOC), and $155x10^3$ t N yr^{-1} of Total Nitrogen (TN) and, together with the Adige and Brenta rivers, contributing to 84% of the river input (Pettine et al., 1998; Cozzi and Giani, 2011). Most of these nutrients come from livestock, agriculture activity, civil and industrial sectors (Trombino et al., 2007).

In **Slovenia**, river run-off mostly originates in the Julian Alps and flows through Isonzo, whereas from **Croatia,** the Mirna River, situated in the Istria Peninsula, is the most important tributary (Knežević, 2003; Comici and Bussani, 2007; Frantar, 2007; Cozzi and Giani, 2011). They contribute 16% of the total river input in the basin. Such high river inputs support primary production in an area that depends on the precipitation and snow melting regime in the Alps, as well as on the flow of nutrients from the Po River, creating strong seasonality. A variation on primary productivity and an increase in salinity has been observed in the basin due to oscillations of river inputs and run-off in the past (Cozzi and Giani, 2011). Such variations were mainly due to changes in precipitation and their intensity and snow-melt in the mountains, and future projections suggest that such variations will increase with time due to climate change, with important consequences for biogeochemical cycles and nutrient regulation, and for water circulation, not only in the North Adriatic basin but in the whole Adriatic Sea (Cozzi and Giani, 2011). Overall, the main impacts affecting nutrient and freshwater regulation are water usage and climate change (Cozzi and Giani, 2011). Excessive **nutrient inputs** of anthropogenic origin, such as nitrogen, associated with other pressure sources (e.g. climate change) have caused eutrophication phenomena, with consequent hypoxia events (that can cause mass mortality events of marine communities), mucilage and toxic/harmful algal blooms (HAB) in the North Adriatic (Malone and Newton, 2020), greatly affecting the quality of the marine environment and diverse maritime sectors, such as fisheries and tourism.

Microbial activity is fundamental to supporting water quality and nutrient regulation in the North Adriatic, not only in terms of organic matter remineralisation processes, but also for microbes' ability to transform and sequester potentially toxic contaminants from the environment, as heavy metals and polycyclic aromatic hydrocarbons. Indeed, the marine areas affected by higher river flood impact correspond to areas with higher prokaryotic C production rate (Zoppini et al., 2019). River deltas can represent hotspots of nutrient regulation service.

The **lagoons and coastal dunes** are key habitats for regulating water quality (Newton et al., 2018; Drius et al., 2019). Their spatial localisation in the case study area guides the identification of hotspots of this regulating service delivery. The economic value of the water quality service provided by lagoons around EUR 6 million per year for the different lagoons assessed (Newton et al., 2018). This study includes the Italian Grado e Marano and the Venice lagoons in the ecosystem services assessment.

The role of **seagrasses** is relevant to both regulating nutrients in sediment and to supporting good water quality by improving its transparency. Indeed, seagrass roots modify the chemical conditions of the sediment (e.g. promote sulfate reduction, modify redox potential and O_2 concentration) and their canopies and dense meadows can trap substantial amounts of sediment particles and organic matter, enhancing water transparency (Najdek et al., 2020). The mollusc fan mussel (***Pinna nobilis)*** contributes to water clarity, being a filter-feeder organism able to retain large volumes of organic matter from the suspended detritus (Basso et al., 2015).

4.3.2 Coastal protection

In Italy, coastal erosion processes affect the coastline on the Italian side of the NAS (MATTM-Regioni, 2017).

Table 12: Approximate quantities and values for coasts needing defences from erosion phenomena and the effects of climate change

	Surfaces (sq.km)		Coastline (km)		Surface balance (sq.km)
Region	Retreating	Advancing	Retreating	Advancing	
EMILIA-R.	20	6.2	65.6	62.3	-13.8
FRIULI-V.G.	1.1	3.2	32.1	50.5	2.1
MARCHE	3.2	1.9	67.1	60.0	-1.3
VENETO	17.9	7.5	70	80.7	-10.4

Source : Tavolo Nazionale sull'Erosione Costiera MATTM-Regioni con il coordinamento tecnico di ISPRA; Project SUPREME (Campostrini et al., 2017).

Liquete et al. (2013) listed the diverse coastal habitat typologies able to deliver coastal protection service in order of capacity (Table 1) and mapped the capacity of delivering this service, its flow and benefit to European countries. Among the habitats able to deliver this regulating service were **rock, hard substrata or biogenic reefs (e.g. coralligenous), coarse or mixed sediments, shallow sands and seagrass beds**.

For instance, **seagrass meadows** are recognised for their fundamental ecological role as a nursery, protection and foraging habitat for several marine organisms. Seagrasses strongly contribute to stabilising and protecting the coastline, as their canopies and dense meadows are responsible for trapping substantial amounts of sediment, enhancing their stability and contributing to coastal protection from erosion (Ondiviela et al., 2013; Najdek et al., 2020). In addition, seagrasses can generate the 'banquette', accumulations of dead leaves carried by the waves on the coastline that provide protection to the sandy shore.

Lagoons and coastal dunes are key habitats to provide coastal protection (Liquete et al., 2013). Indeed, the vegetation present in these habitats and its root systems act as a stabiliser by retaining coastal sediment (Barbier et al., 2011). In the Italian North Adriatic, most of the dune habitats fall within a Natura 2000 site because of their ecological value. Drius et al. (2019) assessed their capacity to deliver erosion regulation service on the basis of their integrity and typology of vegetation present. This assessment was done for each Natura 2000 site with coastal dunes in Veneto, Friuli-Venezia-Giulia and Emilia-Romagna in the North Adriatic (see Table 2 of Drius et al., 2019).

An economic assessment of coastal erosion in Italy is reported in Table 12 (MATTM-Regioni, 2017; MATTM-Regioni con il coordinamento tecnico di ISPRA; Italy

Country Fiche, SUPREME, 2018). These evaluations estimated the cost per km of hard coastal defences, sand replenishment (>20 m) or mixed typology defences.

Table 13: Coastline length, by region, for potential erosion risk and relative nourishment needs

Region	Coastline length exposed to erosion potential risk (km)	Economic needs (EUR million)		
		Needs for hard defences (4.5 million EUR/km)	Needs for beach nourishment (20 m broad) (4 million EUR/km)	Average needs (mixed type) (6.5 million EUR/km)
EMILIA-R	28.5	128.25	114	185.25
FRIULI-V-G	11.9	53.55	47.6	77.35
MARCHE	47.7	214.65	190.8	310.05
VENETO	18	81	72	117
TOTAL in Italian NAS	106.1	477.45	424.4	689.65

In summary, in Italy's NAS, the economic needs for coastal erosion protection based on different defence typologies, amounts to around **EUR 1.6 billion**. Protecting ecosystems such as lagoons would help to reduce erosion risk and thus reduce these costs.

In Slovenia, the areas most impacted by coastal erosion are the right bank of the Drnica River (Piran municipality) and the Rižana River (Koper municipality) (Slovenia case study, SUPREME, 2018).

The Croatian coast presents a high risk of erosion events. Its geomorphology is complex, it is mainly karstic and includes small scattered beaches. Longer beaches occur more frequently within flysch zones, spread to a lesser extent along the coast. The erosion events are affecting the beaches due to coastal urbanisation, while nourishment activities and the numerous artificial hard structures are not resolving the situation (Pikelj et al., 2019). At the beginning of the 21st century, coastal development in Croatia was affected by unplanned and expanding construction that strongly affected coastal stability, and Croatian beaches are still the main component of tourist resources (Pikelj et al., 2019). At present, two sites on the Croatian coast have noticeable coastal erosion problems: the island of Susak and an area of Nin town. However, research has shown that the tendency of most of today's strands is 70% erosion (Campostrini et al., 2017).

Table 14: Approximate economic value provided by *Posidonia* meadows' regulating ecosystem services in the NAS

	Italy	Slovenia	Croatia
Area of NAS covered by *Posidonia* meadows (Telascica, 2015)	Negligible	9 ha (2004)	~ 31,437 ha (2010)
Regulating ecosystem service value based on sediment retention services (Vassallo et al., 2013)	1.72 million EUR/ha/year		
Total value	**= ~ 54 x10^9 EUR/year (for a total of 31,446 ha)**		

Croatia's *Posidonia* meadows provide considerable economic value for the entire NAS in relation to protection from erosion. Using available estimates of *Posidonia* retention values and the total areas of NAS covered by *Posidonia* meadows, this service would amount to **EUR 54 billion per year**, a number that requires further scrutiny. This accounts for the retention of sediment, but also other chemicals such as CO_2, nitrogen, phosphorous, that are relevant to climate regulation (see section 4.3.3).

4.3.3 Climate regulation

The **NAS** is one of the main productive shelf areas of the Mediterranean Sea (where high amounts of inorganic carbon are transformed in organic form) and one of its dense water formation and downwelling sites. It contributes significantly to the continental shelf carbon pump process by enhancing the vertical transport of carbon in the deep sea and the sequestration of CO_2 from the atmosphere (Cossarini et al., 2015). Cossarini et al., 2015 estimated that the area is a sink of CO_2 able to capture 0.46 TgC/y and to contribute with an annual flux of approximately 2.9 mmol/m^2/d. The Northern Adriatic corresponds to 0.15% of the Mediterranean Sea surface, and its CO_2 sink rate represents a substantial fraction of the estimated CO_2 sink rate of the whole Mediterranean Sea, which ranges from 0.24 TgC/y (d'Ortenzio et al., 2008) to 4.8 TgC/y (Canu et al., 2015). This CO_2 flux presents high spatial variability, with strong south–north and onshore–offshore gradients. It also presents great seasonality, with highest peaks in winter. This means that climate change-induced warmer winters can highly affect the delivery of this ecosystem service by the NAS. Some of the benthic habitats present in the Northern Adriatic also contribute to carbon sequestration.

Seagrass meadows are recognised as a long-term carbon sink able to contribute to the abatement of atmospheric CO_2 (Howard et al., 2018). Duarte et al. (2017) reported that, of the net primary production of seagrass meadows, at least 5% is buried within the sediment meadows, 30% of which is exported to the deep sea, becoming a long-term carbon stock. The contribution of **lagoons** to carbon sequestration is also relevant: Newton et al. (2018) assessed the mean capacity of coastal lagoons to retain carbon and found an average of 0.32×10^6 Mg C, an economic contribution of **around EUR 6 million per year**.

4.3.4 Biological control

A recent study demonstrated that high biodiversity systems, such as that represented by **coralligenous**, are fundamental to ensuring higher stability and resilience to climate change and environmental variation by limiting the proliferation of opportunistic species that might parasitise vulnerable organisms (Rastelli et al., 2019). Sites with coralligenous outcrops can be considered able to deliver biological control as a regulating ecosystem service. Biological control is also provided by **coastal lagoons,** with a study on the estimated economic value derived by the delivery of this service finding it to be in the order of some EUR 10 million per year (Newton et. al., 2018).

Table 15: Estimated value of carbon sequestration ecosystem services from biological processes in the NAS

	Italy	Slovenia	Croatia
Value of carbon sequestration ecosystem services from all processes (EUR/km²/year)	119.9	230.3	96.1
Value of carbon sequestration ecosystem services from biological processes (EUR/km²/year)	101.7	186.2	73.7
Approx. NAS marine area (km²)	16670	214	17770
Total value of carbon sequestration from biological processes in NAS (EUR/year)	1.7 million	0.04 million	1.3 million

Source: initial values based on Canu et al. (2015).

These results reveal an economic contribution of NAS biological processes to carbon sequestration of **around EUR 3.04 million per year.**

4.4 Cultural ecosystem services

Cultural ecosystem services are 'the non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences' (MA, 2005). In the NAS, the main beneficiaries of cultural ecosystem services are the inhabitants who profit from recreational activities along the coast, as well as tourists and visitors who profit from those same activities, albeit irregularly.

In the NAS, tourism and recreational cultural ecosystem services are provided by a variety of ecosystem functions related to different processes and structures, as well as tourism and recreation activities and facilities. Coastal tourism mainly consists of beach tourism, profiting from the presence of accessible beaches and beach facilities along shorelines with a certain water quality. Maritime tourism mainly consists of motorised boat activities or nautical sports and activities.

The capacity to provide cultural ecosystem services is linked to ecological integrity, particularly the positive effect of biodiversity, which sustains a larger number of recreational activities (Chung et al., 2015; Drius et al., 2018). For instance, there is evidence that biodiversity in the NAS represents a determining factor for diving locations (Ruiz-Frau et al., 2013).

4.4.1 Tourism and recreation

General statistics

The Adriatic Sea is an important coastal tourism destination in the Mediterranean. Italy and Croatia host most of the tourists targeting this region, representing 71% (>40 million arrivals, with over 90 million overnight stays) and 18% (>10 million arrivals, with over 50 million overnight stays), respectively, of the total tourist arrivals (Campostrini et al., 2017).

In Italy, the key natural characteristics that attract coastal and diving tourism are the sandy beaches, dune habitats, and the rocky outcrops distributed along the Northern Adriatic. The Italian Northern Adriatic sandy beaches with main dune habitat types (e.g. beaches with pioneer annual vegetation, herbaceous dune vegetation) are highly visited by tourists, as are those in the Po River Delta (Drius et al., 2019). Diving activities are popular on the rocky outcrops (tegnùe or trezze, local calcareous sediments cemented by seeping methane) widely distributed on the muddy-detritic bottom of the Northern Adriatic between the Po Delta and the Gulf of Trieste. *Posidonia oceanica* and coralligenous assemblages have also been found to provide cultural ecosystem services to divers in the NAS (Zunino et al., 2020).

In 2019, of a total of 118,376,000 overnight stays, around **45% took place within the NAS study area** (Veneto, Friuli-Venezia Giulia, Emilio-Romagna) (Statista, 2021). Drius et al. (2019a) calculated that the important coastal tourism resorts are **Rimini** (1.6 million arrivals per year, Regione Emilia-Romagna, 2016), **Jesolo** (over 1 million arrivals per year, Turismo Venezia, 2018), and **Caorte** (over 600,000 arrivals per year, Turismo Venezia, 2018). Regarding **Venice** municipality, only 5% of total arrivals are connected to beach tourism and recreational boating, according to regional statistics (over 200,000 arrivals per year recorded in the Lido of **Venice,** Turismo Venezia, 2018).

According to the SUPREME initial assessment (Campostrini et al., 2017), the overall tourism sector is characterised by over EUR 170 billion added value, contributing to 11.8% of Italy's GDP and approximately 12.8% of employment, with positive growth prospects over the coming years (Italian Plan of Sustainable Tourism 2017-2022). In fact, Italy is a major attraction for international tourists from the United States (US) and China, and to a lesser extent Germany, France, UK and Austria. Around 60% of foreign tourists choose the NAS as destination (Organisation for Economic Co-operation and Development (OECD), 2019), with the coastal destination's cultural role possibly overtaking the attraction from the sea. Like the Venice Lagoon, its key role resides in its overall cultural value, estimated at **EUR 530 million (2017)** for cultural ecosystem services (Newton et al., 2018).

In **Slovenia and Croatia,** rich underwater flora and fauna make their coasts attractive destinations for diving. More than **60 diving centres** are distributed along the coast and profit from the submerged karst springs, marine lakes, submerged river canyons and strongly karstified submerged areas, which are reservoirs of biodiversity and are of great paleoenvironmental significance[14].

Slovenia has a very short coastline compared to its total boundary (4.3% of its boundary is coastal), yet coastal tourism and recreational activities reflect the existence of accessible beaches. Two nature parks attract visitors throughout the year (Strunjan Nature reserve and Landscape park; Secovlje Salina Nature park, which is also a RAMSAR site) and are known for birdwatching activities and recreational facilities. In 2018, the total number of tourists visiting Slovenia was around 5,933,267, of which 1,350,971 chose the Mediterranean Macro region as a destination (~23%). Overnight stays reached 15,694,705, of which 3,011,243 were in a seaside municipality (~19%). (Slovenian Tourist Board (STO), 2019). In 2016, 8,637 rooms were available in the coastal municipalities (Campostrini et al., 2017). Although the capital city, Ljubljana, is the most popular destination for tourists in Slovenia (1.1 million, or around 30%), Piran is the second most attractive city with 620,000 tourists (16.4%). Coastal tourism in Slovenia is unevenly distributed across the four municipalities, with most of the tourist and recreational activities based on use of the sea. In fact, the coastal destinations of Piran and Izola together constituted around 20% of total tourist destinations (Statista, 2019).

Summer is high season for maritime and coastal tourism: in 2018, seaside municipalities attracted the biggest percentage of domestic tourists in summer (~33.4%), while foreigners preferred the mountains (38.6%) and only about 18.4% choosing the seaside. Piran ranked first in number of overnight stays in summer 2018 (~21%), followed by Ljubljana (~18%). In Slovenia, in 2016, 52% of tourists saw beach tourism as their primary holiday type, the highest preference in Europe[15].

Among the top five countries accounting for overnight stays, three come from the Northern Adriatic (41.7% domestic, 12% Italian, 4.7% Croatian). Other tourists' origins are Germany (~15%), the Netherlands (~10%) Austria (7%) and Czechia (6%) (STO, 2019). The real estate market reveals a preference among Russian and Ukranian real estate buyers to invest in the Adriatic coastline (Fetyukov, 2015). Although coastal tourism in Slovenia is highly seasonal, trends show it is a fast-growing sector (STB, 2017).

Croatia has a coastline of 6,278 km, of which 70.1% is island coastline (there are 1,244 islands off the coast of Croatia). According to the coast length, the indigenous coefficient is 11, making Croatia's coast one of the most rugged in the world (Campostrini et al., 2017). The richness of the Croatian coast is exploited for tourism purposes, with most

[14] https://www.iliveunderwater.com/scuba-diving-map

[15] https://www.cbi.eu/market-information/tourism/sun-beach-tourism/market-potential

tourist activities taking place within natural coasts and beaches for beach tourism activities. In fact, the most attractive dive locations in Croatia are underwater cliff faces and reefs, caves, and wrecks of ships and airplanes. In 2011, the number of registered and licensed diving centres exceeded 100, with the largest number in Istria and Kvarner, and in the area of Central Dalmatia (ESA HR, 2019).

Coastal activities in Croatia are crucial to the national economy: in fact, the four counties considered in the NAS case study together contribute to 19% of GDP. The tourism sector in Croatia is the most vital economic sector, with a revenue contributing to almost 20% of GDP, the highest proportion among all EU countries (ESA HR, 2019). 95% of this tourism activity takes place on the coast, making coastal tourism the most important sector, employing over 6.8% of total tourism employment in 2016 (Campostrini et al., 2017) and attracting over 88% of total tourist arrivals and 96% of overnight stays (ESA HR, 2019). According to Croatia's publication for 2017, there were 17,430,000 tourist arrivals in total. The NAS region attracted 52.5% of tourists (71.2% if Split-Dalmatia is included): Istria 23.5%, Primoje Gorski Katar 16%, Zadar 8.9% and Lika Senj 4.2%. These numbers were also reflected in overnight stays, whereby NAS accounted for 60.6% (79.9% if Split-Dalmatia is included).

The most popular coastal destinations are all in the NAS, reflected in their number of visitors: Rovinj (561,023), Poreč (511,898), Opatija (413,848), Umag (408,213), Medulin (365,547) and Pula (330,950) (2016 data). KRK is the most visited island, while the largest tourist capacity in 2016 was in Istria (294,339 beds), Split-Dalmatia (239,329) and Primorje-Gorski Kotar (194,126) counties.

In **Croatia**, nautical tourism is widespread throughout the Adriatic coast, with a higher concentration in Istria. By region, the greatest turnover in tourism ports came from Zadar (HRK 102.2 million), Šibenik-Knin (HRK 102 million) and Istria (HRK 84.2 million) (ESA HR, 2019). Unlike in Slovenia, the majority of tourists (89%) are foreigners (Republic of Croatia, 2018). The tourism sector has recorded continuous growth since 2010 (Campostrini et al., 2017). The intense **seasonality,** concentrated in July and August, means that coastal tourism in Croatia results in overcrowding and overcapacity of coastal areas, with significant impacts on the same marine resources on which it relies. This seasonality is also leading to challenges in local businesses operation, and to waste management issues (European Commission, 2018).

Tourism activity leads to a higher than average quantity of municipal waste and is thus a significant source of marine litter: tourism constitutes 8% of municipal waste (ESA HR, 2019).

Birdwatching activities are located in Natura 2000 sites along the coast that host species of importance for conservation in coastal wetlands and other transitional environments, such as the Po River Delta, the Venice Lagoon, the Piave River Estuary. In the Italian NAS, there are **11 coastal RAMSAR sites** (RAMSAR (Italy) that host habitats for breeding and passage birds (e.g. Cavanata Valley in Friuli-Venezia-Giulia, Averto Valley in the Venice Lagoon) or that have international importance for several species of nesting, staging and wintering waterbirds (e.g. Marano-Grado Lagoon). The previouisly mentioned parks in Slovenia attract birdwatchers year-round.

Despite the notable presence of marine megafauna in the NAS, such as the diverse marine mammals inhabiting the Italian, Croatian and Slovenian waters, **dolphin watching activities** are still in their infancy, with few activities organised by local non-governmental organisations (NGOs) in collaboration with local tourism operators as educational or awareness-raising activities.
In **Slovenia,** the Morigenos Slovenian Marine Mammal Society has organised so-called

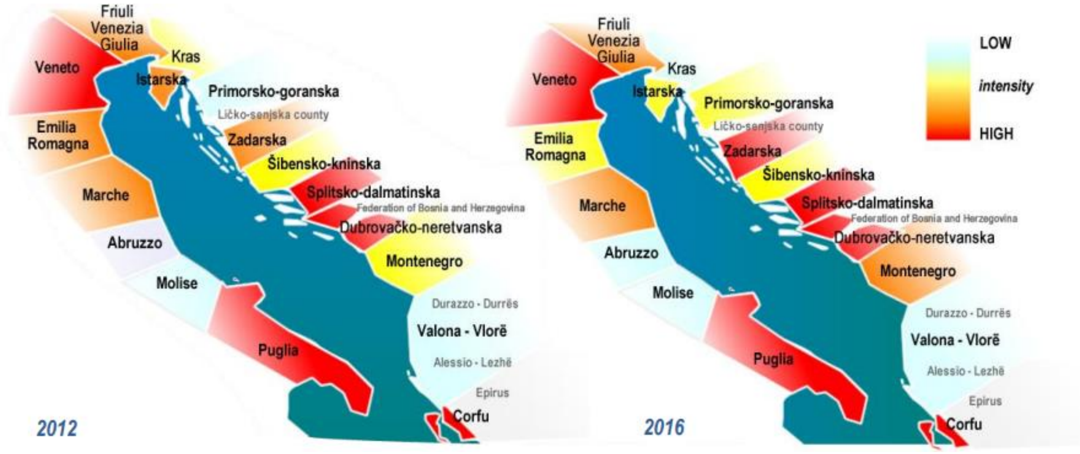
dolphin days[16], while, in **Croatia**, some dolphin watching activities are available in Istria[17].

Looking at **maritime/nautical tourism**, the NAS is a major cruise destination. Venice is the largest cruise ship port in the NAS, with 2,200,328 passengers in 2017, followed by Trieste (121,219), Ravenna, Monfalcone and Chioggia. In Croatia, cruising tourism takes place in Dubrovnik, Split, Zadar, Pula, Opatija, Rijeka, Rovinj and Šibenik, (Campostrini et al., 2017).

Boating, yachting and nautical sports are popular in protected areas characterised by a high natural value and biodiversity, such as high-quality bathing waters and protected areas in Croatia and Slovenia.

There are 253 marinas in Italy's NAS, while there are 81 in Croatia, with over 16,000 moorings at sea (Campostrini et al., 2017). In **Slovenia**, nautical tourism is mainly centered in Izola, which offers 700 quays for vessels up to 45 m long and anchoring sites, and, to a lesser extent, Portorož and Koper. Italy leads the ranking in cruise passenger movement, and Croatia in terms of ferry, hydrofoil and fast catamaran traffic (Adriatic Sea Forum, 2017) The development of nautical tourism is showing extremely positive trends and future growth is expected.

Figure 9: Maritime tourism intensity in the Adriatic regions (cruise, ferry, sail and yacht tourism), 2012 and 2016



Source: Riposte turrismo (2017).

Mass tourism can exert negative impacts on cultural ecosystem processes and structures because of their significant impacts on water resources and disturbance to wildlife. **Solid waste production** (primarily plastic items and debris), **air and water pollution**, mass **consumption of resources and energy** (mostly accommodation), and **onsite activities and transportation** are other sources of threats to cultural ecosystem services from mass tourism (Plan bleu, 2016). Mazaris et al. (2019) found that in Mediterranean marine Natura 2000 sites, outdoor sports, leisure and recreational activities were the most widespread threats reported by the Member States' national monitoring programmes. Considering that recreational activities can both benefit and harm ecosystems, the **tradeoffs** between benefits and threats should be made explicit as part of the management process (Mazaris et al., 2019).

[16] https://www.morigenos.org/en/

[17] https://www.dolphin-watching.com/

Another source of threats to cultural ecosystem services from beach tourism in coastal habitats is **urban expansion** and **land use change**, which can produce natural dune habitat loss, and reduce the related cultural ecosystem services supply, as measured by Carranza et al. (2020) in their analysis of multi-temporal land cover maps (1954, 1986, 2006) in the Adriatic (Molise Region). **Coastal erosion** is also a source of threats for beach-based activities (Drius et al., 2018), which are possible because of the presence of sandy beaches and related facilities. Drius et al. (2018) analysed multiple threats to and from coastal tourism in the NAS. Areas with highest pressures from tourism are located in areas with high urbanisation (e.g. Ravenna, Venice, Trieste), while the areas with higher levels of pressures from boating activities are Venice and the Gulf of Trieste (Drius et al., 2018). The Adriatic is one of the top **nautical tourism** destinations in the Mediterranean, with the **pressures** from this sub-sector being significant.

Table 16: Tourism in the NAS and key economic indicators

	Italy	Slovenia	Croatia
Total tourists/year in the country	89,931 million (2017) (OECD)[18]	5,933,267 (2018) (STB, 2018)[19]	17,430,000 (2017) (Republic of Croatia, 2018)[20]
Total tourists/year in the NAS region	Overnight stays in NAS >> **45%** ***>> ~ 40 million (est.)***	1,350,971 (2018) >> **23%** (STB, 2018)	9,150,075 (2017) >> **52.5%** (Republic of Croatia, 2018)
Total revenue from tourism	USD 51,602 billion (2018) (ceicdata) ~EUR 43 billion	USD 3,377 billion (2018) (ceicdata) ~EUR 2.81 billion	USD 11,917 billion (2018) (ceicdata) ~EUR 9.93 billion
Total revenue from tourism in NAS (approx., based on tourist number/ overnight stays)	Around EUR 19.35 billion (2018)	Around EUR 646.3 million (2018)	Around EUR 4.46 billion (2018)
Key markets	Domestic[21]: ~ 50% **Germany** (13.8%) France (8%) UK (5.4%) **Austria** (4.1%) USA (3.7%) (2017)[22] (OECD)	Domestic: 25% Italy (15.5%) **Austria** (13.3%) **Germany** (10.8%) Croatia (7.1%) Serbia (4.6%) (2017) (STB, 2018)	Domestic: 11% **Germany** (16.7%) **Austria** (8.5%) Slovenia (8.3%) Italy (7.1 %) Poland (5.9 %) (2017) (Republic of Croatia, 2018)

[18] Other sources indicated different values: 123 million arrivals at tourist accommodation (2017) (Istat), 60,523,190 (2017) (Ceicdata). The median value by OECD was selected.

[19] Other sources indicated different values: 3,991,000 (2017, World Bank). The Slovenia Tourism Board figure was retained for consistency.

[20] Other sources indicated much higher values, but were not considered: 59,238,000 (2017, World Bank).

[21] This number is based on the following sources: (Statista>>Domestic) (Statista>>Intl).

[22] Other sources had different values, but OECD values were retained for consistency with the above-mentioned numbers of tourists: Germany (28.2%); France (6.5%); UK (6.3%); US (6%); the Netherlands (5.2% (2017) Statista).

Overall:

- The Italian NAS attracts the largest number of tourists and also brings the biggest revenue. It hosts the largest share of internal/domestic tourism (explained by its vast territory compared to the other two countries).
- The Croatian NAS attracts over 52.5% of total tourist arrivals to Croatia, Italy's northeastern region attracts 45% of total overnight stays, while Slovenia's coasts attract only 23% of the total tourists coming to Slovenia.
- The largest population of tourists visiting all three countries are from Germany and Austria. Other key European markets are France, UK, and Balkan/Central European countries. International (non-EU) tourists are mainly from the US and China.
- If the marine ecosystem in the NAS deteriorates, this would mean the loss of at least two or three major tourist markets that together form a large portion of the region's visitors.
- While Croatia and Slovenia each receive among their top five visitors their two NAS neighbours, Italy attracts higher numbers of tourists from outside the NAS.

4.4.2 Scientific knowledge research and education

When referring to scientific knowledge and educational benefits from the NAS as cultural ecosystem services, the focus is on the scientific knowledge and capabilities environmental spaces and cultural practices deliver or contribute to delivering. Capabilities are defined as 'the role ecological phenomena play in shaping individual and social capacities to understand and do things. For instance, ecological phenomena are used in processes of knowledge acquisition at the level of general intellectual and scientific advancement (such as making sense of biodiversity), but also in patterns of individual development, such as the acquisition of personal skills and knowledge through which people flourish as individuals (such as wisdom, judgement, insight) and advance their situation in life (for example through acquiring gainful employment). The idea of capabilities is therefore about capturing how people and human cultures more generally, equip themselves, through nature to prosper (Fisher et al., 2016).

Scientific research and educational activities are widespread in the NAS area, with several ecosystems, and related processes and structures increasing beneficiaries' capabilities to understand natural processes and engage in natural conservation to support human well-being. The quantification and valuation of cultural ecosystem services related to scientific knowledge and education is challenging, as there is no simple way to assess their importance. NAS ecosystems are intensively studied, with a vast number of research centres and academic institutions, and several permanent and temporary offshore observation facilities. The following examples help to capture the importance of science and education in the NAS, although it is not possible to provide an exhaustive list of all relevant scientific and educational activities:

- Of the 42 rescue centres for marine megafauna in the Mediterranean, six are located in the NAS (Ullmann and Stachowitsch, 2015).
- Six **LIFE-funded projects** concerning *Posedonia oceanica* were funded between 2001 and 2014. The average annual funding from LIFE related to *Posidonia oceanica* is estimated at 0.33 EUR/ha/year between 2001 and 2014 (Campagne et al., 2015). If extrapolated to the NAS, it would mean an average of 10,377 EUR/year for the region. An interesting LIFE project is LIFE VIMINE[23], designed

[23] https://webgate.ec.europa.eu/life/publicWebsite/index.cfm?fuseaction=search.dspPage&n_proj_id=4555

to prevent erosion of valuable salt marshes in the Venice Lagoon via bio-engineering methods, coupled with monitoring and maintenance efforts. The project ran from September 2013 to September 2017, with a total budget of EUR 2,024,295. The LIFE-funded SERESTO project[24] aimed to restore and consolidate the aquatic seagrass ecosystems in the Northern Venice Lagoon, mainly through transplantation activities involving local fishermen and communities. The project ran from January 2014 to April 2018, with a total budget of EUR 1,563,898.

- **ADRI.BLU** promotes a cross-border sustainable process of socioeconomic development for the fisheries sector of the Northern Adriatic area. Partner countries are Italy (Veneto, Fruili-Venezia-Giulia and UNIPROM consortium), Croatia (Istria region and the coastal mountain county), Slovenia (Izola municipality) and Bosnia-Herzegovina (NORFISH, and the Chamber of Commerce of the Federation). The total financial resources allocated to the project are EUR 2,706,707[25].
- Another initiative targeting ecosystems is **Long-Term Ecosystem Research (LTER) Europe,** which aims to better understand ecosystems' functions and structures, as well as their long-term responses to various drivers. These targets are achieved through research and monitoring, and capitalise on research infrastructure (E-LTER). Various national networks have been established in Italy (LTER Italia) and Slovenia (LTER Slovenia). LTER Italia has established 25 research parent sites, of which six are coastal/marine and three are located within the NAS (Northern Adriatic Sea, the Venice Lagoon, Po River Delta). ISMAR is the coordinating institution of LTER Italia. In the context of LTER Italia and the NAS marine ecological observatory, the **EcoNAOS** (Ecological Northern Adriatic Open Science Observatory System) task was developed to test and apply the open science approach (Minelli, 2018).
- The **ECOSS (Ecological Observsive System in the Adriatic Sea)** project[26]: oceanographic observations for biodiversity contribute to the protection and restoration of biodiversity. ECOSS aims to establish the ECOlogical observing system in the Adriatic Sea (ECOADS[27]). The project duration is from January 2019 to June 2021, and the total budget allocated is EUR **3**.390.551,05.

[24] https://webgate.ec.europa.eu/life/publicWebsite/index.cfm?fuseaction=search.dspPage&n_proj_id=4838
[25] https://keep.eu/projects/3591/Adriatic-Blue-Table-for-a-Su-EN/
[26] https://www.italy-croatia.eu/web/ecoss
[27] https://ecoads.eu/sites/fixoss/

5 Learning from the willingness to pay survey

Respondents to the survey frequently (>5 times a year) **visit the seaside** to enjoy the scenery and the sounds and smells of the sea, to swim and spend time on the beach (e.g. sunbathing, jogging, cycling). These activities are free and thus are accessible to a large number of inhabitants, irrespective of their level of income. The least popular activities are fishing, hunting, cruising and other water sports (e.g. diving, stand-up paddleboarding, water skiing).

Inhabitants of the three countries are aware of the **current challenges facing their societies** and the environment. All respondents agreed or strongly agreed that the state of their environment, climate change, social issues, health (beyond the COVID-19 pandemic) and economic well-being are key challenges for themselves and for their community. The **state of the environment and health** are the two challenges most often cited by respondents[28]. A significant majority of respondents 'strongly agree' or 'agree' that the NAS is essential to the development of their country.

The main result of the WTP survey found that **biodiversity, water quality and recreation are elements that matter to the respondents** of the three countries in their choice of scenario[29]. These are elements that have an impact on the probability of choosing the good state option. Looking at the socioeconomic variables, the level of education is significant and positive, i.e. the higher the level of education, the higher the chance of choosing the good health option. Household revenue is also significant and positive, i.e. higher revenue makes people more willing to pay to improve the status of NAS ecosystems). Age, sex and experience do not influence the choice of scenarios.

On average for the three countries, respondents' WTP for healthy marine ecosystems in the NAS is equal to **EUR 54 per household per year (EUR 21 for biodiversity, EUR 23 for water quality, EUR 10 for recreation)[30]**. Accounting for the total population of each country, the total value of the NAS healthy ecosystems is estimated at around **EUR 1 billion annually[31].** Differences were observed between the three countries: inhabitants of Slovenia are willing to invest higher amounts to contribute to improving the environmental status of the NAS, followed by inhabitants from Italy and then Croatia. The latter do not see recreation as an important (and positive) attribute in their choice of scenario. This may be because tourism in Croatia - an important source of income during the summer and a major industry dominating the Croatian service sector and accounting for up to 20% of Croatian GDP[32] - has a large mass tourism component, which might not be well considered (and experienced) by inhabitants from Croatia. Indeed, they see tourists as responsible for pollution, thus they are not willing to pay to solve pollution problems or for additional recreational services[33]. In addition, many Croatian citizens go outside Croatia to enjoy recreational activities. This was reflected in

[28] It is unclear how the current COVID-19 crisis affected answers to these questions.

[29] This is evident in P>(Z), which is very close to zero (between 0 and 0.05) or with high statistical significance ('***') for these variables.

[30] In the Baltic questionnaire, the total WTP was between EUR 105 and EUR 123 per person per year. This is quite an important difference, but is mainly due to the use of different methodologies. Nieminen et al. (2019) designed a contingent valuation where people are asked an open question to reveal their WTP for the achievement of GES of the sea. In the choice modelling, the WTP was obtained for each attribute and people did not have an open question but were offered three financial contributions: 20, 50 and 100.

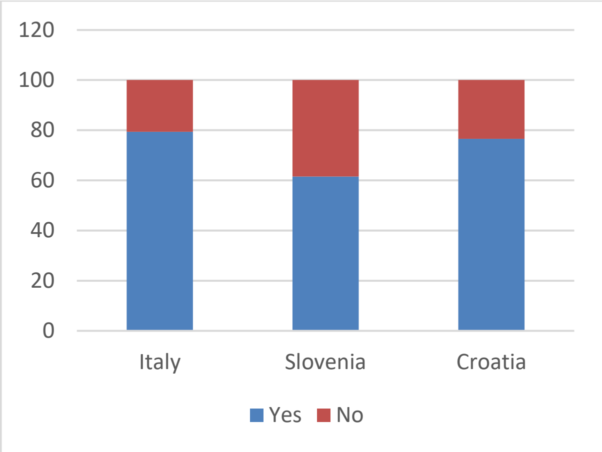
[31] This estimation is based on the number of persons per household in Italy, Croatia and Slovenia (INSEE, 2019). Croatia has around 2.7 people per household, 2.4 in Slovenia and 2.3 in Italy. The total number of inhabitants in 2019 was: Italy: 59,729,081; Croatia: 4,067,206; Slovenia: 2,088,385 (Eurostat data). This was used to assess the total value, accounting for the share of households willing to pay (73% of the sample) in these three countries and multiply it by 54.

[32] https://ec.europa.eu/info/publications/economic-and-financial-affairs-publications_en

[33] UNESCO warned that Dubrovnik's world heritage status was at risk due to the significant number of tourists 'in regard to the sustainable carrying capacity of the city'. In 2017, the city introduced a 'Respect

answers to the question 'to which criterion did you attach the least importance', with the majority (28%) of Croatian respondents choosing the option 'Ensure the availability of recreational services'.

Figure 10: In general, would you be willing to pay for the implementation of additional measures that are necessary to ensure the good health of the NAS ecosystem?



73% of the respondents (similar across the three countries) are willing to pay for the implementation of additional measures for the good health of the NAS[34]. The most common reason for not being willing to pay for an improvement in the NAS ecosystem was that the respondents **do not want to pay an extra charge (30%)** or they believe that **those who pollute and harm the ecosystem should pay more (34%)**. Another result found that **among the individuals who always choose the scenario without restoration (business as usual), 85% justified it by 'I do not believe that the money collected with the tax would actually be used for that purpose'**, a response rate even stronger for Slovenian respondents[35].

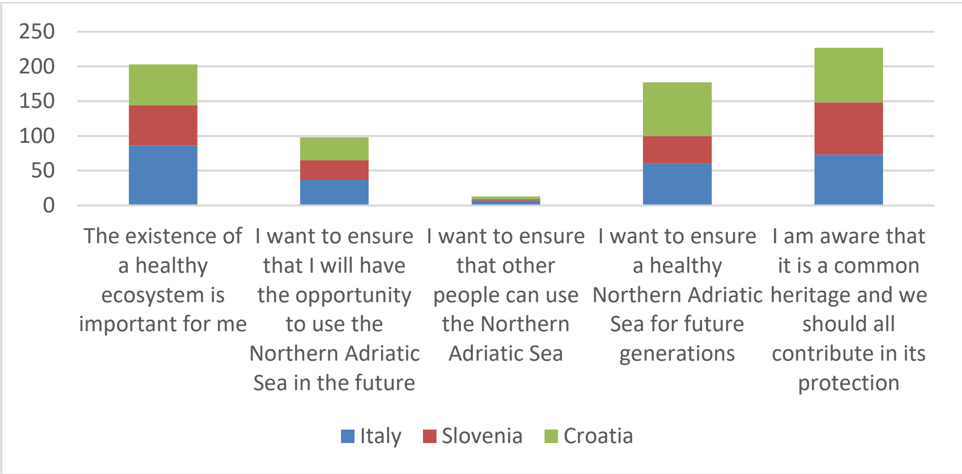
The WTP survey found that **water quality and biodiversity are the most important elements for respondents.** Factors that strongly affect the experience of respondents on the NAS or the coast are the presence of litter on the beach (64%) or in the sea (e.g. plastic items, debris) and water pollution (54%). It is therefore understandable that they wish to pay to remove these pollution issues.

the City' plan to limit the number of tourists from cruises visiting the Old Town to 4,000 at any one time (https://www.reuters.com/article/us-croatia-dubrovnik-idUSKBN1KP0BF).

[34] A similar study in Finland for the Baltic Sea found that 86% had a positive WTP.

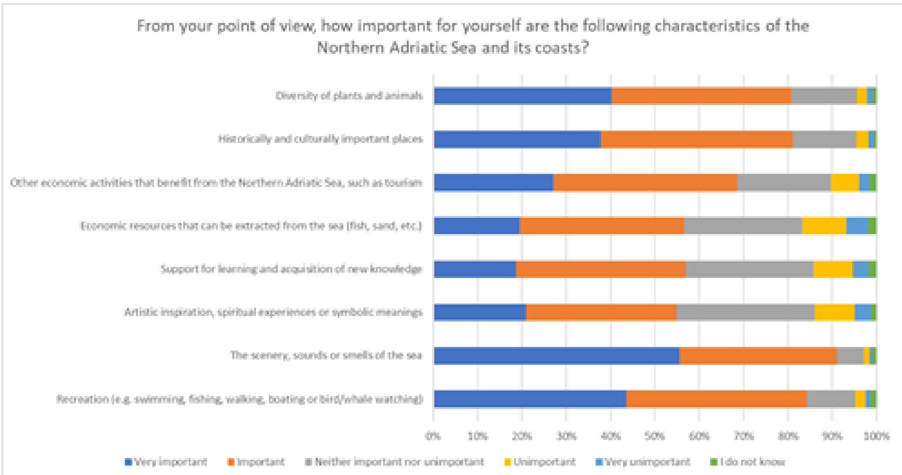
[35] In Slovenia, only 24% of people are satisfied and have confidence in their national government (the average across OECD countries is 45%) (OECD, 2019, https://www.oecd.org/gov/gov-at-a-glance-2019-slovenia.pdf).

Figure 11: What is the most important reason for you to be willing to pay for supporting the achievement of the good health of the ecosystem of the Northern Adriatic Sea?



The existence of a healthy ecosystem is important for respondents (28%), as is the use of the sea (13%). They want to ensure this use for future generation (24%)[36] (Figure 12). This allows for conclusions to be drawn on the existence of both bequest and existence value of this ecosystem.

Figure 12: What are the most important characteristics of the NAS?



Recreational activities and the scenery, sound and smell of the sea are very important characteristics of the NAS for a vast majority of respondents, at a personal level. The least popular NAS characteristics at the individual scale for respondents (i.e. artistic and spiritual meaning, support for learning and acquisition of new knowledge, economic resources provided by the sea) are all more valued at the community/country scale. The sea also represents a way to reduce stress levels, with a majority of respondents agreeing or strongly agreeing that spending time at the coast or at sea improves their health and reduces their stress level (88% and 87%, respectively).

[36] In the Baltic Sea survey, the most important reason for WTP was that the respondents wanted to ensure a healthy Baltic Sea for future generations (52%). The existence value was also seen as an important reason (35%), whereas altruistic (5%), recreational (4%) and option values (3%) were less important.

6 Conclusions

6.1 General synthesis

Table 16 summarises the socioeconomic importance of the ecosystem services provided by the marine ecosystems of the NAS. Those marine ecosystems of NAS are **very diverse:** they **provide benefits to a wide range of economic sectors, professionals and inhabitants**, directly or indirectly, on the NAS coast and other EU countries, including landlocked countries such as Austria.

Some of these ecosystem services directly benefit **local populations** (e.g. small-scale fisheries from the coastal areas of the three riparian countries), while others deliver ecosystem services that benefit **people and economic sectors located outside of the ecological and administrative boundaries of the NAS** (e.g. carbon sequestration).

> *The protection and management of marine ecosystems concerns many stakeholders and parties benefitting from these services, going far beyond (a) traditional maritime sectors that are mobilised in MSP planning processes and (b) political borders.*

The assessment of the monetary value of the benefits provided by NAS ecosystem services built on **a wide range of methods and approaches**. It attempted to provide qualitative, quantitative and monetary values for all services, but monetary values could not be obtained in all cases (e.g. cultural services). For some sectors, such as the tourism sector, the monetary values represent the importance of the sector as a whole rather than assigning a share of the sector's socioeconomic importance specifically to the (health of) NAS marine ecosystems. Many factors drive tourists to the NAS, including man-made facilities and services. Thus, only a portion of the market-based values presented are connected to marine ecosystems *per se*.

> *It is not possible to compare or add the monetary values estimated for different services as these cover different socioeconomic realities and variables (e.g. revenues, gross margin, added value, importance of exports).Figure 13 presents the diversity and (qualitative, quantitative and/or monetary) importance of benefits obtained from ecosystem services: (1) demonstrating that the protection and sustainable management of marine ecosystems are important for many sectors and inhabitants; (2) contributing to the (ocean) literacy of all relevant stakeholders[37]; and (3) providing integrated knowledge facilitating discussions between interested parties.*

[37] Who may be unaware of the importance of services delivered by marine ecosystems to other sectors and interest groups.

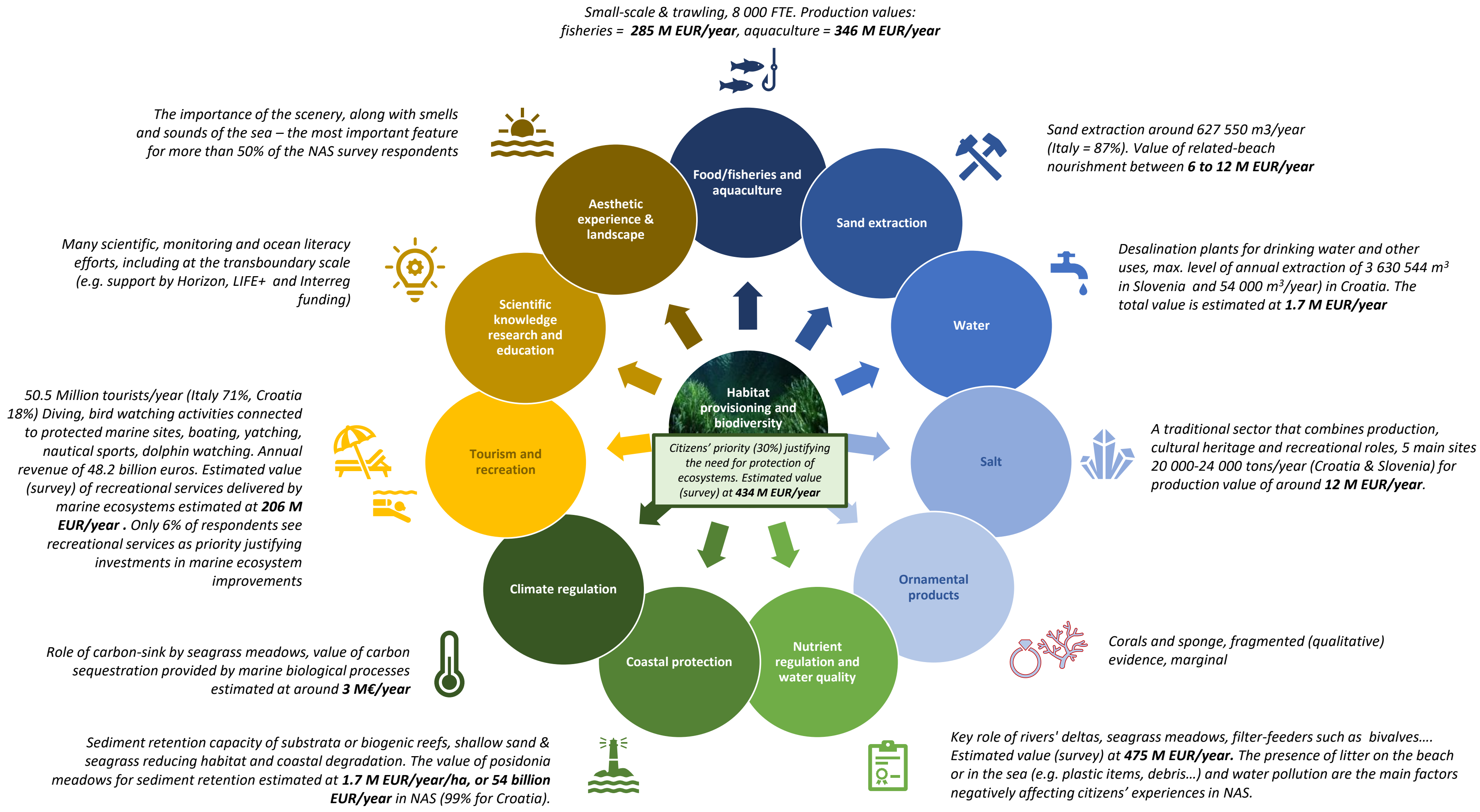
Table 17: Key evidence illustrating the socioeconomic importance of services delivered by NAS marine and coastal ecosystems

Service category	Service type	Socioeconomic importance of services at the scale of the NAS	Comments
Support-ing	Habitat provision-ing and bi-odiversity	Sandy and muddy habitats, seagrass meadows, unique rocky outcrops (trezze and tegnue), pelagic hab-itats provide nursery and feeding habitats (area with high primary production) for benthic and pelagic species of protection priority and economic value. High biodiversity that provides a great array of eco-logical functions (e.g. nutrient cycling). The importance of habitats and biodiversity is captured by: • Valuation of **supporting services provided by *Posidonia* meadows** ranging from **EUR 8.9 million/year to EUR 15.9 million/year** (using unit value of EUR 283-513 per ha/year from Vassallo et. Al., 2013), and a total area of meadows around 31,500 ha (most on the Croatian coast); • Biodiversity and the protection of NAS habitats is the **first reason justifying the protection of NAS marine ecosystems,** with 30% of the citizens surveyed defining it as priority; • Respondents to the survey are willing to pay on average **EUR 21 per household/year for biodiversity alone**, (Italy: EUR 21 per household/year; Slovenia: EUR 26 per household/year; Croatia: EUR 15 per household/year). Total aggregated **value for the NAS biodiversity is estimated at EUR 434 per year**.	There is uncertainty about the population size to use to extrapolate survey results to estimate the total value. With respondents from all re-gions and parts of the three countries, the total country population was used for this extrapolation.
Provi-sioning	Food/fish-eries and aquacul-ture	**Fisheries** are a leading sector for Italy (the NAS represents 25% of the total national catch) and Croatia, including both small-scale and commercial fishing (small-scale fishery within 6-7 nm, bottom and pelagic trawling beyond 3 nm). It is a source of revenue for the local economy and for export from neighbouring landlocked countries (e.g. Austria) to Japan (tuna). The Slovenian fisheries sector is limited to small-scale fishing along the coast. The main species targeted in the three countries are anchovies, sardines, red mullet, hake and sea bream, with overfishing reported for anchovies, sardines, common sole, hake, red mullet and mantis shrimp. The most valuable species (in value/kg) are sole, sea bass, squid, sea bream and hake. The developing sector of **aquaculture** differs by country, with Italy specialising in shellfish farms (65% of national production), while Slovenia and Croatia (the only country with a positive trade balance for fish and seafood trade) have mainly developed fish farms. While Italy and Croatia's aquaculture is com-mercial, Slovenia has more small-scale family aquaculture farms. In 2017, **NAS employment** amounted to an estimated 2,983 FTE, 2,935 FTE and 2,180 FTE for the fisheries, aquaculture and seafood processing sectors, or slightly under **8 000 FTE** in total. Production value is **EUR 285 million/year** and **EUR 346 million/year** for the **fisheries** and **aquaculture** sectors, respectively.	With important nurseries and feeding habitats, and as a primary biomass production hotspot, it is likely that eco-systems from the NAS also contribute to fish populations beyond the NAS (and even NAS) limits. However, it was not possible to assess the benefits to fisheries else-where in the NAS as a whole, or beyond the NAS in the Mediterranean Sea.
	Sand ex-traction	Sand extraction (including from deep sea deposits) is used for **beach nourishment** in Italy, limited to port harbour dredging in Slovenia, and is marginal in Croatia. Sand extraction for the Italian part of the NAS is around 525,550 m^3/year (average for the period 1997-2017), versus around 80,000 m^3/year for Slovenia and 2,000 m^3/year for Croatia.	Sand extraction is also used for construction purposes, especially in Croatia. Reve-nue from this activity can

Service category	Service type	Socioeconomic importance of services at the scale of the NAS	Comments
		Based on cost figures for beach nourishment from Italy (between EUR 10-20 million/m^3), the total value of sand extraction could range from **EUR 6-12 million/year for the NAS**.	compensate for the costs of extraction.
	Water	Water is extracted from the sea to be treated by desalination plants for drinking water and other uses. In **Slovenia**, water abstraction is regulated, with 31 permits along the coast and a maximum level of annual extraction of **3,630,544 m^3**. In Croatia, desalination technologies are under development for water supply to **small islands**, in particular (current use: 54,000 m^3/year in Lastovo islands, for example). The value of water extracted from the NAS is estimated at **EUR 1.7 million/year** using an average unit cost for desalination costs.	It is unclear if the total maximum annual volume permitted is currently used. Thus, part of the total value estimated might represent potential rather than current service value.
	Salt	A **traditional sector** that is well developed in the NAS, salt extraction has significantly decreased in importance in recent decades. Today, it combines **production, cultural heritage and recreational roles**. There is one active saltwork within the Po Delta Park in Italy, two salt pans in Slovenia within natural protected areas, and two main salt extraction locations in Croatia. In Italy, no values or quantities are available. In Slovenia, salt production is estimated at 2,000-4,000 tonnes/year for a total production value of around EUR 12 million/year. In Croatia, 18,000 to 20,000 tonnes are produced annually. Using the Slovenian figures, the total value for the NAS is estimated at **EUR 84 million/year** minimum. Sale prices in shops to tourists vary between EUR 6 and EUR 10 for 100 g, leading to a value of tonne of salt (adequate packaging included) directly sold to tourists at EUR 60,000 to EUR 100,000. However, not all quantities are directly sold to tourists.	In Italy, there are no values or quantities for salt production relevant to the NAS. Thus, the total value for the NAS is likely to be underestimated.
	Ornamental products	There is fragmented (qualitative) evidence on quantities of coral or sponge produced in the NAS. Market prices for one gramme of red coral can be to up to USD 1,000. Red coral is mainly purchased by clientele from China.	Likely to be marginal for the NAS.
Regulating	Nutrient regulation and water quality	Key components of the ecosystem that plays a role in the nutrient regulation ecosystem service include the river delta hotspots, seagrass meadows, filter-feeders such as bivalve P. nobilis along with microbial components that are fundamental to the biogeochemical cycles and sequestration of potential toxic contaminants. The value of the service is estimated from the survey's results, with an average of EUR 23 per household/year (Italy: EUR 27 per household/year; Slovenia: EUR 21 per household/year; Croatia: EUR 20 per household/year. Aggregated at the scale of the NAS, the total value of the service is estimated at **EUR 475 million/year**. The presence of litter on the beach or in the sea (e.g. plastic, debris) and water pollution are the main factors affecting the experience of survey respondents in the NAS coast and marine area.	There is uncertainty about the population size to use to extrapolate survey results to estimate the total value. With respondents from all regions and parts of the three countries, the total country population was used for this extrapolation.
	Coastal protection	Erosion strongly affects the Italian coastline of the NAS. Rock, hard substrata or biogenic reefs, as well as shallow sands, and seagrass beds, have a high capacity to reduce habitat and coastal degradation. In Italy, the high exposure to erosion risk is addressed through hard defences, beach nourishment, or a mixture of both. **Investment costs for addressing erosion risks in Italy are estimated at EUR 1.6**	The total value estimated is likely to consider the retention capacity of Posidonia meadows beyond sediment retention. Thus, there is

Service category	Service type	Socioeconomic importance of services at the scale of the NAS	Comments
		billion. The potential value of Posidonia meadows for sediment retention that contribute to coastal protection has been estimated at **EUR 1.7 million/year for one hectare of meadows**, or a total of **EUR 54 billion/year** for an area of Posidonia meadows estimated at 31,446 hectares (99% in Croatia).	clear double counting, with values estimated for the retention of CO_2, nitrogen, phosphorous, etc. that are also relevant to water and climate regulation.
	Climate regulation	Seagrass meadows are recognised as long-term carbon sinks able to contribute to the abatement of atmospheric CO_2. The value of carbon sequestration provided by marine biological processes is estimated at around **EUR 3 million/year**.	Carbon sequestration from other components and habitats of the NAS coasts and seas are not considered here. This value is thus clearly underestimated.
Cultural	Tourism and recreation	Beaches and high biodiversity support beach and maritime tourism, with Italy and Croatia hosting 71% and 18%, respectively, of total tourists to the NAS. Diving, birdwatching activities connected to protected Natura 2000 and Ramsar sites, boating, yachting and nautical sports, as well as dolphin watching (in its infancy and mainly in Croatia) are all reported in the NAS. Key figures for the tourism sector in the NAS include: **50.5 million tourists/year**, with non-NAS tourists mainly from Germany and Austria; a total annual revenue of **EUR 48.2 billion** (2018), 90% of which was in Italy. However, only a small part of these economic indicators can be attributed to the coastal and marine ecosystems of the NAS, as many other (man-made) services and factors explain tourists' choices to visit NAS. The value of leisure and tourism services is estimated from the survey, with an average value of EUR 10 per household/year (Italy: EUR 12 per household/year; Slovenia: EUR 14 per household/year; Croatia: EUR 4 per household/year but not statistically significant), or a **total value of EUR 206 million/year for the NAS**. Only 6% of the survey respondents saw the delivery of recreational services as a priority justifying improvements in the state of NAS marine ecosystems. The low and non-significant value for Croatia might result from the mass tourism experienced by the country, which negatively impacts inhabitants (leading municipalities to set quotas for tourists in tourist hotspots like Dubrovnik).	There is uncertainty about the population size to use to extrapolate survey results to estimate the total value. With respondents from all regions and parts of the three countries, the total country population was used for this extrapolation.
	Scientific knowledge research and education	The NAS receives considerable attention from the scientific community, evident in the existing monitoring and research infrastructure, research (including transboundary) projects implemented in the NAS, as well as the many EU-funded innovation and operational projects (e.g. financed by LIFE+ and Interreg). Many educational and ocean literacy activities are organised in the area.	It was not possible to assign a monetary value to this service.
	Aesthetic experience and landscape	The importance of the **scenery**, along with the **smells** and **sounds** of the sea, are seen as a priority for survey respondents (more than 50%).	It was not possible to assign a monetary value to this service.

Figure 13: Ecosystem services delivered by the NAS: diversity and importance at a glance



6.2 Survey learnings on marine ecosystem protection and management

Having been to the sea for any activity makes individuals more willing to pay for its protection… Half of the respondents in Italy and Croatia, and 65% of respondents in Slovenia, have spent time at the sea or on the coast at least once during the last 12 months. By contrast, only 3% of respondents have never spent time on the coast or at sea in Slovenia and Croatia, and 13% for Italy. Respondents who have been (recently or not) to the coast or to the sea were either at the NAS (84% of Slovenian respondents and 82% of Croatian respondents, but only 34% of Italian respondents with easy access to other seas) or visited other sea locations (57% of Croatian respondents visited the sea locations along the southern Adriatic Sea, 48% of Italian respondents visited other areas of the Mediterranean Sea). For respondents who have visited many seas, the NAS was nevertheless their most-visited.

Having been to any sea in the last five years increases the likelihood of choosing the good health scenario in the WTP survey. Having gone to the NAS specifically has a positive influence on the choice of scenario, with more respondents choosing the good health option, compared to non-users of the NAS[38].

No matter where they were born or where they currently live… There is **no distance effect**, i.e. how far someone lives from the sea does not affect their WTP. Values reported by inhabitants living close (within 5km) or far (beyond 50km) from the sea are similar, which is quite common for this type of questionnaire[39].

… but it depends on their knowledge of the degradation affecting the sea. The majority of respondents in Italy and Slovenia have not heard or are only partly aware of the degradation of biodiversity in and around the NAS, and about the changes in NAS fish stocks. However, 46% and 54%, respectively, of Croatian respondents were aware of these two issues. The impact of tourism and related urban development on the ecosystem of the NAS and the physical impacts on the NAS caused by human activities proved to be the most widely known subject among respondents, in particular in Italy. Respondents' knowledge of the impacts of tourism and associated urban development on the NAS ecosystem is significant in the statistical models developed (Annex VII) with a negative coefficient: this means that the lower the knowledge about this impact, the less likely someone is to choose the more ambitious good health option.

Relevance for management and policy? Survey responses were extracted that are relevant to policy, management and maritime activities in the riparian countries of the NAS.

- In general, respondents reported a relatively low level of trust (in particular among Slovenian respondents) as to whether the funds collated would be allocated to marine ecosystem improvement. The Slovenian results may highlight the need to address governance, the balance between top-down and bottom-up approaches, and the role of citizens in policy-making.
- Croatian respondents are more aware than Slovenian and Italian citizens of the impact of (mass) tourism on marine ecosystems. This likely reflects the significance of tourism in Croatia (20% of GDP), with 95% of tourism activities, revenue and turnover the coastal area of the Adriatic (ESA HR, 2019). It may also be related to ongoing public discussion of the negative impacts of mass tourism (over-tourism) on marine ecosystems, cultural heritage, and wider socioeconomic development, as illustrated by the plans to impose daily limits on the total

[38] For the NAS in particular, the regression of the model represented in Annex VIII shows that the variable 'use_NAS' is significant and positive, which means that there is an effect.

[39] Nieminen et al. (2019) ; Tuhkanen et al. (2016).

number of tourists visiting Dubrovnik[40]. Similarly, it might explain the low WTP for recreational activities of Croatian inhabitants compared to the Italian and Slovenian respondents. Overall, the non-favourable view of the tourism sector and its impacts highlights the need to find new solutions to address the destinations' carrying capacity and over-tourism.

- Croatian respondents reported the highest awareness rate of changing fish stocks, followed by Slovenian and Italian respondents. Fishing and fish processing in Croatia is linked to traditional activities, and many communities are dependent on the sector for subsistence, particularly around the islands. This, in turn, contributes to tourism development (ESA HR, 2019).
- Finally, the survey highlights Italians' low level of knowledge and awareness of the impacts of human activities on the NAS marine ecosystems. This points to a need to raise awareness and increase ocean literacy if there is to be any real transition to sustainable practice.

6.3 The value of assessment and valuation of ecosystem services for MSP: recommendations

The results of the assessment and valuation of ecosystem services carried out for the NAS have yet to be used by MSP planners, as they have come at too late a stage in the current MSP process[41]. However, such results could help to:

- Make more explicit the importance of the NAS marine ecosystems as **shared transboundary resources** between the sectors and inhabitants from its riparian countries (Italy, Slovenia and Croatia) and beyond (in particular when considering the international character of tourism in the area);
- Strengthen the diagnosis of the **current state of marine space**, identifying marine areas that deliver significant ecosystem services and that need specific attention and management, including by reducing (maritime and land-based) pressures imposed on these marine areas;
- Contribute to the ***ex ante* assessment** of different options for managing and sharing marine space, highlighting ecosystem services potentially impacted (positively or negatively) by these different options in order to facilitate an informed decision on the best option;
- Contribute to **stakeholder processes**, stressing the many benefits, values and interests that relate to the management of marine ecosystems and that need to be linked to the MSP process. In some cases, this might help to build stronger support for the decisions emerging from this process;
- Justify a **broader focus for monitoring** the implementation of the MSP Directive[42]. Beyond its ecological component, monitoring needs to pay attention to changes in activities (including land-based) and related pressures on marine ecosystems, development of maritime activities, and changes in ecosystem services delivered to different groups that might justify adaptations to the plans adopted;
- **Communicate** to different target groups the societal importance of protecting, managing and sharing marine space, highlighting the diversity of benefits from marine ecosystems, and the importance of human actions in supporting their delivery (including by adapting individual and collective land-based and marine activities and practice to reduce pressures in areas that are essential to deliver ecosystem services). The differences between Italian, Slovenian and Croatian respondents make it clear that the communication focus needs to be adapted for the public in each country.

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[40] https://www.responsibletravel.com/copy/overtourism-in-dubrovnik

[41] The deadline for Member States to adopt their Maritime Spatial Plans was 31 March 2021.

[42] Building on the monitoring carried out for other policies, such as the MSFD, Water Framework Directive, the Common Fisheries Policy…

Assessment and valuation proved challenging because of the very fragmented nature of the information available (e.g. different assessment techniques, metrics, time periods and reporting scales), particularly in transboundary marine ecosystems such as the NAS. This challenge is not limited to monetary estimates, but is also evident in quantitative estimates of the importance of ecosystem services delivered (particularly in relation to regulation and cultural services). Fragmented information and the absence of data to quantify some ecosystem services highlights the importance of **combining qualitative, quantitative and monetary information to gain a broader understanding of the importance of ecosystem service flows and delivery**.

In cases, it was not possible to allocate quantitative and monetary information to **specific marine areas** within the NAS that play different roles in the delivery of ecosystem services. New approaches need to be found that facilitate the comparison of ecological and biophysical information with socioeconomic information at the scale of spatial (marine) units with ecological, socioeconomic and management relevance. In addition, more work is required to connect the functioning of the NAS to **ecosystem services delivered elsewhere in the Mediterranean Sea** (e.g. fish spawning grounds in the NAS that contribute to fish stocks and fishing activities elsewhere in the Mediterranean Sea). This will help to identify impacts and beneficiaries beyond the administrative boundaries of the NAS that can justify potentially specific management within the NAS MSPs.

This assessment provides a picture of the ecosystem services delivered today. It could be complemented by an assessment of **future potential for additional/new ecosystem services** that could support socioeconomic development, in particular for local coastal communities. Marine areas that could deliver future (new) ecosystem services could then receive particular attention in MSPs and in the management of long-term development and sustainability of marine ecosystems.

Finally, the challenges in quantifying and assessing the socioeconomic importance of services provided by the NAS ecosystems, and the limited evidence available for some services, highlights the limited research on marine ecosystem services. **More attention and resources** are required to strengthen the knowledge base on the importance of ecosystem services delivered by marine ecosystems in different European regional seas. Beyond supporting the implementation of the MSP and MSFD, that knowledge would contribute to strengthening the ocean/marine component of the European Mapping and Assessment of Ecosystems and their Services (MAES)[43].

[43] https://ec.europa.eu/environment/nature/knowledge/ecosystem_assessment/index_en.htm

7 Annexes

Annex I - CICES reference for ecosystem services

BIOTIC ecosystem outputs		
Section	**Division**	**Group**
Provisioning (Biotic)	Biomass	Cultivated terrestrial plants for nutrition, materials or energy
Provisioning (Biotic)	Biomass	Cultivated aquatic plants for nutrition, materials or energy
Provisioning (Biotic)	Biomass	Reared animals for nutrition, materials or energy
Provisioning (Biotic)	Biomass	Reared aquatic animals for nutrition, materials or energy
Provisioning (Biotic)	Biomass	Wild plants (terrestrial and aquatic) for nutrition, materials or energy
Provisioning (Biotic)	Biomass	Wild animals (terrestrial and aquatic) for nutrition, materials or energy
Provisioning (Biotic)	Genetic material from all biota (including seed, spore or gamete production)	Genetic material from plants, algae or fungi
Provisioning (Biotic)	Genetic material from all biota (including seed, spore or gamete production)	Genetic material from animals
Provisioning (Biotic)	Other types of provisioning service from biotic sources	Other
Provisioning (Abiotic)	Water	Surface water used for nutrition, materials or energy
Provisioning (Abiotic)	Water	Ground water for used for nutrition, materials or energy
Provisioning (Abiotic)	Water	Other aqueous ecosystem outputs
Regulation & Maintenance (Biotic)	Transformation of biochemical or physical inputs to ecosystems	Mediation of wastes or toxic substances of anthropogenic origin by living processes
Regulation & Maintenance (Biotic)	Transformation of biochemical or physical inputs to ecosystems	Mediation of nuisances of anthropogenic origin
Regulation & Maintenance (Biotic)	Regulation of physical, chemical, biological conditions	Regulation of baseline flows and extreme events
Regulation & Maintenance (Biotic)	Regulation of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection
Regulation & Maintenance (Biotic)	Regulation of physical, chemical, biological conditions	Pest and disease control
Regulation & Maintenance (Biotic)	Regulation of physical, chemical, biological conditions	Regulation of soil quality
Regulation & Maintenance (Biotic)	Regulation of physical, chemical, biological conditions	Water conditions
Regulation & Maintenance (Biotic)	Regulation of physical, chemical, biological conditions	Atmospheric composition and conditions
Regulation & Maintenance (Biotic)	Other types of regulation and maintenance service by living processes	Other
Cultural (Biotic)	Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting	Physical and experiential interactions with natural environment
Cultural (Biotic)	Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting	Intellectual and representative interactions with natural environment
Cultural (Biotic)	Indirect, remote, often indoor interactions with living systems that do not require presence in the environmental setting	Spiritual, symbolic and other interactions with natural environment
Cultural (Biotic)	Indirect, remote, often indoor interactions with living systems that do not require presence in the environmental setting	Other biotic characteristics that have a non-use value
Cultural (Biotic)	Other characteristics of living systems that have cultural significance	Other

ABIOTIC ecosystem outputs		
Section	**Division**	**Group**
Provisioning (Abiotic)	Water	Surface water used for nutrition, materials or energy
Provisioning (Abiotic)	Water	Ground water for used for nutrition, materials or energy
Provisioning (Abiotic)	Water	Other aqueous ecosystem outputs
Provisioning (Abiotic)	Non-aqueous natural abiotic ecosystem outputs	Mineral substances used for nutrition, materials or energy
Provisioning (Abiotic)	Non-aqueous natural abiotic ecosystem outputs	Non-mineral substances or ecosystem properties used for nutrition, materials or energy
Provisioning (Abiotic)	Non-aqueous natural abiotic ecosystem outputs	Other mineral or non-mineral substances or ecosystem properties used for nutrition, materials or energy
Regulation & Maintenance (Abiotic)	Transformation of biochemical or physical inputs to ecosystems	Mediation of waste, toxics and other nuisances by non-living processes
Regulation & Maintenance (Abiotic)	Transformation of biochemical or physical inputs to ecosystems	Mediation of nuisances of anthropogenic origin
Regulation & Maintenance (Abiotic)	Regulation of physical, chemical, biological conditions	Regulation of baseline flows and extreme events
Regulation & Maintenance (Abiotic)	Regulation of physical, chemical, biological conditions	Maintenance of physical, chemical, abiotic conditions
Regulation & Maintenance (Abiotic)	Other type of regulation and maintenance service by abiotic processes	Other
Cultural (Abiotic)	Direct, in-situ and outdoor interactions with natural physical systems that depend on presence in the environmental setting	Physical and experiential interactions with natural abiotic components of the environment
Cultural (Abiotic)	Direct, in-situ and outdoor interactions with natural physical systems that depend on presence in the environmental setting	Intellectual and representative interactions with abiotic components of the natural environment
Cultural (Abiotic)	Indirect, remote, often indoor interactions with physical systems that do not require presence in the environmental setting	Spiritual, symbolic and other interactions with the abiotic components of the natural environment
Cultural (Abiotic)	Indirect, remote, often indoor interactions with physical systems that do not require presence in the environmental setting	Other abiotic characteristics that have a non-use value
Cultural (Abiotic)	Other abiotic characteristics of nature that have cultural significance	Other

Annex II: Sand dredged in Italy 1997-2017 (source: MATTM-Regioni, 2018, Annex 1, p. 304)

Situated off-shore of	Title	Depth (m)	Dredging technique	Entity/concession-holder	Year	Dredged volume (m3)	Destination
Tagliamento e Adige			Trailer/suction	Magistrato alle acque di Venezia	1997	1.921.604	Cavallino (VE)
Tagliamento e Adige			Trailer/suction	Magistrato alle acque di Venezia	1998	4.097.119	Litorale di Pellestrina (VE)
Tagliamento e Adige			Trailer/suction	Magistrato alle acque di Venezia	2000	565.362	Jesolo (VE)
Tagliamento e Adige			Trailer/suction	Magistrato alle acque di Venezia	2003	351.000	Jesolo - Cortellazzo (VE)
Tagliamento e Adige			Trailer/suction	Magistrato alle acque di Venezia	2004	296.485	Eraclea (VE)
Eraclea	JC	20-25	Trailer/suction	Regione del Veneto	2011	70.000	Eraclea (VE), Caorle (VE)
Eraclea	JC	20-25	Trailer/suction	Regione del Veneto	2012	70.000	Eraclea (VE), Caorle (VE)
Eraclea	JC	20-25	Trailer/suction	Regione del Veneto	2013	60.000	Eraclea (VE), Caorle (VE)
Tagliamento e Adige	JC	20-25	Trailer/suction	Magistrato alle acque di Venezia	2013	100.000	Jesolo (VE)
Tagliamento e Adige	JC	20-25	Trailer/suction	Magistrato alle acque di Venezia	2014	92.875	Jesolo (VE), Cavallino
Ravenna	C1	40	Trailer/suction	Regione Emilia Romagna	2002	165.300	Misano Adriatico (RN)
Ravenna	C1	40	Trailer/suction	Regione Emilia Romagna	2002	253.750	Riccione sud (RN)
Ravenna	C1	40	Trailer/suction	Regione Emilia Romagna	2002	65.200	Igea Marina
Ravenna	C1	40	Trailer/suction	Regione Emilia Romagna	2002	27.000	S. Mauro Pascoli - Savignano (FC)
Ravenna	C1	40	Trailer/suction	Regione Emilia Romagna	2002	28.000	Gatteo a Mare (FC)
Ravenna	C1	40	Trailer/suction	Regione Emilia Romagna	2002	43.500	Zadina (FC)
Ravenna	C1	40	Trailer/suction	Regione Emilia Romagna	2002	176.100	Milano Marittima nord (RA)
Ravenna	C1	40	Trailer/suction	Regione Emilia Romagna	2002	41.000	Lido di Classe - Foce Bevano (RA)
Ravenna	C1	40	Trailer/suction	Regione Emilia Romagna	2007	149.000	Misano Adriatico (RN)
Ravenna	C1	40	Trailer/suction	Regione Emilia Romagna	2007	105.065	Riccione sud (RN)
Ravenna	C1	40	Trailer/suction	Regione Emilia Romagna	2007	105.787	Igea Marina - Rimini nord (RN)
Ravenna	C1	40	Trailer/suction	Regione Emilia Romagna	2007	68.391	Cesenatico nord (FC)
Ravenna	C1	40	Trailer/suction	Regione Emilia Romagna	2007	90.108	Milano Marittima nord (RA)
Ravenna	C1	40	Trailer/suction	Regione Emilia Romagna	2007	107.128	Lido di Dante (RA)
Ravenna	A	35	Trailer/suction	Regione Emilia Romagna	2007	189.869	Punta Marina (RA)

Situated off-shore of	Title	Depth (m)	Dredging technique	Entity/concession-holder	Year	Dredged volume (m3)	Destination
Ravenna	C1	40	Trailer/suction	Regione Emilia Romagna	2016	219.000	Misano Adriatico (RN)
Ravenna	C1	40	Trailer/suction	Regione Emilia Romagna	2016	188.686	Riccione sud (RN)
Ravenna	C1	40	Trailer/suction	Regione Emilia Romagna	2016	171.047	Igea Marina, Rimini nord (RN)
Ravenna	C1	40	Trailer/suction	Regione Emilia Romagna	2016	128.331	Cesenatico nord (FC)
Ravenna	C1	40	Trailer/suction	Regione Emilia Romagna	2016	218.713	Milano Marittima nord (RA)
Ravenna	C1	40	Trailer/suction	Regione Emilia Romagna	2016	116.460	Lido di Dante (RA)
Ravenna	C1	40	Trailer/suction	Regione Emilia Romagna	2016	229.125	Punta Marina (RA)
Total						10.511.005	

ANNEX III: Census of submarine sand deposits (source: MATTM-Regioni, 2018, Annex 2 p. 307)

					Potential Mm3				
Region	Name	Name of sand deposit and general location	Depth m (max)	Depth m (max)	theoretical	accessible	supposed	verified	notes
Emilia Romagna	Area A0	43 km offshore	34	34	6.12	6.12	3.57	3.57	fine sand
Emilia Romagna	Area A1	43 km offshore	36	36	12.82	12.82	6.13	6.13	fine sand
Emilia Romagna	Area A2	44 km offshore	35	35	0.26	0.26	-	-	fine sand
Emilia Romagna	Area B	36 km offshore	34	35	2.82	2.82	1.8	1.8	fine sand
Emilia Romagna	Area C1	59 km offshore	39	41	55.1	55.1	39.53	39.53	fine sand
Emilia Romagna	Area C2	66 km offshore	40	39	16.21	16.21	10.56	10.56	fine sand
Emilia Romagna	Area C3	46 km offshore	40	42	104.39	104.39	58.84	58.84	fine sand
Emilia Romagna	Area H	65 km offshore	50	54	195.22	195.22	101.55	101.55	sandy silt
Veneto	RV_A	Laguna di Venezia	24	20	4.85	4.85	-	-	medium to fine sand
Veneto	RV_D	Caorle	21	24	18	18	-	-	medium to fine sand
Veneto	RV_G	Laguna di Venezia	30	31	2.6	2.6	2	2	sand from very fine to fine
Veneto	RV_C	Chioggia	26	32	6.1	3.9	3.9	3.9	medium to fine sand
Veneto	RV_H	Chioggia	29	31	60.53	51.86	51.86	51.86	medium to fine sand
Veneto	RV_B	Tagliamento	11	16	48.4	48.4	-	-	medium to fine sand
Friuli Venezia Giulia									No searches are carried out

ANNEX IV: Quantification of CES related to scientific knowledge and education provided by ecosystems in NA according to environmental spaces (EVS) and cultural practices (CP) delivering them, and related capabilities.

CES cat.	Title, Description, Capabilities	Country
EVS	**The Italian Long-Term Ecological Research Network (LTER-Italy).** The Italian Long-Term Ecological Research Network (LTER-Italy; www.lteritalia.it) includes terrestrial, freshwater and marine ecosystems distributed throughout our country, with a marked transecodomain approach. At the LTER-Italy sites ecological observations are carried out at the multidecadale scale, appropriate to support understanding and management of the environment. LTER represents one of the main tools for analysing how ecosystems change over time, and for describing and interpreting natural variability as opposed to 'man-made' variability. LTER-Italy is one of the twenty-five national networks that make up the LTER-Europe Network (LTER-Europe; www.lter-europe.net) and it pertains to the LTER International Network (ILTER; www.ilternet.edu/), globally distributed. LTER networks were created to share and integrate the ecological information, from local to global scale, becoming a scientific reference for policy makers. LTER-Italy is also one of the key nodes of the E-infrastructure for Biodiversity and Ecosystem Research LifeWatch (LifeWatch Italy; www.servicecentrelifewatch.eu/home). In the Northern Adriatic Sea there are three marine sites of LTER plus the Venice Lagoon. Source: http://www.ismar.cnr.it/infrastructures/observational-systems/lter-italy/index_html?set_language=en&cl=en In the NA, there are other LTER sites which are the site Gulf of Trieste, and the Emilia-Romagna and LTER monitoring program, managed by the Environmental Agency of Emilia Romagna Region (ARPAE). **Capabilities**: Scientific research, and education	IT
EVS	With respect to the **existing ecological monitoring observing systems**, the ECOSS project analyzed the current ecological observing systems in the area and the available level of knowledge with emphasis on the connections with the main Directives, the EUSAIR pillar and topics and the Maritime Spatial Planning (MSP) principles. ECOSS mentioned the following ecological monitoring observing in the Adriatic, including the NA (Vilibić et al., 2019): 3.1. Aqua Alta Tower 3.2. E1 Meteo oceanographic buoy 3.3. S1-GB dynamic pylon 3.4. Tele Senigallia dynamic pylon 3.5. Tide gauge network 3.6. High-frequency oceanographic radars 3.7. Meteotsunami research and warning network Here below some details from the research infrastructures in the NA ***About buoys, platforms, and other fixed sites*** The **Italian National Research Council (CNR)** operates several multi-parametric observational systems, most of them are located along the Italian coasts and transmit real-time data to the receiving stations along the coast. The complete real-time operation has not yet been reached by some of the systems, even if there is a development in this direction. In the Northern Adriatic - Gulf of Trieste, there are:	IT, HR, SL

CES cat.	Title, Description, Capabilities	Country
	• 3 inshore meteorological stations. Data: wind speed and direction, air temperature, relative humidity, precipitation (warmed rain gauge during winter time), solar radiation, air pressure. Data acquisition and elaboration every 10 minutes. Data Transmission in real time (hourly frequency). • 1 meteo-marine station inside the harbour, water depth 6 m. Data: sea temperature (0.4 m, 2.0 m and 6.0 m below s.l.), air temperature, wind speed and direction. Data acquisition and elaboration every 10 minutes, Data Transmission in real time (hourly frequency). • 1 tide gauge station. Parameters: sea level. Data acquisition every minute, Data transmission in real time (every 30 minutes). • PALOMA mast (45°37.097'N, 13°33.913'E), 12 km offshore, bottom depth 25 m. Data: sea temperatures (0.4, 2, 15, 25 m below s.l.), wind speed and direction, air temperature, relative humidity, precipitation, solar radiation, air pressure. Data acquisition and elaboration every 5 minutes. Data transmission in real time (every 3 hours). Paloma station (45°37.097'N, 13°33.913'E), 12 km offshore, bottom depth 25 m. Data: hydrological (CTD) and biogeochemical parameters (dissolved oxygen, inorganic nutrients, pHT, Total Alkalinity). Manual operations, monthly frequency. The Gulf of Trieste meteo-marine network is part of the LTER Northern Adriatic Site. In the Gulf of Venice there are: • "Acqua Alta" oceanographic platform (45° 18.83' N, 12° 30.53'E), 15 km offshore, bottom depth 16 m. Meteorological data: wind speed and direction, air temperature, humidity, solar radiation, precipitation. Oceanographic data: sea temperature, sea level, ADCP currents, waves. Surface and scuba web cams Wide band intranet connection allowing real time data transmission. • Abate meteo-marine station, 20 nmiles offshore the Venice riviera. Meteorological dataand hydrological data are provided by the buoy owned by the Regional Agency for Environment Protection (ARPAV), hydrological data, current measurements and vertical fluxes. hydrological (CTD) and biogeochemical parameters (dissolved oxygen, inorganic nutrients, pHT, phyto and zooplankton,,chlorophyll are sampled with monthly frequency. The station is part of the LTER Northern Adriatic Site. In the Venice Lagoon there is a network of 5 hydro-bio-chemical stations. Data: hydrological and chemical parameters, phyto- and zooplankton abundance, species composition. Monthly data and samples collection. The site joined the LTER network in 2008. In the Po Delta there is the S1 Station (44.741042°N - 12.456111°E), bottom depth 22.5 m. Multi-parametric buoy. Oceanographic data: temperature, salinity, dissolved oxygen, pH, ADCP currents, waves. Meteorological data: air temperature, atmospheric pressure, relative humidity, net radiation, wind speed and direction. Real time data transmission. The station is part of the LTER Northern Adriatic Site. **OGS, Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (National Institute of Oceanography and Applied Geophysics)** has a monitoring network that, in a continuous and discontinuous way, collects basic information on the marine ecosystem, an essential prerequisite for understanding the ecosystem's sensitivity to climate changes and for accurate forecasting. OGS deals with the continuation of marine ecological research, started by the University of Trieste in 1970, at the site called "C1 - Gulf of Trieste" which, since 2006, has been formally included in the Italian network of long-term ecological research (LTER- Italy) as part of the LTER - Alto Adriatico macrosite. Since 1998, discontinuous monitoring has been accompanied by continuous monitoring thanks to the positioning of a meteo-oceanographic buoy called "MAMBO" (Operational Environmental Monitoring) dedicated to the continuous acquisition of meteorological and oceanographic data. The observing site thus implemented ("Gulf of Trieste" site) was endorsed by IMBER (Integrated Marine Biogeochemistry and Ecosystem Research). Also in the Gulf of Trieste OGS coordinates, on behalf of the Civil Protection, the system of	

CES cat.	Title, Description, Capabilities	Country
	MAMBO buoys positioned at the mouth of the Isonzo and Tagliamento rivers and at the mouths of the Grado and Marano Lagunare lagoons. A further observation site, E2-M3A, is located in the southern Adriatic basin at a depth of 1205 m and about 60 miles from the coast in an area of high scientific interest for the formation of dense water through convective processes in the open sea. Two anchorages are positioned on the site whose configuration allows to identify the formation of dense water by simultaneously measuring physical and chemical parameters. The site is integrated into the OceanSITES worldwide network. (source: https://www.inogs.it/it/content/reti-di-monitoraggio-marino) **Capabilities**: Scientific research	
EVS	**Existing ecological monitoring programs** The ECOSS project analyzed the current activities, the relevant observing programs carried out in the area and the available level of knowledge with emphasis on the connections with the main Directives, the EUSAIR pillar and topics and the Maritime Spatial Planning (MSP) principles. ECOSS mentioned the following monitoring programs in the Adriatic, including the NA (Vilibić et al., 2019): 1. Monitoring of parameters needed for evaluation of descriptors the state of according 2. to Adriatic Monitoring Plan enabling fulfillment of obligations of the Republic of 3. Croatia according to MSFD 4. Systematic research of water quality in transitional and coastal waters of the Republic 5. of Croatia 6. Adriatic Dolphin Project 7. Monitoring of sea turtles in the Adriatic 8. Regional Water Protection Plan - Monitoring of marine waters 9. Monitoring of water and shellfish quality in shellfish farming areas 10. Bathing water quality monitoring 11. Visual census of the seafloor by ROV 12. Seagrasses and macroalgae monitoring UNITS and FVG Region 13. Coralligenous monitoring UNITS; TRECORALA; PRIN ReefReseArcH Resistance and 14. resilience of Adriatic mesophotic biogenic habitats to human and climate change 15. threats Research project of national interest 16. Integrated monitoring programme of transitional water bodies in according to 17. legislative decree n. 152/2006 (aimed to chemical and ecological status classification 18. and to assessment of the quality of shellfish waters - specific destination waters) For details on each monitoring program refer to Vilibić et al. (2019) **Capabilities**: Scientific research	IT, HR, SL
CP	**Adriatic Fisheries and Oceanography Observing System** Since 2003, CNR-ISMAR runs a program aimed at using Italian fishing vessels as Vessels Of Opportunity (VOOs) for the collection of scientifically useful datasets. In the framework of the EU-FP5 project MFSTEP, 7 commercial vessels fishing for small pelagic species in the northern and central Adriatic Sea were equipped with an integrated system for the collection of data regarding catches, position of the fishing operation, depth and water temperature during the haul (Falco et al. 2007); this system was named "Fishery Observing	IT

CES cat.	Title, Description, Capabilities	Country
	System" (FOS) and until 2013 produced a great amount of data that could be helpful both for oceanographic and fishery biology purposes (Falco et al 2011; Martinelli et al. 2012; Carpi et al. 2015; Aydoğdu et a. 2016; Sparnocchia et al. 2016). Since 2014, CNR-ISMAR implemented in the Adriatic Sea the "AdriFOOS" observational system, by installing the FOOS on 10 commercial fishing boats. Since then the CNR-ISMAR datacenter in Ancona receives daily data sets on GPS tracks, water temperature/salinity/pressure (profiles and bottom), meteorology, catch amounts, species caught and target species sizes. Forecasts of sea height are sent daily on board thanks to the collaboration with the KASSANDRA Storm Surge Modelling System (http://kassandra.ve.ismar.cnr.it:8080/kassandra). Data of temperature and (in few cases) salinity measurements acquired by the FOOS, from January 2014 to March 2015, along the fishing tracks and at the various fishing depths were published within the JERICO project (http://www.jerico-ri.eu/previous-project/service-access/targeted-operation-phase/top-2-data-and-maps-from-sensors-on-board-fishing-vessels/adriatic-sea-fishery-and-oceanography-observing-system/). Source: http://www.ismar.cnr.it/infrastructures/observational-systems/adri-fishery-observing-system **Capabilities**: Scientific research, and life-long learning	
EVS	**The Miramare Biosphere Reserve (MBR)** infringe with the commercial and amateur fishing as well as other recreational activities. There is a significant conflict between mussel farming and fishing activities. The aim of this reserve is to maintain biological diversity through scientific research, monitoring activities and conserving its cultural value. The environmental education designed for students and the public is the major activity in the MBR (UNESCO- MAB, 2002). (source: http://www.riservamarinamiramare.it/) **Capabilities**: Scientific research, and education	IT
CP	**Blue flags** The foundation for environmental education in the beaches of Italy, Slovenia and Croatia coast under the Blue Flag beach certification program have educational events which have both cultural and scientific principles. The iconic Blue Flag is one of the world's most recognised voluntary awards for beaches, marinas, and sustainable boating tourism operators. In order to qualify for the Blue Flag, a series of stringent environmental, educational, safety, and accessibility criteria must be met and maintained. Central to the ideals of the Blue Flag programme is the aim of connecting the public with their surroundings and encouraging them to learn more about their environment. As such, environmental education activities must be offered and promoted in addition to a permanent display of information relevant to the site in terms of biodiversity, ecosystems and environmental phenomena. The Blue Flag has been awarded to 103 Italian Adriatic beaches and 29 marinas, 116 Croatian beaches and 19 marinas, 7 Slovenian beaches and 2 marinas under this program (data at year 2019, from https://www.blueflag.global/). Source: https://www.adriagate.com/Croatia-en/Blue-flag-beaches-Croatia **Capabilities**: education	IT, SL, HR
CP	**The Blue World Institute of Marine Research and Conservation (BWI)** Croatia has several educational programs structured by the marine education center, marine science museum, and also the sea turtle rescue center. The Blue World Institute of Marine Research and Conservation (BWI) works to protect the marine environment in the Adriatic Sea. To that purpose, the Blue World Institute operates three programmes – research, education, and conservation. BWI research focuses mainly on large marine vertebrates (dolphins and whales, sea turtles, sharks and giant devil rays) informing our education activities and conservation projects. BWI works from the Adriatic islands of Lošinj, Murter and Vis, with the local communities, and	HR

CES cat.	Title, Description, Capabilities	Country
	collaborate nationally, regionally and internationally to advance sustainable marine management and environmental sustainability in the Mediterranean Basin. (source: https://www.blue-world.org/) **Capabilities**: Scientific research, and education	
CP	**Rescue centers in the NA** In the Northern Adriatic, sea turtles spend parts of their life. The rescue centers have an opportunity to educate visitors about sea turtles and marine conservation. In addition, during the tourist season, workshops and special events for children are organized. Besides all the above mentioned activities, Adria-Watch, Fonda Fish Farm, and the Marine Educational Center, contribute to cultural services by their extensive educational programs that generate scientific knowledge on the marine environment. The **Marine educational centre Pula (MEC)** is a small non-government organisation established in 2005. Currently, it has 15 members which are heading the Sea Turtle Rescue Centre. The Centre is the only sea turtle recovery centre in Croatia and it is supported by the Ministry of culture, Republic of Croatia (5.000 € per year, since 2006). The current state of the infrastructure is suitable for a simultaneous recovery of 7 turtles (7 pools with a marine water flow system which is closed in the cold season and additionally heated). Three members (biologist, chemist and an aquarist) are in charge of the Centre's activity (cleaning of the equipment, turtle care, management, education etc.). Two members are veterinarians. Besides the rehabilitation of sea turtles, MEC Pula is involved in the conservation and protection of endangered species and non-institutional education of young people (preschool, school and student age) and citizens. For many years MEC Pula has been taking care of injured turtles, with little or no possibilities to improve the Centre. With NETCET we will increase the Centre capacity, technical support and set up a laboratory for better diagnosis. All improvements will be in order to obtain a fully equipped rescue centre for the acceptance, rehabilitation and release of marine turtles in the Eastern part of the Adriatic Sea, with the main aim of increasing the turtle recovery and consolidating the regional cooperation to the whole Adriatic. This will create the need for highly trained personnel who will be able to specialize within the project activities and continue through the established long lasting network. Through non-institutional education, permanent educational exhibits, release events, inauguration days and raising public awareness of stakeholders and others, MEC Pula will actively contribute to the conservation of sea turtles as a global goal of the project. All activities will be coordinated together with other beneficiaries to maintain a long lasting network. (source: http://www.netcet.eu/2013-01-04-21-36-00/marine-educational-centre-pula). **Cetacea Foundation** is a non-profit organization founded in 1988 with the commitment to protect the marine ecosystem especially Adriatic, through dissemination, education and conservation activities. Since 2008 it has undergone a radical transformation and has achieved total independence, taking the actual form of a non-profit organization. It makes use of the precious contribution of biologists, veterinarians, naturalists and volunteers. It is active in the rescue of animals in difficulty, especially sea turtles and cetaceans. The Foundation participate in numerous European projects including: Sharklife, NetCet, Tartalife. Adriatic +, Clean Sea Life. In addition, the Cetacea Foundation manages the reference center for the recovery of sea turtles for Emilia Romagna and Marche, one of the most important and active in the nation and for the Adriatic. In the Center over 500 sea turtles have been treated and returned to the sea, with a notable increase in recent years. The Foundation also intervenes on all beached turtles already dead to collect data on the health of our sea: in fact, turtles are a biological indicator of the health conditions of our sea. The Cetacea ONLUS Foundation is officially recognized by the Emilia-Romagna Region as an Environmental Education Center. He carries out research activities with Italian and foreign bodies. (source: http://fondazionecetacea.org/)	IT, HR, SL

CES cat.	Title, Description, Capabilities	Country
	In Slovenia, at the **Aquarium Piran**, veterinarians of the Wildlife Sanctuary "Zatočišče za živali prosto živečih vrst" take care of injured sea turtles. Aquarium Piran provides space for first aid treatment; it does not, however, have holding tanks for a longer rehabilitation phase (Ullmann and Stachowitsch, 2015). **Capabilities**: Scientific research, and education	
CP	**Morigenos – Slovenian Marine Mammal Society** is an independent, scientific, non-profit, non-governmental organisation that combines scientific research, monitoring, education, public awareness, capacity building and management, to achieve effective conservation of the marine environment and biodiversity. »Morigenos« means »sea-born« in ancient Celtic language. The organization was established in 2001 and is carrying out several projects in the field of scientific research, education, public awareness and conservation. Morigenos is officially recognized as "an organization working in public interest of nature conservation", by the Ministry of Republic of Slovenia of Environment and Spatial Planning. The central activity of Morigenos is the Slovenian Dolphin Project, a long-term research, monitoring and conservation programme, focusing on bottlenose dolphins (*Tursiops truncatus*) in Slovenian and adjacent waters in the northern Adriatic Sea. It is the first systematic and long-term study of any cetaceans (whales, dolphins and porpoises) in Slovenia. Morigenos has been studying and monitoring these animals since 2002 and has documented the presence of a resident population of bottlenose dolphins in the area. Before that, hardly anything was known about dolphins in Slovenia and few people knew that they are a regular occurrence in our waters. By using photo-identification techniques, we have been able to compile the first photographic identification catalogue of dolphins off the Slovenian coast. The catalogue now contains more than 150 dolphins that use Slovenian and neighbouring waters as their habitat. The team of Morigenos is composed of biologists, veterinarians, geographers, educators, chemists, etc. The work of Morigenos involves people from all over Europe and Morigenos team members are actively participating in several research projects and organisations all over the world, for example the European Cetacean Society. Through various activities, such as Dolphin Research Courses, Adopt a Dolphin programme and various lectures, we enable anyone to take part in our work. Morigenos is a partner to several Slovenian and international projects, organisations and expert groups and is the only Slovenian organization with the status of a partner organization to ACCOBAMS (Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Neighbouring Atlantic Area), of which Slovenia is a contracting party. Source: https://www.morigenos.org/en/ **Capabilities**: Scientific research, and education	SL

ANNEX V: Distribution of the survey sample among the 3 countries according to their age, income, gender, etc.

Criteria		Italy	Croatia	Slove-nia	Total
Sex	Male	161	159	170	**484**
	Female	173	174	163	**517**
	Other				**0**
	Prefer not to say				**0**
Age	18-24 years old	31	34	30	**95**
	25-34 years old	45	50	51	**146**
	35-44 years old	51	56	58	**165**
	45-54 years old	64	51	56	**171**
	55-64 years old	53	61	58	**172**
	More than 65 years old	91	81	80	**252**
CSP	Student, traineeship	31	30	23	**84**
	Employed full time	83	133	148	**364**
	Employed part-time	28	11	9	**48**
	Farmer	1	0	0	**1**
	Self Employed	45	12	8	**65**
	Retired	80	108	104	**292**
	Stay-at-home parent	22	0	7	**29**
	Unemployed	36	30	29	**95**
Reve-nue	Less than 500 €/month	10	16	20	**46**
	De 501 à 1000 €/month	26	52	90	**168**
	De 1001 à 1500 €/month	44	60	79	**183**
	De 1501 à 2000 €/month	62	51	42	**155**
	De 2001 à 2500 €/month	33	34	36	**103**
	De 2501 à 3000 €/month	40	33	16	**89**
	De 3001 à 3500 €/month	27	18	3	**48**
	De 3501 à 4000 €/month	23	10	2	**35**
	De 4001 à 4500 €/month	10	7	3	**20**
	De 4501 à 5000 €/month	2	1	0	**3**
	De 5001 à 5500 €/month	2	0	1	**3**
	De 5501 à 6000 €/month	4	4	2	**10**
	More than 6001 €/month	52	47	39	**138**
	No answer	10	16	20	**46**
Total		**335**	**333**	**333**	**1001**

Annex VI: Detail on the econometric analysis and regression table

First of all, a database clean-up was performed to remove "outliers", based on the following:

- Participants who responded in less than 8 minutes were removed assuming they did not carefully respond to the questionnaire.
- Participants who answered "no opinion" in questions related to their diploma, revenue and profession were also removed.

In total we obtained a data base of 5117 observations.

The Probit model was selected for the analysis as it is a statistical model in which the explained variable can only take one of two modalities (dichotomous variable), 1 or 0. Thus, to conduct the statistical and econometric analysis of the results, the data was firstly modelled as follows:

To the question "Would you be able to pay x€ for the program described? "the individuals answer :

- 1 if yes
- 0 otherwise.

The willingness to pay is defined by the following formula:

$$WTP_i(z_i u_i) = z_i \beta + u_i$$

Z is the vector of explanatory variables which are the variable influencing the choice of scenario or not, β the parameter vector (that is to say the coefficient associated with each variable) and U the error term.

To determine the willingness to pay it is necessary to first run a probit regression. In this regression, the explanatory variables correspond to the attributes and are equal to 1 if they are in good condition and 0 if not. The financial contribution is also part of the explanatory variables and its value is equal to the associated price: 0, 20, 50 or 100.

The dependent variable y (variable to be explained) represents the choice (binary choice: 1 or 0). Thus, the Probit model takes the following form:

$$Y = \beta_0 + \beta_1 Attr1 * \beta_2 Attr2 * \beta_3 Attr3 * \beta_4 Price * \beta_5 Sex * \beta_6 Diploma * \beta_7 Age + \varepsilon$$

Then, the model was performed on Stata software, and the results of the regression are presented in the following table:

	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
Interept.	0.494***	1.137***	0.266*		4.294*	4.475
WTP variables						
Biodiversity	0.257***	0.258***	0.258***	0.262**	0.257***	0.257***
Water quality	0.276***	0.279***	0.278***	0.284**	0.276***	0.276***
Recreation	0.124***	0.124***	0.124***	0.128**	0.125***	0.125***
Financial contribution	-0.12***	-0.12***	-0.01***	-0.01**	-0.01***	-0.01***
Socio economic variables						
Diploma	0.046**		0.041*			
Age	0.189		0.023			
Sexe	-0.408				-0.04	-0.04
year					-0.00	-0.00
revenu				0.028**		
Knowledge effect						
degradation-tourism		-0.11*				
degradation-human		-0.04				
degradation-fish		-0.00				
degradation-biodiv		-0.05				
Distance effect						
distance		-0.01				
coastline-region-born						-0.09
coastline-region-live					-0.05	
Sea User effect						
Sea-user			0.196*			
NAS-user				0.187**		
Country effect						
Country : Slovenia				-0.41**		
Country : Croatia				0.062		
Common value of NAS						
Q23-solidarity			0.132***			
Nb Observations	5117	5117	5117	5117	5117	5117
R^2	0.08	0.08	0.08	0.08	0.08	0.08

*"***" significant at 0.001; "**" 0.01 and "*" 0.05*

Box 2: Statistical Significance

Significance refers to the point at which we can be sure that the **explanatory variable influences the dependent variable**. In our case when one of the attributes influences the choice of scenario. An insignificant variable means that if the explanatory variable changes it will not impact the dependent variable (e.g. if the weather changes, it won't impact my ability to play basketball in a gymnasium).

To test significance a test is carried out to assess if p(z) < a (with a=0.05).

When p(z) < 0.05 then the result is significant at a confidence level of at least 95% and we can interpret the sign (negative or positive) of the corresponding coefficient obtained and use its value for the calculation of the willingness to pay. On the contrary, if p(z) > 0.05 then the coefficient obtained is not significant and in other words we cannot rely on either the sign or the coefficient obtained.

For example, for biodiversity we obtained a coefficient of 0.257 and a p(z) of 0.000. We can thus say that we are 100% certain that the variable "biodiversity" influences the choice of scenario in a positive way.

Annex VII: WTP per countries

	Biodiversity	Water Quality	Recreation	Total
Italy	21	27	12	60
Slovenia	26	21	14	62
Croatia	15	20	Not significant[44]	34

	Biodiversity	Water Quality	Recreation	Total
Italy	398 107 309,45 €	511 852 255,00 €	227 489 891,11 €	1 137 449 455,56 €
Slovenia	28 590 951,81 €	23 092 691,84 €	15 395 127,90 €	67 078 771,55 €
Croatia	9 528 256,56 €	12 704 342,08 €	Not significant[45]	22 232 598,64 €

Annex VIII: Regression table for the 3 countries sub-sample

	Italy			Slovenia	Croatia	
	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
Intercept	-4.40	0.539***	0.246	0.260*	0.686***	0.653***
WTP variables						
Biodiversity	0.281***	0.279***	0.281***	0.330***	0.175***	0.176***
Water quality	0.357***	0.358***	0.356***	0.273***	0.232***	0.233***
Recreation	0.156*	0.156*	0.155*	0.182***	0.044	0.045
Financial contribution	-0.13***	-0.01***	-0.01***	-0.01***	-0.11***	-0.01***
Socio-economic variables						
Diploma			0.133**			0.076*
Age					0.686***	
Sexe	-0.06					
Profession						
year	0.002					
revenu		0.053***		0.033**		
Knowledge effect						
degradation-tourism		-0.11*				
degradation-human		-0.04				
degradation-fish		-0.00				
degradation-biodiv		-0.05				
Distance effect						
coastline-region-born	0.171**					
Nb Observations	1477	1477	1477	1799	1841	1841
R^2	0.1	0.1	0.1	0.09	0.08	0.08

[44] See Box 1 for explanation
[45] See Box 1 for explanation

8 References

Supporting ecosystem services:

- Bonizzoni, S., Furey, N. B., & Bearzi, G. (2020) Bottlenose dolphins (Tursiops truncatus) in the north-western Adriatic Sea: Spatial distribution and effects of trawling. Aquatic Conservation: Marine and Freshwater Ecosystems.
- Claudet, J., Loiseau, C., Sostres, M., & Zupan, M. (2020). Underprotected Marine Protected Areas in a Global Biodiversity Hotspot. One Earth, 2(4), 380-384.
- Costanza, R., de Groot, R., Braat, L., Kubiszewski, I., Fioramonti, L., Sutton, P., Farber, S., & Grasso, M., 2017. Twenty years of ecosystem services: How far have we come and how far do we still need to go?. Ecosystem Services, 28, 1-16.
- Falace, A., Kaleb, S., Curiel, D., Miotti, C., Galli, G., Querin, S., ... & Bandelj, V. (2015). Calcareous bio-concretions in the northern Adriatic Sea: habitat types, environmental factors that influence habitat distributions, and predictive modeling. PLoS One, 10(11), e0140931.
- Fonda Umani, S. (1996): Pelagic production and biomass in the Adriatic sea. Scientia Marina, 60 (2): 65-77.
- Jones, PJS., Qiu, W., De Santo EM. (2011): Governing Marine Protected Areas - Getting the Balance Right. Technical Report, United Nations Environment Programme.
- Manea, E., Di Carlo, D., Depellegrin, D., Agardy, T., & Gissi, E. (2019). Multidimensional assessment of supporting ecosystem services for marine spatial planning of the Adriatic Sea. Ecological Indicators, 101, 821-837.
- Manea, E., Bongiorni, L., Bergami, C., Pugnetti, A. (2020). Challenges for Marine Ecological Observatories to promote effective GMS of Natura 2000 network: The Case Study of ECOAdS in the Adriatic Sea. in “Governing Future Challenges in Protected Areas” Ruoss E., Alfaré L. In print.
- Millennium Ecosystem Assessment (MA), 2005 Biodiversity synthesis report. World Resources Institute, Washington, DC.
- Micheli F, Halpern BS, Walbridge S, Ciriaco S, Ferretti F, Fraschetti S, et al. (2013) Cumulative Human Impacts on Mediterranean and Black Sea Marine Ecosystems: Assessing Current Pressures and Opportunities. PLoS ONE 8(12): e79889.
- Nieminen et al, (2019) The economic benefits of achieving Good Environmental Status in the Finnish marine waters of the Baltic Sea, Marine Policy, V99-P181-189
- Tuhkanen et al (2016) Valuing the benefits of improved marine environmental quality under multiple stressors ' , Science of the Total Environment. V551-552 , pp. 367-375

Provisioning ecosystem services (food):

- Bastardie, F., Angelini, S., Bolognini, L., Fuga, F., Manfredi, C., Martinelli, M., ... & Grati, F. (2017). Spatial planning for fisheries in the Northern Adriatic: working toward viable and sustainable fishing. *Ecosphere*, *8*(2), e01696.
- Campostrini, P., Manea, E., Bassan, N., Fabbri, F., Farella, G., Di Blasi, D., Morelli, M., Montanaro, O., Gomez-Ballesteros, M., Borg, M., Giret, O., Maragno, D., Innocenti, A., Cervera-Nuñez, C., Rosina, A., Venier, C., Sarretta, A., Barbanti, A., Braida, M., … Gissi, E. (2019). SIMWESTMED - Initial Assessment MSP oriented (R1). Zenodo. https://doi.org/10.5281/zenodo.2590100
- FAO. 2019. General Fisheries Commission for the Mediterranean. Report of the twenty-first session of the Scientific Advisory Committee on Fisheries, Cairo, Egypt, 24–27 June 2019 / Commission générale des pêches pour la Méditerranée. Rapport de la vingt-et-unième session du Comité scientifique consultative des pêches. Le Caire, Égypte, 24-27 juin 2019. FAO Fisheries and Aquaculture Report/FAO Rapport sur les pêches et l’aquaculture No. 1290. Rome

- European Commission website (n.d.) Oceans and Fisheries – Facts and Figures – Facts and figures on the common fisheries policy – Employment. Available on: https://ec.europa.eu/oceans-and-fisheries/facts-and-figures/facts-and-figures-common-fisheries-policy/employment_en#f4
- Millennium Ecosystem Assessment (MA), 2005 Biodiversity synthesis report. World Resources Institute, Washington, DC.
- MIPAAF (2015) Piano strategico per l'acquacoltura in Italia 2014-2020
- MIPAAF (2016) Programma Nazionale Triennale della Pesca e dell'Acquacoltura 2017-2019
- North Adriatic Case Study SUPREME, 2018.
- Scientific, Technical and Economic Committee for Fisheries (STECF) – 2019 Stock Assessments part 2: European fisheries for demersal species in the Adriatic Sea (STECF-19- 16). Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76-14558-5, doi:10.2760/95875, JRC119057
- SUPREME, 2018, Addressing MSP Implementation in the Case Studies, Slovenia Case Study, Deliverable C1.3.8, CORILA & MIT, p. 234. Available at: http://www.msp-supreme.eu/results www.eurofish.dk
- www.fao.org
- Soullard A. and Bencetic D. (2016), The Fish sector in Croatia, Flanders investment and Tradde Market Survey December 2016. Available at: https://www.flandersinvestmentandtrade.com/export/sites/trade/files/market_studies/2016-Croatia-Fish-Sector.pdf
- Scientific, Technical and Economic Committee for Fisheries (STECF) (2018), Economic Report of the EU Aquaculture Sector (STECF-18-19), Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-79402-5, doi:10.2760/45076, JRC114801. Available at: https://op.europa.eu/en/publication-detail/-/publication/7f9c98f0-0fe4-11e9-81b4-01aa75ed71a1/language-en/format-PDF/source-132387268
- Scientific, Technical and Economic Committee for Fisheries (STECF) (2019a), The 2019 Annual Economic Report on the EU Fishing Fleet (STECF-19-06), Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-79-79390-5, doi:10.2760/56158), JRC112940. Available at: https://op.europa.eu/en/publication-detail/-/publication/ca63ab82-c3bf-11e9-9d01-01aa75ed71a1/language-en/format-PDF/source-132387066
- Scientific, Technical and Economic Committee for Fisheries (STECF) (2019b), The EU Fish Processing Sector – Economic report (STECF-19-15), Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76-14666-7, doi:10.2760/30373, JRC119498. Available at: https://op.europa.eu/en/publication-detail/-/publication/782537d7-36a5-11ea-ba6e-01aa75ed71a1

Provisioning ecosystem services (sand):

- Grottoli, E.; Cilli, S.; Ciavola, P., and Armaroli, C., 2020. Sedimentation at river mouths bounded by coastal structures: A case study along the Emilia-Romagna coastline, Italy. In: Malvárez, G. and Navas, F. (eds.), Global Coastal Issues of 2020. Journal of Coastal Research, Special Issue No. 95, pp. 505–510. Seville (Spain), ISSN 0749-0208
- MATTM-Regioni, 2018. Linee Guida per la Difesa della Costa dai fenomeni di Erosione e dagli effetti dei Cambiamenti climatici. Versione 2018 - Documento elaborato dal Tavolo Nazionale sull'Erosione Costiera MATTM-Regioni con il coordinamento tecnico di ISPRA, 305 pp
- Simonini, R., Ansaloni, I., Bonini, P., Grandi, V., Graziosi, F., Iotti, M., Massamba-N'Siala, G., Mauri, M., Montanari, G., Preti, M. and De Nigris, N., 2007. Recolonization and recovery dynamics of the macrozoobenthos after sand extraction in relict sand bottoms of the Northern Adriatic Sea. Marine Environmental Research, 64(5), pp.574-589.
- Campostrini, P., Manea, E., Bassan, N., Fabbri, F., Farella, G., Di Blasi, D., Morelli, M., Montanaro, O., Gomez-Ballesteros, M., Borg, M., Giret, O., Maragno,

D., Innocenti, A., Cervera-Nuñez, C., Rosina, A., Venier, C., Sarretta, A., Barbanti, A., Braida, M., … Gissi, E. (2019). SIMWESTMED - Initial Assessment MSP oriented (R1). Zenodo. https://doi.org/10.5281/zenodo.2590100SUPREME, 2018, Addressing MSP Implementation in the Case Studies, North Adriatic Case Study, Deliverable C1.3.8, CORILA & MIT, p. 234. Available at: http://www.msp-supreme.eu/results..

- United Nations Economic Commission for Europe, 2014, Environmental Performance Reviews, Second Review, ECE/CEP/172, UNITED NATIONS, pp. 234. Available at https://www.unece.org/fileadmin/DAM/env/epr/epr_studies/ECE_CEP_172_En.pdf

Provisioning ecosystem services (water):

- Borović, S., Terzić, J. and Pola, M., 2019. Groundwater quality on the adriatic karst Island of Mljet (croatia) and its implications on water supply. Geofluids, 2019.
- Capó, X., Tejada, S., Ferriol, P., Pinya, S., Mateu-Vicens, G., Montero-González, I., Box, A. and Sureda, A., 2020. Hypersaline water from desalinization plants causes oxidative damage in Posidonia oceanica meadows. Science of The Total Environment, p.139601.
- Geres, D., 2009. Water Management in Croatia: What is at Risk. In Decision Support for Natural Disasters and Intentional Threats to Water Security (pp. 159-171). Springer, Dordrecht.
- Palomar, P. and Losada, I.J., 2008. Desalinisation of seawater in Spain: aspects to be considered in the design of the drainage system to protect the marine environment. Revista de Obras Públicas, 3486, pp.37-52.
- Parihar, P., Singh, S., Singh, R., Singh, V. P., & Prasad, S. M., 2015, Effect of salinity stress on plants and its tolerance strategies: a review. Environmental Science and Pollution Research, 22(6), 4056-4075.
- Verdier, J. and Viollet, P.L., 2015. Les tensions sur l'eau en Europe et dans le bassin méditerranéen. Des crises de l'eau d'ici 2050. La Houille Blanche, (6), pp.102-107.
- Vlahović, T. and Munda, B., 2012. Karst aquifers on small islands—the island of Olib, Croatia. Environmental monitoring and assessment, 184(10), pp.6211-6228.

Campostrini, P., Manea, E., Bassan, N., Fabbri, F., Farella, G., Di Blasi, D., Morelli, M., Montanaro, O., Gomez-Ballesteros, M., Borg, M., Giret, O., Maragno, D., Innocenti, A., Cervera-Nuñez, C., Rosina, A., Venier, C., Sarretta, A., Barbanti, A., Braida, M., … Gissi, E. (2019). SIMWESTMED - Initial Assessment MSP oriented (R1). Zenodo. https://doi.org/10.5281/zenodo.2590100

Provisioning ES (salt):

Campostrini, P., Manea, E., Bassan, N., Fabbri, F., Farella, G., Di Blasi, D., Morelli, M., Montanaro, O., Gomez-Ballesteros, M., Borg, M., Giret, O., Maragno, D., Innocenti, A., Cervera-Nuñez, C., Rosina, A., Venier, C., Sarretta, A., Barbanti, A., Braida, M., … Gissi, E. (2019). SIMWESTMED - Initial Assessment MSP oriented (R1). Zenodo. https://doi.org/10.5281/zenodo.2590100Provisionning ES (Ornamental):

- Sidell M. (2015), Mediterranean Red Coral Jewelry Prices Soar Due to Chinese Demand, WWD, Noember 7 2018. Available at: https://wwd.com/accessories-news/jewelry/red-coral-jewelry-prices-china-demand-10274710/#!

Regulating ecosystem services:

- Basso, L., Vázquez-Luis, M., García-March, J. R., Deudero, S., Alvarez, E., Vicente, N., ... & Hendriks, I. E. (2015). The pen shell, Pinna nobilis: A review of

population status and recommended research priorities in the Mediterranean Sea. *Advances in marine biology*, *71*, 109-160.
- Campostrini, P., Manea, E., Bassan, N., Fabbri, F., Farella, G., Di Blasi, D., Morelli, M., Montanaro, O., Gomez-Ballesteros, M., Borg, M., Giret, O., Maragno, D., Innocenti, A., Cervera-Nuñez, C., Rosina, A., Venier, C., Sarretta, A., Barbanti, A., Braida, M., … Gissi, E. (2019). SIMWESTMED - Initial Assessment MSP oriented (R1). Zenodo. https://doi.org/10.5281/zenodo.2590100
- Canu, D.M., Ghermandi, A., Nunes, P.A., Lazzari, P., Cossarini, G. and Solidoro, C., 2015. Estimating the value of carbon sequestration ecosystem services in the Mediterranean Sea: An ecological economics approach. *Global Environmental Change*, 32, pp.87-95.
- Comici, C., & Bussani, A. (2007). Analysis of the River Isonzo discharge (1998–2005). *Bollettino di Geofisica Teorica ed Applicata*, *48*(4), 435-54.
- Cossarini, G., Querin, S., & Solidoro, C. (2015). The continental shelf carbon pump in the northern Adriatic Sea (Mediterranean Sea): Influence of wintertime variability. *Ecological Modelling*, *314*, 118-134.
- Cozzi, S., & Giani, M. (2011). River water and nutrient discharges in the Northern Adriatic Sea: current importance and long term changes. *Continental Shelf Research*, *31*(18), 1881-1893.
- d'Ortenzio, F., Antoine, D., Marullo, S., 2008. Satellite-driven modeling of the upper ocean mixed layer and air–sea CO2flux in the Mediterranean Sea. *Deep Sea Res.I* 55, 405–434.
- Drius, M., Jones, L., Marzialetti, F., de Francesco, M. C., Stanisci, A., & Carranza, M. L. (2019). Not just a sandy beach. The multi-service value of Mediterranean coastal dunes. *Science of the total environment*, *668*, 1139-1155.
- Duarte, C. M., & Krause-Jensen, D. (2017). Export from seagrass meadows contributes to marine carbon sequestration. *Frontiers in Marine Science*, *4*, 13.
- Frantar, P. (2007). Geographical overview of water balance of Slovenia 1971–2000 by main river basins. *Acta geographica Slovenica*, *47*(1), 25-45.
- Howard, J. L., Creed, J. C., Aguiar, M. V., & Fourqurean, J. W. (2018). CO2 released by carbonate sediment production in some coastal areas may offset the benefits of seagrass "Blue Carbon" storage. *Limnology and Oceanography*, *63*(1), 160-172.
- Knežević, R. (2003). Water flow conditions and stream flow regime in the catchment area of the Mirna River. *Hrvatski geografski glasnik*, *65*(2.), 81-97.
- Malone, T. C., & Newton, A. (2020). The globalization of cultural eutrophication in the coastal ocean: causes and consequences. *Frontiers in Marine Science*, *7*, 670.
- MATTM-Regioni, 2017. Linee Guida per la Difesa della Costa dai fenomeni di Erosione e dagli effetti dei Cambiamenti climatici. Documento elaborato dal Tavolo Nazionale sull'Erosione Costiera MATTM-Regioni con il coordinamento tecnico di ISPRA
- Millennium Ecosystem Assessment (MA), 2005 Biodiversity synthesis report. World Resources Institute, Washington, DC.
- Newton, A., Brito, A. C., Icely, J. D., Derolez, V., Clara, I., Angus, S., ... & Béjaoui, B. (2018). Assessing, quantifying and valuing the ecosystem services of coastal lagoons. *Journal for Nature Conservation*, 44, 50-65.
- Ondiviela, B., Losada, I. J., Lara, J. L., Maza, M., Galván, C., Bouma, T. J., & van Belzen, J. (2014). The role of seagrasses in coastal protection in a changing climate. *Coastal Engineering*, *87*, 158-168.
- Pettine, M., Patrolecco, L., Camusso, M., & Crescenzio, S. (1998). Transport of carbon and nitrogen to the northern Adriatic Sea by the Po River. *Estuarine, Coastal and Shelf Science*, *46*(1), 127-142.
- Rastelli, E., Petani, B., Corinaldesi, C., Dell'Anno, A., Martire, M. L., Cerrano, C., & Danovaro, R. (2020). A high biodiversity mitigates the impact of ocean acidification on hard-bottom ecosystems. *Scientific reports*, *10*(1), 1-13.
- Trombino, G., Pirrone, N., & Cinnirella, S. (2007). A business-as-usual scenario analysis for the Po Basin-North Adriatic continuum. *Water resources management*, *21*(12), 2063-2074.

- Zoppini, A., Ademollo, N., Bensi, M., Berto, D., Bongiorni, L., Campanelli, A., ... & Amalfitano, S. (2019). Impact of a river flood on marine water quality and planktonic microbial communities. *Estuarine, Coastal and Shelf Science*, *224*, 62-72.

Cultural ecosystem services (tourism & recreation):

- Alberini A., P. Rosato, A. Longo, V. Zanatta, 2020, Information and willingness to pay in a contingent valuation study: The value of S. Erasmo in the Lagoon of Venice Journal Of Environmental Planning and Management, 48 (2).
- Carranza, M.L., Drius, M., Marzialetti, F., Malavasi, M., de Francesco, M.C., Acosta, A.T. and Stanisci, A., 2020. Urban expansion depletes cultural ecosystem services: an insight into a Mediterranean coastline. Coastal Protection, Rendiconti Lincei. Scienze Fisiche e Naturali, 31, 103–111.
- Chung, M. G., Kang, H., & Choi, S. U., 2015. Assessment of coastal ecosystem services for conservation strategies in South Korea. PloS one, 10(7), e0133856.
- Drius, M., Bongiorni, L., Depellegrin, D., Menegon, S., Pugnetti, A. and Stifter, S., 2019a. Tackling challenges for Mediterranean sustainable coastal tourism: An ecosystem service perspective. Science of the Total Environment, 652, pp.1302-1317.
- Drius, M., Jones, L., Marzialetti, F., de Francesco, M. C., Stanisci, A., & Carranza, M. L., 2019b. Not just a sandy beach. The multi-service value of Mediterranean coastal dunes. Science of the total environment, 668, 1139-1155.
- Fetyukov A. (2015), Three facts you should know about the housing market in Slovenia, EE24, January 2nd 2015. Available at: an. 21, 2015
- Mazaris, A. D., Kallimanis, A., Gissi, E., Pipitone, C., Danovaro, R., Claudet, J., ... & Benedetti-Cecchi, L., 2019, Threats to marine biodiversity in European protected areas. Science of The Total Environment, 677, 418-426.
- Newton, A., Brito, A.C., Icely, J.D., Derolez, V., Clara, I., Angus, S., Schernewski, G., Inácio, M., Lillebø, A.I., Sousa, A.I. and Béjaoui, B., 2018. Assessing, quantifying and valuing the ecosystem services of coastal lagoons. Journal for Nature Conservation, 44, 50-65.
- Plan Bleu, 2016. Tourism and Sustainability in the Mediterranean: Key Facts and Trends. Plan Blue. Regional Activity Centre, Valbonne.
- Ruiz-Frau, A., Hinz, H., Edwards-Jones, G., & Kaiser, M. J. (2013). Spatially explicit economic assessment of cultural ecosystem services: Non-extractive recreational uses of the coastal environment related to marine biodiversity. Marine Policy, 38, 90-98.
- Campostrini, P., Manea, E., Bassan, N., Fabbri, F., Farella, G., Di Blasi, D., Morelli, M., Montanaro, O., Gomez-Ballesteros, M., Borg, M., Giret, O., Maragno, D., Innocenti, A., Cervera-Nuñez, C., Rosina, A., Venier, C., Sarretta, A., Barbanti, A., Braida, M., … Gissi, E. (2019). SIMWESTMED - Initial Assessment MSP oriented (R1). Zenodo. https://doi.org/10.5281/zenodo.2590100SUPREME, 2018, Addressing MSP Implementation in the Case Studies, North Adriatic Case Study, Deliverable C1.3.8, CORILA & MIT, p. 234. Available at: http://www.msp-supreme.eu/results Zunino, S., Melaku Canu, D., Marangon, F. and Troiano, S., 2020. Cultural Ecosystem Services Provided by Coralligenous Assemblages and Posidonia oceanica in the Italian Seas. Frontiers in Marine Science, 6, p.823.

Cultural ecosystem services (research & scientific knowledge):

- Chan, K. M., Goldstein, J., Satterfield, T., Hannahs, N., Kikiloi, K., Naidoo, R., ... & Woodside, U. (2011). Cultural services and non-use values. In: P. Kareiva, H. Tallis, T.H. Ricketts, G.C. Daily, S. Polasky (Eds.), *Natural Capital: Theory and Practice of Mapping Ecosystem Services*, Oxford University Press, Oxford (2011), pp. 206-228.
- Costanza, R., Kubiszewski, I., Ervin, D., Bluffstone, R., Boyd, J., Brown, D., ... & Shandas, V. (2011). Valuing ecological systems and services. F1000 biology reports, 3. p. 14, 10.3410/B3-14

- Fish, R., Church, A. and Winter, M., 2016. Conceptualising cultural ecosystem services: A novel framework for research and critical engagement. Ecosystem Services, 21, pp.208-217.
- Campostrini, P., Manea, E., Bassan, N., Fabbri, F., Farella, G., Di Blasi, D., Morelli, M., Montanaro, O., Gomez-Ballesteros, M., Borg, M., Giret, O., Maragno, D., Innocenti, A., Cervera-Nuñez, C., Rosina, A., Venier, C., Sarretta, A., Barbanti, A., Braida, M., … Gissi, E. (2019). SIMWESTMED - Initial Assessment MSP oriented (R1). Zenodo. https://doi.org/10.5281/zenodo.2590100SUPREME, 2018, Addressing MSP Implementation in the Case Studies, North Adriatic Case Study, Deliverable C1.3.8, CORILA & MIT, p. 234. Available at: http://www.msp-supreme.eu/results.
- Ullmann, J., & Stachowitsch, M. (2015). A critical review of the Mediterranean sea turtle rescue network: a web looking for a weaver. Nature Conservation 10: 45-69. doi: 10.3897/natureconservation.10.4890
- Vilibić, I. et al. (2019), D3.1.1 Report on the assessment of existing ecological monitoring programs and observing systems, WP3 – Design of the Ecological Observing System in the Adriatic Sea (ECOAdS), A3.1 – Assessment of existing ecological monitoring programmes and observing systems, www.italy-croatia.eu/ecoss
- OECD, 2019 https://www.oecd.org/gov/gov-at-a-glance-2019-slovenia.pdf
- Web-site: https://www.reuters.com/article/us-croatia-dubrovnik-idUSKBN1KP0BF

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