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Update on the elaboration of the chapters on marine and coastal biodiversity of the report on the State of the Environment and Development in the Mediterranean 2019 (SoED 2019)

UNEP/MAP
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Introductory Note

The UN Environment/MAP Mid-Term Strategy (MTS) 2016- 2021 sets the objective to publish "Periodic assessment based on DPSIR approach" addressing inter alia interaction between environment and development in the Mediterranean (Key Output 1.4). This objective has been translated in the 2018-2019 Programme of Work through Activity 1.4.1.1.

The Report on the State of the Environment and Development in the Mediterranean (SoED 2019) will provide a comprehensive and up-to-date assessment of the state of the environment and main sustainability issues in the region, insisting on interactions. SoED 2019, scheduled for publication early 2020, will be the result of a collective work involving jointly the Mediterranean Action Plan (MAP) components, the Contracting Parties to the Barcelona Convention and numerous external partners on a voluntary basis.

Throughout 2018, collaboration methods and modalities for SoED 2019 preparation were refined and set in place, involving more than 100 contributors and reviewers, organised in thematic chapter working groups. In March 2018, voluntary contracting parties were invited to nominate experts to participate in the chapters' preparation. Following a recommendation by the MAP Bureau, the report Steering committee also associated national representatives from the North, South and East Mediterranean countries, together with MAP components and four technical partners. The Steering Committee, to which also SPA/RAC is member, supported in particular the preparation of the SoED 2019 main findings and conclusions, through three successive meetings in October 2018 (via teleconferencing), January 2019 (Geneva, Switzerland), and March 2019 (Marseille, France).

During preliminary consultations on ongoing elaboration of distinct chapters of the SoED 2019, a series of comments have already been received, some of them already taken into account, but others still needing to be addressed throughout the next months.

Under the overall supervision of the MAP Coordinating Unit, Plan Bleu is responsible of the SoED 2019 elaboration process with the support of all MAP Components. A draft of the SoED 2019's Chapter 3: Biodiversity and ecosystem services is currently being prepared under the lead of Plan Bleu and SPA/RAC and in collaboration with partners including among others IUCN Mediterranean, FAO, European Topic Centre UMA and Tour du Valat.

This chapter will particularly emphasise the assessment of the current state of coastal and marine biodiversity in terms of ecosystems, species and ecosystem services supply and will further explore future perspectives for a realistic biodiversity protection and sustainable use of natural resources. This chapter will also present some broader perspectives on Mediterranean ecosystems recognising strong interactions between different landscape components in particular on a watershed basis in the form of complex ecological and resource systems. Finally, this chapter will take into account the conclusions of the 4th CBD Global Biodiversity Outlook and other relevant ones.

Draft elements to feed into *Biodiversity and ecosystem services* chapter elaboration are herein below shared with the participants to the Fourteenth Meeting of SPA/BD Thematic Focal Points to allow them to identify most significant gaps and additional sources of information for further development and refinement of the content presented, and contribute to identify key messages and priority responses for the further elaboration of the SoED 2019. Contributions compiled in this document have been provided by several partners and are still work in progress, at different stages of review and editing and have not yet undergone a thorough harmonization process. Figures and tables numbers are also provisory and will be completed and refined in further versions.

Table of Contents

3.1. Transversal introduction 1
3.2. Coastal ecosystems and biodiversity 1
3.3. Marine ecosystems and biodiversity 19
3.4. Responses and priorities for action 34
References 41
Annexes 49

Contributions compiled in this document have been provided by several partners with different institutional backgrounds, fields of expertise and styles of writing. The current preliminary version of this chapter is still work in progress. Contributions have not yet undergone a thorough harmonization process.

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State of the Environment and Development 2019: Preliminary version of Chapter 3: Biodiversity and ecosystem services

3.1. Transversal introduction

[To be completed]

During the last decades human activities have increasingly reduced the extent of wild areas and natural ecosystems on land and at sea. The main threats to coastal and marine ecosystems are generally the same in most countries and include: pollution, over-exploitation of biological resource, coastal alterations (change in land use for infrastructures, urbanisation, industries, etc.), changes in fluvial dynamics, increasing sea use as well as climate change effects.

The Mediterranean has a low primary production with values decreasing from the western part to the eastern part of the basin. Nevertheless, some specific areas are known to locally host high productivity, such as the Alboran Sea or the North zones of the Adriatic Sea.

Species encountered in the Mediterranean can be distinguished between (i) endemic species, (ii) warm temperate species of Atlantic origin, (iii) northern species of Atlantic origin, (iv) subtropical species of Atlantic origin, (v) species of broad oceanic distribution and (vi) Indo-Pacific species (Bianchi & Morri, 2000). The wide variety of hydrological and climate conditions and the existence of communication and introduction paths (Gibraltar strait, Suez Canal) for non-indigenous species (Boudouresque, 2004) determine the distribution of these different species (cold affinity species in the northern basin and warm affinity species in the south). The level of endemism (from 20 to 30% according to the authors) is the highest at the global level, two species being particularly emblematic, the red coral (*Corallium rubrum*, Metazoa, Opisthochonta) and *Posidonia oceanica* (Magnoliophyta, Viridiplantae, Plantae).

The knowledge about Mediterranean marine species and ecosystems varies between countries, and between the shallow and deep waters, the continental shelf (from 0 to 200m depth) being better known than the deeper areas of canyons, trenches and seamounts, reaching more than 5267m in the Ionian Sea.

Having made biodiversity the theme of its first Ecological Objective, the Ecosystem Approach (EcAp) to the management of human activities with a view to conserve natural marine heritage and protecting vital ecosystem services recognises the importance of habitats and species in achieving good environmental status.

3.2. Coastal ecosystems and biodiversity

The section will describe status and trends, ecosystem services, major pressures and management practices – for wetlands and coastal aquifers; coastal forests; other coastal ecosystems; endangered and local/indigenous species; invasive species.

3.2.1. Wetlands and coastal aquifers[1]

Wetlands[2] represent an estimated 6 % of global land mass and are among the most diverse and productive ecosystems on the planet. The ecosystem services they provide (e.g. protection against floods, filtration, carbon sequestration) are disproportionately larger than their relative land surface. In particular, coastal wetlands play a key role in connecting salt and freshwater systems. The status and trends of Mediterranean wetlands have been assessed by the Mediterranean Wetlands Observatory[3] since in 2012 and 2018. Coastal aquifers contribute to the integrity and functioning of the coastal and marine ecosystems through the hydrological processes that commonly occur in this land-sea interface.

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1 Coastal aquifers are developed here only in the view of the biodiversity and the ecosystem services provided. The aspect on water resources is developed in chapter 6 of the report.

2 Ramsar Convention on Wetlands define wetlands as: "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres".

3 Encompassing also Portugal, Andorra, Serbia, Bulgaria, Jordan and North Macedonia (FYROM).

3.2.1.1. Status and trends of wetlands and coastal aquifers and linked biodiversity

The Mediterranean basin hosts 19 to 26 million hectares wetlands (MWO 2018). A sample of 400 Mediterranean wetland sites have lost, on average, 48% of their natural wetland habitats between 1970 and 2013, far more than the average on the three surrounding continents (Africa -42%, Asia -32% and Europe -35%), or than the world overall (-35%) (UNEP-WCMC 2017; Ramsar Convention on Wetlands, 2018).

Within the Mediterranean ecosystems, wetlands are of paramount importance for biodiversity: although they occupy only around 2 % of the land area, they are home to more than 30 % of the basin's vertebrate species, and there are twice as many endangered species in wetlands than in all Mediterranean ecosystems. Coastal wetlands are crucial for many species and ecosystem processes. Coastal lagoons provide important feeding areas for many species of marine origin and are therefore strongly involved in ensuring the sustainability of fish stocks exploited at sea (e.g. the sea bream *Sparus aurata*). They are also a preferred habitat for juveniles of the European eel (*Anguilla anguilla*), a migratory fish evaluated as Critically Endangered by the IUCN Red List (Jacoby and Gollock, 201'). Several coastal rivers are characterized by a high level of endemism with a number of highly range-restricted species (many freshwater mollusks and fish). River deltas host tens of millions of migratory, wintering, and breeding waterbirds travelling from as far away as the Arctic and Southern Africa. Coastal wetlands represent 70 % of the 551 wetlands of international importance for waterbirds in the Mediterranean countries, by regularly hosting more than 20,000 waterbirds and/or more than 1 % of the biogeographical population of at least one waterbird species (Ramsar criteria, Figure 2, in red). However, less than 10 % of these coastal sites have been designated as Ramsar sites so far (Popoff et al. ongoing work).

Populations of fish species specialist of coastal wetlands strongly declined between 1990 and 2013 (MWO 2018; Figure 2). Conversely, waterbird populations show a general positive trend, most likely due to three reasons. First, many waterbirds have suffered massive destruction in the past, resulting in a low baseline for 1990. Second, specific protection laws (e.g. the EU Birds Directive) and effective governance have led to a significant increase of breeding populations in some countries (MWO 2018; Gaget et al. 2018). Third, artificial water bodies have also increased, providing additional habitat for some water birds (MWO 2018).

In the Mediterranean region, groundwater is an essential source of water supply used in many socio-economic sectors. Excessive abstraction of groundwater, for irrigated agriculture is leading to rapid depletion of aquifers (Dalin, et al., 2017) inducing significant environmental degradation, such as land subsidence and seawater intrusion (Caló, et al., 2017; Custodio, 2018). Most groundwater conservation and management efforts focus on protecting groundwater for drinking and other human uses but tend to neglect addressing the viability of groundwater biodiversity and groundwater-dependent ecosystems (GDEs). Nevertheless, trends of increased degradation of the health of coastal aquifers and GDEs have become major environmental concerns in the Mediterranean basin (UNEP/MAP/MED POL, 2004). However, alterations of the quality (temperature, chemistry, etc.) and quantity of groundwater, as well as changes of seasonal patterns present a threat to GDEs, and consequently to their biodiversity. The most important impacts on ecological values of underground aquifers affect invertebrates namely stygobitic and oligochaetes species (Achurra and Rodríguez, 2008) as well as water quality and ecosystem goods and services provided by GDEs and connected ecosystems such as wetlands, springs lagoons, rivers, and lakes. The use of hydro-ecological approaches are essential corrective management schemes to reduce the implications of anthropogenic disturbance (Abdul Malak et al. 2019).

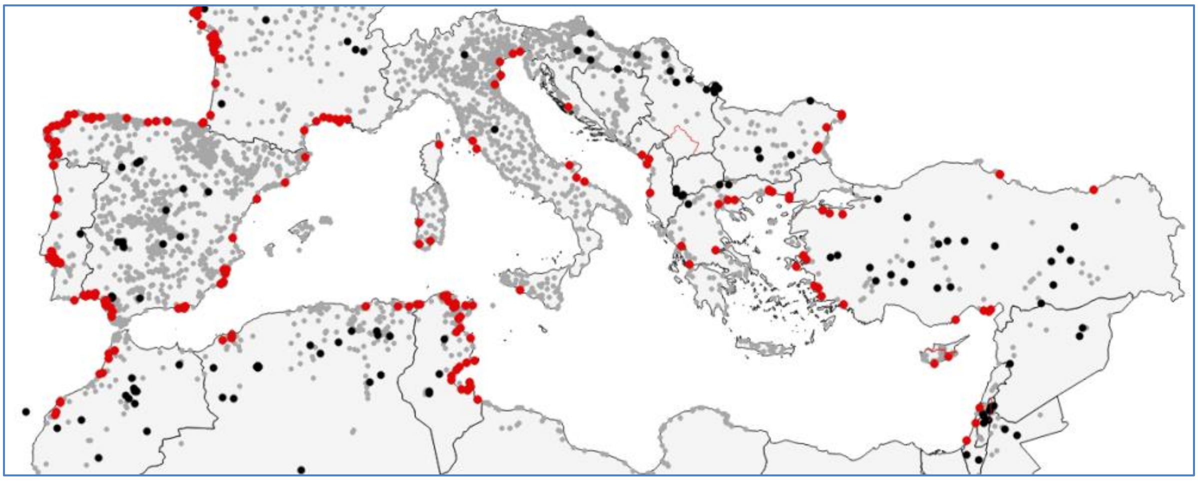

Figure 1 Wetlands of international importance for waterbirds (black and red points) which regularly host more than 20,000 waterbirds and/or more than 1% of the species population of the Mediterranean flyway (based on mid-January counts made during the 1991-2012 period). Sites in red (resp. black) are located less (resp. more) than 30 km away from the coast Grey points are the other wetlands sampled by the International Waterbird Census (Wetlands International) (Source: Popoff et al. ongoing work).

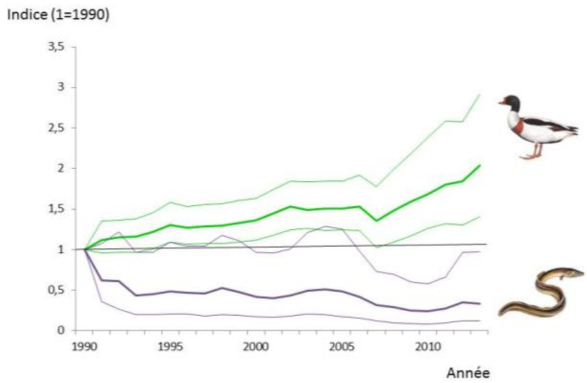

Figure 2 Living Planet Index for birds and fishes dependent on coastal wetlands in the Mediterranean basin. The index gives the relative abundance over time for populations of birds and fish for which there are data available. The value of the index is chosen to be 1 in 1990 and values lower than 1 in other years indicate a significant reduction of the general abundance of monitored species (95 % confidence intervals are shown as thinner lines). The bird index (green) is based on 10,611 time-series of 54 species and the fish index (purple) is based on 2,171 time-series of 18 species (source Galewski, unpublished work).

3.2.1.2. Ecosystem services

Wetlands and coastal aquifers contribute in many different ways to the well-being of people (Ramsar Convention on Wetlands, 2011, 2018; MWO2, 2018). Examples of the ecosystem services provided include but are not limited to: 1) purification of water; 2) mitigation of floods and droughts and 3) water provision (Ramsar Convention on Wetlands, 2011; Griebler and Avramov 2015). Water availability for people and nature is of particular importance in the Mediterranean climate, but it is under increasing pressure due to lower groundwater levels. Even in coastal wetlands, many ecosystem services are derived or supported by the presence of groundwater inflow because of its role in regulating the hydrology (UNEP-MAP, 2015).

Ecosystem services contributions from wetlands and aquifers are increasingly under pressure (MWO2, 2018; Geijzendorffer et al. 2018). The loss of natural wetland habitats reduces the capacity of Mediterranean wetlands to provide services, whereas the demand and use for ecosystem services has been rapidly increasing. Thanks to investments in management, facilities and accessibility, an increasing number of people visit and enjoy Mediterranean wetlands during leisure time or for educational outings. However, the continued loss of natural wetlands habitats caused e.g. by dam building or drainage creates enormous carbon emissions and reduces the availability of groundwater and its quality. Especially the capacity of wetlands to mitigate the impacts of floods has been significantly reduced (by 20% between 1987 and 2016 in a sample of five Mediterranean coastal watersheds) mainly due to the conversion of natural wetland habitats into agricultural and urban zones and the artificialisation of flooding prone areas (MWO2, 2018).

Box 1 Ichkeul Ecosystem Services

Ichkeul National Park in northern Tunisia is a Ramsar site covering 12,600 ha, including 8,500 ha of lake and 2,700 ha of peripheral marshes. Highly threatened in the 1990's due to water diversion and dam building on its tributaries, a change in management strategy assisted by a series of wet years avoided an impeding ecosystem collapse. The Park is internationally important for its waterbird populations, and also provides very diverse ecosystem services to local and regional populations. These were recently assessed and quantified in 2015. They amounted to c. 3.2 million USD per year, or 254 USD per ha, with regulating services providing the bulk of this value (73 %) whereas provisioning services (18 %) and cultural services (9 %) came next. In particular, protection against floods (34 %), groundwater replenishment (23 %) and sediment retention (12 %) were the specific services with the highest value, followed by grazing (10 %), recreation/ tourism (9 %) and fisheries (7 %). Among the various habitats present, the lake had the highest value of services provided per hectare (268 USD per ha per year). The total value of annual services is almost 10 times the annual expenses for the Park management (i.e. 335,000 USD per year), which are therefore highly justified. Although the share of the total value benefitting the local population is comparatively low (11%), the actual amount per household is far from negligible and amounts in average to c. 1600 (resp. 1000) USD per year for households located inside (resp. outside) the National Park. All these values will be used to argue for water releases from upstream dams in order to maintain the wetlands and the services they deliver, and to communicate locally on the importance of the Park for the economy in order to obtain local support. After Daly-Hasen, 2017

3.2.1.3. Major pressures

Mediterranean coastal wetlands face many anthropogenic pressures: alteration of the hydrological functioning, water pollution, conversion of wetlands to agricultural and urban areas, overfishing and coastline retreat.

The Mediterranean Region is characterized by its water stress situation, largely derived from population increase, economic and social development, and irrigated agriculture, but also by climate change (Black, 2009) impacting coastal wetlands and aquifers. The intensive use of water in the Mediterranean catchments to meet human demand may lead to groundwater depletion and inrushing seawater. The main consequences are the salinization of soils and underground resources, and a trend for freshwater wetlands to become more brackish. Several coastal aquifers along the densely populated Mediterranean coasts are already suffering seawater intrusion (e.g. the Nile Delta aquifer –Egypt-, Cyprus Akrotiri – Cyprus) a problem that is expected to exacerbate with climate change (Kundzewicz & Döll, 2009). Excessive water abstraction upstream also reduces the duration and extent of flooding in many wetlands downstream, and affects their overall ecological functioning. Conversely, farmland irrigation can locally increase water inputs to wetland habitats, increasing the flooding period in naturally temporary habitats, leading to eutrophication and to dramatic changes in plant and animal communities (e.g., Álvarez -Rogel et al., 2007, Chappuis et al., 2011).

Groundwater recharge is expected to be further reduced in the Mediterranean, especially along the southern rim. The situation will aggravate further, because of water quality degradation in coastal Mediterranean aquifers and seawater intrusion, contributing to the ongoing salinization of coastal areas, wetlands and agro-ecosystems (Hoff, 2013).

Groundwater-dependent ecosystems (GDEs) are under pressure from excessive groundwater extraction and land use activities which impact the amount or seasonal patterns of groundwater flow or alter groundwater chemistry or temperature. Threats also include leaching of nitrate and pesticides from agriculture, aggravated by the increased production of biofuels, promoted by some EU policies. Leaking sewage pipes, particularly in urban areas, channel and introduce nitrates and other contaminants polluting groundwater and GDEs (Kløve, et al., 2011).

The most radical and frequent phenomenon affecting wetlands, including coastal ones, is habitat loss. This often starts with a conversion of natural habitat to farmland, then potentially to urban areas (MWO, 2014, 2018). The Mediterranean Wetlands Observatory quantified this phenomenon by measuring changes in 302 major wetland sites (210 coastal and 92 inland) throughout the Mediterranean basin. Between 1975 and 2005, more transformations took place in coastal than in inland sites (Figure 3) – except for farmland expansion. In both coastal and inland sites, natural wetland habitats were converted predominantly into either farmland or manmade wetlands, with conversions to other land-cover types being minimal. The south-eastern part of the basin has seen by far the largest changes in land cover, followed by the Maghreb, the Balkans and south-western Europe (MWO, 2018).

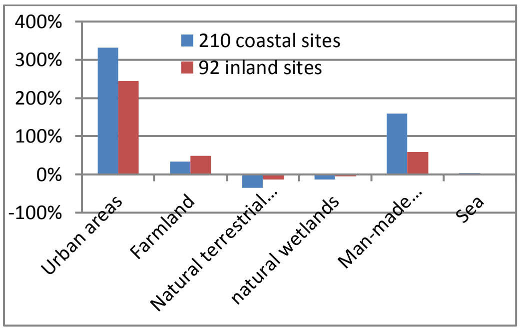

Figure 3 Rate of change between 1975-2005 of the main land-cover categories in coastal vs. inland sites (source Perennou & Guelmami, unpublished work).

Box 2 Agriculture and Mediterranean wetlands

While livestock and agricultural intensification have in many cases provided food security and agricultural employment, these models have also contributed to exploiting more water resources, including groundwater, and to polluting many bodies of water, with consequences, sometimes serious and irreversible, on the habitats and biodiversity of some natural wetlands (Ramsar, 2014). Indeed, the expansion of cultivated land is one of the main direct causes of wetland loss in the Mediterranean: Out of 302 sites monitored by the MWO, more than 46% of the loss of natural wetland habitats is due to their conversion to agricultural areas.

Intensive agriculture also affects natural wetlands' ecological integrity indirectly through a decrease in water inputs due to water overexploitation, particularly following retention at upstream dams. This is especially true for Mediterranean regions characterized by a high concentration of irrigated agriculture, because even if rainfed crops remain largely dominant in terms of area (with ~ 80% of all exploited land), there is a net increase in total irrigated land area over the last 3 decades (Mediterra, 2009). The consequences of such practices can sometimes be catastrophic for natural wetlands, and may also include a deterioration of water quality with pollution from pesticides, chemical fertilizers, antibiotics, disinfectants or animal waste and sediment from eroded pastures (FAO, 2016) as well as a disruption of wet ecosystems with the introduction of exotic and potentially invasive species, often for economic and / or aesthetic reasons.

3.2.1.4. Management of wetlands and coastal aquifers

Groundwater resources have generally not been managed in an integrated way to date; as aquifer systems are difficult to observe, they are mostly ignored in spatial planning decisions (Kløve, et al., 2011). The diversity of wetlands and GDEs makes it difficult to provide a one-size-fits-all management solution, since each ecosystem has different ecological water requirements, contains different species, fosters specific habitat conditions, and can face a variety of threats from groundwater basin activities.

The European Mediterranean countries, through the EU Water Framework Directive (WFD), adopted an Integrated Water Resources Management (IWRM) approach principles focusing on the recovery and conservation of the ecological status of rivers, lakes, wetland and coastal waters. Furthermore, considering the interaction of underground water resources with wetlands and other water ecosystems is mandatory under this legislation, where the water cycle is considered in a holistic way (GWP, 2000). The main obligations of the WFD and its companion Directive on Groundwater Protection (EC, 2006) in relation to GDEs refer to achieving a good groundwater status and to preventing significant damage to terrestrial ecosystems that directly depend on groundwater bodies.

Overall in south-western Europe, water quality has improved in many waterbodies for nutrients and heavy metals at least, thanks to the application of the EU WFD. However, North African and Middle Eastern countries which do not benefit from the WFD still witness an overall degradation of their water quality and an intensification of the overexploitation of water resources (MWO, 2018).

At the international level, the Ramsar Convention is the key instrument promoting wetland protection. The number and surface of Ramsar sites[4] in the MedWet countries have steadily increased over time: since 1971, 397 Sites covering 6.7 million hectares have been designated. In 2017, 44 % of all

4 Wetlands of International Importance

Mediterranean Ramsar sites had developed a management plan, and 30 % had implemented it.
Other measures taken to manage wetlands include the restoration of wetlands as nature-based solutions to mitigate the impacts of flooding by rivers and the sea, sustainable water use to ensure a prolonged provision of water for ecosystems during droughts, and the protection of remaining natural wetland habitats and their water quality.

Box 3 Examples of application of Nature-based Solutions to coastal urban ecosystems, wetlands and seagrass meadows

At the 2016 World Conservation Congress, IUCN's members adopted a resolution (WCC-2016-Res-069-EN) on a definitional framework for Nature-based Solutions (NbS) with a set of eight preliminary principles. The resolution defines NbS as "actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits".
As an umbrella and integrative concept, NbS have been further defined, adopted and applied differently by IUCN and other organizations, such as the European Commission and the World Bank. Despite the diversification of the concept, all come across with a common goal: contribute to all dimensions of sustainability, the science, political and practical dimensions (Nesshöver et al, 2017).
Nature based Solutions move beyond safeguarding nature and include people´s need to address societal challenges such as climate change, biodiversity loss, food security, water security, disaster risk or health effects from changing conditions. They bring together established ecosystem-based approaches such as ecosystem-based adaptation and ecological engineering with the social and economic dimension. All types of ecosystems can be intervened with NbS, as wide range of Nbs exists and can be adapted to any kind of ecosystem.
Despite the complexities, uncertainties and trade-offs in their implementation, NbS can provide multi-benefits and foster win-win situations. Examples of successful implementation of the NbS concept can be found in the projects "Ecosystems Protecting Infrastructure and Communities" and "Water Infrastructure Solutions from Ecosystem Services Underpinning Climate Resilient Policies and Programmes" (WISE-UP).
Several institutions, such as the IUCN Centre for Mediterranean Cooperation, the IUCN French and Spanish National Committees, Plan Bleu, Tour du Valat, and Conservatoire du Littoral are promoting the dissemination and encourage the implementation of NbS across the Mediterranean region through two mains actions: 1) generating knowledge by collecting information from project implementation in the field and research on what benefits they can provide; 2) seeking government and stakeholder engagement through participatory processes as to achieve more integrated policies and guaranty NbS acceptance.
A collection of examples of NbS application have been identified by the above institutions to represent the range of ecosystem services and societal challenges that can be addressed by NbS interventions. Building an evidence base for NBS is the key to support future replication and upscaling of these solutions in this rapidly changing, modern world. These evidences will provide conservation and development practitioners, policy makers, researchers, and NGO, useful basis for understanding what NBS offer in terms of benefits for human and nature. The global standard for design and verification of NbS under development by IUCN is foreseen to be ready by 2020, and will contribute to the consolidation of this innovative approach.
Examples of NBS in adapted to natural ecosystems
The Oristano area in Sardinia (Italy) is rich in wetlands, including 6 Ramsar areas of the MARISTANIS project. Water and food sectors are strongly linked with traditional fisheries meanwhile livestock farming are source of water pollutions. Conflicts affect relations between ecosystem conservation and food sector, since birds feed on fish and crop seed, especially in rice fields. The Maristanis project is looking into Nature based solutions, such as growing reed, for improving water quality and enhancing food production as a way to, reducing the excess load of nutrients coming from agriculture.
The Ad'Apto project, highlights the strategies of ten representative sites on the French coast, in order to demonstrate that a flexible management of the coastline is feasible and efficient regarding adaptation to climate change. Similar objective has the project of restoration of the Camargue saltflats lagoons and marshes, to restore the coastal ecosystems for nature conservation and coastal protection.
Other marine habitats, such as seagrass meadows, are considered important habitats under the criterion of NbS. The Life Blue Natura project aims to quantify the carbon deposits and sequestration rates of marsh and seagrass meadows in the coasts of Andalusia. The project's ambition is to generate the tools necessary for designing carbon offset projects that could be incorporated into the recent approved Climate Change Act of Andalusia, because no tools for marine ecosystems exist to date. To this end, the most threatened areas and/or those of greatest value blue carbon ecosystems (seagrass and coastal wetlands) will be define to implement conservation and revegetation projects - that contribute to climate change mitigation and coastal protection.

There is great potential and opportunity for the Mediterranean region of the combination of IWRM and the Integrated Coastal Areas Management (ICAM) approaches that would contribute to an integrated management of Mediterranean coastal areas and river basins (ICARM). Such solutions using holistic management approaches in Mediterranean coastal areas are political challenges that must be faced to reduce pressures on coastal wetlands and groundwater aquifers.
Regarding the management and conservation of GDEs, a holistic and effective management approach is required, that includes the prioritization of the most valuable ecosystems and services. The

management of ground water and GDE should better consider the total economic value. The integration of natural and social sciences can contribute to a holistic understanding of relevant processes and problems associated with GDE management and help to design consistent policies. Such solutions using holistic management approaches in Mediterranean coastal areas are political challenges that must be faced to reduce pressures on coastal wetlands and groundwater aquifers and consequently on the biodiversity of their GDEs.

3.2.2. Forests

3.2.2.1 Status and trends of Mediterranean forests

According to the Global Forest Resources Assessment programme (FAO, 2015), the forest area of Mediterranean countries at national scale has been increasing from 68 million ha in 1990 to 82 million ha in 2015 that is an increase of 0.72 percent per year over 25 years (Annex x). This moderate but stable trend upwards has been paralleled by an increase in growing stock (from 6.3 billion m^3 in 1990 to 9.2 billion m^3 in 2015, + 1.56 percent per year) and carbon storage (from 3.2 billion tons in 1990 to 4.6 billion tons in 2015, + 1.52 % per year). The 0.86 % per year net increase in forest area between 1990 and 2010 has largely been the result of forest expansion (0.66 % per year), with reforestation contributing 0.25 % per year and deforestation remaining at a low level of 0.06 % per year (though it is trending upwards). One specificity of the Mediterranean region is the importance of other wooded lands, reflecting the importance of small trees, shrubs and bushes in these dryland ecosystems. These other wooded lands accounted in 2015 for an additional 32 million ha in Mediterranean countries. Contrary to forests, the area of other wooded lands has been constantly decreasing from 36 million ha in 1990 to 32 million ha in 2015 (─ 0.45 % per year over 25 years) (Annex x).
Another specificity of the Mediterranean region is the importance of trees outside forests that are found in extensive agroforestry systems, urban forests and as elements of the landscape. These trees outside forests covered in 2015 more than 8.2 million ha in the Mediterranean, with an area that has been increasing between 2000 and 2010 (FAO and Plan Bleu, 2018).

Figure 4 Esterel parc, SouthEast France. Typical Mediterranean forests are composed of broadleaved species mainly oaks, both evergreen and deciduous (eg: *Quercus ilex, Q.suber, Q. coccifera*), and conifers (eg: *P.halepensis, P;brutia, P;Pinea*). The degradation of such forests has produced low-density woody vegetation known as the *macchia* and the *garrigue*.

Because forest statistics are provided at country level and not according to the biogeographical Mediterranean region, a fraction of forest growth has taken place outside the Mediterranean biome. Geo-spatial information complementing country-level statistics (such as the Copernicus High Resolution Layer Forest) are required to locate forest areas and monitor their spatio-temporal trends. Based on Hansen et al.'s map (Hansen et al., 2013), forests cover 9.1 % of the Mediterranean countries' territory. When restricting to the Mediterranean biome, this proportion increases to 18 %. When further restricting to coastal areas (here the land within 5 km of the coastline), it increases to 28 % (Annex x). Therefore, forests are proportionally three times more widespread in Mediterranean coastal areas than at country level.
Though forest coverage is showing increasing trends in the Mediterranean region, forests are subjected to several drivers of change that have impacts on their condition, biological diversity, and functional capacity.

Statistics on forest area and land-cover changes in the Mediterranean tell us little about forest degradation. While new forests are generated from ecological succession after land abandonment, or from national afforestation programmes, Mediterranean forests are subjected to fragmentation due to land cover change including urban sprawl and expansion of infrastructure. It has been estimated that 80 million ha of land in the Mediterranean – including forests – are degraded (Martín-Ortega et al., 2017), thus making land degradation a major issue for the region.

Short term climate change effects are also visible where observed shifts in vegetation to the north of the Mediterranean climate is likely to continue (Lelièvre et al., 2010), with corresponding changes in Mediterranean climate adapted vegetation (Dreyfus, 2007). In the longer term, projected trends in Mediterranean forests are highly uncertain, on the one hand because of the uncertainty of vegetation models (Keenan et al., 2011) and, on the other hand, because the response of vegetation to climate change is intrinsically non-linear, with gradual change in climate potentially resulting in drastic switches in vegetation when a tipping point is reached (Scheffer et al., 2001).

3.2.2.2. Ecosystem services

Based on an analysis of the total economic value, one specificity of the Mediterranean forests is that their value relies more on non-wood forest products and services than on wood products (Croitoru, 2007). At the same time, the value of non-wood products and services of Mediterranean forests is largely unrecognized or undervalued by decision-makers, leading to the paradox that Mediterranean forests have become a sink of public resources while they may play a role as a green infrastructure to address the challenges faced by the region (Martínez de Arano et al., 2016). Awareness raising to local population on the importance of their natural and cultural heritage and conservation of these unique habitats, such as *Dehesas*, and their valuation is essential.

The recognition of the goods and services provided by Mediterranean forest ecosystems will require a fair and accurate assessment of their economic value. Participatory approaches will be key in the development of economic valuation methods. Local communities and stakeholders should be invited to participate in the valuation process itself in order to observe the method in practice, provide information and understand the results. Fair and accurate economic valuation of goods and services is key for the structuration of the value chains in the Mediterranean, especially the value chains of non-wood forest products that are currently poorly understood, with limited official information available about their added value, stakeholders and inter-linkages (Vidale et al., 2015). Incentives from climate change policy (wood products as substitutes for other products with carbon footprint, adaptation to climate change) will also be key in the promotion of the ecosystem services provided by Mediterranean forests.

3.2.2.3. Major pressures

Climate change and human population growth are two overarching processes whose secondary processes (conversion from forests to shrublands, wildfires, pest and pathogen outbreaks, overgrazing and land abandonment) threaten Mediterranean forests. For instance, the area burnt by wildfires in five European Mediterranean countries has been trending downwards from 570,000 ha per year between 1980 and 1985 to a minimum of about 320,000 ha in 2014 but has been rebounding in the last four years, mainly because of increasing burnt areas in Portugal. A similar pattern of increased burnt areas in the recent years has also been observed in North Africa and the Middle East, with a total burnt area of 119,491 ha in 2017 (mostly in Algeria and Tunisia), around three times the amount recorded in 2016 (San-Miguel-Ayanz et al., 2018). Mediterranean forest ecosystems are resilient to wildfires but repeated or intense fire events are beyond the capacity of most species to cope with fire, thus bringing forest degradation and loss of biodiversity (Bradshaw et al., 2011).

Consequences from the drivers of forest degradation include the alteration and pollution of water resources, land degradation and fragmentation, forest dieback and regeneration decline, soil erosion, biodiversity loss and genetic erosion. Mediterranean forests are generally located close to settlements; as a result, untreated solid waste landfills are often established in forest areas, with a negative impact on freshwater quality.

The degrading impact of soil erosion is serious in Mediterranean forests where soils are thin and poor, particularly in mountain areas following disturbance events (fires, windstorms and pest outbreaks) (De Rigo et al., 2016). Forests in Europe are generally fragmented; woodland landscapes, which account for 70 % of the subcontinent, are poorly connected (Estreguil et al., 2013), making them more vulnerable to fragmentation. The combined effect of warming and drought has resulted in several instances of forest decline or dieback of oak, fir, spruce, beech and pine species in Spain, France, Italy and Greece (e.g. Peñuelas et al., 2007). Forest dieback has also occurred in the Mediterranean basin's southern rim, having an enormous impact on *Cedrus atlantica* in Algeria (but also other tree species including pine, oak and juniper).

3.2.2.4. Management of Mediterranean forests

All Mediterranean countries have forest-related policy documents that orient the management of forests (FAO and Plan Bleu, 2018). National forest policy statements vary and range from extensive documents to declarative, long-term sectoral visions. Forest policy statements in the region are affected by a number of legally binding or non-legally binding international and regional agreements and conventions, such as the United Nations Strategic Plan for Forests 2017-2030, the three Rio Conventions, the Paris Agreement (signed by all Mediterranean countries except the Syrian Arab Republic), the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the Ramsar Convention and the World Heritage Convention. International commitments on forests are particularly relevant for Mediterranean forests but, since the average validity of national forest programmes is 20 to 25 years, the most recent international and regional agreements may not be fully reflected yet in national forest policy documents.

Sustainable forest management is consistently prioritized in national forest policy programmes and statements across Mediterranean countries. However, ecosystem services and wood and non-wood forest products; forest restoration; biodiversity conservation; climate change mitigation and adaptation; wildfire prevention; and communication, coordination, cooperation and capacity building are not systematically present in all policy documents. Biodiversity is deeply rooted in forest policies throughout the region, the main focus being the biodiversity-climate change nexus (FAO and Plan Bleu 2018). Fifteen countries in the region and the European Union have an action plan or a strategy as required by the Convention on Biological Diversity. Nine countries in the region have mapped national targets against the Aichi Biodiversity Targets. Efforts on forest conservation have been achieved in the region through protected areas. Over 42 % of land area in protected areas in the Mediterranean has tree cover of more than 10 %, to be compared to 19 % of land area in the Mediterranean biome (with both protected and unprotected areas), which shows that protected areas in the Mediterranean are densely covered with forests. More efforts for regional planning are needed to ensure connectivity between forests (through the building of green infrastructures) and increasing forest function and resilience that are essential to reduce the impact of climate change, pest outbreaks, etc.

Wildfire prevention is among major declared policy priorities in the Mediterranean. In policy documents, forest wildfires are often treated as an emergency rather than part of a continuous interaction between society and the environment in the context of climate change. In addition, at the national level, extinction generally receives much greater attention (and funding) than prevention, which can lead to over-expenditure (as more investment in prevention would reduce overall expenditure).

A number of Mediterranean countries have included pledges for forest and landscape restoration and afforestation plans into their policy documents. Forest and landscape restoration is the process of regaining ecological functionality and enhancing human well-being across deforested or degraded forest landscapes. Ten Mediterranean countries, for instance, have adopted the Agadir Commitment to support forest and landscape restoration, land degradation neutrality and biodiversity conservation efforts, with an objective on a voluntary basis to restore eight million hectares of degraded lands in the Mediterranean by 2030.

Policies and instruments on climate change mitigation and adaptation are in their initial phase in the Mediterranean region. Nationally Determined Contributions (NDCs) and the Paris Agreement are not mentioned in most forest policies. The primary focus of forest policy in the Mediterranean region is on researching the ecophysiological response of forests to climate change. Policies are therefore oriented towards an adaptive approach to climate change. On the short run, revisions of forest policies are expected to take place to include the role of forests in NDCs. On the longer run, fostering the role of forests in a green low carbon economy (e.g. as a renewable resource that can substitute for products with heavy carbon footprint) is expected to take place.

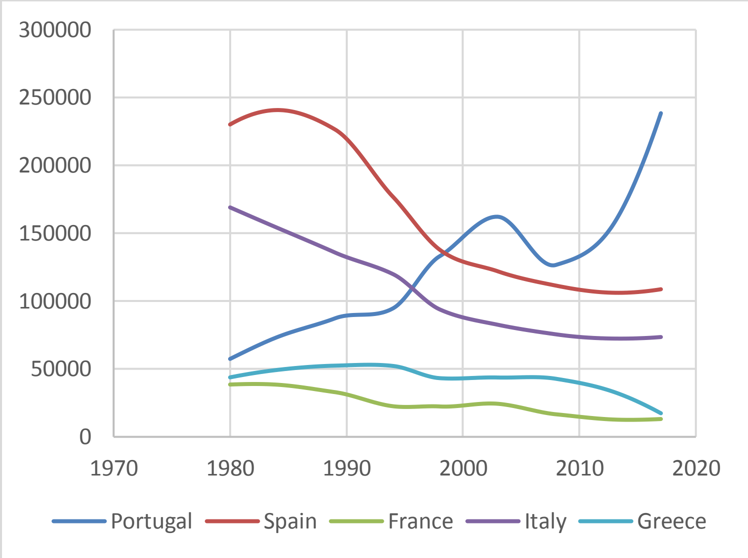

Figure 5 Area (in ha) burnt by wildfires in five European Mediterranean countries. Source: San-Miguel-Ayanz et al. (2018). Note: Annual data are smoothed using a local second-degree polynomial regression with a smoothing parameter of 0.75.

3.2.3. Other coastal ecosystems: soft and rocky shores ***[to be shortened]***

The Mediterranean coastline is a heterogeneous landscape, influenced mostly by factors like winds and storm surges but also strongly affected by past and current human activities. The tidal oscillation is generally small (of the order of few cm), except for the north Adriatic Sea, the north Aegean Sea and the Gulf of Gabès where tidal amplitudes can reach 1m during spring tides (Tsimplis et al., 1995).
The total length of the Mediterranean coastline is approximately 46,000 km, of which 19,000 km represent island coasts (UNEP/MAP, 2012). Approximately 54% of the Mediterranean coastline are sea cliffs and rocky shores (Furlani et al 2014), while the rest is comprised of soft sedimentary shores made of beaches, estuarine shores of fine sediment, coarse sediments (shingle, gravels and coarse sand) shores in the upper reaches of estuaries and muddy shores found in association with coastal lagoons and river mouths. The following description describe therefore these main four types of coastal environments:

- Soft sediment coasts: Beach and dune systems
- Soft sediment coasts: Muddy environments
- Hard rock coast: Rocky shores and cliffs
- Soft sea cliffs and rocky shores

3.2.3.1 Status and trends

Soft sediment coasts: Beach and dune systems

Mediterranean soft sediment coasts, mostly formed by sandy beaches backed by dunes, boulders or sandstone, are dynamic ecosystems driven by diverse prominent physical processes, notably wind incidence and storm intensity as well as wave exposure, shoreline orientation, sediment supply, and geology (Sabatier et al 2009; Simeone and De Falco, 2012). Sand and gravel supply is made from the discharge of rivers. On those Mediterranean coasts without rivers or with low fluxes of particulate matter from land to the sea, the sand comes mostly from marine sedimentation or a result of coastal erosion processes. A particularity also found of many sandy beaches along the Mediterranean, is the deposit of large volumes of Posidonia wrack (leaves and rhizomes) forming a permanent or semi-permanent structure on the beach, named banquettes (Otero et al., 2018).
Although not as rich in species as other coastal habitats, species in sandy shores show high adaptation to changes in salinity and water levels. The beach habitat is home to annual plants such as the European sea rocket (*Cakile maritima subsp*. aegyptica) and the tumbleweed *Salsola kali*. On beaches less trampled some perennial plants also occur, such as the knotgrass *Polygonum maritimum* and the purple spurge *Euphorbia peplis*. It is also habited by crustaceans able to live outside water such as *Talitrids*

genus Orchestia, predator insects such as the tiger beetles (some species genus *Cicindela*), algal grazers as shore flies (*Ephydridae*), beach flies (*Tethinidae*). This habitat is used for nesting by loggerhead turtle, *Caretta caretta* and green turtle, *Chelonia mydas* in parts of the Eastern Mediterranean. Adjacent coastal dunes host a highly specialized fauna and plant communities sharing relatively few of them with other close-by environments. Its dynamic nature includes an important proportion of bare sand and young vegetation species that evolve into a more stable ecosystem dominated by different stages of woody shrubs and tree species (Grove, 2012).

There is no quantitative data of the total area of soft sediment coastline in the Mediterranean nor their trends. Some estimations from EU countries indicate that sandy beaches could be around 8,509 km^2 (Otero 2016a) and a loss of 30 % of this particular habitat inferred from the development of harbors, dikes and others coastal structures over the last 50 years. Dams are the prime reasons for the loss of sand supply to the coastal environment (and its beaches). For coastal dunes, habitat decline has been estimated at more than 20 % over the past 50 years in EU Mediterranean countries with a range of 10 to 40 % among countries (Acosta, 2015).

Soft sediment coasts: Muddy environments

Muddy shores are present but not common in the four sub-basins of the Mediterranean. These very rich habitats in terms of biodiversity are typically found in association with coastal lagoons and river mouths. They are feeding grounds for several types of birds that feed on the high variety of invertebrates that occur in these grounds. The most extensive examples are found around the deltas of the Ebro (Spain), Rhône (France) and Po (Italy) while smaller, very localised pockets are present across the region (Soldo et al 2016). Nutrient enrichment, altered flow regimes following coast protection works, and coastal zone developments have most probably affected these coastlines.

Hard rock coasts: Rocky shores and cliffs

Cliff and rocky coasts represent more than 50 % of the coast in the Mediterranean. The interaction of waves, weathering and relative sea-level changes shaped these types of rocky coastlines and its main landforms including sloping and horizontal shore platforms with flat rock surfaces and cliffs that sometimes are indented by rocky promontories, bays, sea arches, inlets and coves. Limestone coasts are also common features of many coastlines in the basin and have further allowed the development of a rich set of karst landforms in some areas.

The majority of supralitoral rocky shores is typically characterized by diverse maritime communities of yellow and grey lichens, such as *Xanthoria parietina*, *Caloplaca marina*, *Lecanora atra* and *Ramalina spp*. The black lichen *Verrucaria maura* is also present. The higher parts of sea cliffs are colonized by disjunct assemblages of salt-tolerant, halophytic or even halo-nitrophilous crevice plants (chasmophytes) or by more or less closed salt-tolerant grasslands.

In the surf zone on the areas of bedrock, boulders and stones, associated marine species are adapted to long periods of emersion.

The Mediterranean Sea cliffs harbor numerous endemics of extremely local occurrence, in particular many plant species belonging to the genus *Limonium*, which comprises at least 43 and probably 120 to 150 Mediterranean cliff species, many of which restricted to a few localities. Several of these species are threatened, like for instance *Limonium remotispiculum* of southern Italy and *Limonium strictissimum* of Corsica and Caprera. Some stable and high coastal cliffs are inhabited by shrub communities of *Ficus carica, Colutea arborescens* and *Ulmus minor*.

At few locations along the Mediterranean coastline, unique bioconcretions made of reefs with the red algae *Lithophyllum byssoides* and rim platforms formed by the algae *Neogoniolithon brassica-florida* and the vermetid gastropod *Dendropoma petraeum* develop just above the mean sea level, where waves break. Their distribution is very restricted to the warmest part of the basin and only in specific areas where climatic, hydrological and sedimentary conditions are suitable. This particular habitat has experienced a continuing decline in spatial extent and biotic quality as a result of water discharge, pollution, trampling and climate change affecting 30 % of the habitat over the past 20 years and is considered vulnerable at the EU Red list of habitats (Chemello and Otero, 2016).

Quantitative data on cliff retreat and the erosion of rocky shore platforms are scarce and restricted to a few localities (Furnalli et al 2014). The past and ongoing development of harbors, dikes and others coastal structures is further declining the extent of this environment and is estimated that of this, approx. 20 % has been lost over the last 50 years in EU countries (Otero, 2016b).

Soft sea cliffs and rocky shores

Rocky coasts of soft materials along coastal cliffs and slopes are less common in the Mediterranean and have been less studied. The combination of local morphological settings, lithological features (e.g. cliffs on marine conglomerates, cliffs on sandstone, and cliffs on continental deposits), tectonic setting and geomorphological processes produce the diverse variability of landforms along these coastlines. Moreover, these coastlines are poorly resistant to the natural processes of erosion and landsliding and retreat rates are highly variable on the type of shore platforms formed. In general terms, there is little information on its ecological and floristic features or status. Soft rocky shores are more easily colonized by vegetation. The erosion is much quicker than hard cliffs and vegetation is therefore restricted to pioneer stages in many places. They may support scrub similar to the ones on dunes with species like *Hippophae rhamnoides*, *Juniperus* spp. and *Crataegus monogyna* as well as breeding populations of vulnerable species of birds (e.g. the yelkouan shearwater *Puffinus yelkouan*; Tzonev 2015a).

3.2.3.2 Ecosystem services

Coastal ecosystems provide shoreline stabilization and buffering services. For example, seagrass banquettes on beaches reduce erosion by mitigating wave impact while sandy and rocky shores serve as a first line of defense, mitigating and responding to natural forces like waves and storms (Drius et al 2019; Boudouresque et al., 2016).

Many of the coastal ecosystems linked to soft sediment coasts (beach and dune systems or muddy environments) also have outstanding ecological, socioeconomic and cultural values as well as important roles in providing a diversity of ecosystem services linked to the nutrient and energy exchange in the coastal landscape. Several studies have also demonstrated the role of soft sediment environment such as dunes in coastal defense, groundwater storage and water purification, while their importance in nutrient cycling, soil formation and climate regulation (on carbon sequestration) is less known (e.g. Bazzichetto et al., 2016).

Obtaining further quantitative information for the ecosystem capacity of these types of Mediterranean ecosystems would be valuable to provide management options and relevant information for decision-making. Moreover, considering that the provision of these ecosystem services is strongly linked to the distribution, size and conservation status of the different natural habitats (Maes et al., 2012).

Table 1: Ecosystem services provided by some coastal habitats in the Mediterranean

	Provisioning	**Regulating**	**Supporting**	**Cultural**
Soft sediment coasts				
Beaches	Import marine organic matter and nutrients from the sea to the coastal ecosystems	Erosion control, recycling of nutrients	Habitat/refugia for coastal biodiversity – gastropods, small crustaceans, myriapods, insects, etc. Nesting areas for marine turtles and shorebirds	Recreation and tourism: more people use sandy beaches than any other type of seashore
Dunes	Soil formation - sand and other minerals to beaches.	Erosion control Water purification	Habitat/refugia for coastal biodiversity - Dunes provide unique habitats for highly specialized plant and animal species due to the strong environmental sea-inland gradient. The lower slopes of sand dunes with natural vegetation such as Goat's Foot and Spinifex are ideal nesting sites for turtles (Choudury et al., 2003).	Recreation and tourism: image of natural sand dunes and beach fronts as part of their marketing packages
Muddy environment	Food provisioning- e.g. shellfish	Nutrient cycling Storm protection Decomposition and fixing processes.	Habitat/refugia for coastal biodiversity - the high biodiversity and abundance of invertebrates is the feeding basis for many birds. Bacteria in mud flats help to break down contaminants from urban runoff, such as heavy metals, hydrocarbons (oil, gasoline, solvents) and other organic	

			chemicals.	
Soft rocky shores				
Soft sea cliffs and rocky shores	Raw material		Habitat/refugia for coastal biodiversity - sea cliffs harbor a diversity of vegetation types with variable maritime influence	Tourism: nature watching
Hard rocky coast				
Rocky shores and cliffs	Food provisioning- Finfish and seaweeds are collected on rocky coastlines.	Sea defense	Habitat/refugia for coastal biodiversity - sea cliffs harbour a diversity of vegetation types with maritime influence. It is an important feeding area for birds and fish in ponds, and nursery grounds for invertebrates	Recreation and tourism: recreational fishing

3.2.3.3 Major pressures

Like all coastal ecosystems, soft sediment coasts and rocky and soft cliffs and shores are subject to multiple impacts that are often from inland sources (Orth et al., 2006). Accelerated erosion is a widespread phenomenon along most of the basin mainly because of anthropogenic interventions, e.g. the proliferation of marinas and other urban and touristic infrastructure, sea level rise as a result of global warming, reduced river sediment inputs as a consequence of damming, river bed quarrying, land use changes, harbours and other coastal defense structures (Otero 2016a).

The development of coastal projects (marinas, urban and tourist infrastructures), has also had a significant effect on soft sediment coasts with beaches and coastal dunes by altering the erosion-accretion dynamics of the coastal zone and their quality and quantity. In some countries, invasive non-native species such as the succulent plant species, *Carpobrotus acinaciformis* or *C. edulis* represent an important threat.

For rocky shores and cliffs, the main pressures and threats are associated with substratum loss due to direct destruction by human modifications of the coastline from building and harbor development, and also from degraded water quality. Urban and industrial waste as well as wastewater are discharged directly into the sea in some areas and chemical contaminants can lead to reduced growth of some of the associated species and general degradation of the habitat.

The major threats on soft sea cliffs and rocky shores are new urbanized areas and human habitation because of touristic development in coastal areas, particularly the construction of homes, roads and infrastructure development in the erosion-prone zone of these areas. The increasing human pressure has exacerbated these erosion problems at some points. Additionally, natural catastrophic events and storm events could further drive erosion (Tzonev, 2015b).

3.2.3.4 Management

There are various legal provisions and policies which relate to the above mentioned types of ecosystem landscapes at national level, EU level (Habitat and Birds Directive, MSFD and MSP) as well as within the ICZM Protocol of the Barcelona Convention. Altogether, these Mediterranean policies constitute a good umbrella for the development of national policies and coastal and marine area planning and management at national and local level. In addition, other regional and national policies aim to protect local coastal features while maintaining a commitment to manage the development of coastal areas.

Soft sediment coasts

For EU countries, most of the plant communities growing on coastal dunes lining the Mediterranean have been listed as EC Habitats of interest in Annex I of the Habitats Directive. EU countries are also encouraged to designate Natura 2000 sites and some beaches are also protected because of the presence of breeding sites of marine turtles. Even so, it is important to highlight that in many situations the coverage of Natura 2000 sites and the designation of protected areas has been focused on single habitats, while not considering the functional connectivity among continuous habitats in the land-sea interface (e.g. Otero et al., 2018). Improving the integration and management of these connective habitats will reduce the fragmentation and facilitate the ecological integrity of the coastal environment.

In some Mediterranean countries, strict limits and distance from the coast for dredging of sands and gravel from beaches are in place. Additional beneficial actions could include legal protection of vulnerable habitats (dunes) in some Mediterranean countries, better planning and limitation of coastal development, preventing activities such as coastal protection works that destabilize the habitat or interfere with the natural dynamics; beach nourishment schemes using appropriate materials and developing management practices for the beach cleaning which avoid the use of heavy machinery.
For other soft sediment landscapes like muddy flats and estuarine environment or deltas, management and mitigation measures could be improved and prioritize to diminish land and marine based pollution sources such as reduce the problems of outfalls discharging untreated wastewater, industrial effluents and agricultural runoff among others.

Hard rock coast and Soft sea cliffs and rocky shores

A wide range of anthropogenic stressors affect these types of landscapes and their habitats and communities. While such stressors are encountered all along the Mediterranean, their frequency, intensity and impacts vary spatially and temporally. These types of ecosystem landscapes may not be subject to specific conservation measures, although they are present in some protected areas, due to the presence of endangered and protected species or as part of a larger area with multiple objectives.
Beneficial priority actions could include those which improve water quality and the regulation of coastal development in order to avoid both direct and indirect damage. Moreover, establishing new protected sites and restoring degraded coastal areas are also important. Direct engagement of stakeholders in the planning of the management process, and analysis of social and economic costs and benefits of different management options is essential to the successful implementation of conservation actions.

3.2.4. Genetic diversity and threatened species in the coastal zone

Genetic diversity is one of three forms of biodiversity recognized by the IUCN as deserving conservation, along with species and ecosystem diversity (McNeely et al. 1990). High levels of genetic variability buffer species against environmental change by increasing the likelihood that at least some individuals will survive (Pilczynska et al. 2016).

Many coastal habitats have isolated spatial patterns, highly changing environmental conditions and strong influence of the surrounding environment. The organisms that are able to survive on these ecosystems frequently experience strong selective pressures and constrictions on gene flow, which could contribute to increase genetic divergence among populations (Vergara-Chen et al.2010). However, if natural populations consist of reduced numbers of individuals, loss of genetic variability may dramatically influence the populations themselves, since genetically impoverished populations might fail to adapt to future environmental changes, eventually causing their disappearance.

Fragmentation of formerly continuous sand dune habitats is most likely leading to the local extinction of species and the loss of genetic diversity (Frey et al. 2015). Although there are only few studies on genetic diversity for Mediterranean coastal species, an example on such a case with low genetic diversity levels is the plant *Stachys maritima*. It is a typical species of coastal dunes that has been subjected to severe fragmentation during the last century (Masso et al 2016). Therefore, management programmes with the objective to enhance the conservation status of the specie need to consider connectivity patterns and gene exchange among populations in its planning (Palumbi 2003).

Currently, more than 6 000 species including all vertebrates and an important number of invertebrates and plants have been recorded from the Mediterranean region into the IUCN Red List of Threatened Species (IUCN RLTS). About 1 247 species of them are recorded as being native and occurring in

coastal terrestrial habitats and 253 of them are endemic to the Mediterranean region.
At least 168 (14%) of the coastal species assessed in the IUCN RLTS (101 of them endemics) are threatened with extinction at global or regional level in the Mediterranean region (Table 2). Half of the threatened coastal species are animals (84 species), with birds and insects (18 and 17 species) making up the greatest number of threatened animals. The other half are plants making up for 84 threatened species.

Table 2: Conservation status of species habiting Mediterranean coastal habitats based on the results of the extinction risk assessments of the IUCN Red List at global and Mediterranean regional level. IUCN Red List categories CR, EN and VU correspond to the number of species in risk of extinction. IUCN Red List categories: CR Critically Endangered, EN Endangered, VU Vulnerable, NT Near Threatened, LC Least Concern, DD Data Deficient, RE Regionally Extinct, EX Extinct.

Taxonomic Group	CR	EN	VU	NT	LC	DD	RE	EX	Total of coastal threatened taxa	Total coastal taxa assessed	% coastal threatened taxa in the Mediterranean region *
Vascular plants	29	27	28	37	271	40	0	0	84	432	21%
Vertebrates- Total	19	15	29	49	458	13	2	1	63	586	11%
Freshwater Fishes	9	2	0	1	42	5	0	0	11	59	20%
Amphibians	2	1	3	6	33	1	0	0	6	46	13%
Reptiles	2	5	6	16	59	1	0	0	13	89	15%
Birds	3	3	12	19	255	0	0	1	18	293	6%
Mammals	3	4	8	7	69	6	2	0	15	99	16%
Invertebrates (freshwater) – Total	1	17	3	11	179	15	0	0	21	229	10%
Freshwater molluscs	0	2	1	1	21	6	0	0	3	31	12%
Freshwater crabs, scrayfish and shrimps	0	0	1	1	1	0	0	0	1	3	33%
Odonata (Dragonflies and Damselflies)	0	0	0	1	48	1	0	0	0	50	0%
Invertebrates (Insects) – Total	1	15	1	8	109	8	0	0	17	145	12%
Butterflies	1	2	0	2	85	2	0	0	3	95	3%
Dung Beetles	0	10	1	6	14	6	0	0	11	37	35%
Saproxylic beetles	0	3	0	0	10	0	0	0	3	13	23%
Total	49	59	60	97	908	68	2	1	168	1247	14%

**Mid-point (CR + EN + VU) / (assessed – EX – DD)*

Spain, France, Italy and Morocco have in this order the highest number of threatened species living in coastal habitats. Most of the threatened coastal birds are found in France and Spain, a high number of freshwater fishes, occur in Spain and highest number of threatened amphibians and reptiles are found in Spain and Italy. The highest number of threatened invertebrates and plants are also found in Spain and France.

Table 3 Number of threatened coastal species by country. The highest number of threatened species (under IUCN Red List categories CR, EN and VU at global and/or Mediterranean level) by taxonomic group in bold

Coastal threatened taxa in the Mediterranean region												
Countries	Amphibians	Aves	Reptiles	Mammals	Freshwater Fishes	Freshwater Molluscs	Freshwater crabs, shrimps and crayfishes	Butterflies	Dung Beetles	Saproxylics	Plants	Total
Spain	**2**	**18**	**4**	5	4				**6**	2	22	63
France	1	**18**		6	1				5	**3**	**28**	62
Italy	**2**	16		3	2	1			4	2	19	49
Morocco		16	3	**9**				1	4	1	14	48
Greece		15	1	5	**5**			1			12	39
Algeria		14	2	7	1				1	2	9	36
Turkey	1	15	2	**9**	3		1	1			2	34
Israel	1	16	1	6		1					4	29
Croatia	1	14	1	4	3				1		3	27
Tunisia		12	3	6	1				1	1	2	26
Egypt		13	2	4					1		4	24
Montenegro	1	15	1	5	1				1			24
Syria		12	2	6							4	24
Lebanon		10	2	6							2	20
Bosnia and Herzegovina	1	13	1	3								18
Slovenia	1	11		4							2	18
Albania		10		3	2				1			16
Malta		11							1		4	16

Palestine	1	9		2		1					3	16
Cyprus		12		2							1	15
Libya		10	1	1					1		1	14
Monaco		4		2								6

Drivers and threats to coastal biodiversity

The analysis of the threats affecting 163 Mediterranean coastal species in risk of extinction in the IUCN Red List (IUCN 2018) showed that tourism and recreation areas, urbanization, agriculture, livestock, recreational activities and invasive species are the main drivers of species extinction in coastal areas (Figure 6).

In coastal lowlands, the Mediterranean have experienced urbanization and development associated with tourism for decades (Grenon & Batisse, 1989; Vogiatzakis et al., 2005). These include the reduction in plant diversity and deterioration or destruction of coastal dunes by tourism infrastructure, the drainage of wetlands, which is leading to a loss of habitat for migratory birds and many other aquatic species. Water-related leisure activities damage aquatic plant communities (sea grass and coralligenous species) and nesting areas of marine turtles.

The prospects of short-term financial gain from tourism are often winning over the long-term security of biodiversity and maintenance of ecosystem services. Further, some of the endemic taxa in the hotspot are confined to islands and small river catchments and have a narrow genetic base, which reduces competitive abilities and limits dispersal opportunities, and so increases their vulnerability.

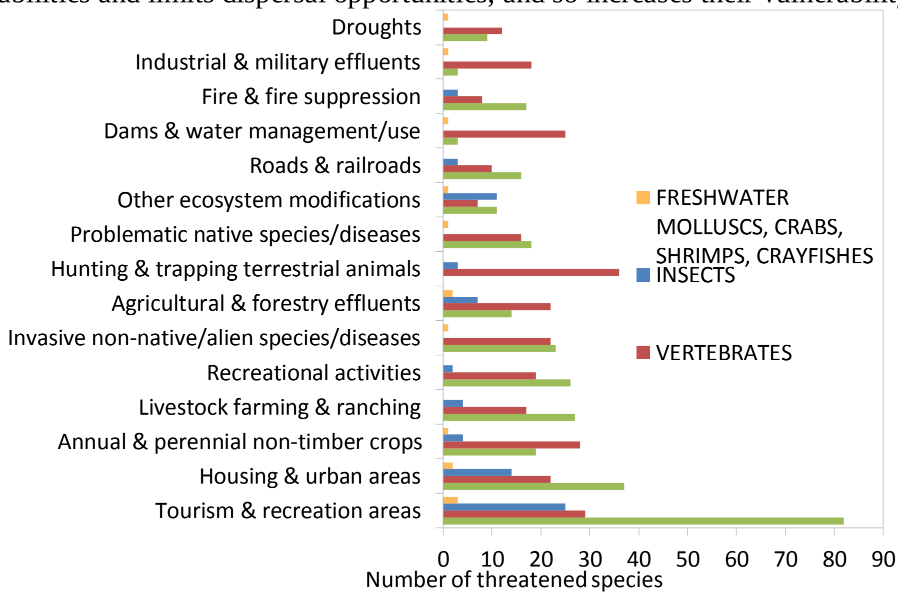

Figure 6 Main threats affecting coastal species in risk of extinction (IUCN Red List Categories CR, EN and VU) in the Mediterranean region

Table 4

TOP 15 OF THREATS							

Threat_ref0	Threat_desc0	Threat_ref1	Threat_desc1	VERTEBRATES	FRESHWATER MOLLUSCS, CRABS, SHRIMPS, CRAYFISHES	INSECTS	PLANTS
1	Residential & commercial development	1.3	Tourism & recreation areas	**29**	3	25	82
1	Residential & commercial development	1.1	Housing & urban areas	**22**	2	14	37
2	Agriculture & aquaculture	2.1	Annual & perennial non-timber crops	**28**	1	4	19
2	Agriculture & aquaculture	2.3	Livestock farming & ranching	**17**	0	4	27
6	Human intrusions & disturbance	6.1	Recreational activities	**19**	0	2	26
8	Invasive and other problematic species, genes & diseases	8.1	Invasive non-native/alien species/diseases	**22**	1	0	23
9	Pollution	9.3	Agricultural & forestry effluents	**22**	2	7	14
5	Biological resource use	5.1	Hunting & trapping terrestrial animals	**36**	0	3	0
8	Invasive and other problematic species, genes & diseases	8.2	Problematic native species/diseases	**16**	1	0	18
7	Natural system modifications	7.3	Other ecosystem modifications	**7**	1	11	11
4	Transportation & service corridors	4.1	Roads & railroads	**10**	0	3	16
7	Natural system modifications	7.2	Dams & water management/use	**25**	1	0	3
7	Natural system modifications	7.1	Fire & fire suppression	**8**	0	3	17
9	Pollution	9.2	Industrial & military effluents	**18**	1	0	3
11	Climate change & severe weather	11.2	Droughts	**12**	1	0	9

The composition of coastal ecosystems may change as a result of climate change, with a greater risk of extinction of species, especially those with a restricted climatic distribution, those that need highly specific habitats and/or small populations which are naturally more vulnerable to modifications in their habitats. Climate change is also expected to amplify biological invasions and proliferation of pathogens and diseases, fostered by the rise in temperature of the marine waters.

3.2.5. Invasive species in the coastal zone

Invasive Alien Species (IAS), introduced species which out-compete native species and cause economic and ecological damage by spreading in natural ecosystems (IUCN SSC Invasive Species Specialist Group, 2000), have been recognized as the second cause of species disappearance at global level, behind habitat loss and deterioration, affecting above all islands and isolated ecosystems. The globalization of markets has raised the rate of introduction of non-indigenous species (NIS) everywhere, but only a small number of introduced non-native species have established and caused detrimental ecological impacts (Genovesi and Shine 2004).

It is not certain exactly how many non-native coastal species are present within the Mediterranean, although this is much better known for the marine environment than the terrestrial biome. On a regional scale, however, the number of terrestrial non-native animal and plant species seems to be quite low in comparison to the marine alien species invasions. Among the best-known examples are the Brown rat, *Rattus norvegicus,* with strong negative effects on native fauna, particularly on islands; the redeared slider turtle *Trachemys scripta elegans* in ponds or the Cordgrass *Spartina patens* and *S. densiflora* in Mediterranean marshes (MIO-ECSDE 2013; Duarte et al. 2018).

Even well managed protected areas suffer from the introduction and settling of invasive alien species (Otero et al. 2013). Their effects on the biodiversity and habitats of the Mediterranean cannot be generalized, as alien species can cause very diverse effects at different locations and times, sometimes with a strong invasive component.

Several alien species, vertebrates and invertebrates, are also today affecting freshwater communities in the Mediterranean, imperiling native species and altering ecosystem processes. Illustrative examples are the Stone moroko fish *Pseudorasbora parva* and the Brook trout *Salvelinus fontinalis* which are among the world's 100 most invasive species. Others like the Tiger mosquito *Aedes albopictus* are also one of the most invasive alien species in the region (MIO-ECSDE 2013).

3.3. Marine ecosystems and biodiversity

3.3.1. Marine ecosystems

The Mediterranean basin is a globally unique biodiversity hotspot with high diversity and endemism of flora and fauna. It represents 0.3 % of the global oceans‘ volume and hosts 7 % of the identified global marine species. The complexity in the ecology of the Mediterranean Sea is mainly attributed to its geological history combined with the diverse climate conditions prevailing in its different zones. These resulted in the coexistence of many ecosystems with a wide range of extent and distribution.

Around 30 % of the 12,000 species occurring in the Mediterranean are endemic to the region (Bianchi and Morri 2000, Boudouresque 2004 Briand and Giuliano 2007). Endemism, i.e. numerous species living exclusively in the Mediterranean, is another marked feature of marine biodiversity in the Mediterranean. It is greater in the Mediterranean than in the Atlantic (Bianchi & Morri, 2000). At biogeographical level, Mediterranean biota include 55-77% of Atlantic species (present in the Atlantic and the Mediterranean), 3-10% of pan-tropical species (species from the globe's hot seas), 5% of Lessepsian species (species from the Red Sea which entered the Mediterranean via the Suez Canal) and between 20 and 30% of endemics. This ratio of endemism, relatively high compared to other seas and oceans, varies according to taxonomic group (Tab 5). It is 18% for decapodal crustaceans, 27% for hydras, 40% for Rhodobionta (Plantae), 46% for sponges, 50% for ascidians, 90% for nesting sea birds (Metazoa) (Zenetos et al., 2002; Boudouresque, 2009). These are basically neo-endemics like the *Cystoseira* genus (Chromobionta, *Stramenopilous*) with over thirty species known in the Mediterranean, 20 of them endemic, and to a lesser extent, paleo-endemics like species of the *Rodriguezella* genus (Rhodobionta, Plantae), the red coral *Corallium rubrum* (Metazoa, Opisthochonta) and *Posidonia oceanica* (Magnoliophyta, Viridiplantae, Plantae) (UNEP-MAP RAC/SPA 2010).

Table 5 Rate of endemism for some taxonomic groups in the Mediterranean (cf. Boudouresque, 2004 for sources)

Phylum	Number of species in the Mediterranean	Number of endemic species	% of endemism
Echinodermata	134	32	24
Priapulida	1	0	0
Polychaeta Errantia	371	88	24
Echiuria	6	1	17
Sipuncula	20	4	20
Brachiopoda	15	2	13
Mollusca	401	65	16
Crustacea Decapoda	286	52	18
Pogonophora	1	1	100
Phoronida	4	0	0
Hemichordata	5	2	40
Pisces	638	117	18
Total	**1 882**	**364**	**19**

The current state of the unique and endemic Mediterranean biodiversity is dire as the current use of natural resources is not sustainable. Healthy ecosystems provide essential services such as clean water, clean air or food provision, amongst many others. Nevertheless, unsustainable human uses are impacting Mediterranean ecosystems at unprecedent rates that are reducing their functionality and their capacity to provide local livelihoods with such services.
During the last decades, a particular focus was on some of these ecosystems because of their special ecological role and the ecosystem services they provide, including in supporting the main human activities in the region. The special attention paid to these ecosystems, their habitats and their key species derived also from the seriousness of the threats hanging over them.
The most typical Mediterranean habitats lie in the coastal strip. These include *Lithophyllum byssoides* (e.g. *L. lichenoides* and *L. tortuosum*) rims in the medio-littoral stage, seagrass meadows, notably *Posidonia oceanica* meadows and Fucal forests (biocenoses with *Cystoseira*) in the infra-littoral stage, and the coralligenous in the circa-littoral stage (Zenetos et al., 2002; Boudouresque, 2004). Added to these habitats are the Vermetid platforms and the *Neogoniolithon brassica-florida* concretion (Boudouresque, 2004).
Seagrass meadows, coralligenous formations and beds and dark habitats (habitats where the absence of light precludes photosynthesis, from caves in the coastal strip to deep seas in the open ocean) are among the components that are considered particularly representative of the Mediterranean ecosystems. All of them are facing crucial conservation challenges which prompted the Contracting Parties to the Barcelona Convention to adopt specific Action Plans for their conservation within the framework of joint coordinated efforts by all Mediterranean countries and partner organisations and further developed below.
[Map of marine habitats pending]

3.3.2. Seagrass meadows

One of the most recent assessments that provided a comprehensive compilation of the available data on seagrass meadows in the Mediterranean is provided in Pergent et al. (2012). It shows that of the five species of strictly marine Magnoliophyta found in the Mediterranean Sea, one is endemic (*Posidonia oceanica*), three are also found in the Atlantic Ocean (*Cymodocea nodosa, Zostera mari*na and *Zostera noltii*) and one is a Lessepsian migrant (*Halophila stipulacea*), usually migrating across the Suez Canal from the Red Sea.
Posidonia oceanica forms vast meadows, between the sea-surface and a depth of 35 to 40 m, in the entire Mediterranean basin with the exception of the extreme south-east. The most extensive meadows

are those in the Gulf of Gabès (Tunisia), Hyères and Giens bays (France), the eastern coast of Corsica, and the western coast of Sardinia and Sicily (Boudouresque, 2004). The species plays an important role at ecological, sedimentary and economic levels; it is also a powerful integrator of the quality of the water and plays a major role in carbon fixation and storage – "carbon sinks" (Pergent et al., 1994; Mateo et al., 1997; Duarte et al., 2005). Regression of the meadows is often related to the impact of human activities (eg: mooring, seabed disturbing fishing, excessive sand/organic matter discharge, other types of marine pollution), but this species also seems to regress in sectors where anthropogenic pressures are very low (Boudouresque et al., 2009). The absence of *P. oceanica* in the extreme south-east of the basin seems to be directly related to excessive summertime water temperatures (Celebi et al., 2006). Furthermore, diminished vitality of *P. oceanica* has been documented in several regions of the western basin following sporadic weather events, responsible for an exceptional rise in water temperature (Marbà & Duarte, 2010).

Cymodocea nodosa is found all over the Mediterranean basin, in the Sea of Marmara and in the Atlantic. It ranks second, after *P. oceanica*, in terms of occupied surface areas in the Mediterranean; it is particularly evident in the eastern part of the Oriental Basin. While local regressions of *Cymodocea nodosa* have been recorded in sectors subjected to heavy pressure from human activities, this species seems to be more influenced by long-term natural fluctuations, such as variations in salinity, the action of herbivores and climate change. In general, this warm affinity species seems to benefit somewhat from the overall warming of the environment (Boudouresque et al., 2009). In several sectors of the Mediterranean, *Cymodocea nodosa* has taken advantage of the regression of *P. oceanica* to further its own development (Montefalcone et al., 2007).

Zostera marina is the most widely distributed species, from the Atlantic Ocean to the Pacific Ocean, and from temperate regions to the Arctic Circle (Green & Short, 2003). In the Mediterranean, *Zostera marina* forms very large meadows in sublittoral zones, generally between the sea surface and a depth of about 10 m. This species is above all present in a number of coastal lagoons and at the innermost part of very sheltered bays. It is rare in the Mediterranean, only growing very locally (mainly in the north-western Mediterranean, the Adriatic, and the Aegean Sea). While the main causes of its regression are of an anthropogenic nature (eutrophication, modifications of sedimentary environments, mechanical degradations and pollution), the amplitude of this phenomenon leads us to wonder about its more global dynamics on the scale of the Mediterranean basin. In fact, *Zostera marina* is one of the cold affinity species likely to regress, or even disappear from the Mediterranean if global warming intensifies. Today, this species seems to have disappeared from numerous sites where it was present several decades ago (Pergent-Martini, 2000) and, in localities where this species is still present, significant regressions have already been recorded (Boudouresque et al., 2009).

Zostera noltii most often develops in the loose substrates of the intertidal zone where it can form very vast meadows which are subject to wide variations of light intensity and temperature. In the Mediterranean, it is confined to coastal lagoons, the innermost part of some sheltered bays and small harbours where it forms permanently submerged meadows. This species is widespread throughout the North Atlantic (from Sweden to Mauritania) but rarer and more locally growing in the Mediterranean (western Mediterranean, the Adriatic, Greece, Syria and Egypt) (UNEP-MAP RAC/SPA 2010). This species is often associated with *Zostera marina* or *Cymodocea nodosa*, with which it may form mixed meadows. In terms of dynamics, this species demonstrates high resilience, even though several examples of regression have been reported, related to modifications in salinity or nutrient enrichment (Ben Maiz & Shili 2007; Bernard et al. 2007). However, the few regressions recorded do not represent a general trend and *Zostera noltii* may benefit from the regression of other species of Magnoliophyta (Boudouresque et al., 2009).

Halophila stipulacea can form meadows extending to depths of 35 to 40 m in the Mediterranean, though it is most often found in shallower habitats (-2 to -10 m), in zones of low hydrodynamism and within, or near, harbours. The initial distribution range of *Halophila stipulacea* was in the western part of the Indian Ocean, the Persian Gulf and Red Sea (Den Hartog, 1970). The opening of the Suez Canal enabled it to enter the Mediterranean where it was first reported in 1894 (Fritsch, 1895). Since then, *Halophila stipulacea* has continued to advance, usually following prevailing currents (Galil, 2006), and thus colonizing a large part of the eastern basin. It has already reached the Gulf of Gabès in Tunisia and the Tyrrhenian Sea in Italy (UNEP-MAP RAC/SPA 2010). This trend seems, however, to have accelerated over the past few years, with colonization of new sectors formerly considered as hardly compatible with the development of tropical affinity species.

Major pressures

The regression of seagrass meadows is a phenomenon that has been observed over several decades, though the amplitude of this regression varies depending on the species and geographical zones under consideration (Short & Wyllie-Echeverria, 2000). The five marine species of Magnoliophyta present in the Mediterranean are subjected to natural and anthropogenic pressures of a kind likely to lead to significant regressions (Marbà et al., 1996; Boudouresque et al., 2009). Mediterranean coastal zones are sectors characterized by increasing urbanization, in which many activities are performed that are not without consequences on the quality of the water and the sustainability of natural populations.

The main regressions of marine Magnoliophyta meadows recorded in the Mediterranean are related to shores restructuring, management of living resources (fisheries and aquaculture), solid and liquid waste, the development of pleasure boating and tourism (cruises) and the introduction of exotic species. More recently, the rising temperature of the water and the rise in the sea level could explain certain regressions (Marbà & Duarte, 2010). These regressions primarily concern the emblematic species *Posidonia oceanica*, though other species are also affected by anthropogenic impacts (Boudouresque et al., 2009). Within the Mediterranean basin, the decline of seagrass meadows seems to be relatively limited between 0 and 10% throughout the 20th century (Boudouresque et al., 2009). In sectors subject to strong anthropogenic pressures, declines can be much more significant (5 to 8 % per year; Marbà et al.,1996). The ecological characteristics of seagrass species in the Mediterranean enable them to cover a wide spectrum of abiotic conditions, and their sensitivity to anthropogenic pressures is also very different (Boudouresque et al., 2009). While *Posidonia oceanica* constitutes the "climax" species for a large part of Mediterranean shorelines, *Cymodocea nodosa* and, to a lesser extent, *Zostera noltii*, can constitute pioneer species in the succession, allowing for the settlement of *Posidonia oceanica* meadows (Boudouresque et al., 2006). Furthermore, when environmental conditions become unfavorable for one species, it may be replaced by another. However, while *Posidonia oceanica* can be replaced by native species, it can also be replaced by opportunistic "introduced" species (Montefalcone et al., 2010). Furthermore, these substitutions by species with weaker structuring capacities may trigger profound changes within the communities.

3.3.3. Coralligenous

3.3.3.1 State and trends of coralligenous and associated biodiversity

The Coralligenous assemblages are biological formations among the most representative components of the Mediterranean marine biodiversity. These are biogenic constructions present in many Mediterranean areas. The most recent estimates of their extent show that the coralligenous outcrops cover about 2,760 km^2 and the maërl beds, another coralligenous component, cover about 1,655 km^2. Knowledge about the distribution, species composition and functioning of coralligenous and other calcareous bio-concretion remained fragmentary for a long time. However, recent technical advances have made it possible to acquire more data on the coralligenous. Thus, several sites rich in coralligenous have been identified and inventoried as areas of conservation interest. In addition, it has been possible to highlight the negative effect of certain human activities which is expected to be exacerbated by the interdependent effects of climate change and growing human pressure. Considering the ecological and natural heritage value of Mediterranean coralligenous assemblages, several international bodies have issued recommendations and adopted conservation and management measures targeting theses assemblages (Barcelona and Bern Conventions, EU Habitat Directive).

3.3.3.2 Ecosystem services

The coralligenous assemblages contribute to carbon sequestration and storage and generate a remarkable natural productivity which contributes to the maintenance and development of fisheries resources. Numerous species (more than 1,700 species, i.e. 15 to 20 % of Mediterranean species) use coralligenous environments as feeding, breeding or nursery grounds, including species of commercial interest for fisheries as well as endangered or threatened species.

Furthermore, being attractive for scuba diving activities, they support, in some Mediterranean areas, important recreational economic activities whose existence depends on the presence and the state of conservation of these assemblages.

3.3.3.3 Major pressures

The main pressure on coralligenous assemblages comes from the destructive effect of some gear used for fishing, such as bottom trawls or gill nets, as well as from boat anchoring systems (anchors and anchor chains) that exert a mechanical aggression on coralligenous formations.

In addition, cases of invasion by invasive non-indigenous species have been recorded in some Mediterranean areas where they covered the coralligenous beds, hindered its normal development and thus caused the regression of its assemblages. Among these invasive species there are some algae such as *Womersleyella setacea*, *Acrothamnion preissii*, *Asparagopsis taxiformis* and *Caulerpa taxifolia*.

As with the rest of the marine environment, coralligenous assemblages are affected by pollution and climate change. Massive mortalities of species related to these environments were reported in recent years in depths of 30 to 40 m and were attributed by scientists to disturbances in the position of the thermocline, under the influence of marine waters warming.

Ocean acidification impacts a wide array of organisms producing carbonate shells and skeletons (Palmieri *et al*, 2015; Kapsenberg *et al*, 2017). These effects are biological (e.g. early stage survival) as well as ecological (e.g. loss in biodiversity, changes biomass and trophic complexity) processes (Gattuso *et al*, 2015). Effects of recent acidification in the Mediterranean Sea have led to a significant decrease in the thickness of coccolith, calcareous plates harbored by some phytoplankton, between 1993 and 2005 (Meier *et al*, 2014). Overall, effects are highly species-dependent. At the community level, modifications in species composition and abundance shifting from assemblages dominated by calcifying species to non-carbonated species (e.g. erect macroalgae) were reported even under moderate decrease in pH (Hall-Spencer *et al*, 2008; Kroeker *et al*, 2011; Linares *et al*, 2015). In coming decades, synergies between warming and acidification are likely to affect a large number of marine species including commercial species such as mussels (Rodrigues *et al*, 2015).

The simultaneous effects of multiple stressors - such as pollution, siltation, destructive fishing practices, anchoring, scuba diving, biological invasions, anomalies in the sea water temperature regime, etc. - generate irreversible consequences on these fragile biological formations.

3.3.3.4 Management of coralligenous ecosystems

Given the relatively limited knowledge about the geographical distribution of coralligenous habitats, as well as about the actual level of damages they undergo, priority should be given to (i) improving current knowledge to fill gaps in the information about the occurrence of coralligenous communities (ii) promoting the use of standard methods for the inventory and monitoring of sites with coralligenous assemblages, (iii) capacity building in Southern and Eastern Mediterranean countries to improve skills in habitat mapping and (iv) information sharing /exchange among the Mediterranean countries about the occurrence of invasive species having the potential to negatively impact the coralligenous.

As part of the implementation of the Action Plan for the conservation of Coralligenous and other Calcareous Bio-concretions in the Mediterranean, adopted by the Contracting Parties to Barcelona Convention, the following conservation and management activities were undertaken during the last five years:

- Elaboration of a reference list of species that are found in coralligenous outcrops,
- Promoting taxonomic identification of species constituting these assemblages through an inventory of taxonomist experts and researchers/institutions working in the field,
- Elaboration of standardised methods for the inventory and the monitoring of coralligenous assemblages,
- Mapping of sites with coralligenous formation with the view establishing marine protected areas.

3.3.4. Dark habitats

3.3.4.1 Status and trends of Dark habitats and linked biodiversity

Dark habitats are among the fragile components of the Mediterranean marine biodiversity. They occur in deep zones as well as in areas with a very limited luminosity and are usually associated to specific geomorphological structures such as underwater caves, slopes and abyssal plains.

Since the absence of photosynthetic processes in these environments does not allow for the presence of herbivorous, the species forming the biocenosis in dark habitats are mainly filter feeders, scavengers and carnivores. Unlike the Atlantic, the Mediterranean deep waters are characterized by the absence of typical deep-sea species (bathypelagic species like the foraminifers *Xenophyophora*, the sponges *Hexactinellidae*, the sea-cucumber of the *Elasopodida* order, etc.) (Zenetos et al., 2002; WWF-IUCN, 2004). Mediterranean deep-sea life forms are essentially eurybathic (wide depth range) species. Other faunistic groups (decapodal crustaceans, mysidaceae, echinoderms and gastropods) are weakly represented in the deep sea. The macrofauna of the Mediterranean deep sea is dominated by fishes and decapodal crustaceans. Differences exist between the western and eastern Mediterranean in both specific composition and abundance. The species of macrofauna are typically smaller than those of the Atlantic. The meiofauna is less abundant in the eastern Mediterranean.

In the deep sea, the rate of endemism for many taxa (i.e. 48 % for amphipods) is clearly higher than the average endemism rate in the Mediterranean (UNEP-MAP RAC/SPA 2010).

In the Mediterranean, dark habitats are the least surveyed elements of the marine environment, and the measures for their conservation and management remain very limited, in particular because of the substantial gaps in knowledge about the distribution and the extent of these marine habitats. Work published by WWF and IUCN (WWF/IUCN, 2004) draws the broad outlines of deep-sea ecosystems in the Mediterranean. The bathyal and abyssal domains cover respectively about 60 % and 10 % of the total surface area of the Mediterranean Sea (UNEP-MAP RAC/SPA 2010). Deep-sea Mediterranean habitats include: underwater canyons, chemosynthetic communities, cold water corals, seamounts and deep hypersaline habitats (UNEP-MAP RAC/SPA 2010).

Underwater canyons are of major importance in the Mediterranean since they represent, for many species, places for reproduction and feeding (fishes, cetaceans like *Grampus griseus* and *Physeter macrocephalus*). Also, they represent a remarkable reservoir of endemism in the Mediterranean (jellyfish, *polychaetes*).

Chemosynthetic communities are communities of the hydrothermal springs characterized by symbiosis between invertebrates and chemotrophic bacteria which, using the energy freed by the chemical transformation of certain compounds of the hydrothermal fluid, in particular hydrogen sulphide, can synthesize the first organic molecules from carbonic gas and nutritive salts. Their interest lies in their originality and rarity in the Mediterranean. These habitats are found in southern Crete, southern Turkey (Anaximander Seamounts) and off Egypt and Gaza (ICSEMS, 2004).

Cold water corals are habitats of great ecological value but that are threatened by deep sea trawling and by the effects of global warming (CIEMS, 2004).

Seamounts are underwater mountains that emerge from the seabed and constitute singular habitats in the marine environment. They represent essential habitats for the life-cycles of several species and contain high density levels of macro- and megafauna. Seamounts are characterized by a high rate of endemism (i.e. hydrozoa). They are also feeding places for many species of fish and cetacean. In the Mediterranean, the Sea of Alboran (Spain), the Balearic Sea (Spain), the Gulf of Lions (France) and the abysses of the Ionian Sea are of special interest for these habitats.

Deep hypersaline habitats, known as brine pools are deep-sea habitats of high biodiversity importance, particularly to extremophilic bacteria and metazoan meiofaunal assemblages (IUCN-WWF, 2004). Little data exists on these habitats but they are considered to be important environments because of their specific Mediterranean feature (CIEMS, 2004).

3.3.4.2 Ecosystem services

Besides their importance as natural heritage, dark habitats provide valuable services in particular through the support to commercial fishing resources and through their role in the biogeochemical cycles sustaining the balance of the marine trophic chain (cycles of nitrogen, phosphorus, carbon, sulphur, etc.). For example, marine canyons play a very important role in the continents/oceans exchanges and are among the main paths for the surface/bottom transfers of energy and matter.

3.3.4.3 Major pressures

Land-based sources of pollution and of other kind of pressures generate the major impacts on dark habitats that may reach even those located in the deeper zone. The coastal river inputs significantly contribute in nutrient enrichment, marine acidification and the local disturbance in sea water temperature recorded in some dark habitats. The increasing oil and gas activities in Mediterranean deep zones constitute other sources of pressures for the dark habitats mainly the drilling operations and the laying of pipelines. Furthermore, recent deep-sea surveys conducted in the Mediterranean revealed the increasing pollution of these habitats by solid wastes, including lost or abandoned fishing gear and plastic containers/debris from terrestrial origin.

3.3.4.4 Management of Dark habitat ecosystems

During decades the dark habitats – in particular those located in deep sea zones of the Mediterranean- remained without any conservation or management measures. However, following alerts from scientists and from several conservation organisations, there is a growing awareness of the need to preserve such environments. One of the concrete measures taken was the banning decided by the General Fisheries Commission for the Mediterranean (GFCM) concerning the use of towed fishing gears in depth beyond one thousand meters. Furthermore, several field surveys were undertaken to collect data about marine canyons which led to the declaration of protected areas covering some of these sites; the declaration processes being underway for others.

Nevertheless, preserving dark habitats remains for the Mediterranean Sea a crucial challenge whose success requires further efforts to improve knowledge concerning these environments and to overcome the technical and legal challenges faced, in particular in areas beyond national jurisdictions.

3.3.5. Genetic diversity and threatened species and habitats

Today the Mediterranean Sea is known to host more than 17,000 marine species and contributes to an estimated 4 to 18 % of the world´s marine biodiversity (Bianchi and Morri, 2000; Coll et al. 2010). About 694 of the species assessed for the IUCN Red List in the Mediterranean are recorded as being native and occurring in the Mediterranean Sea and 68 of them are endemic.

Past changes in oceanographic conditions in the Mediterranean Sea have influenced the current patterns of biodiversity and genetic structure of species due to changes in environmental conditions across time (Coll et al. 2010). Differences between the Western and Eastern basins of the Mediterranean Sea, with the latter being more oligotrophic and warmer but less biodiverse than the western basin, coincide with the genetic boundaries described for various species including seagrasses (Alberto et al. 2008, Chefaoui et al. 2017), fish (Bahri-Sfar et al 2000), sea cucumbers (Valente et al. 2015), and bivalves (Nikula and Väinölä 2003).

Recovery from fragmentation or events of mass mortality, either natural or human induced, may be critical for some species in the Mediterranean Sea. This is the case of the pen shell *Pinna nobilis*, a listed endangered species of the Mediterranean Sea (Barcelona Convention, protocol SPA/BD Annex 2) that recently is experiencing a mass mortality across the Mediterranean Sea[5]. The high genetic diversity and low inter-population differentiation have strong consequences for conservation of this species, as directly influence how could be naturally recovered from the *P. nobilis* populations located elsewhere (Wesselmann et al., 2018).

At least 78 (11 %) of the marine species assessed in the IUCN RLTS (68 of them endemics) are threatened with extinction at global or regional level in the Mediterranean region (Table 6). Cartilaginous fishes constitute the group with the highest number of threatened species (40 species), followed by anthozoa with 17 threatened species. The estimated percentages of threatened species by group indicate that reptiles and cartilaginous fishes have the highest percentages of threatened species (75 % and 65 % of species) followed by marine mammals (64 %).

Table 6: Conservation status of species habiting Mediterranean marine habitats based on the results of the extinction risk assessments of the IUCN Red List at global and Mediterranean regional level. IUCN Red List categories CR, EN and VU correspond to the number of species in risk of extinction. IUCN Red List categories: CR Critically Endangered, EN

5 https://www.iucn.org/news/mediterraneo/201807/emergency-situation-pen-shells-mediterranean

Endangered, VU Vulnerable, NT Near Threatened, LC Least Concern, DD Data Deficient, RE Regionally Extinct, EX Extinct.

Taxonomic Group	CR	EN	VU	NT	LC	DD	EX	Total of marine threatened taxa	Total marine taxa assessed	% estimated marine threatened taxa in Mediterranean region (Mid-point)
Anthozoa	1	9	7	10	40	69	0	17	138	25%
Marine fishes (Bony fishes)	1	3	7	8	316	120	0	11	455	3%
Marine fishes (Cartilaginous fishes)	20	11	9	10	12	13	0	40	75	65%
Marine mammals	1	3	3	0	3	7	0	7	18	64%
Marine reptiles	1	1	1	0	1	0	0	4	4	75%
Marine plants	0	0	0	0	4	0	0	0	4	0%
Total	**24**	**27**	**28**	**28**	**376**	**209**	**0**	**78**	**694**	**16%**

*****Mid-point (CR + EN + VU) / (assessed – EX – DD)*

France, Spain, Italy and Greece have in this order the highest number of threatened species living in marine habitats in the entire region. Most of the threatened cartilaginous and bony fishes are found in France. The highest number of threatened anthozoa is recorded in Greece, while a high number of threatened marine mammals are found in Spain and Morocco (Table 7). Notably, although the assessed species represent an important percentage of the Mediterranean biodiversity, there is no certainty that the regions and countries which show high numbers of threatened species exactly coincide with the true distribution of the different taxa in the Mediterranean, and rather could be a reflection of the research efforts in certain regions.

Table 7: Number of threatened species by country. The highest number of threatened species by taxonomic group in bold

	Marine threatened taxa in Mediterranean region					
Countries	Anthozoa	Marine Fishes (Bony fishes)	Marine Fishes (cartilaginous fishes)	Marine Mammals	Marine Reptiles	Total
France	13	11	60	6	2	92
Spain	15	10	38	7	2	72
Italy	15	9	37	6	1	68
Greece	17	8	33	6	1	65
Croatia	11	8	30	6	1	56
Morocco	7	7	34	7	1	56
Algeria	9	7	33	6		55
Tunisia	8	8	31	6	1	54

Turkey	10	8	28	6	1	53
Albania	5	7	30	6	1	49
Montenegro	5	6	29	6	1	47
Egypt	2	7	26	6	3	44
Libya	2	7	27	6	1	43
Slovenia	4	8	25	5	1	43
Israel	3	6	26	5	2	42
Cyprus	3	7	22	6	2	40
Syria	2	6	23	6	1	38
Lebanon	2	6	22	6	1	37
Malta	9	6	16	6		37
Bosnia and Herzegovina	1	3	23	6	1	34
Monaco	3	8	8	5		24
Palestine			12	3		15

Major pressures to marine biodiversity

The analysis of the threats affecting 77 Mediterranean marine species in risk of extinction in the IUCN Red List (categories CR, EN and VU) (IUCN 2018) showed that fishing (overfishing, bycatch and damage impacts on habitats) is the main driver increasing the species extinction risk. Other important threats are urbanization, pollution and climate change (Figure 7). As human populations and levels of consumption increase, overfishing presents a growing threat to the region's fish diversity, with potentially significant indirect impacts on other species through, for example, depletion of food supply. For example, bottom trawling fisheries are identified as the main cause for the decline of the Maltese skate, *Leucoraja melitensis* or the bamboo coral, *Isidella* elongata by 80 %, making both native species as Critically Endangered of extinction (Dulvy andWalls, 2015; Dulvy et al. 2016; Otero et al 2017).

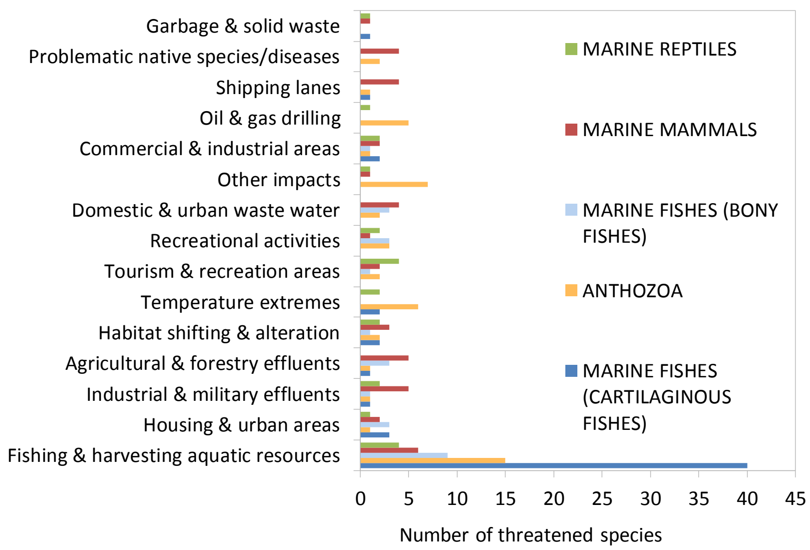

Figure 7 Main threats affecting Mediterranean marine species in risk of extinction (IUCN Red List Categories CR, EN and VU) in the Mediterranean region

Under the Convention on Biological Diversity, EBSAs (Ecologically or Biologically Significant Areas) are marine areas deserving management, warranting their sustainability using seven scientific criteria. These criteria were adopted at the 9th Conference of the Parties to the Convention on Biological Diversity in 2008[6]. The criteria are (i) uniqueness or rarity, (ii) special importance for life history stages

6 CBD Decision IX/20, Annex I

of species, (iii) importance for threatened, endangered or declining species and or habitats, (iv) vulnerability, fragility, sensitivity or slow recovery, (v) biological productivity, (vi) biological diversity, and, (vii) naturalness. An EBSA process has been realized in the Mediterranean and has provided a list of 17 areas defined of which 15 have been agreed upon by the countries for official listing in CBD Repository (Table 8/Figure 8). The decision for conservation efforts or special management measures remains the responsibility of each country surrounding the area, alone or together.

Table 8 Ecologically or Biologically Significant Marine Areas (EBSA) considered by the CBD Conference of the Parties in the Mediterranean Sea

EBSA name	Countries
North Aegean	Greece, Turkey
Northern Adriatic	Italy, Slovenia, Croatia
Sicilian channel	Italy, Tunisia, Malta
Akamas and Chrysochou Bay	Cyprus
East Levantine Canyons	Lebanon, Syria
Gulf of Sirte	Libya
Nile Delta Fan	Egypt
Hellenic Trench	Greece, Turkey
North-East Levantine Sea	Greece, Turkey, Cyprus, Syria
Le Golfe de Gabès	Tunisia
North-western Mediterranean benthic ecosystems	Spain, France, Monaco, Italy
Jabuka/Pomo Pit	Italy, Croatia
North-western Mediterranean Pelagic Ecosystems	Spain, France, Italy
Central Aegean Sea	Greece, Turkey
South Adriatic Ionian Straight	Italy, Montenegro, Albania

Source: Secretariat of the Convention on Biological Diversity (SCBD)

Figure 8 Ecologically or Biologically Significant Marine Areas (EBSA) *considered by the CBD Conference of the Parties* **in the Mediterranean Sea**

The vulnerable marine ecosystem (VME) concept emerged from discussions at the United Nations General Assembly (UNGA) and gained momentum after UNGA Resolution 61/105 in 2006. The FAO International Guidelines for the Management of Deep-sea Fisheries in the High Seas (FAO DSF Guidelines) build on the resolution and provide details on the VME concept for fisheries management. In order to identify VMEs, five criteria have been agreed upon: (i) uniqueness or rarity, (ii) functional significance of the habitat, (iii) fragility, (iv) life history traits of component species that make recovery difficult, and (v) structural complexity.

For the Mediterranean, the General Fisheries Commission for the Mediterranean (FAO) is developing the process for identifying, recording, declaring and managing VMEs in the region. A list of species that may contribute to form VMEs has been prepared and a protocol has been proposed for VME encounter and registration.

Concerning habitats, IUCN is developing a methodology similar to the Red List of Species that will provide a classification of the status of ecosystems. Using this methodology, a recent project (2016-2017) developed by the European Union was covering the Mediterranean waters of European countries and has provided a provisional evaluation of the existing benthic habitats on the continental platform (0-200m). For the 47 habitats considered, the study indicates that none are critically endangered, 5 endangered, 10 vulnerable, 5 near threatened, 4 of least concern and 23 data deficient. This last figure confirms that the knowledge about the Mediterranean is still limited and that any evaluation does not represent the full reality, supporting a precautionary approach.

Some specialized organisations, such as the ACCOBAMS, for cetaceans' conservation, have or are developing their own system for identifying critical habitats for the survival of species, considering the threats. The Cetacean Critical Habitats (CCH) have been described in the Mediterranean and are helping the countries in reducing the potential impacts by developing site specific conservation plans. A similar approach has been taken by BirdLife for identifying important Bird and Biodiversity Areas, IBAs.

Concerning threatened and endangered species, Annexes II and III of the SPA/BD Protocol of the

Barcelona Convention are considered as reference lists of species in need of special care in the Mediterranean. These lists are regularly evaluated and, where necessary, amended through a process based on the expertise available at national level as well as with the relevant IGOs and NGOs. The most recent amendment to these lists7 concerns endangered and threatened species in the Mediterranean, including 163 species (Mammalia, Aves, Reptiles, Pisces, Echinodermata, Crustacea, Mollusca, Bryozoa, Cnidaria, Porifera, Rhodophyta, Heterokontophyta, Chlorophyta, Magnoliophyta).

Box 4 The ACCOBAMS survey initiative, a mediterranean large-scale survey for collecting new data on cetaceans, marine macro fauna and marine litter

The Mediterranean Sea is exceptionally rich regarding marine megafauna and regularly or occasionally hosts more than 20 species of cetaceans, about half of which are considered threatened or with insufficiency of data.
Subject to high anthropogenic pressures, cetacean populations benefit from particular attention from Mediterranean States willing to better coordinate their actions in their favor. Coordinated by the Permanent Secretariat of the Agreement on the Conservation of Cetaceans of the Black Sea, the Mediterranean and the Adjacent Atlantic Area (ACCOBAMS), the ACCOBAMS Survey Initiative (ASI) aims establishing an integrated, collaborative and coordinated monitoring system regarding the status of cetacean populations.
During the summer 2018, an unprecedent large-scale synoptic survey combining visual and passive acoustic monitoring methods was conducted across the whole Mediterranean. The ASI Survey has represented a considerable logistical and administrative challenge: over 100 scientists from the region and beyond were involved, 6 ships and 8 aircrafts were mobilized, and more than 30 national and international partners have collaborated in this very unique effort. The ASI survey followed a multispecies approach, with cetaceans as primary targets, collecting data on elasmobranches, sea turtles, seabirds and other mega-vertebrates but also on anthropic pressure such as marine litter.
An analysis of the ASI data is conducted collectively in 2019 with the aim of developing accurate mapping of cetacean populations distribution and abundance. The results of this survey will be cross-referenced with existing data on relevant indicators and will lead to confirm existing areas of interest for cetaceans' conservation and potentially identify new ones (Cetacean Critical Habitats, Important Marine Mammals Areas). The results of this large-scale survey will also support the formulation and adoption of conservation actions, including MPAs.

The ASI has proven to be a unifying project both in terms of biodiversity conservation and for the reinforcement of national capacities around the Mediterranean. For the first time, all Mediterranean countries have collaborated for implementing this unique biodiversity conservation effort.

Figure 9 ASI aerial observations of small cetaceans (summer 2018)

As remarked by Templado (2014) and Boero (2015), the Mediterranean marine ecosystems are going through important modifications with the following general trends:

7 Through Decision IG23/10 that amended the Annex II of the SPA/BD Protocol.

- *Tropicalization*: Non-indigenous species of warm water affinity (tropical) become increasingly established;

- *Meridionalization*: The species that usually thrive in the southern part of the basin expands northwards, adding to tropical ones in changing northern biota;

- *Impairment of cold water engines*: The Eastern Mediterranean Transient showed that, in a period of global warming, the cold engines might fail renewing deep Mediterranean waters, with vast consequences on MSE;

- *Changes in the phenology of species*: reproductive patterns are modified by different thermal conditions: species of warm water affinity have greater opportunities to grow and thrive than species of cold water affinity;

- *Species extinction*: cold water species will be pushed in deeper waters, their surface populations having already suffered severe mass mortalities, with a risk of extinction though some of them may adapt to the new conditions (Boero et al., 2013);

- *Less fish, more jellyfish and jellyfish eaters*: the fish-jellyfish transition is already happening at a world scale, with possible prediction of an increase of predators like sun fish and marine turtles;

- *Habitat destruction*: the cumulative effects of land-based human activities, along the watershed (e.g. pollution) and at the land-sea interface (e.g. maritime infrastructures) greatly contribute to habitat destruction (Claudet et Fraschetti, 2010).

3.3.6. Invasive species

The Ecosystem Approach (EcAp) recognises that to achieve good environmental status "non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystem". A total number of more than 1,000 non-indigenous marine species were recorded in the Mediterranean, of which 618 are established (UNEP-MAP, 2017). Of those established species, 106 have been flagged as invasive. These estimates exclude vagrant species and species that have expanded their range without human assistance through the Straits of Gibraltar. The increase in introduction rate goes back to the last decades and is attributed by specialists to the intensification of some human activities, such as shipping, and also to the global changes that started to result in more favourable conditions that facilitated the settlement in the Mediterranean of viable populations of alien tropical marine species.

Some of these non-native species proved to be invasive in the meaning of the CBD definition[8]. An assessment published in 2014 (Katsanevakis et al., (2014)) concluded that 64 invasive species were reported to occur in the Mediterranean. The most represented groups were crustaceans (23 species),

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[8] CBD Definition of Invasive alien species: Plants, animals, pathogens and other organisms that are non-native to an ecosystem, and which may cause economic or environmental harm or adversely affect human health. In particular, they impact adversely upon biodiversity, including decline or elimination of native species - through competition, predation, or transmission of pathogens - and the disruption of local ecosystems and ecosystem functions.

followed by molluscs (20 species) and macroalgae (16 species).

The introduction paths of non-native species to the Mediterranean include the natural communication openings, but there is scientific evidence that most of the alien species recorded in the Mediterranean entered through the Suez Canal. Other introduction paths were also identified in particular ballast waters and aquaculture.

Besides their impacts on the ecosystems, several macroalgae (eg: Codium fragile fragile, Gracilaria vermiculophylla, Grateloupia turuturu, Sargassum muticum, Undaria pinnatifida) were reported to cause negative economic impacts on aquaculture and fishing through fouling of shellfish aquaculture facilities, invading shellfish beds and obstructing dredges and other towed fishing gears. Cases of decline in commercial stocks due to direct predation or competition for resources by invasive species were also reported and concerned several groups of such as decapods (Homarus americanus and Paralithodes camtschaticus), fish species (Fistularia commersonii, Neogobius melastomus, Saurida undosquamis, Liza haematoche, Siganus luridus and S. rivulatus), bivalves (Crassostrea gigas and Pictada imbricata radiate) and gastropods (Urosalpinx cinerea and Rapana venosa).

Table 9 Number of marine non-indigenous species reported to generate significant adverse impacts on ecosystem services and biodiversity. Source: compiled from Katsanevakis et al., (2014)

Phylum	Number of species	Phylum	Number of species
Crustacea	18	Cnidaria	3
Mollusca	18	Ascidiacea	3
Macroalgae	15	Tracheophyta	3
Fish	8	Bryozoa	2
Polychaeta	5	Ctenophora	2
Dinophyta (Myzozoa)	4	Haptophyta	1
Ochrophyta	3		

Table 10 List of species identified as of very high or of high priority species for risk analysis (Source: compiled from Roy et al., 2015)

MAC: Macaronesia (Canary Islands, Madeira, Azores); MED: Mediterranean ; BLK: Black Sea; ATL: NE Atlantic ; BAL : Baltic; WTA: Western Tropical Atlantic; CIP: Central Indo-Pacific ; TNWP: Temperate NW Pacific (Japan, Korea, N China, E Russia); TNEP: Temperate NE Pacific (W Canada, W USA (California northwards), S Alaska); TNWA:Temperate NW Atlantic (E USA, E Canada); TNEA: Temperate NE Atlantic (Europe, NW Africa); EIP: Eastern Indo-Pacific (Hawaii, Guam); CIP: Central Indo-Pacific (Philippines, Malaysia, Taiwan, N Australia); WIP: Western Indo-Pacific (India, E Africa, Red Sea); TEP: Tropical Eastern Pacific (Central America); TWA: Tropical Western Atlantic (Caribbean, Brazil); TSWA: Temperate SW Atlantic (Argentina); TA : Temperate Australasia (Australia, NZ)

Species	**Invaded zones**	**Threatened Bio-regions**
Pterois miles	MED, WTA	MED, MAC, ATL
Penaeus aztecus Ives, 1891	MED, CIP	MED, MAC
Plotosus lineatus (Thunberg, 1787)	MED, TNWP, CIP, TA	MED, MAC
Homarus americanus H.M. Edwards, 1837	TNEA, ATL	MED, ATL, MAC
Codium parvulum P.C.Silva, 2003	MED	MED, MAC
Botrylloides giganteum (Pérès, 1949)	MED	MED, MAC
Crepidula onyx G. B. Sowerby I, 1824	CIP, TNWP	MED, ATL, MAC
Mytilopsis sallei (Récluz, 1849)	MED, CIP, WIP, TNWP	MED, MAC, ATL, BAL, BLK
Pseudonereis aNonmala Gravier, 1900	MED	MED, MAC
Acanthophora spicifera Børgesen, 1910	EIP, CIP	MED, MAC
Charybdis japonica (Milne-Edwards, 1861)	TA	MED, MAC, ATL
Perna viridis (Linneaus, 1758)	TA, CIP, EIP, TNEP, TNW	MED, MAC, ATL
Symplegma reptans (Oka, 1927)	ETP, EIP	MED, MAC, ATL, BLK
Potamocorbula amurensis (Schrenck, 1861)	TNEP, TA	MED, MAC, ATL, BLK, BAL
Macrorhynchia philippina Kirchenpauer, 1872	MED, MAC, ATL	MED, MAC, ATL
Polyopes lancifolius Kawaguchi & Wang, 2002	TNEA, ATL	ATL, MED, MAC
Rhodosoma turcicum (Savigny, 1816)	WTA, MED	MED, MAC, ATL

Dorvillea similis (Crossland, 1924)	MED	MED, MAC
Ciona savignyi Herdman, 1882	TNEP, TSWA, TA	ATL, BLK, BAL, MED, MAC
Didemnum perlucidum F. Monniot, 1983	WTA, EIP, CIP, ETP, TA	MED, MAC
Ascidia sydneiensis Stimpson, 1855	ETA, WTA, CIP, EIP, TSA	MED, MAC, ATL
Balanus glandula (Darwin 1854)	SWA, TNWA, TSA	ATL, BA
Dictyosphaeria caverNonsa Børgesen, 1932	EIP	MED, MAC
Zostera japonica Ascherson & Graebner, 1907	TNEP	MED, MAC, ATL, BLK, BAL

Given the seriousness of the issue of biological invasion by marine non-indigenous species, the riparian countries to the Mediterranean Sea adopted in 2003, under the Barcelona Convention, the Action Plan on Introductions of Species and Invasive Species. To assist countries in implementing the Action Plan, SPA/RAC elaborated in consultation with Mediterranean experts, two technical tools: “Guidelines for controlling the vectors of introduction into the Mediterranean of non-indigenous species and invasive marine species”, and “Guide for risk analysis assessing the impacts of the introduction of non-indigenous species”.

Furthermore, REMPEC and SPA/RAC collaborated to elaborate the Mediterranean strategy for the management of ballast waters whose objective is to facilitate the implementation in the Mediterranean the relevant provisions of the International Convention for the Control and Management of Ships’ Ballast Water and Sediments (BWM Convention) adopted in 2004 under the auspices of the International Maritime Organisation (IMO).

Box 5 Introduction of alien species via maritime transportation

Shipping is a pathway for non-indigenous species introduction in the Mediterranean Sea via both ships’ ballast water and ships’ hull biofouling. Translocation via ships’ ballast water and sediments has been the focus area of action, and with the recent entry into force of IMO mandatory regulations there is an expectation that introduction of such invasive species will be minimised by 2024, when all ships globally will have to be equipped with the required ballast water treatment systems. Biosafety risks from ship biofouling have so far been neglected despite the fact that the relationship between ship's biofouling and non-indigenous species introduction in marine ecosystems has been known for a long time.

Studies suggest that vessel biofouling accounts for more than 40 % of all marine invasions and is therefore a major pathway for non-indigenous species introduction. Specifically, it was estimated that at least 55 % of the 1780 recognised non-indigenous species detected around the world have life history characteristics that make them likely to be associated with biofouling on vessel hulls (Hewitt & Campbell, 2010), as shown in the Figure 10 below.

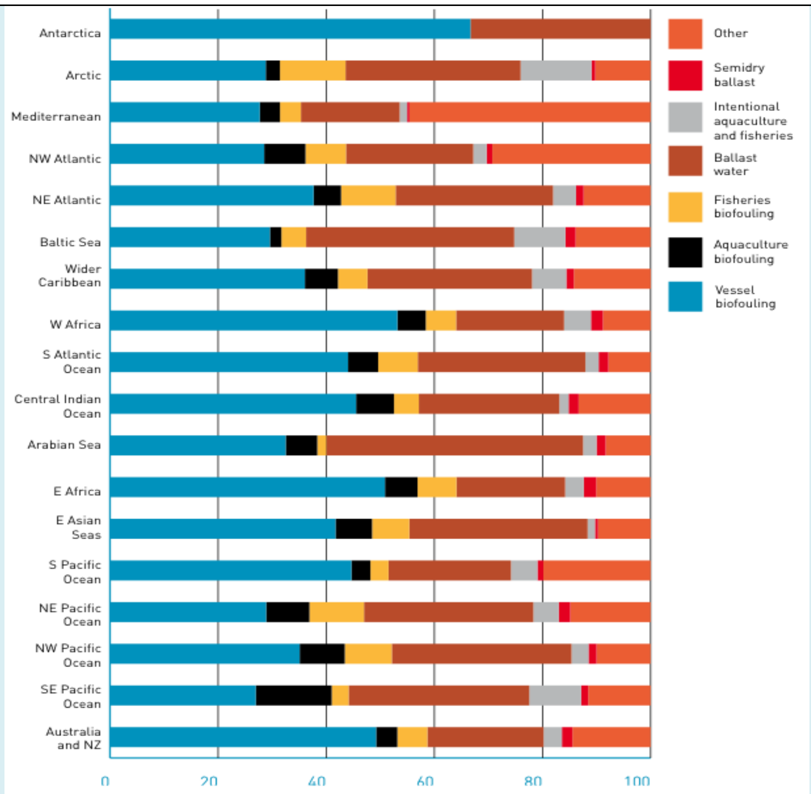

Figure 10 Percentage of marine bio-invasions by regions according to contribution of specified transport mechanisms. Source: Hewitt & Campbell (2010)

While international measures (International Convention for the Control and Management of Ships' Ballast Water and Sediments) entered into force in September 2017, with a requirement for shipowners to equip their ships with a ballast water treatment system, there is no mandatory international framework to address marine bio-invasions from ship fouling. IMO has adopted Guidelines on biofouling (2011 Guidelines for the control and management of ships' biofouling to minimize the transfer of invasive aquatic species) that set out best practices to prevent, monitor and clean biofouling but these are voluntary, and implementation is left to the good will of countries and the industry. However, this issue is gaining attention at IMO given that some countries have developed or are developing domestic regulations to address bio-invasion risks from ship hull biofouling.

3.4. Responses and priorities for action

3.4.1. Marine and coastal protected areas

Box 6 The MAPAMED Database

MAPAMED, the Mediterranean database and GIS including MPAs and Other Effective Area-Based Conservation Measures (OECMs) of the region and covering the marine and coastal environment, is a database developed by the SPA/RAC and MedPAN to assist the countries in the registration and spatial description of MPAs and OECMs in the region. As a database on sites of interest for the conservation of the marine environment in the Mediterranean Sea, MAPAMED can be used by the countries for preparing reports and evaluating their activities.
In the MAPAMED database, a "Marine Protected Area" is understood as "a clearly defined marine geographical space - including subtidal, intertidal and supratidal terrain and coastal lakes/lagoons connected permanently or temporally to the sea, together with its overlying water - recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values".

In order to develop a coherent, representative and well managed network of marine protected areas (MPAs) or other effective area-based conservation measures (OECMs), as recommended by the CBD and in particular the Aïchi target 11, as well as by the UN Sustainable Development Goal 14 (SDG 14), to preserve 10 % of the waters under their jurisdiction by 2020, the Mediterranean countries have to develop a proper legal and institutional system for the management and monitoring of these areas. Most of them have to-date established a proper system, based on regulations related to environment, fisheries, ICZM, marine spatial planning or other legal tools, allowing a better implementation of the management, including control and surveillance, funding, fishing or maritime transport.

Within the framework of the CBD, countries have to prepare and adopt a National Biodiversity Strategy and Action Plan (NBSAP). Most of them have done so, for a given period, and are presently revising it. Some others have adopted it until 2030 (Egypt and Algeria). These documents normally include a section on marine and coastal protected areas (MCPAs). In parallel, some of these countries have prepared or adopted a national strategy or plan for MCPAs or for MPAs, such as Albania, Algeria, Egypt, France, Lebanon and Libya.

At least, 251,690 km² of the Mediterranean Sea should be covered by MPAs or OECMs by 2020 to reach target value Aichi 11 and SDG 14. Based on MAPAMED, considering all the categories/labels, national and international designations, and Other Effective area-based Conservation Measures (OECMs), the number of MPAs and OECMs in the Mediterranean has reached 1233. In terms of areas covered, it includes the national declarations (about 82,600 km^2), the Natura 2000 declarations for the European countries (about 59,700 km^2), the Pelagos sanctuary concerning three countries (France, Italy and Monaco, about 87,300 km^2), the Strait of Bonifacio Particularly Sensitive Sea Area (IMO) concerning two countries (France and Italy, about 11,000 km^2), the Fisheries Restricted Areas (GFCM) with an objective of conservation of ecosystems or species concerning three countries (Cyprus, Egypt and Italy, about 15,700 km^2), the Ramsar sites (about 3,300 km^2), the World Heritage Sites (UNESCO, about 200 km2), the Biosphere Reserves (UNESCO, about 1,600 km^2) and the SPAMIs (UN Environment/MAP-Barcelona Convention, about 90,000 km^2). Values are not cumulative since several areas have multiple designations. Strong boost towards the Aichi target value 11 and SDG 14 reaching was done in 2018 through the declaration on 30 June 2018 of the Spanish Cetacean Corridor along East coast of Spain, embracing 42,262.82 km². That way, the marine area covered by conservation measures (MPAs and OECMs) nearly reached 223,000 km^2, representing more than 8,9 % of the Mediterranean Sea surface. The over eight-fold enlargement of Cabrera National Park and SPAMI approved on January 2019, also in Spain, with 807.73 km² of open sea, including deep sea, renders a Mediterranean national designation increase of 43,070.55 km², summing a total Mediterranean surface up to just over 9 %. Assuming the January 2019 coverage as 226,665 km², 25,025 km² are additionally needed by 2020 to reach target value Aichi 11 and SDG 14, regardless of management effectiveness or whether regulations are implemented, challenging but not impossible.

The national fisheries reserves (more than 120 in the Mediterranean) that have, in addition to a sustainable use of fishing resources, an objective of conservation of species or ecosystems have not been considered, as it is necessary to review each site declaration text for identifying their specific objectives. For the coming years, numerous areas are proposed (by experts) or considered by countries in their strategies for the declaration as MPAs or OECMs, representing 118 sites in 12 countries. The national fisheries reserves with an objective of conservation of ecosystems, habitats or species are under development in numerous countries and will be included in the MAPAMED database in the future.

The legal and institutional aspects of participation of all stakeholders in the different aspects of development and conservation, in particular for MPAs or OECMs are taken into consideration by all countries, usually under the Environmental Impact Assessment process, respecting the principles of the UNECE Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters (Aarhus Convention).

Most of the countries have included in their legislation the obligation of adoption, implementation and revision of management plans for protected areas. In some countries, specific administrations have been identified for this purpose, and others for training the national staff on management, enforcement or regulations. Nevertheless, management remains one of the weakest points in the Mediterranean, where it is estimated that only about 10 % of existing MPAs or OECMs[9] have a proper implementation of their management plans, with sufficient funds and skilled staff for ensuring all the necessary management and conservation tasks. The main reasons behind these weaknesses are linked to the lack of financial

9 MedPAN *et. al.* 2016. The 2016 status of Marine Protected Areas in the Mediterranean: Main findings. Brochure MedPAN & UN Environment/MAP - SPA/RAC

resources, with only 12 % of the needs for effective MPA management covered by regular financial resources10, as well as of skilled staff and to gaps in the legislation and regulations governing the management of protected areas and the enforcement of conservation measures.

In line with all the proposals and recommendations made during the past 20 years, and in particular with the Tangier Declaration and the updated 2020 Mediterranean MPA Roadmap11 prepared during the Mediterranean MPA Forum of 2016, where all the concerned stakeholders have joined efforts for a continuous improvement of the conservation and sustainable use of marine resources in the region, the following elements seem to be key for the future of Mediterranean region:

- Continuous efforts have to be made in specific countries and outside territorial waters using all the existing options, including MPAs, OECMs or Fisheries Restricted Areas, but also voluntary options by stakeholder groups such as fishermen or local populations;
- The coverage and implementation of no-entry, no-take and no-fishing zones, within either existing or future MPAs, need to be increased from the current coverage of 0.04% of the Mediterranean Sea to reach at least 2 % of no-take zones by 2020, especially in key functional areas;
- For the identification and declaration of new sites, it is essential to focus on representativity and connectivity, based on knowledge (including local communities), research (including mapping) and permanent monitoring of ecosystems, species and ecological conditions;
- For management, which is the weakest point at the present stage, different steps have to be taken, including:
    - the assessment of the legislation, not only the environmental one, but also looking at the fisheries, tourism, maritime transport and enforcement (police, coast guard, navy, using modern technologies) sectors. All these elements are important for allowing both the administration and MPA managers to fulfil their enforcement duties,
    - the training of nationals at all levels, including administrations, field staff, local stakeholders, as well as public awareness and education,
    - the development of co-management mechanisms, first between competent ministries listed above, but also with local administrations and local communities, NGOs and private initiatives,
    - the need to establish national environmental funds and/or other mechanisms for supporting conservation actions and particularly MPAs creation and management;
    - work towards creating a win-win relationship of MPAs with decision-makers, donors and private sector interested in marine and maritime spatial planning, integrated coastal zone management, blue growth strategies, sustainable tourism and sustainable fisheries policies, in order to respond to pressures beyond MPA borders, while considering MPAs as natural capital and a management instrument to reach sustainability targets.

For all these elements, networks of managers at different levels (i.e. national, regional and sub-regional) are and will be essential for achieving the above targets. Knowledge and capacity building, for a range of subjects, have been facilitated by MedPAN. The network of managers for marine protected areas has been developing a series of trainings, tools and experience sharing between Mediterranean MPAs to support MPA management. In this regard, MedPAN, SPA/RAC and WWF have developed the long-term capacity-building strategy for Mediterranean MPAs since 2012 to support MPA management. These activities will also contribute to the 'objectives set in the Regional Working Programme for the

10 Binet, T., Diazabakana, A., Hernandez, S. 2015. Sustainable financing of Marine Protected Areas in the Mediterranean: a financial analysis. Vertigo Lab, MedPAN, SPA/RAC, WWF Mediterranean. 114 pp.

11 Monbrison D., Rais C., Lopez A., Romani M., 2016, Updated Mediterranean MPA roadmap. MedPAN, SPA/RAC, Turkish General Directorate of Natural Assets Protection, UNDP Turkey/GEF project, Haut Commissariat aux Eaux et Forets et à la Lutte contre la Désertification 56 p.

Coastal and Marine Protected Areas in the Mediterranean including the "High Sea" and in the "Roadmap for a Comprehensive Coherent Network of Well-Managed Marine Protected Areas (MPAs) to Achieve Aichi Target 11 in the Mediterranean" adopted by the 19th Meeting of the Contracting Parties to the Barcelona Convention (Decision IG.22/13).

3.4.3. Regional regulatory tools, strategies and action plans

[To be completed, featuring EcAp indicators for the Ecological Objectives Biodiversity and NIS, and reporting under MSFD]

3.4.4. Economic and management tools

Sustainable financing of MPAs in the Mediterranean

In most developing or least developed countries, MPAs remain underfunded resulting in a less efficient protection of species and habitats. In the Mediterranean, MPAs also face operational difficulties, especially in non-European countries. In general, existing MPAs suffer from a significant lack of resources to finance recurrent costs including staff costs but also costs of equipment, monitoring, research, training and management, boundary demarcation, effective law enforcement and the provision of adequate park infrastructure. Existing financial contributions are well below requirements and reveal a strong disparity between the northern and southern basin. All of which affect protected area performance. **Establishing sustainable financing for MPAs is thus essential to help MPA reach an effective management.**

According to a study lead by MedPAN, SPA/RAC and WWF in 2015 (Binet et al., 2015), 86 % of MPA managers consider that their needs are not covered to effectively manage their MPA. There is an urgent need to consider an increase in current funding for existing MPAs in the Mediterranean region, given that only 8 % of the financing needs for effective management of MPAs are covered by current resources.

Currently, main financial resources for MPAs come from national and local public funds and multilateral (GEF) and bilateral cooperation (FFEM…). Other financial resources are: sub-regional projects (MAVA Foundation…), European financing instruments (LIFE, INTERREG MED, ENI MED…), but also private funds (foundations, sponsorship…), local financing mechanism and self-financing.

The 2016 Mediterranean MPA Forum Tangier declaration:

- Encourage leverage mechanisms to support the Contracting Parties to the Barcelona Convention and other relevant organisations in guaranteeing the basic funding needs of their national MPA systems.
- Encourage Official Development Assistance agencies and private donors to invest in MPAs as a potential contributor to achieving SDGs through food security, poverty alleviation and climate change adaptation and mitigation.
- Support the development of small funding programmes within MPAs as means, inter alia, to develop local project management capacities and as a lever to attract new and matching funding sources.
- Support, as an example of innovative financial mechanism, the establishment of the Trust Fund for Mediterranean MPAs, and welcome the recent progress made in this regard.
- Support the creation of a permanent financing facility to ensure, in case needed in times of crisis and during limited periods, the continuity of management in certain MPAs.

Box 7 M2PA – The association for the sustainable financing of Mediterranean MPAs

The 2020 Mediterranean MPA Forum (Antalya, Turkey) highlighted the need to establish a regional financial mechanism to support the sustainable financing of the Mediterranean MPAs to help countries meet their commitments under the Barcelona Convention. Following this recommendation, France, Monaco, and Tunisia launched a joint initiative in October 2013 to develop such mechanism.

In 2015, the Association for the Sustainable Financing of the Mediterranean MPAs (M2PA) was created to bring together States and civil society to lead the establishment of this mechanism. The Association, which is a non-profit Monaco based organization is a cooperation platform that aims to set up a regional conservation trust fund. Since 2015 the Mediterranean Fund has been dedicated to promote sustainable funding to contribute to MPAs long term financing needs to cover their operational costs.

Founding members of the association are France, Monaco, Tunisia and the Prince Albert II of Monaco Foundation. Active members are Morocco, Albania, Spain and several organizations (Monaco Oceanographic Institute, UNEP-SPA/RAC, MedPAN, French Coastal Protection Agency, WWF-Med, UICN Med, Mediterranean Small Islands organization, Critical Ecosystem Partnership Fund).

The association is currently supported by the French Facility for Global Environment (FFEM), the Government of Monaco, the GEF, the French Development Agency (AFD), the Prince Albert II of Monaco Foundation, the Leonardo Di Caprio Foundation, Zoo Basel, the Oceanographic Institute Prince Albert I of Monaco.

The initiative received political support from the countries bordering the Mediterranean at the Union for the Mediterranean Ministerial Meeting on Environment and climate change and the parties to the Barcelona convention in 2016.

3.4.5. Major knowledge gaps

[To be completed]

Box 8 Difficulties in monitoring of indicators of good ecological status

Concerning the habitat distribution and the state of species and communities (CI1/EO1), there are significant gaps in the southern Mediterranean countries regarding the effects of the gelatinous macro zooplankton on the functioning ecosystems and more generally on deep Mediterranean systems and pelagic habitats. There is a wide disparity in the overall distribution of research efforts for marine mammals and marine reptiles (CI3/EO1). Indeed, most of the research is concentrated in the north-western part of the Mediterranean basin, where long series of data are available and provide a reliable picture of the situation of these species. However, in the absence of at least an equivalent effort in the southern countries, it is difficult to understand all the processes related to these species at the Mediterranean level. In southern Mediterranean countries, information on the occurrence and distribution of species is sporadic and highly localized. When it comes to marine reptiles, the knowledge deficit concerns several aspects, particularly the location of breeding / nesting sites, overwintering, feeding and development sites for adults, females and juveniles, connectivity between different Mediterranean sites and the vulnerability / resilience of these sites.

For many countries in the eastern and southern Mediterranean, as well as for some Adriatic countries, information on seabird breeding populations (CI4 / EO1) is fragmented or absent. The same is true for the demography data of many populations of marine mammals, sea turtles and seabirds (CO5 / EO1).

Regarding non-native species introduced through human activities (CI6/EO2), the assessment of trends in both the abundance of these species and their spatial distribution is particularly lacking in the southern Mediterranean countries. In addition, the deficit in these countries, in taxonomy experts has most likely led to neglect several of these species. In the current state of knowledge acquired in the countries of the southern shore of the Mediterranean, it is difficult to have a detailed understanding of the processes of introduction, installation and adaptation of these species.

The level of information regarding spawning stock biomass (CI7/EO3) and fishing mortality (CI9/EO3) differs widely between countries on both sides of the Mediterranean but also between species and geographical areas. This information relates to some commercially exploited stocks and stocks for which reference points exist are still very limited. In these conditions, it is difficult to give precise indications of current levels of biomass, especially considering the large deficit of long time series. In addition, and given the specificity of the fisheries in the southern Mediterranean, dominated by artisanal fisheries, it is very difficult to have reliable data on total landings (CI8/EO3). This situation is further complicated by the lack of reliable estimates of illegal and / or reported fishing activities.

Regarding the location and extent of habitats directly impacted by hydrographic changes (EO7), there is a lack of sound methodologies and assessments. Assessments that estimate the extent of hydrographic alterations and intersections with marine habitats are currently rare in the Mediterranean, apart from local environmental impact assessment (EIA) and strategic environmental assessment studies (SEA). In countries on the southern shores of the Mediterranean, experts with knowledge of the processes and methodologies used are not always available in sufficient numbers and quality.

Knowledge about the interactions and mechanisms that govern different biological and physical phenomena at the cross-border level, whether at the sub-regional (south) or regional (Mediterranean) level, remains largely unknown and under-documented. Today, this deficit does not allow a complete and correct understanding of the processes related to species migrations, introductions and biological invasions.

Until the early 2000s, most climate change studies and scenarios addressed the Mediterranean on a macro scale (IPCC group scale). This level of analysis provides broad indications but does not allow for an understanding of changes and effects at national and local scales. Over the last decade and since the Paris Climate Agreement, several programs and research projects have been conducted to reduce the scale of observation in order to refine the analysis of climate processes and their effects on the region. The downscaling was carried out quickly and almost systematically and enabled the countries on the northern shore of the Mediterranean to substantially improve understanding of climate phenomena. On the other hand, due to lack of means and adequate resources and adapted local competences, important insufficiencies must be highlighted concerning the effects of climate change on the ecosystems and economies of the southern Mediterranean countries, as well as on their level of vulnerability and their resilience to these climate changes.

Very significant efforts by countries and organizations working on the conservation and protection of biological diversity in the Mediterranean, particularly those of RACSPA/MAP, IUCN, WWF, MEDPAN, should be highlighted.

3.4.6. Priorities for action

[To be completed]

Box 9 Tools for monitoring biological effects in the Mediterranean

Generalizing the tools for monitoring biological effects in the southern Mediterranean countries through the use of the biomarker technique (the stability of the lysosomal membrane (LMS) as a general condition screening method; cetylcholinesterase (AChE) as a method for evaluating neurotoxic effects, and Micronucleus (MN) testing as a tool for assessing cytogenetic / DNA damage in marine animals.

Moving from habitat conservation approaches to biodiversity and ecosystem functioning approaches is a much better reflection of the reason behind the management and conservation of marine ecosystems. This shift calls for holistic, integrative and ecosystem-based approaches, which are still under development and will require a reassessment of how ocean monitoring, assessment and management are approached.

The risk-based approach for monitoring should be implemented to assess the distribution of marine mammals throughout the Mediterranean Sea. Additional efforts should be devoted to less-guarded areas where there is a risk. Species listed as those for which data are insufficient, according to the red list criteria, should be considered a priority.

The importance of assimilating all the information on the distribution of green turtles and loggerhead turtles in the Mediterranean on breeding, foraging, development and wintering grounds in order to understand the links that unite these areas in a management and conservation perspective. In addition, parallel mitigation strategies are needed to strengthen the resilience of existing populations.

Demographic information on key populations and sensitive and / or commercially exploited species remains largely fragmented, often old, and subject to potentially high biases. It is necessary to improve the demographic knowledge of these populations.

Systematic and long-term photo-identification programs, coupled with the use of appropriate instruments to measure observed animals, would be essential tools for providing the basic knowledge of the population structure required for conservation plans (Demographic Characteristics of Marine Mammals).

Strengthening skills, particularly in taxonomy in Southern Mediterranean countries, to carry out and update national and regional inventories of exotic species and to evaluate their trajectories and impacts in these countries. The rate of introduction of new exotic species into the Mediterranean is increasing. Corridors are the main pathways for new introductions into the Mediterranean, followed by shipping and aquaculture. There is a need to improve coordination at the national and sub-regional levels for monitoring non-native species in order to achieve broad mapping for the

Mediterranean basin. Regular monitoring and a long time series will be needed to estimate these trends in the future. The use of molecular approaches including bar coding is often useful in addition to the traditional identification of species.

The reduction of fishing mortality requires the adoption of sub-regional management plans under the GFCM, in addition to those already in place for the small pelagic fisheries of the Adriatic and the demersal fisheries of the Strait of Sicily, and the adoption of measures to manage fishing capacity.

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Annexes

Table 11 Area of forests and of other wooded lands in Mediterranean countries from 1990 to 2015, and forested area in 2000. Source: FAO (2015) for forest area and other wooded land area; Hansen et al. (2013) for forested areas.

Country	Forest area (× 1000 ha)					Other wooded land (× 1000 ha)					Forested area as % of land area		
	1990	2000	2005	2010	2015	1990	2000	2005	2010	2015	country level	biome level	coastal areas
Albania	789	769	782	776	772	256	255	258	255	256	29.7%	28.8%	13.9%
Algeria	1,667	1,579	1,536	1,918	1,956	2,063	2,374	2,529	2,457	2,569	0.7%	4.7%	29.9%
Bosnia and Herzegovina	2,210	2,185	2,185	2,185	2,185	500	549	549	549	549	57.0%	35.1%	48.5%
Croatia	1,850	1,885	1,903	1,920	1,922	277	415	484	554	569	46.8%	32.6%	36.6%
Cyprus	161	172	173	173	173	195	214	214	213	213	20.1%	20.1%	20.1%
Egypt	44	59	67	70	73	20	20	20	20	20	0.9%	20.7%	22.4%
France	14,436	15,289	15,861	16,424	16,989	2,038	1,804	887	739	590	33.5%	49.1%	45.7%
Greece	3,299	3,601	3,752	3,903	4,054	3,212	2,924	2,780	2,636	2,492	36.2%	35.7%	36.2%
Israel	132	153	155	154	165	34	33	33	33	60	2.3%	6.0%	4.9%
Italy	7,590	8,369	8,759	9,028	9,297	1,533	1,650	1,708	1,761	1,813	34.9%	34.1%	25.5%
Lebanon	131	131	137	137	137	117	117	106	106	106	9.4%	9.4%	16.8%
Libya	217	217	217	217	217	330	330	330	330	330	0.0%	0.4%	1.0%
Malta						0	0	0	0	0	0.4%	0.4%	0.4%
Monaco	0	0	0	0	0	0	0	0	0	0	22.4%	22.4%	22.4%
Montenegro	626	626	626	827	827	118	118	118	137	137	51.9%	43.9%	56.3%
Morocco	4,954	4,993	5,401	5,672	5,632	407	407	607	607	580	2.8%	3.0%	12.1%
Palestine	9	9	9	9	9	0	0	0	0	0	0.3%	0.3%	0.2%
Slovenia	1,188	1,233	1,243	1,247	1,248	41	38	29	25	23	67.4%	67.4%	32.8%
Spain	13,809	16,977	17,282	18,247	18,418	11,997	10,360	10,259	9,278	9,209	28.5%	23.0%	20.4%
Syria	372	432	461	491	491	35	35	35	35	35	0.8%	2.9%	16.7%
Tunisia	643	837	915	990	1,041	328	314	307	300	293	1.9%	2.9%	7.7%
Turkey	9,622	10,183	10,662	11,203	11,715	10,946	10,679	10,586	10,334	10,130	16.6%	20.2%	30.1%
Total	**68,195**	**74,098**	**76,495**	**79,926**	**81,599**	**35,732**	**34,048**	**33,314**	**32,066**	**31,893**	**9.1%**	**17.8%**	**27.8%**

Note: Forest area is the area that complies with FAO definition of forests. Forested areas are areas with tree cover ≥10%. Coastal areas are land areas within 5 km of the coastline of the Mediterranean Sea