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Fifth Meeting of National Correspondents of the Strategic Action Programme for the Conservation of Biological Diversity in the Mediterranean Region (SAP BIO)

Marseilles, France, 13-14 February 2019

Agenda item 7. Exchange on the content and eventual information update by participants regarding the SoED 2019 chapters on Marine and Coastal Biodiversity

Draft chapters concerning the Marine and Coastal Biodiversity for the document "State of the Environment and Development in the Mediterranean 2019" (SoED 2019)

UNEP/MAP
SPA/RAC - Tunis, 2019

Draft chapters concerning the Marine and Coastal Biodiversity for the document "State of the Environment and Development in the Mediterranean 2019" (SoED 2019)

Preliminary compilation of contributions to Chapter 3: Biodiversity sustainability

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Preface

The 2016-2021 Mid-Term Strategy of the Mediterranean Action Plan (MAP) for the implementation of the Barcelona Convention provides for the elaboration of assessments, notably on the state of the environment, and interactions between environment and development. The preparation of the Report on the State of the Environment and Development in the Mediterranean 2019 (SoED 2019) is part of this framework.

The SoED 2019 aims at presenting a comprehensive and updated assessment of the environmental status, trends and main sustainability issues related to the environment and development in the Mediterranean region, in the context of the mandate of the MAP - Barcelona Convention system.

The SoED 2019 is prepared as a collective effort of Contracting Parties, Members of the Mediterranean Commission on Sustainable Development (MCSD), MAP Components and other partners with particular expertise on the Mediterranean. 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 Sustainability" 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 (including the terrestrial part of the coastal zone) 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 GBO 4 of the CBD, the Global Wetlands Outlook of the Ramsar Convention, (2018), and the 2nd Mediterranean Wetlands Outlook of the Mediterranean Wetlands Observatory (2018).First draft elements to feed into this Chapter elaboration are herein below shared for consultation with the participants to the Fifth Meeting of the National Correspondents of the Strategic Action Programme for the Conservation of Biological Diversity in the Mediterranean region (SAP BIO). That will allow participants 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. 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 provisory and their sequence referring only to the section where they appear.

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3.1. Transversal introduction

The Mediterranean is a semi-enclosed sea with multiple types of coastline, from delta and coastal plains to high cliffs and mountainous area providing various natural and anthropogenic landscapes (forest, agriculture, grazing lands, wild areas) and multiple types of sea-bottoms (sandy, rocky, gentle slopes, canyons and seamounts) that allowed over the centuries the installation of multiple ecosystems or habitats. The coastal zone was over the centuries, the cradle for great civilisations that shaped the landscapes and led during the last decades to a strong increase of the human occupation and activities, reducing 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: pollutions, over-exploitation of biological resource, coastal alterations (change in land use for infrastructures, urbanisation, industries, etc.), changes in fluvial dynamics (e.g. caused by a dam on a river) that may affect sediment and nutrient transport, increasing sea use and natural changes as well as climate change effects.
The Mediterranean coastal ecosystems and species (see section 3.2 when completed)
Coastal forest
Coastal dune
Coastal wetlands
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 (Southern Spain, Northern Morocco) or the North zones of the Adriatic Sea (Italy, Slovenia, Croatia, Montenegro).
The chorology of species now encountered in the Mediterranean makes it possible to distinguish (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, some human activities) for recent immigrants (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%) 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 .

3.2. Coastal ecosystems and biodiversity (terrestrial part)

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

3.2.1. Wetlands

Wetlands represent an estimated 6% of global land mass and are among the most diverse and productive ecosystems on the planet. Their importance and the wide range of services

they provide are well recognized, including their key role in the achievement of Sustainable Development Goals. Their relative contribution of ecosystem services is much 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 since 2010, and two regional Outlooks published (Mediterranean Wetlands Outlooks 1 and 2/ MWO1 and MWO2), making wetlands one of the very few ecosystems that have been assessed at this scale (MWO 2012, 2018). Being placed under the aegis of the MedWet Initiative of the Ramsar Convention, this ongoing monitoring work of the Observatory is supported by all the countries in the Region, which are all members of MedWet.

3.2.1.1. Status and trends of wetlands and linked biodiversity

At the global scale, natural coastal wetlands are less common than natural inland wetlands, covering an area 7 to 8 times smaller (Davidson & Finlayson 2018). As no similar statistics exist for the Mediterranean basin (which hosts ca. 19-26 million hectares wetlands ; MWO 2018), experts consider it is likely that Mediterranean coastal wetlands are rarer than inland ones. A broad sample of 400 Mediterranean wetland sites have lost, on average, 48% of their natural wetland habitats between 1970-2013. This suggests that the region's wetlands have fared worse than those of 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).
Nota : It must be highlighted that for wetlands, the definition of the "Mediterranean" as used by the Mediterranean Wetlands Observatory (e.g. MWO 2012, 2018) in all its analysis presented here is broader than the geographical scope of the Barcelona Convention: it encompasses also Portugal, Andorra, Serbia, Bulgaria, Jordan and Northern Macedonia (FYROM).
Within the Mediterranean ecosystems, wetlands are of paramount importance for biodiversity: although they occupy only 1.7% to 2.4% of the area of these countries (Perennou et al. 2012), they are home to more than 30% of the basin's vertebrate species. There are twice as many endangered species in wetlands than in all Mediterranean ecosystems. These figures illustrate the importance of preserving wetlands to prevent the erosion of biodiversity in the region (MWO2, 2018). Wetlands along the Mediterranean coast are crucial for many species and ecosystem processes. For instance, 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*, the European bass *Dicentrarchus labrax* or the common sole *Solea solea*). Mediterranean lagoons 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, 2014). 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 and their associated coastal lakes, lagoons and marshlands host tens of millions of migratory, wintering, and breeding waterbirds travelling from as far away as the Arctic and Southern Africa. The Greater Flamingo (*Phoenicopterus roseus*) is one of the 150 waterbird species that shelter in Mediterranean coastal wetlands. Many coastal sites meet the Ramsar criteria of international importance for waterbirds as they regularly host more than 20,000 waterbirds and/or more than 1% of the biogeographical population of at least one waterbird species (Figure 1). Among 551 sites identified as internationally important for waterbirds, 70% are located at less than 30 km from sea. However, less than 10% of these coastal sites have been designated as Ramsar sites so far (Popoff et *al. ongoing work*).

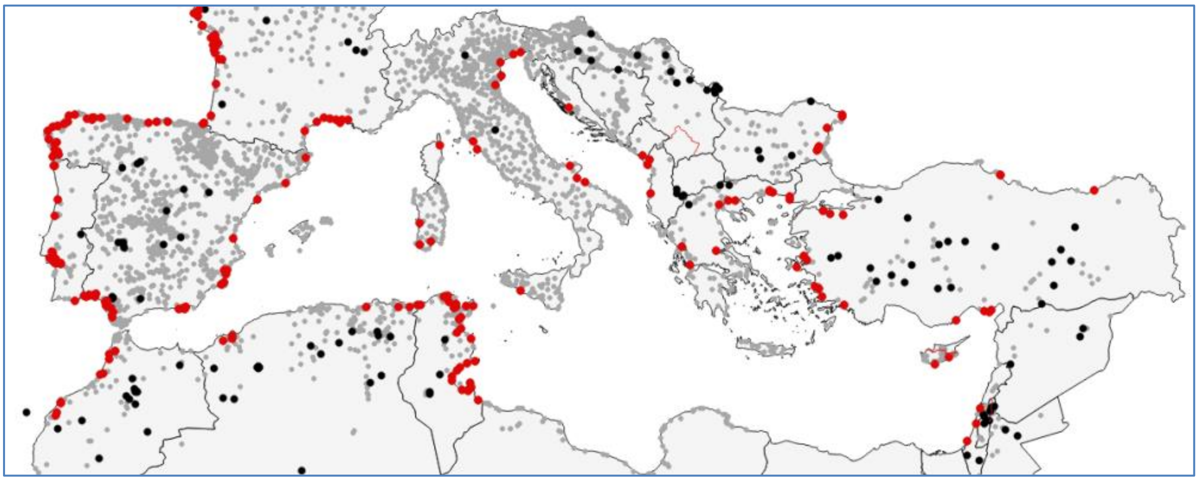

Figure 1: Wetlands of international importance for waterbirds (black and red points) which regularly host more than 20,000 waterbirds and/or more than 1% of the species population of the Mediterranean flyway (based on mid-January counts made during the 1991-2012 period). Sites in red (resp. black) are 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).*

Species living in Mediterranean coastal wetlands face many anthropogenic pressures: conversion of wetlands to agricultural and urban areas, water pollution, alteration of the hydrological functioning, overfishing, coastline retreat and sea level rise. As a result, the populations of many of their species show a negative trend. This is especially the case for fish species dependent on coastal wetlands. Out of a sample of 2171 time-series of 18 fish species which are considered to be specialist of coastal wetlands strongly declined between 1990 and 2013 (computation based on the database of the Living Planet Index in MWO 2018, 2018; Figure 2).

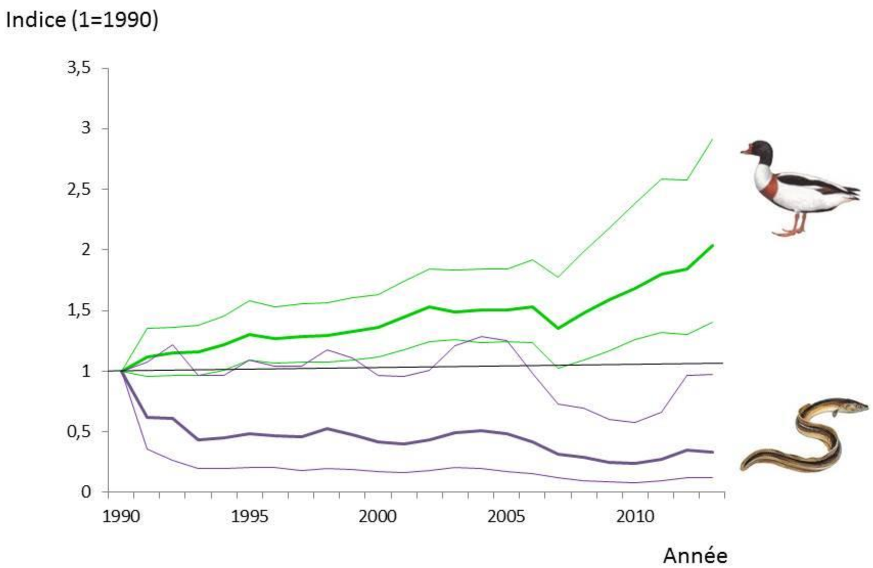

Figure 2: Living Planet Index for birds and fish dependent on coastal wetlands in the Mediterranean basin. The index gives the relative abundance over time for populations of

mammals, birds, reptiles, amphibians 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 *(source Galewski, unpublished work).*

An analysis based on a sample of 10,611 time-series of 54 bird species specialized in coastal wetlands revealed, however, a general positive trend (Figure 2). This is very likely due to three reasons. First, many waterbirds have suffered massive destruction in the past, which had greatly reduced their numbers and range, resulting in a low baseline for 1990. Second, specific protection laws (e.g. the EU Birds Directive) associated with effective governance have led to a significant increase in the number of breeding populations in some countries, including the European Union (MWO 2018; Gaget et al. 2018). Third, artificial water bodies have also increased, which in contrast to many other wetland species, do provide additional habitat space for some water birds (MWO 2018).

3.2.1.2. Ecosystem services

Wetlands bring many different contributions to improve or maintain human well-being (Ramsar Convention on Wetlands, 2011, 2018; MWO2, 2018). Their contributions towards the future is increasingly under pressure (MWO2, 2018; Geijzendorffer et al. 2018). The MWO2 clearly demonstrates a bleaker picture for the Mediterranean basin than what is portrayed at a global level, notably in terms of loss of habitat quality and extent, as well as species abundance reduction. The loss of natural Mediterranean wetland habitats (48% since 1970; MWO 2018) is faster than the global average (c.35%; Ramsar Convention on Wetlands, 2018)), which suggests that ecological and hydrological functioning of wetlands systems has decreased, through urbanisation, construction of dams and agricultural developments. The capacity of Mediterranean wetlands to provide services has diminished, whereas the demand and use for ecosystem services has been rapidly increasing, through the use of irrigation systems in intensive agriculture, increases in population density and increases in per capita consumption. The indicators of the MWO2 demonstrate that especially the capacity of wetlands to mitigate the impacts of floods has been significantly reduced (by 20% between 1987 and 2016) due to the conversion of natural wetland habitats and the artificialisation of flooding prone areas. Use of freshwater has continued to increase with agriculture being the number one consumer. Thanks to investments in the management, construction of facilities and the rising accessibility of Mediterranean wetlands, an increasing number of people visit and enjoy them during leisure time or for educational outings. Unfortunately, the continued loss of natural wetlands habitats caused by for instance the building of dams or drainage creates enormous carbon emissions.

Yet, a holistic and accurate understanding of the spatial distribution of the provisioning services of wetlands and the areas where these services are demanded in the Mediterranean is still not well determined (Abdul Malak et al. 2019). Such effort would allow the prioritisation of conservation and restoration measures and is closely linked to an urging need to track wetland extent through improved national wetland inventories in the Mediterranean.

It seems, therefore, that Mediterranean countries are not yet using the full potential of Mediterranean wetlands to progress towards their obligations of the Sustainable Development Goals. The second Mediterranean Wetlands Outlook (MWO2, 2018) stresses several measures that can be implemented that will increase the progress of countries towards specific Sustainable Development Goals (Figure 3 for the current situation), while simultaneously allowing them to progress on objectives of the Ramsar Convention, to protect and sustainable manage wetlands. These measures include for instance, but are not limited to, restoring wetlands as nature based solutions to mitigate the impacts of flooding of rivers and the sea, implementing sustainable management plans to ensure a prolonged provision of water during periods of drought, and an efficient protection of remaining natural wetland habitats and their water quality.

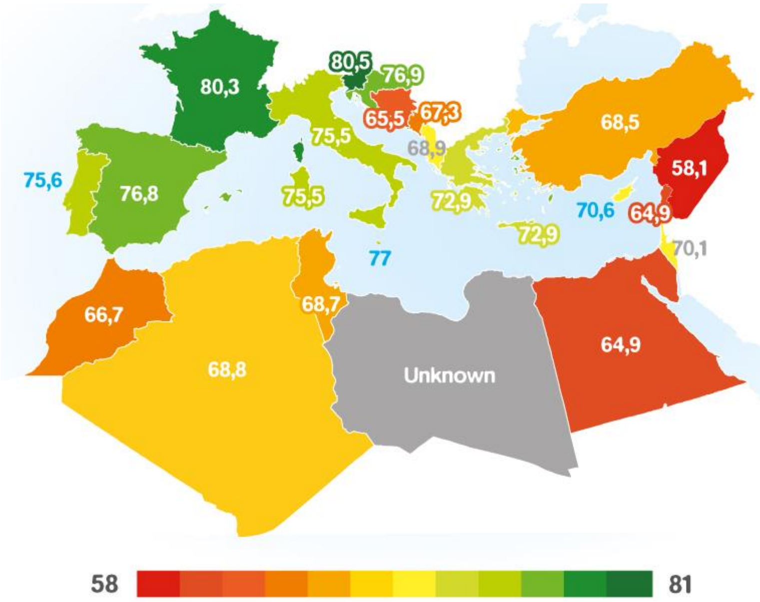

Figure 3: Sustainable Development Index score for Mediterranean countries in 2017 (maps based on data from Sachs et al. 2016). The higher the score, the greener the country and the better it is currently doing on the full suite of Sustainable Development Goals. *(source MWO, 2018).*

3.2.1.3. Major pressures

Coastal wetlands are exposed, like the whole coastline, to increasing pressures resulting from the concentration of human populations along the Mediterranean shore (“littoralisation”) and from climate change and the resulting sea-level rise. Besides wetland loss, these pressures lead to altered hydrology, trophic (eutrophication) and toxic pollution ***(see section 4.8 Pollution)***. In addition the tremendous development of dams on rivers, resulting in a 45% reduction of the volume of freshwater delivered to the Mediterranean Sea in the 20th century (Ludwig *et al*., 2009), prevents the sediment from reaching the coast and thus leads to enhanced coastal erosion (Day et al. 2011). This intensive use of water in the Mediterranean catchments also causes deficits in the water balance. Added to the impacts of climate change, this reduces the duration and extent of flooding in many wetlands downstream, and affects their overall ecological functioning. Conversely, the water used for agricultural fields can locally increase water inputs to wetland habitats, leading to increased flooding periods in naturally temporary habitats. In some rare cases, this has lead locally to a large increase in the surface area of some wetlands, such as Sebkha al-Jabbul in Syria (MWO, 2012). However, this often results instead in a lower salinity and increased eutrophication, and thus to dramatic changes in plant and animal communities (e.g., Tamisier & Grillas, 1994, Álvarez -Rogel *et al.,* 2007, Chappuis *et al*., 2011, Le Fur *et al*., 2017).

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 land cover database of the Mediterranean Wetlands Observatory helps quantify this phenomenon. It contains detailed information on land-cover change (1975-2005) in 302 major wetland sites throughout the Mediterranean basin: 210 coastal (i.e. located less than 30 km from the sea) and 92 inland sites. Between 1975 and 2005, more transformations took place in coastal than in inland sites (Fig 4) – except for farmland expansion.

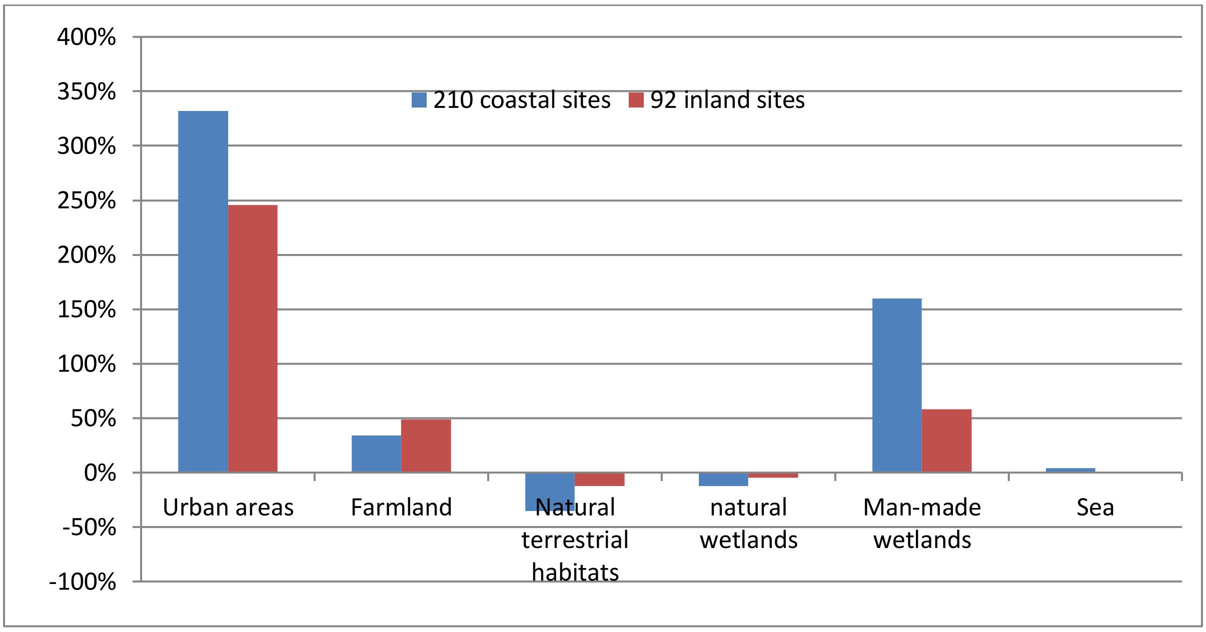

Figure 4: Rate of change between 1975-2005 of main land-cover categories inside coastal vs. inland sites (source Perennou & Guelmami, unpublished work).

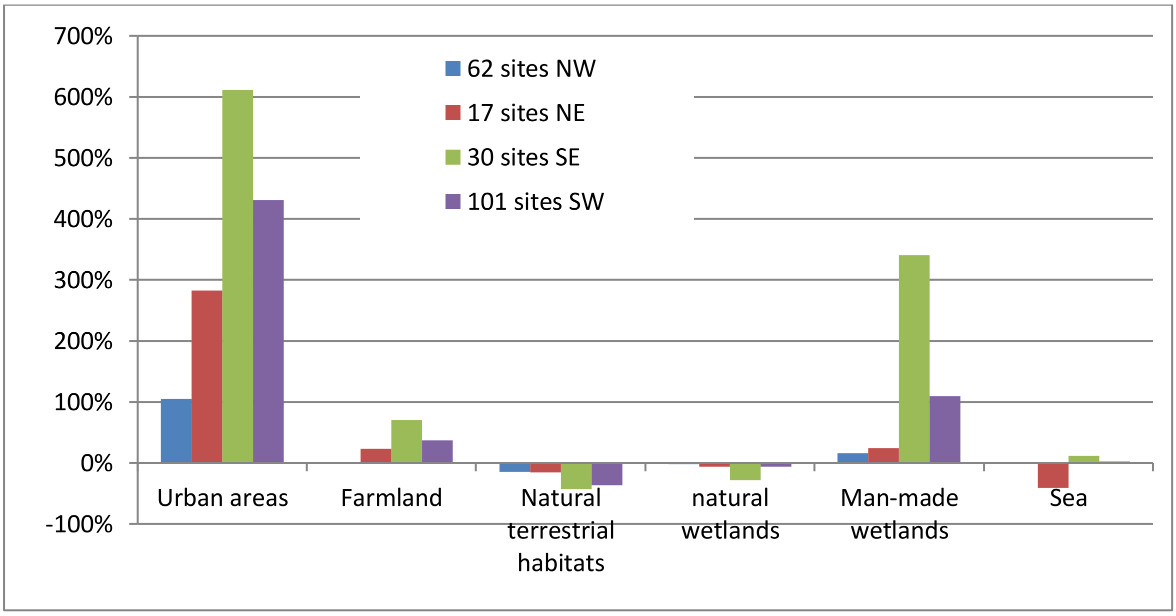

Figure 5: Rate of change between 1975-2005 of the main land-cover categories in coastal sites, per sub-region of the Mediterranean basin (NW Med = from Portugal to Italy; NE = from Slovenia to Greece; SE = from Turkey to Egypt; SW = from Libya to Morocco) (source Perennou & Guelmami, unpublished work).

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.

Not all parts of the Mediterranean coastal region have witnessed similar amounts of change (Fig. 5). 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 (MWO2).

3.2.1.4. Management of wetlands

As a response to the continued loss and degradation of Mediterranean wetlands, various management and conservation actions have been undertaken for at least a century, initially through the designation of protected areas. More recently, in European countries, the Water Framework Directive 2000/60/EC (WFD) has led to good progress in reducing pollution. For “transitional waters” (as lagoons are called in the Directive), which are particularly vulnerable to pressures and pollutions from the watershed (chemical contaminants from industry, agriculture, and urban areas), excessive inputs of nutrients due to anthropic activities have been reduced but still remain high. For instance, in the French Mediterranean basin, domestic pollution has been reduced by 20% in 25 years (Agence de l’Eau Rhône Méditerranée Corse, 2016; 2018) so that in 2017, more than half of the rivers and 82% of groundwaters were in a good status. Improvement of water quality has led to the recovery of the aquatic vegetation in previously eutrophicated lagoons (Le Fur *et al*., 2018). Nevertheless, 86% of the lagoons have not yet reached a good water quality status, with nutrient excesses and toxic substances being the main barriers for reaching a good status. 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 Contracting Parties commit themselves to designate sites for inclusion in a List of Wetlands of International Importance (“Ramsar sites”), and to conserve, manage and use wisely their wetlands. The number of sites and surface of Ramsar sites in the MedWet countries have steadily increased over time : since 1971, 6.7 million hectares have been designated. By the end of 2017, 397 Ramsar Sites had been designated in the Mediterranean Region, 113 sites of which are mainly natural, coastal and marine.

Designation of a Ramsar site is often not sufficient in itself, since effective conservation also requires the development and implementation of a management plan. In 2017, 44% of all the Mediterranean Ramsar sites had developed a management plan, and 30% had implemented it (Fig 6).

Figure 6: Index of availability and implementation of management plans (on a scale from 0 to 100) of Ramsar sites. The darker the colour the more management plans have been developed and implemented relatively to the number of Ramsar sites per country. (Source: MWO, 2018)

How efficient is the Ramsar designation, in terms of curbing wetland conversion to other land-uses? Of the MWO sample set of 210 coastal wetlands (see § 3.2.1.3 above), 125 had been designated Ramsar sites by 2005. These revealed relatively less transformation, notably less loss of natural habitats and less creation of manmade ones, than the non-Ramsar sites (Fig. 7). However, Ramsar may not be the sole reason for this, as designation is often given to wetlands that are already protected at national level. The better protection against land-cover change may therefore result partly from earlier, national protection measures, possibly reinforced by the Ramsar status.

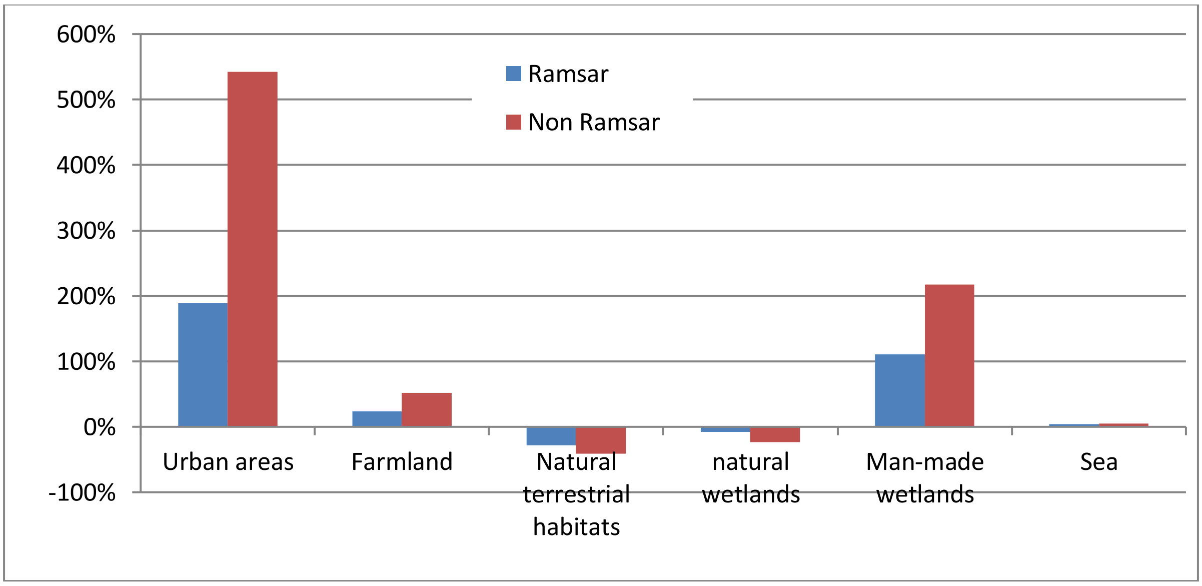

Figure 7: Trends between 1975-2005 of the main land-cover categories inside coastal sites, depending on their Ramsar status (as of 2005) (source Perennou & Guelmami, unpublished work).

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3.2.2. Coastal aquifers

Groundwater is the world's most important source of freshwater. Globally, 2.5 billion people depend solely of this source to satisfy their basic daily water needs and it is used for irrigation of the largest share of the world's food supply (UNESCO, 2012). As a source of water supply, groundwater has several essential advantages when compared with surface water being generally of higher quality, better protected from pollution, less subject to seasonal and perennial fluctuations, and much more uniformly spread over large regions. However, its non-visible nature, located in the subsurface, implies that the exploitation in many cases happens in the absence of a full understanding of the nature and characteristics of the resource.

In the Mediterranean region, groundwater is an essential source of water supply used in many socio-economic sectors with agricultural withdrawal being the main use (Figure 1).

Coastal aquifers contribute to the integrity and functioning of the coastal and marine ecosystems through the hydrological process occurring commonly in this land-sea interface, known as the submarine groundwater discharge. In this region, excessive abstraction of groundwater, mainly caused by tourism and irrigation for agricultural purposes is leading to rapid depletion of many aquifers (Dalin, et al., 2017). This pressure threats the sustainability of food production, inducing significant environmental degradation, such as land subsidence and seawater intrusion (Caló, et al., 2017; Custodio, 2018) and contributing to the major transboundary challenges affecting the Mediterranean Sea (UNEP-MAP, UNESCO-IH, 2015).

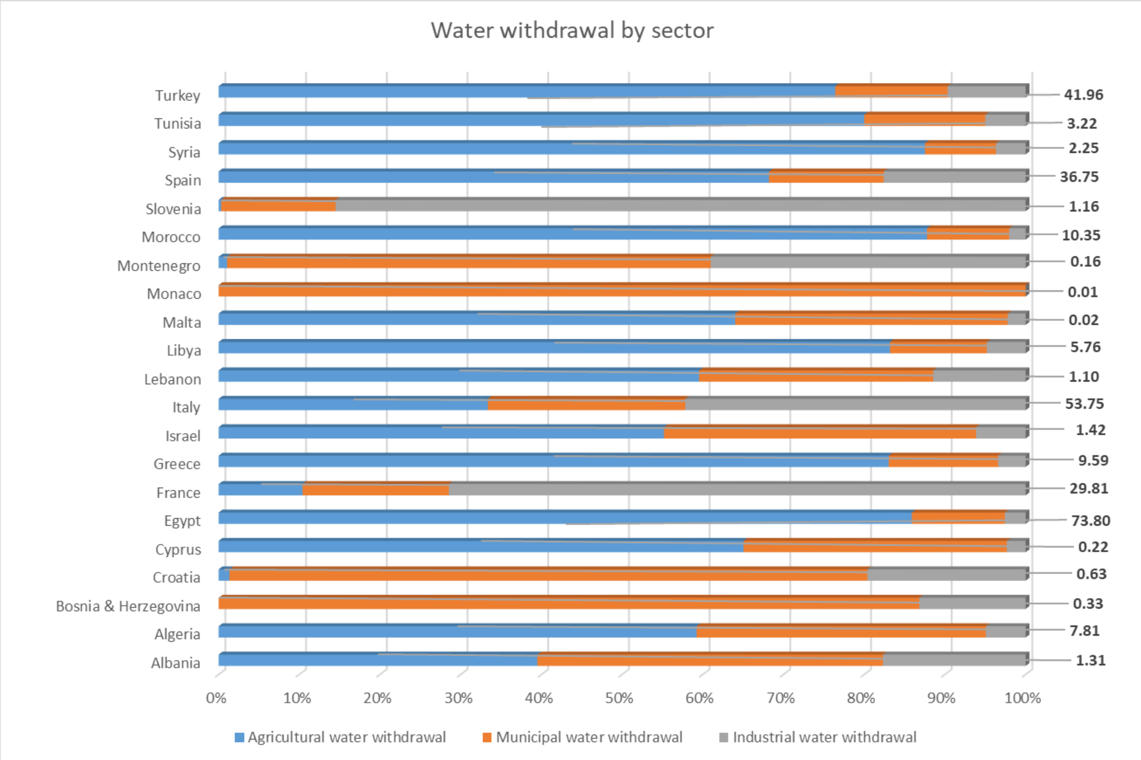

Figure 1: Water withdrawal by sector (relative distribution) in Mediterranean countries. Total water withdrawal (109 m3/year). Source of data: FAO, latest value available on AQUASTAT.

3.2.2.1. Status and trends of coastal aquifers

Water resources in Mediterranean countries are limited and unevenly distributed (Blinda, 2006). Around 60% of the world's population classed as living in 'water poverty' – less than 1000 m^3 of water available per capita per year – inhabits Mediterranean countries. Water demand in the Mediterranean basin doubled in the second half of the 20th century and in 2005 it reached 280 km^3/year for all riparian countries, with predicted increase in demand of 50 km^3/year by 2025 (GWP / Plan Bleu, 2012). In fact, Egypt, Israel, Libya, Malta, Syria, and the Palestine (including Gaza Strip) are already withdrawing as much as, or more than, the limits of their renewable resources (Figure 2).

Overall, renewable groundwater resources in the Mediterranean are estimated to be around 340 km^3/year, of which 72% in the Northern shore, 23% in the Middle East and only 5% in the Southern shore (Figure 2). Additionally, figure 2 shows the dependency ratio per country, an indicator that shows the percentage of total renewable water resources originating outside the country. In the region, Egypt's dependency ratio is the highest with 96.9 % in the region, this water comes from Sudan through the Nubian Sandstone aquifer[1]. The Nubian sandstone aquifer is a strategy source of water for northeast Africa underlying the countries of Chad, Egypt, Libya and Sudan but unfortunately is a 'fossil' water aquifer under increasing pressure from exploitation and pollution (Gad, et al., 2016; IAEA, UNDP, GEF, 2013).

Groundwater is an essential source of water supply at Mediterranean scale, being a major source of water supply for Malta, 95% of Libya and around 70% of Croatia, Tunisia and Cyprus's total water withdrawal (**Erreur ! Source du renvoi introuvable.**). The agricultural sector constitutes the highest consumer of water (see Figure 1, over 80% in almost all Southern countries, and up to 85% in Morocco). As a consequence of irrigation, aquifers

1 http://www.fao.org/nr/water/aquastat/countries_regions/EGY/index.stm

with declining groundwater levels are common in the Mediterranean region—Custodio et al. (2016) cite examples in Spain such as the 300 m decline in the Crevillente aquifer (province of Alicante) in 30 years or in the the extreme case of Libya, ranked by Wada et al. (2012) as the Mediterranean country with the highest groundwater depletion.

Tourism has expanded considerably in the Mediterranean since the 1960s and weighs heavily on groundwater. Tourism also produces a high additional demand in peak seasons in coastal areas that in most of the cases are coincident with the dry season might thus put considerable strain on available water resources as well as wastewater infrastructure (Gössling et al. 2012).

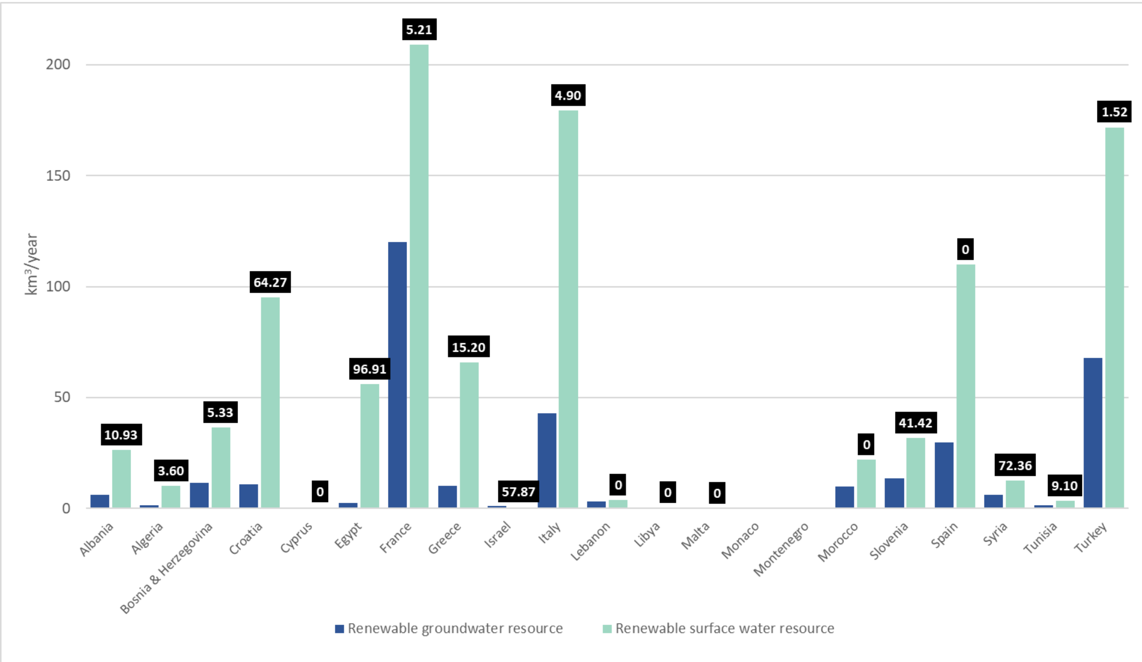

Figure 2: Renewable water resources in Mediterranean countries. Source of data: FAO, latest value available on AQUASTAT. The black label shows the water dependency ratio (Indicator expressing the percentage of total renewable water resources originating from outside the country).

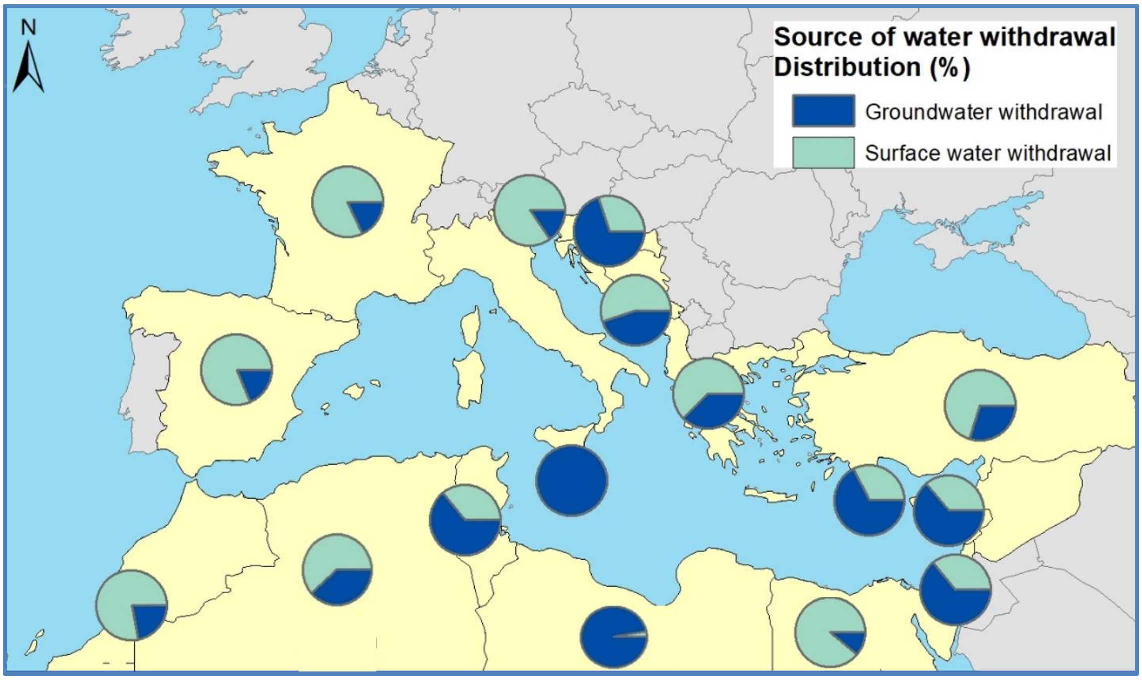

Figure 3: Part of total Water Demand supplied by groundwater in Mediterranean countries. Source of data: FAO, latest value available on AQUASTAT. The statistical value from Albania, Italy, Monaco, Montenegro and Syria are not included in the figure due to missing data in AQUASTAT.

3.2.2.2. Ecosystem services

Though groundwater supports many ecosystems, including wetlands, rivers, lakes, estuaries, lagoons, springs, oases, and terrestrial systems like forests as demonstrated in Figure 4, it has long been the missing link in the ecosystem debate (Tuinstra & van Wensen, 2014). The underpinning role of groundwater has been increasingly recognised in the last decade as supporting human wellbeing and their economies. The major ecosystem services provided by the aquifers include but are not limited to: 1) purification of water and its storage in good quality for decades and centuries, 2) active biodegradation of anthropogenic contaminants and inactivation and elimination of pathogens, 3) nutrient recycling, and 4) mitigation of floods and droughts, in addition to 4). Aquifers are sources of water for domestic and irrigation (Griebler & Avramov 2015).uses, and are also relevant for contaminant processing, nutrient cycling, sub-surface stability, thermal regulation and in-situ biodiversity (Figure 4).

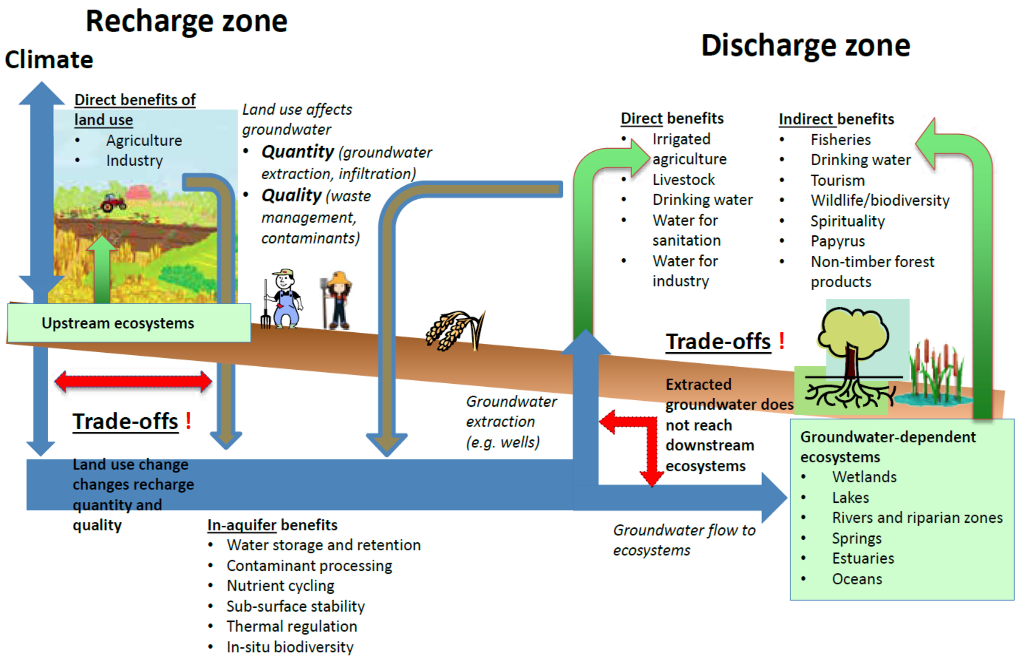

Figure 4: Conceptual diagram of the multitude of ecosystem services associated with groundwater over a landscape scale. People benefitting from as well as interacting with and influencing ecosystems are implicit throughout (WLE, 2015)

In coastal wetlands, many ecosystem services are derived or supported by the presence of groundwater inflow because of its role in regulating the hydrology and as a supporting factor to the ecological functioning of most of the coastal Mediterranean wetlands (UNEP-MAP, 2015). Thus, the assessment of groundwater ecosystem services, their status and trends, are essential for assessing the condition and the values of the services of wetlands; and vice versa. It is to note that there is a need to increase awareness towards the sensitivity and essential role of groundwater for practitioners, policy makers and all type of public who are, in many cases not aware of the connections between groundwater and the health (UNEP-MAP, UNESCO-IH, 2015).

3.2.2.3. Major pressures

The Mediterranean Region is usually characterized by its water stress situation. Current pressures on water resources in Mediterranean countries are derived from population dynamics, economic and social development, and technological trends but also the increment of droughts linked to climate change (Black, 2009). Population growth and unsustainable uses of natural resources in Mediterranean countries are major factors affecting water resources, leading, among others, to over-pumping of ground water to meet peak seasonal demands.

Overexploitation and increased water demand on coastal aquifers lead to groundwater level depletion and inrushing seawater; the latter being the result of the modification of the hydraulic connection between groundwater and seawater. The main consequence of this phenomenon is the salinization of soils and underground resources. In fact, several coastal aquifers along the densely populated Mediterranean coasts are already suffering seawater intrusion (e.g. the Nile Delta aquifer –Egypt-, Cyprus Akrotiri –Cyprus-, Segura River basin –Spain-, among others) a problem that is expected to exacerbate under the reduction of renewable groundwater resources induced by climate change (Kundzewicz & Döll, 2009).

The ICZM protocol implemented in the Mediterranean region, explicitly expresses concerns regarding seawater intrusion in the region being directly linked to water quality problems that affect large coastal areas of the Mediterranean region challenging their sustainable development (UNEP/MAP/PAP, 2008).

Additionally, the International Panel on Climate Change (IPCC, 2013) highlights the Mediterranean as one of the most vulnerable regions in the world to the impacts of global warming. Various studies have attempted to predict the effects of climate change on groundwater in the basin of the Mediterranean Sea, focusing on the most sensitive local conditions of reduced groundwater recharge combined with increased groundwater exploitation for irrigation (Calvache, et al., 2018). Reduction in groundwater recharge is expected to increase in the Mediterranean, especially along the southern rim. This situation will aggravate because of water quality degradation in coastal Mediterranean aquifers and seawater intrusion contributing to ongoing salinization in many coastal areas affecting the condition of wetlands and agro-ecosystems (Hoff, 2013).

3.2.2.4. Management of coastal aquifers

Due to the Mediterranean Region is characterized by its water stress situation, water use has the potential to fuel conflicts specially at transboundary levels (Ferragina, 2008; Amery & Wolf, 2004), but also internally for resource distribution (López-Gunn, et al., 2012). These conflicts could be aggravated in the case of groundwater due to the invisibility of the extension and the limits of the water body.

Groundwater resources have generally not been managed in an integrated way to date; mostly they are ignored in spatial planning decisions (Kløve, et al., 2011). Groundwater must be fully integrated into the general water management plans using a comprehensive approach as proposed in the Integrated Water Resources Management (IWRM), where water cycle is considered in a holistic way (GWP, 2000).

Progress based on implementation of water governance reforms is documented in most Mediterranean countries. Notwithstanding, a greater effort is needed in approaching a more sustainable governance at a local, national and transboundary level, inspired by IWRM principles and practices (Ferragina, 2010).

The European Mediterranean countries, through the EU Water Framework Directive (EU WFD) adopted in 2000, have to adopt the principles of IWRM that are focused on the recovery and conservation of the ecological status of rivers, lakes, wetland and coastal waters. Furthermore, the consideration of the interaction of underground water resources with wetlands and other water ecosystems is mandatory under this legislation.

The implementation of IWRM requires a change on water governance in the Mediterranean from a water supply driven phase to a new one where the water management plan integrates the social, economic and environmental perspectives, requiring important transformations (Scoullos, et al., 2002).

The countries of the Mediterranean have similar water resource problems, and the great experience of water management in several European countries could be transferred to the rest of the Mediterranean.

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 ground water aquifers.

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3.2.3. Forests

3.2.3.1 Status and trends of Mediterranean forests

According to the Global Forest Resources Assessment programme (FAO, 2015), the forest area of Mediterranean countries 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 (Table 1). 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 percent per year). The 0.86 percent/yr net increase in forest area between 1990 and 2010 has largely been the result of forest expansion (0.66 percent/yr), with reforestation contributing 0.25 percent/yr and deforestation remaining at a low level of 0.06 percent/yr (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 the Mediterranean countries. Contrary to forests, the area of other wooded lands has been constantly decreasing from 36 million ha in 1990 (–0.45 percent per year over 25 years) (Table 1). Overall, forests and other wooded lands have been slightly increasing by 0.35 percent per year between 1990 and 2015 (Table 1). Another specificity of the Mediterranean region is the importance of trees outside forests that are found in extensive agroforestry systems (e.g. *dehesas* in Spain and *montados* in Portugal), 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).

There are sub-regional differences in the forest trends in the Mediterranean. In northern Mediterranean countries, the increase in forest area is both the result of the European Common Agriculture Policy that has promoted afforestation (as in the case of Spain) and of forest expansion in rural areas following land abandonment (Denardou et al., 2017; Fernández Nogueira and Corbelle Rico, 2017). In southern Mediterranean countries, demand for fuelwood, food and fibre, overgrazing, overexploitation and forest clearing have, on the one hand, resulted in deforestation (Palahí et al., 2008). On the other hand, national afforestation programmes have resulted in considerable forest expansion (Hansen and DeFries, 2004), compensating or even slightly overcoming the loss in forest area.

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, thus accounting for vegetation growth in northern Atlantic regions such as northern Spain or France. 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. In contrast with country-level forest statistics, remote sensing studies focusing on the Mediterranean region actually show that forest area in the Mediterranean region remains stable. The tree cover map by Hansen et al. (2013) shows a good match between the forest area as reported by FAO (2015) and the area with tree cover: ≥ 10 percent. Based on Hansen et al.'s map, forests cover 9.1 percent of the Mediterranean countries' territory. When restricting to the Mediterranean biome, this proportion increases to 18 percent. When further restricting to coastal areas (here the land within 5 km of the coastline), it increases to 28 percent (Table 1). Therefore, forests are proportionally three times more widespread in Mediterranean coastal areas than at country level.

Statistics on forest area and land-cover changes in the Mediterranean tell us little about forest degradation. In many countries where forests are not continuously monitored (e.g. using a national forest inventory), statistics on growing stock and biomass are extrapolated from forest areas and are therefore not indicative of the forest condition. While new forests are generated from ecological succession after land abandonment, or from national afforestation programmes, Mediterranean forests are subjected to fragmentation with implications on their biological diversity. 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.

Forest trends in the coming decades are likely to be strongly influenced by human population growth and climate change.

During the last decades, the southern and eastern Mediterranean region has shown increasing trends in the population mainly in urban and peri-urban settings (World Bank 2015), these trends are expected to continue with the same increasing trends in the future (2050 scenarios).

The Mediterranean biome is one of the world's biomes where highest climate change impacts are expected (Giorgi, 2006). In the short term, the already observed shift 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).

3.2.3.2. Ecosystem services

Mediterranean forests ecosystems provide a variety of ecosystem services that can be classified as

- provisioning services, i.e. the material output from forests, including timber, fuelwood, biomass for energy, fodder for cattle, and an impressive lists of non-wood forest products (fruits of trees and shrubs: carob, chestnuts, acorns, pine nuts, berries; other tree products: cork, resin, mastic; mushrooms, including truffle; honey; medicinal and aromatic plants; game);
- regulating services, which relate to conserving the quality of our life environment, such as maintaining the quality and flow of water, carbon sequestration, the moderation of extreme events (e.g. floods), soil erosion prevention, pest control, and the reduction of noise and temperature in cities;
- cultural services, including recreation and tourism (e.g. trees contributing to the aesthetics of the Mediterranean landscapes, attractive hikes and other forest-related activities like adventure parks).

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 the 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).
A projection made by Ding et al. (2016) of the total values of some ecosystem services in northern Mediterranean in 2050 shows their dependence on the emission scenario that will be followed. Scenario A2 that is characterized by the highest population growth, a regional oriented economic development, and a high CO_2 concentration, is often used by the European Commission as the reference scenario for interpreting the costs of policy inaction. As compared to A2, scenario A1F1 that is fossil intensive, predicts a reduction of the total value of all ecosystem services, with a stronger negative impact on regulating services and cultural services than on provisioning services (Table 2). On the contrary, B1 and B2 scenarios that are environmental oriented scenarios show a stronger positive impact on regulating services and cultural services than on provisioning services (Table 2).
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 size, 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.

3.2.3.3. 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 has been trending downwards from 570,000 ha/year in 1980-1985 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 (Figure 1). It remains to be seen if this recent increase is a short term aberration or a new trend. 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).
The geographical heterogeneity of the drivers of forest degradation and threats is the result of contrasting social and economic pathways. For example, differing processes prevail in the north (e.g. lack of forest management following land abandonment and increased risk of forest fires due to biomass accumulation) and south and east Mediterranean (e.g. overgrazing and overexploitation of fuel-wood). Diverse causes of forest degradation (anthropogenic pressures combined with forest fragmentation and climate change) interact, creating a series of new, complex and unpredictable feedback loops and consequences.
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. In addition, the increasing trends in the population in some urban and peri-urban settings of the Mediterranean have severely threatened patches of remnant forest, vacant wooded lots and other fragments of natural habitat as a result of expansion of infrastructure, predominantly housing and transportation. This has led to uncontrolled urban sprawl, particularly in the southern and eastern Mediterranean (CIDOB, 2015).

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 percent 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).

3.2.3.4. Management of Mediterranean forests

All Mediterranean countries have forest-related policy documents that orientate 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 20-25 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; forest degradation and deforestation; 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, as demonstrated by its prevalence in forest policy documents across 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, e.g. the Natura 2000 in the European Mediterranean. Over 42 percent of land area in protected areas in the Mediterranean has tree cover of more than 10 percent, to be compared to 19 percent 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 is 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.

Table 1: Area of forests and of other wooded lands in Mediterranean countries from 1990 to 2015, and forested area in 2000

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 & 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%
Jordan	98	98	98	98	98	51	51	51	51	51	0.0%	0.4%	
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%
Portugal	3,436	3,343	3,296	3,239	3,182	1,091	1,218	1,281	1,503	1,725	34.1%	30.0%	
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%
Syrian Arab Republic	372	432	461	491	491	35	35	35	35	35	0.8%	2.9%	16.7%
North Macedonia	912	958	975	998	998	143	143	143	143	143	37.2%	42.7%	
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%**

Source: FAO (2015) for forest area and other wooded land area; Hansen et al. (2013) for forested areas.

Note: Forested areas are areas with tree cover ≥10%. Coastal areas are land areas within 5 km of the coastline of the Mediterranean Sea.

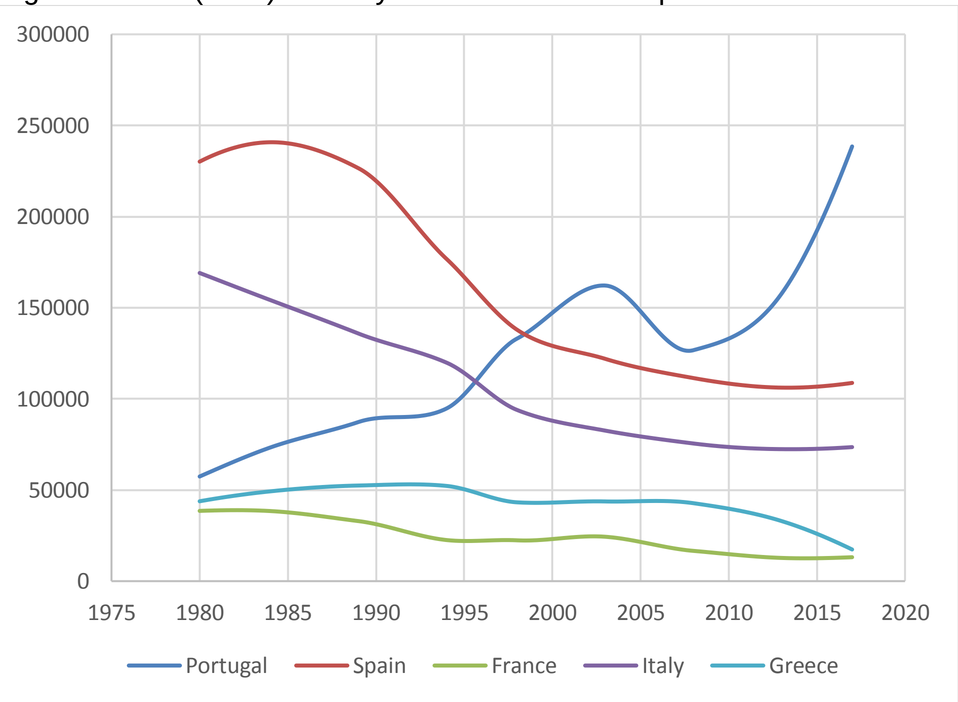
Table 2: Projected total value of some provisioning services (wood products), regulating services (carbon sequestration) and cultural services (recreational use and passive use) in Mediterranean Europe in 2050 under different climate scenarios

Services	Total value (million USD/yr)			
	A2	A1F1 — A2	B1 — A2	B2 — A2
Wood products	6,449	—40	1,565	2,283
Carbon sequestration	45,810	—8,614	20,785	17,819
Recreational use and passive use	4,850	—862	4,156	3,607

Source: Ding et al. (2016).

Note: Wood products include wood pulp, industrial roundwood, recovered paper, sawnwood, wood-based panels, paper and paperboard, and woodfuel. A1F1, A2, B1 and B2 are the storylines defined by the IPCCC (2000). Storyline A2 is used as a benchmark to assess the other storylines.

Figure 1: 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.

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3.2.4. Soft and rocky shores

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 Gabes 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

3.2.4.1 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). Thus, different shorelines might form such as high energy environment beaches, sandy cliff shores and sheltered beach environments in gulfs, bays, embayments and behind islands on the open coast.

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 of biogenic origin materials (animal skeletons, coral, foraminifera, calcareous remains of benthic algae and shell fragments) or a result of coastal erosion processes. A particularity also found of many sandy beaches along the Mediterranean, is the deposits of large volumes of Posidonia wrack (leaves and rhizomes) forming a permanent or semi-permanent structure on the beaches from a few centimetres to several metres thick, named banquettes (Otero et al., 2018).

Although not as richer 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 of 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 (family Ephydridae), beach flies (subfamily 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 (embryonic and mobile dunes) that evolve into a more stable ecosystem dominated by different stages of woody shrubs and three species (fixed and wooded dunes) (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 Km2 (Otero 2015) and a loss of 30% of this particular habitat inferred from the development of harbours, dikes and others coastal structures over the last 50 years. The dammed of rivers is also one of the prime reasons for the loss of sand supply to the coastal environment (and its beaches) and no data is available for southern Mediterranean countries. For coastal dunes, it has been estimated the habitat has declined in quantity 20.8% over the past 50 years in EU Mediterranean countries with a range of 10-40% among countries (Acosta, 2015)..

Soft sediment coasts: Muddy environments

Muddy shores are present but not common in the four sub-basins of the Mediterranean. They are typically found in association with coastal lagoons and river mouths. The most extensive examples are found around the deltas of the Ebro (Spain), Rhone (France) and Po (Italy) while smaller, very localised pockets are present across the region (Soldo et al 2016). Its current overall distribution is unknown and limited information is available on its status and trends. Nonetheless, nutrient enrichment, altered flow regimes following coast protection works and coastal zone developments has most probably affected largely these coastlines.

Hard rock coast: Rocky shores and cliffs

Cliffed and rocky coasts represents >50% of coast in the Mediterranean area. A detail overview of the different rock coastal formations and their geographical background is described by Furnalli et al (2014).
The interaction of waves, weathering and relative sea-level changes shaped these types of rocky coastlines and its main landforms as the sloping shore platforms, 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 formation in some areas.

The majority of supralitoral rocky shores are typically characterised 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 mediolittoral (surf zone) on the areas of bedrock, boulders and stones, associated marine species are adapted to long periods of emersion.

The Mediterranean Sea cliffs harbour numerous endemics of extremely local occurrence, in particular many 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 harbours, 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, 2016).

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 (from 0.1 m to ~1 m/yr) although they are generally considered two orders of magnitude greater than hard rocky cliffs (Melody et al., 2018).

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).

3.2.4.2 Ecosystem services

Coastal ecosystems provide shoreline stabilization and buffering services. For example, seagrass meadows and banquettes on beaches reduce erosion by mitigating wave impact while sandy and rocky shores serve as a first line of defence, mitigating and responding to natural forces like waves and storms (Drius et al 2019; Boudouresque et al., 2016). Table 1 shows the main ecosystem services associated to these four type of coastal ecosystems.

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 defence, groundwater storage and water purification, while their importance in nutrient cycling, soil formation and climate regulation (on carbon sequestration) is rather less known (e.g. Bazzichetto et al., 2016).

There is presently a reasonable number of studies that have mapped and quantified multiple ecosystem services for the terrestrial Mediterranean environment and more seldom have occurred in these type of coastal ecosystems or on marine environments due to difficulties in obtaining data. 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	Recreation and tourism – image of natural sand dunes and beach fronts as part of their marketing packages

			vegetation such as Goat's Foot and Spinifex are ideal nesting sites for turtles (Choudury et al., 2003).	
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 harbour 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	Sea defense	Habitat/refugia for coastal biodiversity —— sea cliffs harbour a diversity of vegetation	Recreation and tourism – recreational fishing

	collected on rocky coastlines.		types with maritime influence. It is an important feeding area for birds and fish in ponds, and nursery grounds for invertebrates	

3.2.4.3 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, at local, national and global levels (Orth et al., 2006).

Mediterranean coastal sandy and muddy shores, beaches and dunes have been highly modified by human impacts. Accelerated erosion rates is a widespread phenomenon along most of its basin mainly because of anthropogenic impact, e.g. the proliferation of marinas and other urban and tourist-industry 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 defence structures (Otero 2015).
The development of coastal projects, such as the construction of marinas and other 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 harbour development, and also from degraded water quality. Urban and industrial wastes as well as wastewater are discharged directly into the sea in some countries and chemical contaminants that 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 enhance the erosion process (Tzonev, 2015b).

3.2.4.4 Management

There are various legal provisions and policies which relate to these types of ecosystem landscapes at national level, EU level as well as within the ICZM Protocol of the Barcelona Convention. Altogether, these Mediterranean policies, including EU Directives (Habitat and Birds Directive, MSFD and MSP), 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 where these dunes communities develop and some beaches are also protected because the presence of breeding sites of marine turtles. Even so, 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 marine/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 might 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 areas/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 will be essential to the successful implementation of conservation actions.

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3.2.5. Invasive species

Invasive Alien Species (IAS), introduced species which out-compete native species and cause economic and ecological damage by spreading in natural ecosystems (IUCN, 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 new 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 is much well 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 well known examples are the Brown rat, *Rattus norvegicus,* with strong negative effects on native fauna, particularly on islands; the Red-eared 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 or different times, sometimes with a strong invasive component and sometimes not.

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 worst invasive species. Others like the Tiger mosquito *Aedes albopictus* are also one of the worst invasive alien species in the region (MIO-ECSDE 2013).

3.2.6. Threatened species

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 1 238 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 1). Half of the threatened species are animals (84 species), with birds and insects (18 and 17 species) making up the greatest number of threatened species. Plants make up 84 of the threatened species, 50 % of the total threatened coastal species.

Table 1: 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.

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	18	15	30	49	449	13	2	1	63	577	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	1	5	7	16	50	1	0	0	13	80	16%
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 – 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	48	59	61	97	899	68	2	1	168	1238	14%

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

By countries, France, Spain, Italy, Morocco and Greece have in this order the highest number of threatened species living in coastal habitats in the entire region. Most of the threatened coastal birds are found in France and Spain, a high number of marine fishes occur in France and a high number of threatened freshwater fishes, amphibians and reptiles are found in Spain. The highest number of threatened invertebrates and plants are also found in France and Spain (Table 1).

Table 2: Number of threatened forest species by country. The highest number of threatened species by taxonomic group in bold.

	Coastal threatened taxa in the Mediterranean region									
Countries	Amphibians	Aves	Reptiles	Mammals	Freshwater Fishes	Freshwater Molluscs	Freshwater crabs, and shrimps	Butterflies	Dung Beetles	Saproxylics
Spain	2	18	4	5	4				6	2
France	1	18		6	1				5	3
Italy	2	16		3	2	1			4	2
Morocco		16	3	9				1	4	1
Portugal	1	16	3	3	1				2	1
Greece		15	1	5	5			1		
Algeria		14	2	7	1				1	2
Turkey	1	15	2	9	3		1	1		
Israel	1	16	1	6		1				
Croatia	1	14	1	4	3				1	
Tunisia		12	3	6	1				1	1
Serbia	1	13		6	4				1	
Egypt		13	2	4					1	
Montenegro	1	15	1	5	1				1	
Syrian Arab Republic		12	2	6						
Bulgaria		14		5	3					
Jordan		10		6		1				
Lebanon		10	2	6						
Bosnia & Herzegovina	1	13	1	3						
Slovenia	1	11		4						
North Macedonia		13		4						
Albania		10		3	2				1	
Malta		11							1	
Palestine	1	9		2		1				
Cyprus		12		2						
Libya		10	1	1					1	
Monaco		4		2						
Holy See				2						
San Marino				2						

Drivers and threats to coastal biodiversity

The analysis of the threats affecting 216 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 1).

Tourism often has irreversible effects on natural areas rich in biodiversity. 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 grasses and coralligenous species) and nesting areas of marine turtles.

This results in one of the heaviest pressures from visitors and residents on the remaining natural habitats encountered anywhere on earth. 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 (effectively islands) and have a narrow genetic base, reduced competitive abilities and limited dispersal opportunities, and so increasing their vulnerability.

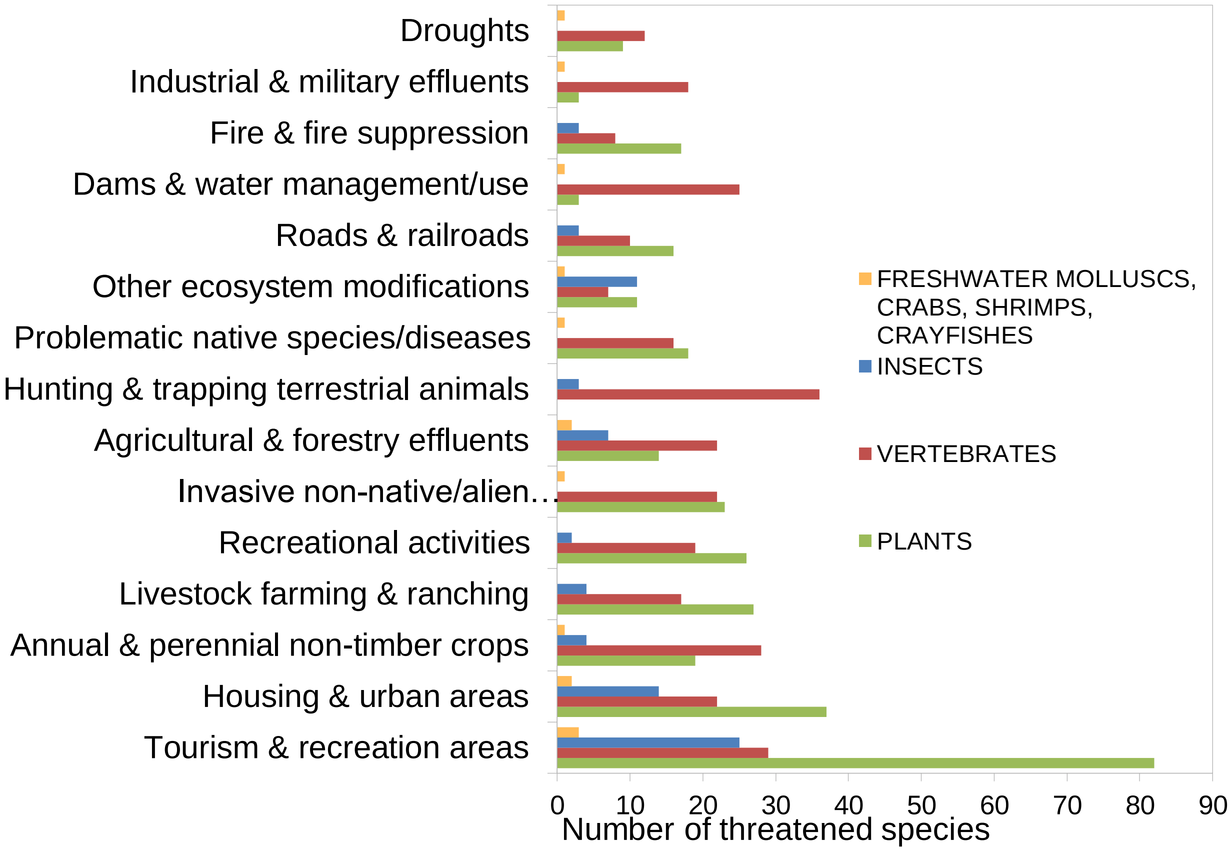


Figure 1: Main threats affecting coastal species in risk of extinction (IUCN Red List Categories CR, EN and VU) in the Mediterranean region.

3.3. Marine ecosystems and biodiversity

3.3.1 Marine ecosystems

The complexity in the ecology of the Mediterranean Sea is mainly attributed to its geological history combined to 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. However, 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 seagrass meadows, the coralligenous formations and beds and the dark habitats (habitats where the absence of light precludes photosynthesis) 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 the Mediterranean countries and partner organisations.

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 marina* and *Zostera noltii)* and one is a Lessepsian migrant *(Halophila stipulacea).*
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 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, but this species also seems to regress in sectors where anthropogenic pressures are very low (Boudouresque *et al*., 2009). The absence of *Posidonia 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 *Posidonia 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 (Turkey) and in the Atlantic. It ranks second, after *Posidonia 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 *Posidonia 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 metres. This species is above all present in a number of coastal lagoons and at the innermost part of very sheltered bays. 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 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: 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.

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). In any event, the estimates available should be considered with prudence, in view of the data obtained, still very fragmentary, on the worldwide distribution of marine Magnoliophyta.
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 consequence 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 restructuring of the shores, 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).

However, 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 1700 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.
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. The low growth rate that characterises most of the species forming the coralligenous communities is a hindrance to their recovery if affected the stressors.

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.
In the Mediterranean, the 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.

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 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 waste, 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 our knowledge concerning these environments and to overcome the technical and legal challenges faced, in particular in areas beyond national jurisdictions.

3.3.5 Threatened species and habitats

Overall, the Mediterranean marine ecosystem is threatened by the increasing pressures by human activities and in particular of fisheries, maritime transport, oil and gas exploration and exploitation, land and marine-based sources pollution, coastal alterations, coastal urbanisation and industrialisation.
Under the Convention on Biological Diversity, "EBSAs" (abbreviation for Ecologically or Biologically Significant Areas) are marine areas deserving management, warranting their sustainability, using seven scientific criteria (9th Conference of the Parties to the Convention on Biological Diversity in 2008, CBD Decision IX/20, Annex I). The criteria are (i) uniqueness or rarity, (ii) special importance for life history stages 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 the CBD Repository. The decision for conservation efforts or special management measures remains the responsibility of each country surrounding the area, alone or together.
The vulnerable marine ecosystem (VME) concept emerged from discussions at the United Nations General Assembly (UNGA) and gained momentum after UNGA Resolution 61/105. 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 lists were through the Decision IG23/10 that amended the Annex II of the SPA/BD Protocol concerning endangered and threatened species in the Mediterranean including 163 species (Mammalia, Aves, Reptiles, Pisces, Echinodermata, Crustacea, Mollusca, Bryozoa, Cnidaria, Porifera, Rhodophyta, Heterokontophyta, Chlorophyta, Magnoliophyta).

Genetic diversity

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

At least 79 (14%) of the coastal species assessed in the IUCN RLTS (68 of them endemics) are threatened with extinction at global or regional level in the Mediterranean region (Table 3.4.1). Cartilaginous fishes is the group with highest number of threatened species (40 species), followed by anthozoa with 17 threatened species. The estimated percentages of threatened species by group indicate that mammals and reptiles have the highest percentages of threatened species (70 % and 100% of species) followed by anthozoans (65%).

Table 1: 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.

Taxonomic Group	CR	EN	VU	NT	LC	DD	EX	Total of marine threatened taxa	Total marine taxa assessed	% estimated coastal threatened taxa in Mediterranean region (Mid-point)
Anthozoa	1	9	7	10	40	69	0	17	136	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	17	70%
Marine reptiles	1	1	2	0	0	0	0	4	4	100%
Marine plants	0	0	0	0	4	0	0	0	4	0%
Total	**24**	**27**	**28**	**28**	**375**	**209**	**0**	**94**	**691**	**16%**

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

By countries, 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 anthozoa is recorded in Greece as whereas a high number of marine mammals are found in Spain and Morocco (Table 1). 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

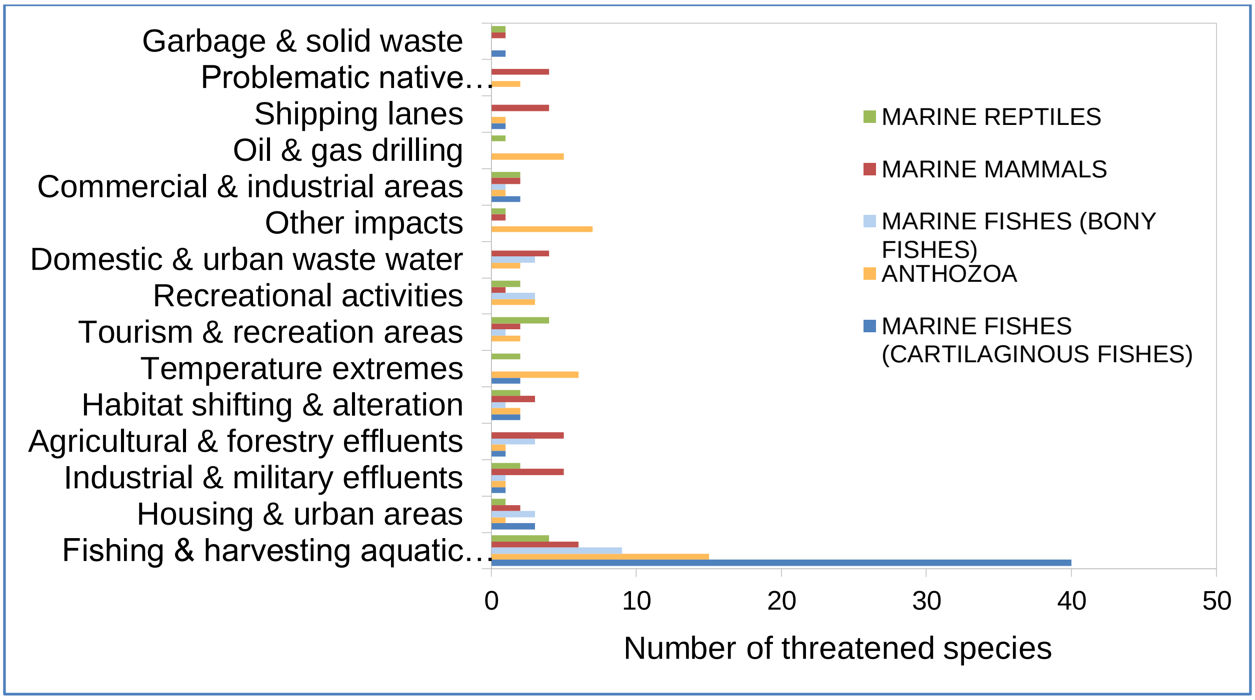
Table 2: Number of threatened forest species by country. The highest number of threatened species by taxonomic group in bold.

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	3	93
Spain	15	10	38	7	3	73
Italy	15	9	37	6	2	69
Greece	17	8	33	6	2	66
Croatia	11	8	30	6	2	57
Morocco	7	7	34	7	2	57
Algeria	9	7	33	6	1	56
Tunisia	8	8	31	6	2	55
Turkey	10	8	28	6	2	54
Albania	5	7	30	6	2	50
Montenegro	5	6	29	6	2	48
Portugal	1	9	31	3	3	47
Egypt	2	7	26	6	4	45
Libya	2	7	27	6	2	44
Slovenia	4	8	25	5	2	44
Israel	3	6	26	5	3	43
Cyprus	3	7	22	6	3	41
Syrian Arab Republic	2	6	23	6	2	39
Lebanon	2	6	22	6	2	38
Malta	9	6	16	6	1	38
Bosnia & Herzegovina	1	3	23	6	1	34
Monaco	3	8	8	5		24
Palestine			12	3		15
Bulgaria		4	4	2		10
Serbia	1			1		2
Jordan				1		1

Drivers and threats to marine biodiversity

The analysis of the threats affecting 78 Mediterranean marine species in risk of extinction in the IUCN Red List (categories CR, EN and VU) (IUCN 2018) showed that overfishing is the main driver increasing the species extinction risk. Other important threats are urbanization, pollution and climate change (Figure 1). 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, the bottom trawling fisheries is identified as the main cause for the decline of the Maltese skate, *Leucoraja melitensis* or the bamboo coral, *Isidella* elongata by 80 percent, making both native species as Critically Endangered of extinction (Dulvy andWalls, 2105; Dulvy et al. 2016; Otero et al 2017).

Figure 1 Main threats affecting Mediterranean marine species in risk of extinction (IUCN Red List Categories CR, EN and VU) in the Mediterranean region.



3.3.6. Invasive species

In the Mediterranean Sea, as in many other regions of the World Ocean, invasive species became in recent decades a serious issue that threatens native species and their habitats. According to recent estimates (Zenetos et al., 2017)[2], a total number of 610 non-indigenous marine species were recorded in the Mediterranean, which represents an increase of 20% over the previous four years. The same estimates indicate an additional number of 227 alien species that were recorded as occasional species. However, these numbers give an underestimated picture of the actual situation because they do not include phytoplankton organisms, foraminifers, cryptogenic species and doubtfully identified species that may be non-native species. 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 climate 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. An assessment published in 2014 (Katsanevakis et al., (2014)) [3] concluded that 64 invasive species were reported to occur in the Mediterranean. The most represented groups were crustaceans (23 species), 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

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.

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[2] Zenetos, A., Çinar, M.E., Crocetta, F., Golani, D., Rosso, A., Servello, G., Shenkar, N., Turon, X., Verlaque, M., Uncertainties and validation of alien species catalogues: The Mediterranean as an example, *Estuarine, Coastal and Shelf Science* (2017), doi: 10.1016/j.ecss.2017.03.031.

[3] Katsanevakis S, Wallentinus I, Zenetos A, Leppakoski E, Çinar ME, Ozturk B, Grabowski M, Golani D, Cardoso AC (2014) Impacts of marine invasive alien species on ecosystem services and biodiversity: a pan-European review. Aquatic Invasions 9: 391–423, https://doi.org/10.3391/ai.2014.9.4.01

Rapana venosa).

Table 1: Number of marine non-indigenous species reported to generate significant adverse impacts on ecosystem services and biodiversity.

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		

(Source: compiled from Katsanevakis *et al*., (2014))4.

Table 2: List of species identified as of very high or of high priority species for risk analysis
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,	TNEP, TA	MED, MAC, ATL,

4 Katsanevakis S, Wallentinus I, Zenetos A, Leppakoski E, Çinar ME, Ozturk B, Grabowski M, Golani D, Cardoso AC (2014) Impacts of marine invasive alien species on ecosystem services and biodiversity: a pan-European review. Aquatic Invasions 9: 391–423, https://doi.org/10.3391/ai.2014.9.4.01

Species	Invaded zones	Threatened Bio-regions
1861)		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

(Source: compiled from (Roy et al., 2015))[5]

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 ofof the International Maritime Organisation (IMO).

3.4. Responses and priorities for action

3.4.1. Marine and coastal protected areas

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 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

[5] Roy HE, Adriaens T, Aldridge DC, Bacher S, Bishop JDD, Blackburn TM, Branquart E, Brodie J, Carboneras C, Cook EJ, Copp GH, Dean HJ, Eilenberg J, Essl F, Gallardo B, Garcia M, García-Berthou E, Genovesi P, Hulme PE, Kenis M, Kerckhof F, Kettunen M, Minchin D, Nentwig W, Nieto A, Pergl J, Pescott O, Peyton J, Preda C, Rabitsch W, Roques A, Rorke S, Scalera R, Schindler S, Schönrogge K, Sewell J, Solarz W, Stewart A, Tricarico E, Vanderhoeven S, van der Velde G, Vilà M, Wood CA, Zenetos A (2015) Invasive Alien Species - Prioritising prevention efforts through horizon scanning ENV.B.2/ETU/2014/0016. European Commission.

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 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 km^2), 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, regardless of management effectiveness or whether regulations are implemented, challenging but not impossible.

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. MAPAMED allows following the regional development of the network of conservation areas and 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".

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 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 or enforcement or of regulations. Nevertheless, management remains one of the weakest points in the Mediterranean, where it is estimated that only about 10% of the sites declared 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 resources 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 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;
- 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 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.

For all these elements, networks at different levels and for every thematic are and will be essential for achieving the above targets and the objectives set in the Regional Working Programme for the 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).

3.4.2. Regional regulatory tools, strategies and action plans

EcAp Indicators for the Ecological Objectives Biodiversity and NIS

(This sub-section should be developed harmonised with the whole EcAp and MSFD)
Common indicator 1: Habitat distributional range (EO1)
Common indicator 2: Condition of the habitat's typical species and communities (EO1);
Common indicator 3: Species distributional range (EO1 related to marine mammals, seabirds, marine reptiles);
Common indicator 4: Population abundance of selected species (EO1, related to marine mammals, seabirds, marine reptiles);
Common indicator 5: Population demographic characteristics (EO1, e.g. body size or age class structure, sex ratio, fecundity rates, survival/mortality rates related to marine mammals, seabirds, marine reptiles);
Common indicator 6: Trends in abundance, temporal occurrence, and spatial distribution of non-indigenous species, particularly invasive, non-indigenous species, notably in risk areas (EO2, in relation to the main vectors and pathways of spreading of such species);

3.4.3. Economic and management tools

3.4.4. Major knowledge gaps

3.4.5. Priorities for action