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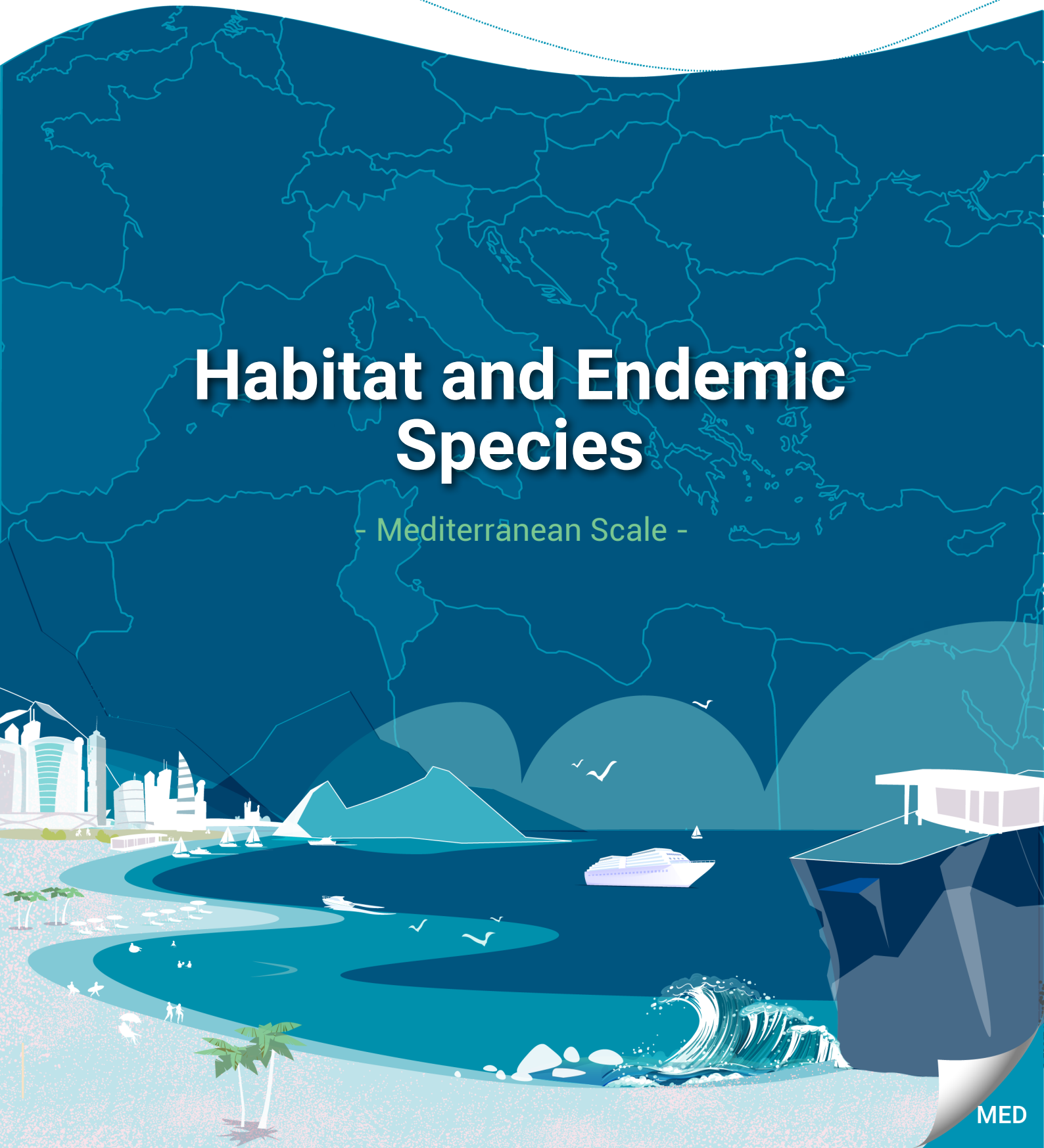
Co-Evolve4BG

Habitat and Endemic Species

- Mediterranean Scale -



MED

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OVERVIEW

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Abstract

This report summarizes the state of the principal habitats and endemic species in the Mediterranean region, focusing on coast and sea areas, climate change context, and their relation with tourism development. It is based on the reports established by the 5 Mediterranean countries involved in this project (Spain, Italia, Tunisia, Greece, Lebanon). The Mediterranean Sea is a hotspot of biodiversity and is characterized by its high level of endemicity. It covers only 0.7% of the world's ocean area (Marx, Let al.. (2021)), , but it is considered one of the significant marine and coastal biodiversity reservoirs since it shelters around 7.5% of the world's marine fauna, and 18% of its marine flora, whose 28% are endemic. In general, biodiversity is concentrated in the 0-50 m depth. But, some other remarkable habitats/ecosystems are distinguished by high biodiversity and certain specificities, such as marine macrophyte beds (mainly Posidonia meadows) the coralligenous and other bio-concretions, wetlands (deltas, marshes, lagoons, estuaries, etc.), islands and marine banks. The main problems that threaten marine and coastal biodiversity in the Mediterranean remain tourism, urbanization, overexploitation of natural resources, proliferation of alien species, increasing maritime traffic, and pollution of the marine ecosystems. In a climate change context, this has led to the loss of the biodiversity, the growing scarcity of the most sensitive endemic species and the degradation of unique coastal and remarkable habitats. Nevertheless, some habitats in Mediterranean Sea are less affected by tourism as they are further offshore, such as the coralligenous, the marine banks and the bio-concretions, so far from tourist activities, except maybe scuba diving and accidental pollution.

I. Introduction

This report summarizes the state of the principal habitats and endemic species in the Mediterranean region, focusing in coast and sea areas, in a climate change context, and their relation with tourism development. It is based on the reports established by the 5 Mediterranean countries involved in this project. The geographical distribution of these countries (Figure 1) makes it possible to have representative data over the entire Mediterranean Sea, one country to the West (Spain), one country to the East (Lebanon), two countries on the northern shore (Italy and Greece) against only one country on the southern shore (Tunisia). Nevertheless, this imbalance of representativeness between the northern shore and the southern shore could lead to a lack of data, mainly for Egyptian and Libyan coasts where the influence of the Red Sea and therefore the Indo-Pacific Ocean is more marked, especially since Egypt is a major tourist country in the Mediterranean.

Figure 1. Countries involved in this synthesis

The Environment and Development Conference (widely known as the Rio Summit or Earth Summit) that was conducted in Rio de Janeiro 3-14 Jun 1992 under the United Nations has resulted in the Convention on Biological Diversity (CBD). It was the first official recognition at a global scale of the emerging necessity for implementing an international policy and relating actions and the worldwide establishment of biodiversity.

The Mediterranean Sea is a hotspot of biodiversity, it is characterized by a high level of endemicity. It is bordered by many lagoons and other wetlands (803 natural and artificial wetlands in Greece with areas longer than 0.1 ha on 75 islands (Chrysoulidis et al., 2021), and has rich islands, underwater beds and significant wintering area, reproduction, and migration for several species. The Mediterranean Sea covers only 0.7% of the world's ocean area, but it is considered one of the significant marine and coastal biodiversity reservoirs since it shelters around 7.5% of the world's marine fauna, and 18% of its marine flora, whose 28% are endemic. Its coastal fringe that shelters, in small surface areas, rich and varied communities remain the most severe threatened by numerous economic activities connected to the tourism (water sports, boating), the exploitation of natural resources (aquaculture and fishing) and the surrounding anthropogenic activities (Chrysoulidis et al., 2021). The artificial beach filling for tourism purposes in the Mediterranean induces the disappearance of marine life, which reappears only after a few years and slowly. In Spain for example, after the artificial beach filling the fishes were also slowly returning to the site, as the algae began to recolonize the bottom and the surface of the rocks, making food available for the initial elements of the trophic chains (Garcia-Bueno et al., 2021).

In terms of biodiversity, the main Mediterranean habitats are the marine macrophyte beds, the coralligenous and other bio-concretions. Some other Habitats, such as wetlands (deltas, marshes, lagoons, estuaries, etc.), islands and marine banks, are also important.

The phanerogam Posidonia oceanica is a Mediterranean endemic species with extensive distribution. It develops in the coastal fringe, from the shore to the lower limit of the infralittoral. It forms enormous underwater meadows that represent the first hotspot of marine biodiversity in the Mediterranean (25% of marine species). Posidonia meadows are unevenly distributed along the Mediterranean coasts. The most important and densest was that of the Gulf of Gabès (South Tunisia). But this meadow has remarkably regressed and the current state of this ecosystem is fragile for various reasons, mainly pollution and trawling operations (Afli, 2021).

The coralligenous biocenosis is formed by a concretion of coralline and sciaphilic calcareous algae. These complex biogenic structures are generally colonized by a large number of animal/vegetal species (e.g. Sponges, Ascidians, Bryozoa, Cnidarians, macroalgae). The coralligenous constitutes the second hotspot of marine biodiversity in the Mediterranean after Posidonia meadows. It is the most beautiful underwater landscape in the Mediterranean, but it is particularly vulnerable to natural and human-induced changes (Afli, 2021).

Some of the main anthropogenic pressures on the coralligenous ecosystem in the Mediterranean include:

- Overfishing: Fishing activities can damage the coralligenous structure and disrupt the natural balance of the ecosystem. Targeted fishing of species such as sea urchins and other herbivores can also cause imbalances in the community, leading to the proliferation of algae and other opportunistic species that can outcompete coralligenous organisms.
- Coastal development: Human activities along the coast, such as urbanization, construction of marinas, and other infrastructure, can cause physical damage to the coralligenous structure, alter water quality, and increase sedimentation rates, which can suffocate the coralligenous organisms.
- Climate change: Rising temperatures, ocean acidification, and changes in seawater chemistry associated with climate change can have significant impacts on coralligenous ecosystems, affecting the growth and survival of calcifying organisms, including corals, algae, and other species.
- Pollution: Chemical pollutants, such as oil spills, heavy metals, and pesticides, can harm the coralligenous ecosystem, affecting the health and survival of the organisms that live within it.

In the Mediterranean Sea, maerl-rhodolith beds which are ordinarily small (<0.01 km2) and multispecific are located from 9 to 150 m of water depth, with an average depth of about 55 m in both sub-basins. Most maerl-rhodolith beds lay within the depth span of 30–75 m, while those reaching deeper than 75 m are only around 18 % of the total, and those shallower than about 25 m are rare.

Wetlands, islands, insulate banks, Cystoseira beds, Lithophyllum lichenoides sidewalks, vermet sidewalks and Neogoniolithon reefs are also remarkable ecosystems sheltering high and specific biodiversity (Chrysoulidis et al., 2021; Afli, 2021).

The main problems that threaten marine and coastal biodiversity in the Mediterranean remain urbanization, overexploitation of natural resources, proliferation of alien species, increasing maritime traffic, and pollution of marine ecosystems. In a climate change context, this has led to the loss of biodiversity, growing scarcity of the most sensitive endemic species and degradation of unique coastal and remarkable habitats.

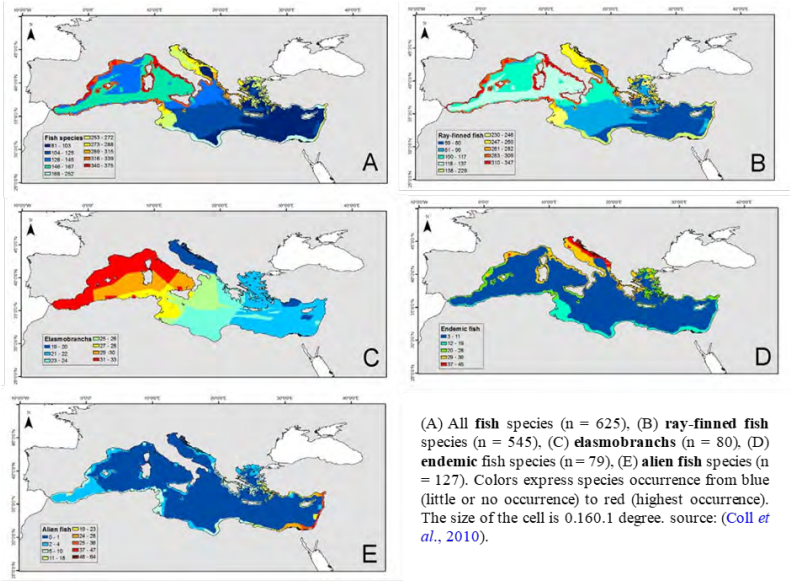
According to the Mediterranean Action Plan of the United Nations Environment Program (UNEP/MAP, 2014), the Mediterranean region is warming 20% faster than the global average. An increase of 2°C global warming will reduce precipitation by 10 to 15%. Particularly, coastal zones face heightened disaster risks, including flooding and erosion, and the salinization of river deltas and aquifers that sustain food security and livelihoods of about 510 million inhabitants. These impacts will exert additional pressure on already strained ecosystems and on vulnerable economies and societies. They will certainly affect seaside tourism, which represent an important part of the economy of several countries bordering the Mediterranean.

II.
State and trends

II. State and trends

II.1. Mediterranean level

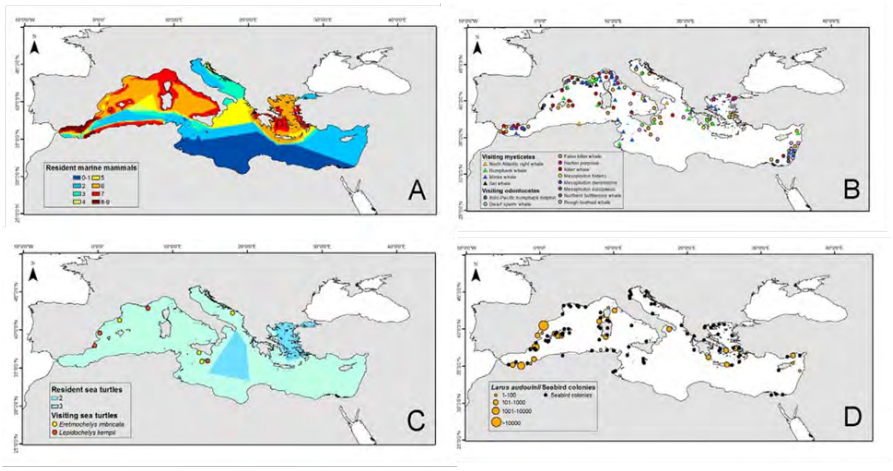
The coastal and marine areas of the Mediterranean Sea are varied in terms of bottom types, materials, landscapes and biodiversity. Globally, the sandy/rocky bottoms and cliffs dominate in Western Mediterranean, however muddy/sandy bottoms dominate in Eastern Mediterranean. This mosaic of bottoms confers a rich and specific biodiversity to the areas. The Mediterranean Basin is recognized as a hotspot for biodiversity: its exceptional flora counts between 15,000 and 25,000 species, 60% of which are unique to the region. Almost a third of the Mediterranean fauna is endemic (CSE, 2008). Although these marine ecosystems are characterized by a rich and diverse flora and fauna, certain marine habitats (e.g. Posidonia meadows, coralligenous, islands, wetlands, insulate banks, etc.) and certain important taxonomic groups (e.g. bryozoans, ascidians, crustaceans, cnidarians) remain little or poorly studied (Chebbi, 2010; Afli, 2021). For example, the distribution of vertebrate species indicates that there was a decreasing inclination from northwest to the southeast. At the same time, the nearby sea Sicily had the most extraordinary richness, followed by other northwestern coastal and shelf areas (Figures 2 A–B). The distribution of elasmobranch species was not homogenous either, conferring a greater concentration of species in the West (Figure 2 C). The endemic richness gradient of fish species was more declared with latitude, the North side exhibiting a more incredible richness, and the Adriatic appearing as a hot spot of endemism with 45 species per cell (Figure 2 D). Spatial patterns also confirmed how most Mediterranean coastal waters had been colonized by exotic species (Figure 2 E) (Chrysoulidis et al., 2021).



(A) All **fish** species (n = 625), (B) **ray-finned fish** species (n = 545), (C) **elasmobranchs** (n = 80), (D) **endemic** fish species (n = 79), (E) **alien fish** species (n = 127). Colors express species occurrence from blue (little or no occurrence) to red (highest occurrence). The size of the cell is 0.160.1 degree. source: (Coll *et al.*, 2010).

Figure 2. Spatial patterns of fish species richness in the Mediterranean Sea based on superimposed expert-drawn maps (Chrysoulidis et al., 2021).

The Western Mediterranean and Aegean seas gather marine mammals (Figure 3 A). Eight marine mammals species were found in the western basin, out of the total nine. This distribution pattern was also recorded for the migrating marine mammals (Figure 3 B). In the central Mediterranean and the Aegean seas two of the three resident sea turtle species (loggerhead, green, and leatherback turtles) are observed. In comparison, the two visiting turtles were absent from the eastern side (Figure 3 C). There were fewer seabird colonies and seabird density was lower in the southeast than in the northwest (Figure 3 D) (Chrysoulidis et al., 2021).



(A) resident marine mammals (n = 9), (B) nonresident marine mammals (n = 14), and (C) resident sea turtles (n = 3), as well as sighting records (dots) of the two visiting sea turtles. Colors express species occurrence from blue (little or no occurrence) to red (highest occurrence). (D) Seabird colonies (the yellow dots show the distribution and population density of colonies in breeding pairs (bp) of Audouin's gull: Some dots represent the epicenter of several smaller colonies in archipelagos). Source: doi: 10.1371/journal.pone.0011842.g003

Figure 3. Spatial patterns of fish species richness in the Mediterranean Sea based on superimposed expert-drawn maps (excluding fish species) (Chrysoulidis et al., 2021).

The Mediterranean Sea alone recorded approximately 6500 species of marine invertebrates such as squid, sea urchins, sponges, jellyfish and starfish. The last group with over 600 species is fish. In the Mediterranean, there are 86 species that are endemic to the area. They are in various sizes, shapes, and colors due to each species' unique adaptions, allowing them to thrive in their inhabit in the marine ecosystem (Chrysoulidis et al., 2021).

II.2. Remarkable habitats/ecosystems

In the Mediterranean, specific/functional biodiversity is unevenly distributed. In general, it is concentrated in the 0-50 m deep coastal strip where benthic macro-algae and phanerogams (Posidonia oceanica, Cymodocea nodosa, Zostera noltii and Halophila stipulacea) live. This distribution is linked to several factors, in particular photic, climatic and hydrodynamic, and is strongly correlated with the presence of

animals, in particular through trophic chain (Boudouresque, 1997; Numa & Troya., 2011; Anonymous, 2012; Afli, 2021). Nevertheless, some other remarkable habitats and ecosystems are distinguished by high biodiversity and certain specificities, such as the high presence of endemic, rare and threatened species (Ghrabi-Gammar et al., 2009; UNEP/MAP-RAC/SPA, 2015).

Posidonia oceanic is a marine phanerogam endemic to the Mediterranean Sea. It forms vast underwater meadows supporting high biodiversity and capable of sequestering around half a million tons of CO2 in the Mediterranean Sea per year. The area of the Mediterranean covered by Posidonia meadows is around 37,000 km², i.e., about 1-2% of its total area, about 25% of the sea bottom between 0 and 40 m depth. It belongs to the soft substrate societies with a maximum depth of distribution of 50 m. More than 300 macro-flora species and more than 1,000 species of marine animals live in the meadows of Posidonia, including many of the fish of fishing importance. These are habitats that play a fundamental role in maintaining the health and productivity of marine ecosystems. First, they are breeding grounds, operating as nurseries for many species. Local fisheries are affected when Posidonia meadows disappear. Second, they prevent coastal erosion through their rhizomes and leaves. With the deforestation of the sea meadows, many beaches are threatened with shrinkage or even disappearance. Third, underwater forests trap carbon from the atmosphere (Elafrou, 2020 in Chrysoulidis et al., 2021).

The current state of Posidonia meadows in the Mediterranean is globally fragile, for various reasons. On the one hand, pollution and trawling operations cause the uprooting and damage of these meadows, destabilize the nature of the substrate and increase the turbidity of the water, which decreases the penetration of the light necessary for their development. On the other hand, the Caulerpa and Zosteira meadows, which facilitate the establishment of Posidonia by enriching the substrate with mucus (organic matter), have also clearly declined (Afli, 2021). The most important in the Mediterranean Sea are those of the Gulf of Gabès (South Tunisia). Unfortunately, their extent has clearly decreased since few decades, mainly due to chemical pollution and abusive trawling activities (Afli, 2021).

The formation of coralligenous concretions needs a minimal depth that depends on the amount of irradiance reaching the sea bottom (Anonymous, 2003). As examples, in vertical slopes from the area of Marseilles this minimal depth reaches -20 m, but it is much lower in some zones, like the Gulf of Fos, where the coralligenous is able to grow in shallower waters (-12 m) because of the high turbidity of the water related to the Rhône mouth. This minimal depth is displaced to deeper waters in insular areas like Corsica or the Balearic Islands, where water transparency is very high (Ballesteros, 2006) and Zembra, Fratelli and la Galite (Ben Mustapha, data not published).

Nevertheless, coralligenous concretions can appear in very shallow waters if light conditions are dim enough to allow a great development of coralline algae (Laborel, 1987; Sartoretto, 1994), even in the clearest waters, like those of Cabrera Island where a coralligenous buildup can be found at only 10 m depth in a cave entrance (Marti, 2002).

The Mediterranean region hosts around 400 coastal lagoons, covering a surface of over 641000 ha differing in both their typology and use. Only 37 coastal lagoons have a surface area greater than 10 km2 in the Mediterranean basin, only six of them are in good ecological condition, but most of them are eutrophic due to the impacts on their environment and the inflow of poor-quality water (Soria et al., 2022). Fisheries and various forms of aquaculture have been traditionally carried out in Mediterranean coastal lagoons since ancient times and are part of the cultural heritage of the region (Anonymous, 2015a). They are generally areas of a strong primary production, induced by the continental inputs of nutritive nutrients and the strong luminosity in the water column.

Other marine ecosystems are remarkably interesting in the Mediterranean Sea, because of their high biodiversity and their specifies as habitats/microhabitats for rare/threatened/endemic species. Marine macrophytes, such as phanerogams, Kelps, Laminaria or Cystoseiras, form real beds hosting high biodiversity. By way of example, the genre Cystoseira which includes 22 species forms beds generally in a good status (Robvieux, 2013). The bio-concretions are also interesting habitats for a fairly wide range of species, e.g maerl-rhodolith beds, sidewalks built by the calcareous rhodophyte Lithophyllum lichenoides, Vermets' sidewalks built mainly by the gastropod Dendropoma cristatum and other species such as the calcareous rhodophyte Neogoniolithon brassica-florida and the foraminifera Miniacina miniacea (Boudouresque, 1997). Lithophyllum lichenoides sidewalks and vermets' sidewalks are characteristic of warm temperate waters of the Atlantic and the Mediterranean. In the Mediterranean Sea, they can be observed on the Southern shore of Corsica, Italy, Algeria and Tunisia (notably in Zembra and Cap Blanc). They are particularly developed in the Eastern Mediterranean (Boudouresque, 1997).

All these habitats and micro-habitats host also several endemic, threatened and rare species. It should be noted that the notion of endemism includes two kinds: narrow endemism, which included taxa found strictly in the Mediterranean Sea and wide endemism, which included taxa that reached the neighboring Atlantic Ocean and Black Sea (Tortonese, 1985; Quignard & Tomasini, 2000).

Some habitats in Mediterranean Sea are less affected by tourism as they are further offshore, such as the coralligenous, the marine banks and the bio-concretions, so far

from tourist activities, except maybe scuba diving and accidental pollution. In fact, during the Messinian crises (5 to 6 million years ago), the Mediterranean more or less dried up with the disappearance of most of its communities. Following these crises, the communities of the Mediterranean Sea had to be reconstituted from the Atlantic. Thus, Atlantic species, entering the Mediterranean, evolved to give rise to several species and varieties. The endemic species are therefore the descendants of certain immigrants. This is a recent endemism or neo-endemism manifested at the specific level. The rate of endemism is very high in the Mediterranean compared to other regions of the world (Capapé, 1986; Stehmann & Bürkel, 1986; Fredj & Maurin, 1987; Fischer et al., 1987; Bradaï, 2000; Afli, 2021).

III.
Key issues: Threats and enabling factors

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III.1. Issues related with climate change

It is really difficult to be able to disassociate the respective parts of the impact factors (environmental/anthropogenic or climate change) in the changes observed in marine ecosystems, because they act together and concurrently.

Climate changes in general are induced by the rise in temperature (i.e. approximately 1.8 °C) resulting from atmospheric pollution by greenhouse gases. It is manifested mainly in the changing in rainfall patterns and increased torrential rainfall. The changing climate has been demonstrated over the past few decades by a number of extreme events, such as floods and mass movements, wet and dust storms, heat waves which resulted in forest fires (Bitar, 2008). With the negative human interference, this has been reflected on the biodiversity (Msayleb et al., 2021).

Climate warming is expected to have a significant influence on the Mediterranean biodiversity, mainly its endemic species. In fact, global warming has a strong effect on the growth, survival, and reproduction rates of many species (Diaz Almela et al., 2007). The Mediterranean Sea comprises only 0.32% of the global oceanic volume, contains 4–18% of all known marine species (Bianchi & Morri, 2000). The forecasts showing an average increase in the surface temperature of the Mediterranean Sea by 2070–2099 of about 3.1°C (Ben Rais Lasram et al., 2010). According to Ben Rais Lasram et al. (2010), the warming lead to add 45 fish species to the IUCN Red List, whereas 14 were expected to become extinct. The same author considered that by the middle of the 21st century, the coldest areas of the Mediterranean Sea (Adriatic Sea and Gulf of Lion) would act as a refuge for cold-water species, but by the end of the century, those areas were projected to become a 'cul-de-sac' that would drive those species towards extinction. Even more serious, the authors consider that the range size of endemic species was projected to undergo extensive fragmentation, which is a potentially aggravating factor. In addition, as a whole, 25% of the Mediterranean Sea continental shelf was predicted to experience a total modification of endemic species assemblages by the end of the 21st century. Nevertheless, this expected change could be mitigated by the establishment of more marine protected areas who face the increase of fishing pressure and competition from exotic species, as well as by other anthropogenic factors such as tourist activities. Coll et al. (2010) estimate that the Mediterranean Sea is a hotspot of marine biodiversity with more than 17,000 reported marine species, of which approximately one fifth are considered to be endemic.

As examples of the impact of climate change, Ben Rais Lasram et al. (2010) estimate that at the end of the 21st century, the wide endemic species Acipenser stellatus and Huso huso are projected to be extinct in the Mediterranean Sea, but they could

continue to survive in the Black Sea, where they are currently abundant (Froese & Pauly, 2009). Similarly, Gobius fallax, Gymnammodytes cicerelus, and Lipophrys adriaticus all are projected to be extinct in the Mediterranean Sea, though they may continue to survive around the Canary Islands, from coastal Morocco to Angola, and in the Black Sea; thus, they might avoid global extinction. Conversely, the extinction of Acipenser naccarii, Buenia affinis, Corcyrogobius liechtensteini, Didogobius schlieweni, Gobius geniporus, Microichthys coccoi, Opeatogenys gracilis, Paralepis speciosa, and Speleogobius trigloides in the Mediterranean Sea would represent irreversible extinction, because these species are strictly endemic. However, Piroddi et al. (2017) have observed in the Mediterranean Sea a reduction in abundance of important fish species amounting to a decrease of 34% of both commercial and non-commercial species and 41% of top predators. They explain that community biomass, trophic levels, catch and diversity indicators all show that the ecosystem has been degraded over time under the influence of a diversity of environmental/anthropogenic factors including climate change. They add that in general, both biomass trends and ecological indicators revealed that the combined effect of excessive fishing pressure and changes in the primary productivity have altered the Mediterranean marine ecosystem over time, especially reducing the proportions of top predators and larger fish (e.g., pinnipeds, large pelagic fish) and increasing the abundance of groups at lower trophic levels (e.g., invertebrates).

III.2 Issues related with anthropogenic activities in general

Ocean and marine ecosystems in general are being stressed by several harmful anthropogenic activities. In fact, marine pollution is 80% land-based, linked to activities carried out on the continent. The Mediterranean is the most impacted sea due to severe impacts from climate change, shipping, urban/industrial discharges (including wastewater), touristic activities, fisheries, aquaculture, industrial/agricultural pollution (via run-off), habitat loss and degradation, water acidification and species invasion (Afli, 2021; Katsanevakis et al., 2014; Garcia-Bueno et al., 2021; Msayleb et al., 2021; Pozzi et al., 2021). WWF-France has established the forecasts of the macroeconomic trends in the Mediterranean basin by 2025-2030 based on the main economic activities related to the sea (Figure 4).

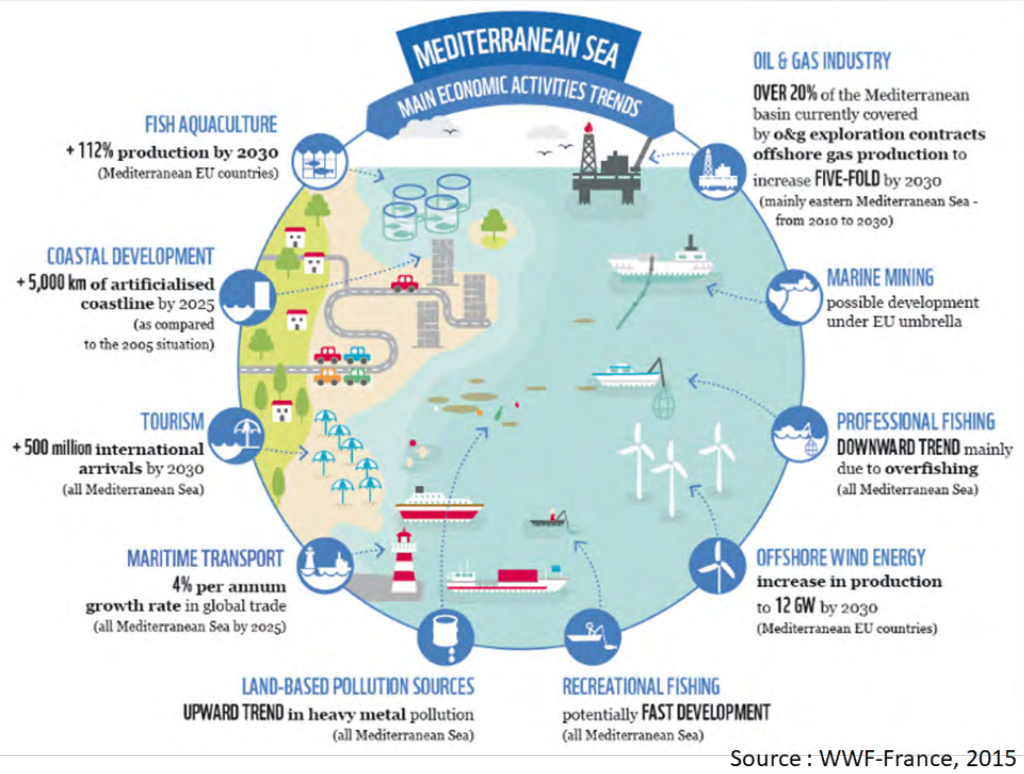

Figure 4. Macroeconomic trends in the Mediterranean basin (Fosse et al., 2016).

In general, remarkable biodiversity hotspots in the Mediterranean Sea such as coralligenous, meadows and biogenic concretions are more vulnerable to environmental disturbance by fishing gears and smothering and water contamination by organic enrichment and sewage. The existing means of legal protection appear unfavorable, because they are based on scientific research principally derived from northern Europe, where specific and diverse environmental settings, species composition, depth pattern, and anthropogenic pressures occur. The protection of a particular habitat type cannot be effectively achieved without access to geospatial and compositional data. An expanded research effort is needed to enhance taxonomic inventories, habitat mapping, and monitoring activities on the entire basin scale (Katsanevakis et al., 2014).

According to Msayleb et al. (2021), lessepsian species may become invasive and have significant effects on the environment (biodiversity loss, habitat modifications and alterations in fish community structure), economy (fishermen) and human health. For example, the bivalve Mytilus galloprovincialis, which was abundant in Lebanon in the past, is now totally replaced by the tropical bivalve Brachidontes pharaonis, and the gastropod Cerithium scabridum (Bitar, 2008).

In the Mediterranean, marine litter represents an exacerbated critical problem, due to limited exchanges with the ocean, densely populated coasts, highly developed tourism, intense maritime traffic (30% of global maritime traffic) and additional input of waste from rivers and highly urbanized areas. Marine litter on beaches comes from tourism and leisure activities and is mainly composed of plastic (bottles, bags, lids/caps, etc.), aluminum (cans, rings) and glass (bottles). For floating waste at sea, plastic (229,000 tones, IUCN 2020) represents 85% of the waste (Anonymous, 2015b).

III.3 Relationships with tourism: impacts and synergies

Due to its long/rich history, its geographic location (linked to 3 Continents and 3 Oceans), a unique combination of a temperate climate, rich heritage and culture, exceptional natural resources and proximity to major outbound markets, the Mediterranean (with around 150 million residents on sea coasts) remains the first tourist destination in the World, with more than 300 million arrivals of international tourists accounting for around 30% of the total number of international tourists in 2014 (Fosse et al., 2016). This number has increased from 58 million in 1970 to almost 314 million in 2014, with a forecast of 500 million by 2030 (WTO, 2015). More than the half of these arrivals are in coastal areas, mainly in summer time aggravating the concentration of anthropogenic pressures on the coasts. In the Mediterranean, the tourism is nature-based, which is often involving excursions to natural sites and wilderness areas, to developing countries where a large portion of the world's biodiversity is concentrated (Olson, 2001). This type of tourism which focuses on the natural environment exerts a number of pressures on the natural resources on which they rely (Msayleb et al., 2021). The tourism sector in the Mediterranean is traditionally highly developed in the northern, in particular France, Italy and Spain. But for a few decades, it has experienced significant growth in several countries of the southern and eastern Mediterranean such as Egypt and Turkey. The top five tourist destinations in the Mediterranean Region represent alone nearly 83% total international tourist arrivals in the region in 2014, with different proportions (France – 84 million, Spain – 65 million, Italy – 48 million, Turkey – 40 million and Greece – 22 million) (Fosse et al., 2016). However, international tourist arrivals in 2020-2021 remained 72% lower than in 2019 following the COVID19 pandemic (WTO, 2021).

Among the ecosystems most affected by tourism in the Mediterranean are wetlands. The wetlands are primarily endangered by point and non-point source pollution (from agriculture, industry, housing facilities, tourism, etc.), the expansion of crops and housing facilities at the expense of wetlands, overpumping, and clearing of natural vegetation. Over the last few decades, new causes of degradation have occurred, such as mass tourism, holiday houses, seaside airports, etc. (Chrysoulidis et al., 2021).

Some of the invasive species (www.naturagraeca.com) which cause problems and disturb the marine and coastal ecosystems balance with negative effect to tourism are : Algae (Caulerpa taxifolia from Indo-Pacific ocean, especially threatening for the Posidonia oceanica meadows and venomous for marine fauna), Sea Fish (the Silver-cheeked Toadfish Lagocephalus sceleratus and the Dusky Spinefoot Siganus luridus, venomous Fish), Crabs (the Sally Lightfoot Percnon gibbesi, Blue Crabs Portunus segnis and Callinectes sapidus), Nudibranchs (the Spotted Sea Hare Aplysia dactylomela), and Corals (Oculina patagonica) (Chrysoulidis et al., 2021).

The impacts of nautical tourism in the Mediterranean can be significant, particularly in terms of anchoring, littering, emission of underwater noise, and trampling. Anchoring can damage delicate marine ecosystems, such as seagrass beds and coral reefs, and littering can cause harm to marine life through ingestion or entanglement.

Underwater noise pollution can also have detrimental effects on marine animals, such as disrupting their communication, causing stress, and even leading to physical harm. Trampling, both on land and underwater, can cause damage to fragile habitats and disturb the plants and animals that live there.

IV.
Conclusions

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Since Antiquity, the Mediterranean has been an important maritime transport route allowing commercial and cultural exchange between the emerging peoples of the region and of the world as well. It was throughout history the cradle of civilizations. However, a clear fault line currently divides the Mediterranean socio-economically and demographically. A richer North opposes a poorer South characterized by a more accentuated demographic evolution. This has increased the socio-economic divide between the north and south of the Mediterranean, and has generated a south-north migratory flow, abusive exploitation of resources, strong pressure on the natural environment, etc. All this anthropogenic pressure has led over time and climate change to modify habitats and impact populations, particularly in the marine environment. Some species have disappeared, and others have become rare or threatened, and therefore require appropriate protection.

For the areas/countries where the tourist activities are an essential resource and a critical developmental asset, we should maintain tourist attraction in these areas, but various protective legal measures must be taken and rigorously applied both within the framework of international agreements (e.g., Barcelona Convention for the Protection of the Mediterranean against Pollution, the Ramsar Convention for the Preservation of Wetlands, Habitat Directive for the Conservation of Natural Biotopes) and at national level (lists of protected species, setting up of Parks and Reserves, regulation of fishing and use of the sea, etc.).

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