Extinction trends of marine species and populations in the Aegean Sea and adjacent ecoregions

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Abstract

Despite its relative oligotrophy, the eastern Mediterranean – and particularly the Aegean and Ionian ecoregions – supports a great marine wealth with considerable populations of endangered species. Available historical and current data indicate severe declining trends reaching sometimes local depletion and extinction of several populations such as the Mediterranean monk seal, loggerhead turtle, bath sponges, red coral, elasmobranchs, cetaceans, and edible bivalves. Intensive exploitation, prey depletion, accidental catches, habitat degradation, pollution and climate change are the major threats, having severely impacted the physiognomy of local marine ecosystems, although monitoring and conservation efforts, focused on *Monachus monachus* and *Caretta caretta* over the last 20 years, have led to a relative stabilization of certain local populations.

1. Introduction

1.1 Regional characteristics

The Aegean Sea represents a distinct Mediterranean ecoregion characterized by extremely complex morphology, with more than 3,000 islands and islets. It comprises wide plateaus and deep canyons and exhibits great habitat diversity alternating rocky coasts, sandy shores, sea-grass meadows algae-dominated bottoms, coralligenous formations and marine caves. This habitat variability, along with its specific temperature, salinity and water circulation profile is reflected in its biota, which is rich and comparable to the other northern Mediterranean subareas, namely the Gulf of Lion and the Adriatic (Coll *et al.*, 2010). As part of the eastern Mediterranean basin, the Aegean Sea is subject to the so-called “tropicalization” or “meridionalisation” process (see Bianchi, 2007; CIESM, 2008; Lejeusne *et al.*, 2010) of the Mediterranean. The warmer water of the Aegean Sea (Skliris *et al.*, 2011), favor the northwards expansion of the biota at the detriment of the native species.

The Aegean is connected with the Black Sea, from which it constantly receives brackish and colder waters. This influence and the higher river runoff are determinant for its northern sector, which is distinct by higher productivity and diversity from the southern (Lykousis *et al.*, 2002). On the other hand, the influence of the saline and warm waters flowing northwards from the Levantine enables the settlement of Lessepsian migrants in the southeastern Aegean and their further dispersal to the rest of the Mediterranean (CIESM, 2013; Zenetos *et al*., 2009).

Beyond the differences between north and south sectors, the Aegean ecosystem as a whole is of great interest for research and conservation purposes. Its rich waters host extensive and healthy *Posidonia oceanica* meadows, shallow reefs covered with *Cystoseira* assemblages, the largest population of monk seals in the Mediterranean, high benthic diversity on soft sediments (especially in lagoonal and estuarine habitats), rich benthic communities on coralligenous and cave habitats, including rare and endemic species, valued commercial invertebrates such as bath sponges and precious corals, and dense populations of small cetaceans.

Yet little of this biodiversity has been adequately studied and evaluated – a lack of knowledge particularly crucial since these areas have suffered centuries of exploitation. Evidence of interaction between humans and the marine fauna dates back to the Paleolithic period and continues through the Greek antiquity, the Roman, and Byzantine periods: fishes, crustaceans, mollusks, sponges, corals, even the monk seal have been harvested or hunted leading to conspicuous local depletions and extirpations (see Coll *et al.*, 2010).

At present, most of the Greek coasts are affected by multiple high-impact anthropogenic activities; tourism and human recreational settlement are fairly widespread, while urbanization, industry, agriculture, aquaculture and waste disposal also impact the natural marine ecosystem (Anagnostou *et al.*, 2005). These factors, along with an ongoing intensive exploitation of fishery resources and the added effects of climate change and biological invasions, especially in the southern Aegean, currently constitute the main threats for marine biodiversity.

Despite the high value and significance of Aegean biodiversity, only one Marine protected area (MPA) has been established to date in the Greek territorial waters, the "National Marine Park of Alonissos Northern Sporades" (NMPANS), which is the second largest Mediterranean MPA, covering approximately 2,260 km^2. Furthermore, there are more than one hundred "Sites of Community Importance" of the Greek NATURA 2000 Network (92/43/EEC) encompassing marine areas (Thessalou-Legaki and Legakis, 2005) for which management measures have <u>not yet</u> been implemented.

1.2 Estimating patterns and processes of local extinction

Under the scope of the extinction threat in the Aegean and adjacent ecoregions, we surveyed: i) the status of Mediterranean species that have been recently assigned as (critically) endangered in this region and ii) certain species, which, mostly due to overexploitation, present a conspicuous decline of their populations, but are still not included in Red Lists. We focused further on two case studies, one for each of the above issues in order to investigate and elucidate the patterns and processes potentially leading to extinction: i) the monk seal, an emblematic, critically endangered species and ii) the bath sponges, a marine resource appreciated worldwide, harvested in this area for centuries. In each case we went through the historical background of the species interaction with humans, their past distribution and abundance, the causes of population depletion and/or distribution shrinkage, and we present the current status of their populations, threats and conservation measures (if any).

2. Megafaunal species under threat

2.1 Case study: the monk seal *Monachus monachus*

Since 1996 this species is critically endangered (IUCN and Greek Red Data Book category: CR) on the basis of its very small, heavily fragmented population structure and declining numbers.

2.1.1 Historical data on population and distribution

The monk seal has been interacting with man for centuries, being now very close to extinction. While originally it had a wide distribution across the entire Mediterranean basin and the Macaronesian region, through time this has been increasingly limited to certain areas, specifically the Aegean Sea (Figure 1). Historical evidence from Antiquity concerning its habitat indicates that it was living along all the Mediterranean mainland coasts in addition to the island populations; it inhabited sandy beaches in large herds, as vividly described by Homer in *Odyssey*, sometimes reaching up to thousands of individuals, not only the rocky coasts of remote islands (see Johnson and Lavigne, 1999 for a detailed review). As Johnson (2004) analytically described, the distribution shrinkage and population depletion of the species, which resulted in the virtually exclusive use of isolated caves, were actually triggered by human disturbance. The shift in habitat might explain the change in monk seal's character traits and behaviour, driven either by survival instinct and natural selection or by individual learning experience: from a gregarious and docile animal it gradually became solitary, retiring, and shy (Johnson and Lavigne, 1999). Moreover, this prolonged decline has produced a severe bottleneck that significantly reduced genetic variability, while at the same time a substantial genetic divergence has been observed between the extant populations (see Aguilar and Lowry, 2008).

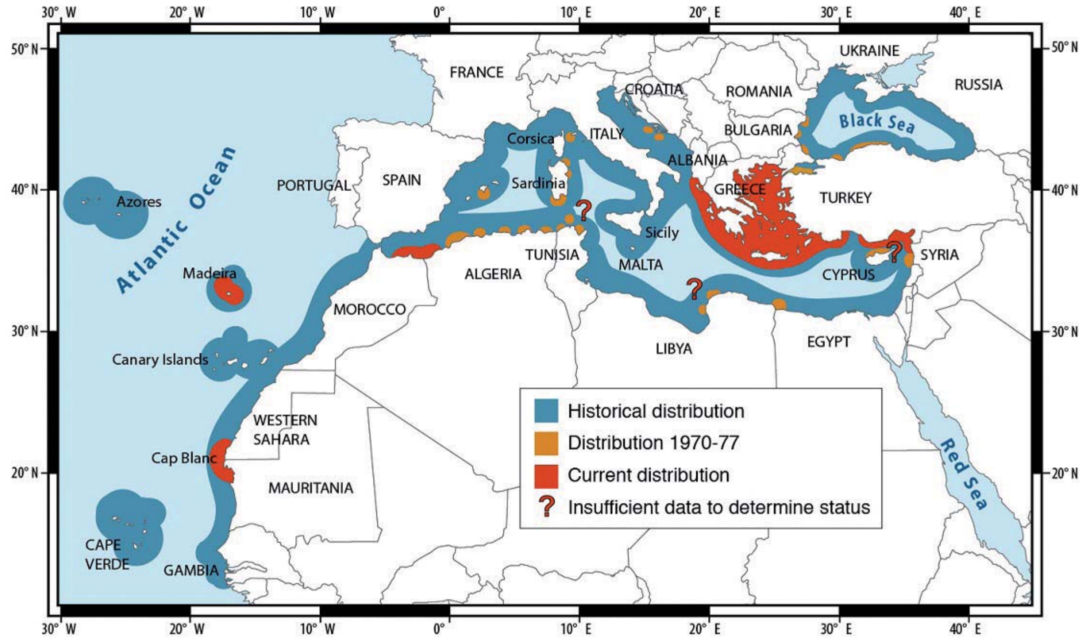

Figure 1. General distribution of the monk seal, modified from Johnson *et al.* (2011); distribution in 1970-77 (depicting only sites additional to the current distribution) was plotted according to Sergeant *et al.* (1978).

2.1.2 Causes of decline

Two main factors caused the historical decline of *M. monachus*:

i) Its intensive exploitation over the Mediterranean during the past two millenniums, particularly during the Roman period. Seals were massively hunted for leather, oil, medicines, and zoo supply, and they continue to be killed by fishermen for damaging their equipment and competing for fish resources. Their commercial exploitation in the Black Sea up to the 1970s led to the species extinction from this area (Kirac, 2001 *in* Johnson, 2004).

ii) Deterioration of the species preferred habitat. This started in the Roman Era as well, with the intensive deforestation and consequent destruction of coastal vegetation, which gave the seals shelter from the sun. The gradual occupation of sandy coastline by humans and the development of tourism in the past century led the species to an almost exclusive use of caves, limiting social interaction and reducing mating and breeding success (Johnson, 2004).

Due to the above reasons, the monk seal populations eventually disappeared through the past century from the western Mediterranean and Adriatic coasts. Furthermore, the species is considered regionally extinct in many areas of the eastern Mediterranean, while its populations suffered a 50% decline on the coasts of Turkey during the last twenty years (Güçlüsoy *et al.*, 2004).

2.1.3 Current population status

Globally

According to the most recent IUCN estimates (Aguilar and Lowry, 2008), the current global population size is 350-450 animals distributed as follows:

- 20-23 individuals in the archipelago of Madeira. The population is under protection, showing signs of recovery (Pires *et al.,* 2008).
- 130 individuals at Cabo Blanco Peninsula, Western Sahara. It is one large colony living in two caves on a 4 km long beach.
- 10 animals on the coast of Morocco and Algeria (Aguilar, 1999). Its survival is questionable.
- 250-300 individuals in the eastern Mediterranean Sea.

IUCN also reports the extinction of many small subpopulations during the last two decades. The estimated eastern Mediterranean population in the 1970s (Figure 1) was 350-390 individuals and the global species population counted around 625 individuals (Sergeant *et al*., 1978).

In the eastern Mediterranean

Out of the total estimated population size, approximately 200 individuals live in the Greek and 100 on the Turkish coasts. The minimum estimated population size for the Greek islands where the species is mainly distributed is 179 adult individuals, representing around 40-50% of the global population and giving annually an average offspring of 27 pups (Dendrinos *et al.*, 2009).

Estimates based on direct observations, remote sensing, mark-recapture methods, but mostly on the recording and monitoring of the suitable habitat and annual pup production (data from Güçlüsoy *et al.*, 2004; Gucu *et al.*, 2004; Mom, 2009), indicate that the largest and best studied sub-populations within this region (the minimum numbers of estimated individuals are given in parentheses) are located at the Northern Sporades Islands (52), the islands of Gyaros (55), Kimolos (49), and Karpathos (23) in Greece and at the Cilician Basin (25) in Turkey. The populations along the Aegean coasts of Turkey count approximately 63 individuals whereas on the rest of the Greek coasts around 46.

The major factor favouring the survival of the monk seal in the eastern Mediterranean and particularly the Aegean Sea is the presence of suitable habitat both for resting and pupping, due to the specific geomorphology of the area. During the last 20 years of research, a large number of monk seal sightings (Figure 2a) and more than 560 suitable monk seal shelters (Figure 2b) have been identified throughout Greece (Mom, 2009). However, IUCN points out the small number of mature individuals in the eastern Mediterranean population, the loss of the original colony structure of the species and the abnormal reproductive rate. It is worth mentioning that recent monitoring of monk seal population on the uninhabited island of Gyaros (southwest Aegean) revealed a colonial population structure of the species on open beaches, unique in the Mediterranean Sea (Karamanlidis *et al.*, 2012).

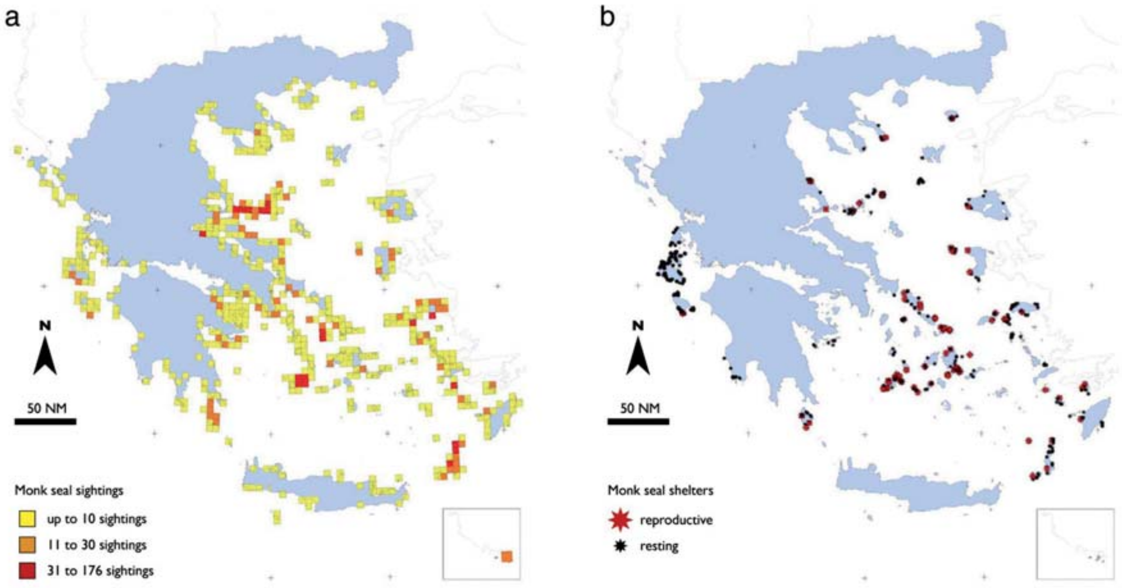

Figure 2. Mediterranean monk seal sightings (A) and locations of suitable shelter (B) recorded through the operation of the Rescue and Information Network in Greece from 1996 to 2009 (from Mom, 2009).

2.1.4 Current threats

Investigations (mostly necropsies of stranded animals) both in Greece and Turkey (Güçlüsoy *et al.*, 2004; Androukaki *et al.*, 2006) suggest that the main current threats to *M. monachus* are habitat destruction through tourism, increased mortality through deliberate killing (by artisanal fishermen, who generally remain hostile towards the seal) or accidental entanglement in fishing gear, as well as the depletion of food sources due to pollution, overfishing and illegal fishing. Susceptibility to diseases should be also taken into account, since small populations have lower resistance due to loss of genetic variability through genetic drift and inbreeding. Nowadays random misfortunes on a relatively small scale can have a dramatic impact on seal populations; as in the case of the Cabo Blanco population which suffered a 66% reduction in only two months in 1996 as a consequence of exposure to toxins through fish consumption (Forcada *et al.*, 1999).

2.1.5 Protection

The species is strictly protected under the Greek law (Presidential Decree 67/1981), European Directives, and International Conventions (Table 1). The NMPANS is the main region assigned specifically to the protection of the monk seal. Moreover, the area of northern Karpathos (since 2002) in Greece, along with several sites on the Aegean and Mediterranean coasts of Turkey, is also under protection, mostly regarding local seal populations.

Because of the limited methodology, it is still very difficult to answer questions about the exact current population size, make comparisons with past times, and evaluate the conservation measures taken (Gucu, 2010). The only area exhibiting stabilization of its population numbers in the past twenty years is the Northern Sporades (along with Desertas in Madeira), but this area only shelters 10% of the global population of the species (Aguilar and Lowry, 2008); the annual birth rate has increased since monitoring efforts started in the area (see Dendrinos *et al.*, 2007). Moreover, individuals recently recorded after more than 50 years on the coasts of Israel (Scheinin *et al.*, 2010) and Italy (Bundone, 2010) are believed to originate from the area of Cilicia in Turkey and the Greek seas, respectively.

IUCN foresees an overall declining trend of the species, mostly due to absence of effective conservation efforts in the field and a high extinction risk of the species unless there is urgent

Table 1. Species reported in the present study and their international and Greek protection status.

SPECIES	1	2	3	4	5	6	7	8	9	10	11
PORIFERA											
Hippospongia communis (Lamarck, 1814) †		III				III					
Spongia (Spongia) lamella (Schulze, 1879) †		III				III					
Spongia (Spongia) officinalis Linnaeus, 1759 †		III				III					
Spongia (Spongia) zimocca Schmidt, 1862 †		III				III					
ANTHOZOA											
Corallium rubrum (Linnaeus, 1758) †	+	III			V	III					
CRUSTACEA											
Melicertus kerathurus (Forskål, 1775) †											
BIVALVIA											
Flexopecten glaber (Linnaeus, 1758) †											
Ostrea edulis Linnaeus, 1758 †											
ELASMOBRANCHII											
Alopias vulpinus (Bonnaterre, 1788)				I					DD	VU	VU
Carcharias taurus Rafinesque, 1810									VU	CR	CR
Carcharhinus plumbeus (Nardo, 1827)				I					NT	EN	EN
Carcharodon carcharias (Linnaeus, 1758)		II	I/II	I		II		II/B	VU	EN	EN
Dipturus batis (Linnaeus, 1758)									CR	CR	CR
Isurus oxyrinchus Rafinesque, 1810		III	II	I		II/III			VU	CR	CR
Lamna nasus (Bonnaterre, 1788)		III	II	I		II/III			VU	CR	CR
Oxynotus centrina (Linnaeus, 1758)									VU	CR	CR
Prionace glauca (Linnaeus, 1758)		III		I		III			NT	VU	VU
REPTILIA											
Caretta caretta (Linnaeus, 1758)	+	II	I/II		*II/ IV	II		I/A	EN	EN	EN
Chelonia mydas (Linnaeus, 1758)	+	II	I/II		II/ IV	II		I/A	EN	EN	EN
Dermochelys coriacea (Vandelli, 1761)	+	II	I/II		IV	II		I/A	CR	CR	CR
MAMMALIA											
Delphinus delphis Linnaeus, 1758	+	II	I/II	I	IV	II	I	II/A	LC	EN	EN
Monachus monachus (Hermann, 1779)	+	II	I/II		*II/IV	II		I/A	CR	CR	CR
Phocoena phocoena relicta Abel, 1905 ‡	+	II	II		II/IV	II	I	II/A	LC	EN	EN
Physeter macrocephalus Linnaeus, 1758		II	I/II	I	IV	II	I	I/A	VU	EN	EN

1, Presidential Decree 67/1981; 2, Council of Europe, 1979 – Convention on the conservation of European wildlife and natural habitats (Bern Convention); 3, Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention, 1979); 4, United Nations Convention on the Law of the Sea (UNCLOS); 5, Habitats Directive 92/43/EEC; 6, Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean (Protocol of Barcelona Convention), 1995; 7, ACCOBAMS - Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic Area (1996); 8, Convention on International Trade in Endangered Species of Wild fauna and flora (CITES, 1973) Council Regulation EC 338/97; 9, IUCN Red List of Threatened Species – International Level; 10, IUCN Red List of Threatened Species – Mediterranean Level; 11, Greek Red Data Book of Threatened Species (2009); I, II, III, IV, V, Appendix/Annex I, II, II, IV, V; A, B, Species of Appendix A and B of the regulation applying CITES in the EC; *, Priority species for the European Union / Priority habitat for *P. oceanica* meadows; †, Fisheries and exploitation of the species/animal group is regulated under relevant national legislation; ‡: Endemic Species or subspecies; DD, Data Deficient; LC, Least Concern; NT, Near Threatened; VU, Vulnerable; EN, Endangered; CR, Critically Endangered

action. Güçlüsoy *et al.* (2004) confirmed this opinion for the Turkish population. It is highly believed that a well developed MPA network is the most realistic solution for maximizing the survival chances of the species (Panou *et al.*, 1993) through the protection of important pupping sites from accidental entanglement and other threats (Karamanlidis *et al.*, 2008).

2.2 Sea turtles

Three species of marine turtles inhabit the Aegean and Ionian Seas, the loggerhead *Caretta caretta,* the green turtle *Chelonia mydas* and the leatherback *Dermochelys coriacea.*

The loggerhead is the only marine turtle nesting in the Greek seas. The island of Zakynthos in the Ionian Sea is the centre of its nesting activity, hosting about 26% of the documented total nesting effort and the highest total nesting density in the Mediterranean (Margaritoulis, 2005). *C. caretta* nests also in other Greek areas, mostly Peloponnesus and Crete. Overall the Greek coasts host about 60% of the total Mediterranean nests, 43% of which are located in Laganas Bay, Zakynthos and 19% in Kyparissia, Peloponnesus (Margaritoulis, 2009). A twenty year survey in Laganas Bay showed that turtle nesting is taking place in six discernible beaches, mainly in Sekania (54% of the total nests), which is the least disturbed area (Margaritoulis, 2005). Standardized beach monitoring in the main nesting areas in Greece was initiated in 1984 and continues until present; moreover, records of the frequency of stranding, incidental catches in fisheries and tag recoveries have revealed that turtles frequently visit many marine areas of the Ionian, south and north Aegean (including the Thracian Sea) as foraging or wintering grounds (Margaritoulis and Panagopoulou, 2010). However, the main areas of migration once they have completed nesting in Laganas Bay are the north Adriatic and the Gulf of Gabes in Tunisia (Zbinden *et al.*, 2008).

Main threats in Greece are: i) degradation of nesting areas due to coastal development and tourism, ii) incidental capture in fishing gear. According to a recent estimate of loggerhead bycatch (Lucchetti and Sala, 2010), the annual number of individuals caught in the Greek drifting longline and bottom trawl fishery range from 1,475 to 9,153 per year; no regional data on direct mortality exist and no mitigation measures have been tested, in contrast to other areas, such as the Italian Ionian Sea, Tunisia and Turkey. A long-term study (15 years) of nesting areas in Crete showed an alarming, highly significant, decreasing trend in nesting levels (Margaritoulis *et al.*, 2005). Although no apparent trend has been observed in the longest monitoring project in Greece, i.e. Laganas Bay (Margaritoulis, 2005), it is worth noting that the number of nests during 2009 represented the lowest number ever recorded (829) since 1984 (Venizelos *et al*., 2009). On the other hand, the population in Kyparissia seems to be increasing, likely due to conservation efforts during the last 15 years (Margaritoulis *et al*., 2012).

The species is listed as endangered (IUCN and Greek Red Data Book category: EN). Recent evaluations of the existing threats in the Mediterranean suggest that, given the lack of bycatch reduction in commercial and artisanal fisheries and the ineffective implementation of conservation measures, the Mediterranean *C. caretta* population is at immediate risk of extinction (Conant *et al.*, 2009).

C. caretta is a protected species in Greece, according to national and international legislation (Table 1). One of the two National Marine Parks (i.e. the NMPZ) is devoted to its protection, since 1999. The MPA comprises primarily the coastal and marine area of Laganas Bay in Zakynthos, which is subjected to a continuously expanding tourist development. Efforts and achievements of NGOs (in particular Archelon) and the Management Agency of the Park include nest management and predation control, public awareness, and beach management; however, there are still problems with the effective enforcement of the legislation because of local reaction and inadequate political will (Margaritoulis and Panagopoulou, 2010). The nesting areas in Kyparissia and Lakonikos Bay (Peloponnesus), as well as in Rethymno, Chania, and Messara (Crete) are under protection as sites of the Natura 2000 network.

The green turtle *Chelonia mydas* is an endangered species with no regular nesting areas in Greece. Its main Mediterranean nesting areas are in Turkey, Cyprus and Syria. It is regularly found in the Greek waters and Lakonikos Bay is considered a developmental habitat of the species, since many young individuals have been observed (Margaritoulis and Teneketzis, 2003). The leatherback *Dermochelys coriacea* is a critically endangered species only visiting the Mediterranean Sea and rarely found in Greek waters. Both these species suffer the same threats as *C. caretta* and are protected under a common legislative framework.

2.3 Cetaceans

The Aegean Sea along with the western Mediterranean is an area of concentration for marine mammals (Coll *et al.*, 2010; Panigada and Pierantonio, this volume). Seven cetacean species are commonly observed in the Aegean and Ionian ecoregions: the striped dolphin (*Stenella coeruleoalba*), common bottlenose dolphin (*Tursiops truncatus*), short-beaked common dolphin (*Delphinus delphis*), Cuvier's beaked whale (*Ziphius cavirostris*), sperm whale (*Physeter macrocephalus*), Risso's dolphin (*Grampus griseus*), and fin whale (*Balaenoptera physalus*); one more species, the Black Sea harbour porpoise (*Phocoena phocoena*) is restricted to a small area in the north Aegean (Frantzis *et al*., 2003).

Out of these, three species have been indicated as Endangered (EN) both in the IUCN Red List (at least their Mediterranean and Black Sea populations) and in the Greek Red Data Book of Threatened Species (Legakis and Maragou, 2009).

- *Phocoena phocoena relicta:* this subspecies (Viaud-Martinez *et al.*, 2007) occurs in the Black Sea, Marmara, and north Aegean, but not in the rest of the Mediterranean. Its Aegean subpopulation is roughly estimated to comprise between 30 and 450 individuals (Paksimadis and Frantzis, 2009), while a total population size of as much as 10,000-12,000 individuals is estimated in the Black Sea, despite a severe 70% decline experienced during the last thirty years; the latter was mainly a result of prolonged hunting for the cetacean-processing industry (up to the 1980s), supplemented by a mass mortality event after the explosion in 1982 at a gas-extraction platform in the Azov Sea (Reeves and Notarbartolo di Sciara, 2006). Among the three Black Sea cetacean species it makes the most significant proportion by far (95%) of the bycatch (Birkun and Frantzis, 2008). Main threats are accidental takes in fishery activities, contamination by xenobiotics, population disruption due to disturbance, and climate change (Reeves and Notarbartolo di Sciara, 2006; Paksimadis and Frantzis, 2009).
- *Delphinus delphis*: the species is found locally in the Aegean and Ionian Seas. The largest population seems to live in the Thracian Sea (north Aegean), while very small populations of few dozens of individuals appear in the eastern Ionian Sea and the Gulf of Corinth (Paksimadis and Frantzis, 2009). The well-studied eastern Ionian population suffered a decline from 150 individuals in 1996 to only 15 in 2007 (Bearzi *et al*., 2008) due to an overall negative impact of local fisheries on the dolphin population (Pirodi *et al.*, 2011). The species is mainly threatened by prey depletion resulting from overfishing, and contamination by xenobiotics (Bearzi *et al*., 2003).
- *Physeter macrocephalus*: The total number of individuals in the Aegean and Ionian Seas is estimated at 180-240, while 200 of them are living or visiting the Hellenic Trench, a key Mediterranean area for the species (Paksimadis and Frantzis, 2009). Main threats are accidental catches in fisheries (pelagic driftnets), along with collisions and accidents with vessels (Reeves and Notarbartolo di Sciara, 2006).

Despite the fact that most cetaceans are protected under international Conventions and Greek law (Presidential Decree 67/1981), practically no specific measures have been implemented. Several areas of the Aegean and Ionian Seas have been indicated by ACCOBAMS (Resolutions 3.22 and 4.15) for the establishment of MPAs in order to maintain a favorable conservation status of cetaceans in this area of special importance.

2.4 Elasmobranchs

Up to date, 63 elasmobranch species have been recorded in the Greek Seas; 13 of them are considered regionally threatened, while the others have not yet been evaluated according to the IUCN criteria (Megalophonou, 2009). Five of these species, namely the sand tiger shark (*Carcharias taurus*)*,* the shortfin mako (*Isurus oxyrinchus*)*,* the porbeagle shark (*Lamna nasus*)*,* the angular roughshark (*Oxynotus centrina*) and the common skate (*Dipturus batis*), are considered critically endangered as far as their Mediterranean (IUCN) and Greek populations are concerned. Although their population status remains uncertain, it is estimated that regional shark populations are lower in abundance than in the western Mediterranean basin due to accidental catches, habitat loss and degradation of coastal areas serving as nursery grounds, combined with intrinsic slow life history traits (Megalophonou, 2009).

Current studies on pelagic shark populations from the eastern Mediterranean reveal the presence of both large and juvenile individuals, with a larger mean size recorded from the Levantine Basin, that receives relatively lower fishing effort (Megalophonou *et al.*, 2005), possibly because of their low commercial value in this area (Golani, 2006). Furthermore, certain areas of the Aegean Sea have been reported as breeding or nursery grounds for particular shark species (*Carcharhinus plumbeus* – Musick *et al.*, 2009; *Carcharodon carcharias* – Kabasakal and Gedikoglu, 2008). Recent studies on the eastern Mediterranean blue sharks (*Prionace glauca*), caught as bycatch from swordfish fisheries, showed that local values of catch per unit effort (CPUE) were much lower compared to those recorded from the western basin (Megalophonou *et al.*, 2009a).

Additionally, the main bulk of shark catches from the Aegean (i.e. *Alopias vulpinus*, *I. oxyrinchus*, and *P. glauca*) is composed of immature and maturing specimens (Megalophonou *et al.*, 2009b). These findings are of great concern and highlight the need for further assessment studies and management actions in the area.

The above-mentioned elasmobranchs are not target species for the Aegean fisheries, yet they are accidentally caught quite often; such is the case for the critically endangered shortfin mako (Peristeraki and Megalofonou, 2007). Despite the fact that several elasmobranchs occurring in the Greek Seas are currently protected under European or International legislative frameworks (Table 1), in practice there is an apparent lack of protection and management. Extended monitoring of the existing stocks and strict enforcement of conservation measures are urgent priorities. Moreover, the protection of local populations, migratory paths and nursery grounds under national legislation or transnational cooperation (e.g. Marine Peace Parks) is critically needed.

3. Local depletions of commercially exploited species

3.1 Case study: the bath sponges

Four sponge species belonging to the family Spongiidae are commercially harvested in the Mediterranean as 'bath sponges': the iconic species *Spongia officinalis* – the nominal archetype of the poriferan phylum – and conspecifics *S. lamella* and *S. zimmocca* along with *Hippospongia communis*. Their exploitation has been extensive historically in the eastern basin of the Mediterranean, including the Aegean Sea, the Apulian coast in the Ionian Sea, and the coasts of Tunisia, Libya, Egypt, Lebanon and Syria (Milanese *et al.*, 2008; Pronzato and Manconi, 2008; Voultsiadou *et al.*, 2011). Harvesting in those regions has been predominantely performed by fleets and crews originating from the Aegean Islands, at least before the second half of the 20th century.

3.1.1 Tracing past and present abundance

An era of rich grounds and thriving production

Although sponge beds in the Mediterranean have purportedly been remarkably rich up till the turn of the 19th century, only scarce official data regarding catch numbers exist for this period, making the assessment of bath sponge abundance mostly a matter of speculation. Sparse bits of information, such as the annual tribute of 4,000 choice sponges routinely paid to the Sultan of the Ottoman Empire from 1522 to 1909 by the people of Syme, a small sponge-producing island of the Aegean (Kalafatas, 2003), give us a glimpse to the rich overall production of times past. References to the widespread use of a nowadays neglected harvesting practice, that of harpooning sponges from atop a boat assisted by a glass bottom bucket (Flegel, 1908), indicate that bath sponges were likely abundant at depths shallower than 10 m. The industrial revolution caused a boost to the worldwide demand for sponges (Bernard, 1987) and a sharp growth of the existing Aegean sponge-fishing fleet (Chadjidakis, 1999); consequently, in the second half of the 19th century, the overharvesting of the Aegean sponge grounds led to the expansion of sponge fishery to the northern African coast. The introduction of the scaphander in 1866 allowed exploitation of previously inaccessible sponge grounds. By the end of the century, annual production had reached 250-300 tons (Voultsiadou *et al.*, 2011). Sporadic references to the number of fishing boats and crews active in the sponge industry at that era let us assume a thriving industry that could only be based upon plentiful stocks. The production for the fleet of Kalymnos, a major sponge-producing island of the Dodecanese, was higher than 80 tons annually for the time span from 1910 to 1940 (Bernard, 1987). It should be noted that since weight estimates actually refer to treated, dried sponges, one kilogram can correspond to more than a hundred individuals, depending on their size.

Decline through the 20th century

A gradual decline of the Aegean sponge fisheries started after the heyday of sponge fishing in the 1910s and carried on towards the 1940s. During that time span, the Greek fleet shrank from somewhat 600 vessels in 1912, to 216 in 1948 (Bernard, 1976); this drop can be assumedly related to a continuous degradation of the exploited sponge banks. The ongoing reduction of sponge production in Greece since the 1950s can be observed from the relevant data (Figure 3), while a similar reduction is observed for the number of active vessels and men employed in the sponge fisheries. It is notable, however, that the yield per man increases despite the negative trend in production, indicating increased fishing effort and pressure to the stocks. During the decade after 1960, the synthetic sponge began to cut sharply into Kalymnian markets (Bernard, 1976), while African Mediterranean countries such as Libya, Egypt, and Tunisia successively nationalized their fishing grounds in the 1960s and 1970s prohibiting access to Greek divers (Kavalakis, 2001). Both factors further contributed to the decline of sponge production in Greece. A global shrinkage of sponge production followed during the course of the 20th century, with total annual output dropping from an average of 347.5 tons during the 1930s to 123.2 tons in the early 1980s (Josupeit, 1991).

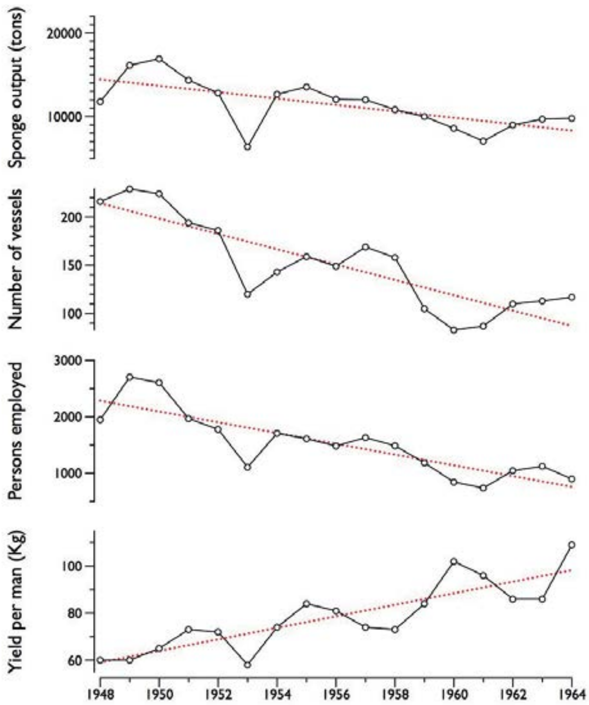

Figure 3. Sponge production, number of active vessels and total persons employed in sponge fishing (divers and crews), and yield per person in Greece from 1948 to 1964. Data from the National Statistical Service of Greece, as reported in Bernard (1987).

Disease and depletion

Through the years 1986 to 1990, a devastating disease spread mainly in the Aegean and the eastern Mediterranean, decimating the already declining populations (Vacelet *et al.*, 1994). Four consecutive years of exposure to the disease caused a rapid decline of the sponge-harvesting fleet and respective production of the Aegean, while also affecting the output of all major Mediterranean sponge-producing countries (Figure 4). As Voultsiadou *et al.* (2011) reported, during the combined fishing seasons of 1988-1989 a total of just 5.3 tons of bath sponges were harvested in the Aegean Sea. While a gradual recovery from the disease was observed in the Aegean and the Mediterranean coast of Egypt (Castritsi-Catharios *et al.*, 2005 and 2011, respectively), the assessed densities of bath sponges remained low. An additional field survey in Libya in 2005, almost twenty years after the first outbreak, reported the absence of *H. communis*, the main species harvested in the area before the disease, at least at the studied sites (Milanese *et al.*, 2008). An extensive survey in the Aegean Sea between 2004 and 2008 (Voultsiadou *et al.*, 2008; 2011) reported moderate to high densities of *S. officinalis* and *H. communis* in certain sites, but also low abundances or complete absence in locations acknowledged as rich sponge grounds before the disease.

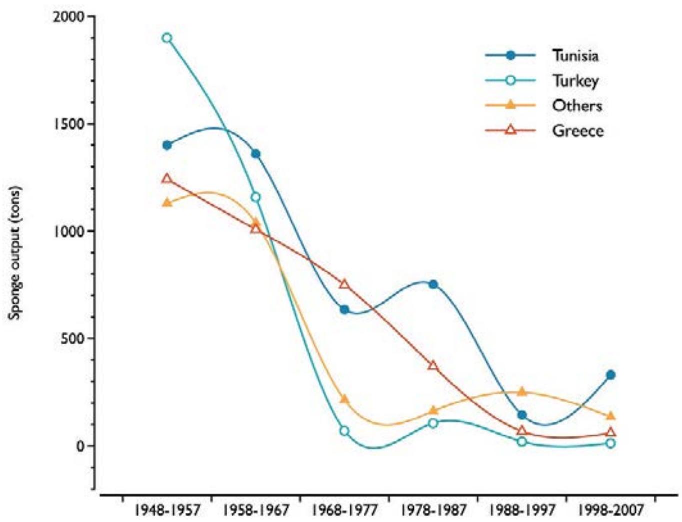

Figure 4. Sponge production decline during the last 60 years for the main Mediterranean producing countries according to the GFCM (General Fisheries Commission for the Mediterranean) database reports from FAO.

3.1.2 Present status and threats

At present, the populations of bath sponges in the Aegean Sea – concerning the most abundant species, *S. officinalis* and *H. communis* – appear fragmented and patchy at least regarding their shallow distribution down to 30 m depth (Voultsiadou *et al.*, 2008; 2011 and authors' unpublished observations). The Greek production originates mainly from sectors of the Aegean (the northern continental coastline, the Dodecanese and Cyclades archipelagos, as well as the islands of Crete and Karpathos) and, occasionally, from the southeast coast of Italy. The only sponge-fishing fleet remaining active is that of Kalymnos, counting 100-120 qualified divers working on 17 licensed boats and producing annually 4 tons of sponges approximately (Voultsiadou *et al.*, 2011).

Two main sources of pressure can be recognized regarding the remaining stocks in the Aegean Sea. (i) The harvesting pressure from the remaining Kalymnian fleet; at least five boats perform extensive fishing trips of variable route each year and exhaustively exploit every sponge bed that appears lucrative, excluding only the smallest cluster of individuals (< 5 cm diameter). Consequently, even though the fishing effort can be presumed low overall, the imposed pressure can be actually high on remaining populations. (ii) Mortality from disease is still an ongoing threat in the Mediterranean, since several severe incidents have been reported in different parts of the basin during the past decades (Webster, 2007; Garrabou *et al.*, 2009), affecting bath sponges and other sessile invertebrates. Mass mortality events have been associated to environmental temperature anomalies that promote stress and, consequently, chemical and microbial shifts in the affected organisms (Webster *et al.*, 2008; Lejeusne *et al.*, 2010), and thus are expected to be more intense and recurring within a reportedly increasing warming trend (Coma *et al.*, 2009).

3.1.3 Protection schemes and outlook

All commercial bath sponge species are included in the Annex III (requiring regulation) of the Barcelona Convention, and Annex III (protected species) of the Bern Convention (Table 1). Practically, however, little or no control is enforced by the Greek authorities over sponge fishers or merchants. Apart from specific locations where general prohibitions apply, such as MPAs or sites of archaeological importance, diving for sponges is practically allowed everywhere, presuming that the vessel is licensed for sponge fishing. The minimum size of harvested sponges is regulated by the Greek legislation (Fisheries Code, Decree 420/1970) and is confined to 5 or 10 cm, according to commercial quality.

Recent studies suggest that protection measures favor the viability of bath sponge populations, in contrast to unprotected sponge fishery areas of the Aegean (Voultsiadou *et al*., 2011). Notably, high abundances of bath sponges have been reported during experimental surveys in the Aegean, where exploitation (including diving for sponge harvesting) is prohibited. Accordingly, high abundances of bath sponges were recorded at the islet of Koufonissi (southeast Crete), where archaeological regulations imposed restrictions to fishing and recreation activities (authors' unpublished data).

Despite centuries-long harvesting and recurrent massive mortality episodes affecting the species in broad geographic scales, high levels of genetic diversity in most populations of *S. officinalis* have been reported in the Mediterranean (Dailianis *et al.*, 2011). One of the putative reasons proposed is the existence of robust populations, scarcely influenced by fisheries and epidemics that could promote re-colonization of affected areas. Indeed, the occurrence of shallow populations that tolerated recent mortality events, probably due to a beneficial current flow regime, has been recently reported (Voultsiadou *et al.*, 2011). Moreover, the existence of robust populations in deep waters and sizes inaccessible to harvesting by diving should be explored. Although increased dimensions and abundances of bath sponges at depths greater than 30 m are reported (e.g. Castritsi-Catharios *et al.*, 2005; 2011), no systematic survey of the deeper zone of distribution of bath sponges in the Mediterranean has been implemented up to present.

3.2 The precious Mediterranean red coral *Corallium rubrum*

The red coral *Corallium rubrum* has been exploited in the Mediterranean Sea since ancient times (Tsounis *et al.*, 2010). Despite its economic value, the available stocks have never been evaluated, and little is known about its ecology, bathymetric and spatial distribution in the eastern Mediterranean. In Greece, the most abundant populations of red coral are found in the north Aegean Sea, as illustrated by the total landings from this area, which are twice as high as those recorded from the Cretan and Ionian Seas taken together (Dounas *et al*., 2010). However, total Aegean and Ionian Greek landings are extremely low compared to those of the western Mediterranean (Bruckner, 2010), confirming the ancient literature sources (e.g. Hesychius and Dioscorides), which indicated the Island of Sicily as its main fishing area.

According to the available Greek fisheries data, shallow water stocks (down to 60 m) are almost depleted, and so professional divers are forced to harvest at greater depths (all the way down to 130 m) by means of mixed gas diving techniques. Evidence for declining of stocks in areas only recently opened up to exploitation suggests that harvesting was carried out in these areas throughout the closed period, possibly by using illegal dragging gears (Dounas *et al*., 2010).

Since 1994 red coral stocks have been regulated in the Greek Seas on a 5-year rotational basis in five large geographic areas (Presidential Decree 174/1994; Ministry Decision 240102/1995). To date only three zones have been harvested (Crete, north Aegean and Ionian Sea). The south-eastern Aegean was recently opened to exploitation (2011-2015) with only four harvesting licenses granted for the current year. Harvesting is permitted only by means of scuba or hookah diving at depths not shallower than 50 m.

Recently, preliminary evidence of a significant decrease of Mediterranean red coral stocks, along with the slow potential for recovery, has generated a debate whether *C. rubrum* should be enlisted on Appendix-II of CITES (Bruckner, 2009). In Greece, additional management measures for the control and monitoring of red coral landings are urgently needed. The rotating harvesting system should be re-examined in order to assess the effectiveness and viability of the present scheme (Dounas *et al*., 2010; Tsounis *et al.*, 2010), especially in the light of recent findings regarding the species' genetic structure that indicate restricted dispersal range and low power of recolonization (Ledoux *et al*., 2010). Apart from management measures, there is a crucial need for scientific investigation of the ecology, size and structure of coral populations in Greek waters. Detailed mapping and effective protection of the coralligenous and cave habitats of the species is of great importance in order to safeguard its future potential exploitation and conservation.

3.3 Edible bivalves

Bivalves have been widely used as food and medicine sources since Greek Antiquity (Voultsiadou, 2010). Several areas of the Greek Seas, such as Thermaikos and Saronikos Gulf, have been overexploited during the past century for bivalves and decapod crustaceans. The existing legislation had a rather poor effect on the sustainability of mollusk natural populations and exploitation resulted in severe population decline and stock collapse (Koutsoubas *et al.*, 2007), even for well established species. Two well-known examples developed in Voultsiadou *et al.* (2010) are:

i) the collapse of the scallop *Flexopecten (=Chlamys) glaber* population since 2003 in Kalloni Bay, Lesvos Island, one of the species' main fishing areas in the Aegean Sea, due to intensive harvesting and lack of rational management. Similar collapses were observed in the distant past, in this area. Aristotle, for example, reports that scallops had vanished from Kalloni Bay due to the fishing method, as fishermen used an instrument which scratched the sea bottom, quite similar to the dredge gear "arghalios" or "lagamna" which is still in used today.

ii) the European flat oyster's (*Ostrea edulis*) populations have severely declined and finally collapsed in the late 1990s in Thermaikos Gulf, its main fishing area in Greece, due to overfishing and parasite infection. This species has been exploited as well, even cultivated in estuarine areas, since the time of Aristotle.

Evidence of local depletion, probably enhanced by mass mortality events, also exists for the edible European thorny oyster *Spondylus gaederopus* in areas of the south Aegean (C. Antoniadou, pers. com.). The decline of its populations, even its disappearance in some areas, for unknown reasons in the beginning of the 1980s, has been previously recorded (see Katsanevakis *et al.*, 2008). Local extinction from many sites has been reported also for the common piddock *Pholas dactylus*, a strictly protected species, due to collection for food and bait and as a result of pollution (Katsanevakis *et al.*, 2008).

4. Biological invasions – a cause for depletion of local species

Until today, a total of 237 alien species have been recorded in the Aegean (mostly the southern part) and Ionian ecoregions, which may function as a gateway for their dispersal to the rest of the Mediterranean (Zenetos *et al.*, 2011). Currently, the Suez Canal is the main vector for aliens of Indo-Pacific origin (around 80%), the Atlantic influx being limited (CIESM, 2001/2002; Corsini-Foca *et al.*, 2010). Most of these species are mollusks (~27%), fishes (~21%), and crustaceans (~20%). The Red Sea species influx is a continuously increasing phenomenon, intensified during the last decades (Raitsos *et al.*, 2010; Turan, 2010) and several species have established sustainable populations in the Levantine and the southeast Aegean (Turkish coasts and Dodecanese Islands). Raitsos *et al.* (2010) using long-term data showed that the mean annual introduction rate of warm and tropical alien species showed an increase of 150% after 1998 in response to an abrupt temperature rise in the Greek Seas, specifically the southern Aegean. As of 2010, their impact on fisheries was of local character and only nine species were regularly occurring in catches in the southernmost areas of the Greek waters (Lefkaditou *et al.*, 2010). Concerning mollusks and decapods, a statistically significant acceleration of the entrance rate of Lessepsian migrants in the Aegean has been recently assessed (Koukouras *et al.*, 2010; Tzomos *et al.*, 2012).

Many of the alien species exhibit invasive behaviour (see Streftaris and Zenetos, 2006), which could potentially cause severe alterations to the natural environment (e.g. replacement of native species, biodiversity loss, decrease of habitat cover, and cascade effects on trophic webs). Notable examples of species which seem or could potentially provoke such phenomena are the following:

- The highly invasive green alga *Caulerpa racemosa var. cylindracea* is established in all Greek seas, occupying diverse substrata, between 0 and 70m, in both polluted and clean areas, exhibiting high adaptability to physical stressors (Zenetos *et al.*, 2009). This species forms extensive mats altering the local vegetation and the composition of the macrofaunal assemblages in parts of the eastern Mediterranean basin (Cyprus – Argyrou *et al.*, 1999). The most vulnerable habitats to its expansion are 'matte morte' (zones of fibrous remnants of a former *Posidonia oceanica* bed), rocky bottoms, and the margins of *P. oceanica* meadows (Katsanevakis *et al.*, 2010).

- The Kuruma prawn *Marsupenaeus japonicus* appears to have evicted the overexploited native Caramote penaeid prawn *Melicertus kerathurus*, which has almost disappeared from the Levantine, its habitats having been overrun by the former (Galil, 2007). The situation is somewhat urgent since the *M. kerathurus* populations are declining due to intensive exploitation in the Greek Seas (Kevrekidis and Thessalou-Legaki, 2011).
- Two species of rabbitfish, *Siganus luridus* and *S. rivulatus*, which have established large populations in the eastern Mediterranean, were found to deplete erect algae (mainly *Cystoseira* spp.) on the Turkish coasts turning algal assemblages into 'barrens', and causing a dramatic reduction in biodiversity and biomass (Sala *et al*., 2011).
- The Indo-Pacific blue cornetfish (*Fistularia commersonii*), a highly invasive piscivore, has developed large populations along the Levantine, parts of the Aegean and Tyrrhenian Seas (Zenetos *et al.*, 2009). It reproduces and grows extremely rapidly, reaches a large size and preys on native fishes of economic value, as well as on small benthic and newly hatched fish (Kalogirou *et al.*, 2007). It has been classified among the top predators of the Greek seas along with *Dentex dentex*, *Epinephelus marginatus*, *Euthynnus alletteratus*, *Sarda sarda* and *Xiphias gladius* (Stergiou and Karpouzi, 2005).

If alien species in the eastern Mediterranean continue to increase, these newcomers could seriously threaten the equilibrium of the regional marine ecosystem.

5. Discussion and conclusions

5.1 Unique biodiversity of the Aegean and adjacent ecoregions threatened with extinction

The Greek Seas (Aegean and Ionian) high biodiversity is under threat. As shown in the present review, a variety of marine taxa exhibit clear trends of decline: these include marine mammals, cetaceans, elasmobranchs and sea turtles, as well as invertebrate groups such as sponges, corals, and mollusks.

Subareas of the Aegean Sea exhibit different characteristics from a biodiversity and conservation point of view. The higher biodiversity of the north Aegean has been shown for different benthic invertebrates (e.g. Voultsiadou, 2005; Lampadariou and Tselepides, 2006), while the diversity characterizing the south Aegean is closer to that of the impoverished Levantine Basin. As shown here, the northern part of the Aegean is also characterized by the largest monk seal population in the Mediterranean, the only Mediterranean population of the Black Sea harbor porpoise, and the most abundant populations of red coral in the area. It also encompasses the most extensive fishing grounds in the Greek territory supporting around 70% of the total Greek fishing effort (Hellenic Statistical Authority, 2011).

The south Aegean, on the other hand, is influenced by an intense wave of biological invasions in the form of Lessepsian migrants, enhanced by climate warming. Evidence of alterations imposed on the local species composition (Streftaris and Zenetos, 2009; Raitsos *et al.*, 2010), as well as diseases and mass mortalities of benthic invertebrate populations in response to extreme temperature events (Voultsiadou *et al.*, 2011) is already available. The same authors suggest that sponge populations in this area are more susceptible to mass mortalities than those in the northern Aegean, where lower temperatures inhibit the rapid spread of diseases.

The Ionian Sea, finally, is the centre of nesting activity for the sea turtle *C. caretta* in the Mediterranean and constitutes remarkable feeding ground for cetacean populations.

Marine conservation practices in the eastern Mediterranean are inferior compared to those implemented in the northwestern basin, where well-enforced no-take reserves seem to have positively affected ecosystem health (Sala *et al*., 2012). Fortunately substantial populations of marine megafauna still exist in the Aegean and Ionian ecoregions (e.g. *C. caretta*, *M. monachus*, and cetaceans). Likely due to the geomorphological complexity of their marine environment. A general West to East gradient regarding the decline of certain marine taxa is apparent in the Mediterranean: the western basin has suffered much more severe population depletions, with the monk seal being the paramount example, followed by sea turtles, etc (see Coll *et al*., 2010). It has been even suggested that the progressively unsuitable conditions prevailing in the western basin make the eastern sector (Levantine and south Aegean) a "heaven" for some cetacean populations (Kerem *et al*., 2012), in spite of ineffective protection and impoverished biomass and primary production levels.

5.2 Local extinction characteristics

Exploitation is generally considered the main cause of marine extinctions (Dulvy *et al.*, 2003). Most of the species examined in this review have been subjected to human harvesting or hunting in the eastern Mediterranean since ancient times. Bath sponges, corals, mollusks, sharks, turtles and seals, have been used by humans since antiquity for food, medicines, crafts, and household purposes (e.g. Johnson and Lavigne, 1999; Voultsiadou 2008; 2010). Industrialization of fisheries during the past centuries combined with habitat degradation has led to severe population declines, even local extinctions. Moreover, the impact of exploiting marine ecosystem engineering species (Coleman and Williams, 2002) may be high for the marine biodiversity of the Aegean area since healthy sponges and corals have been shown to support rich benthic communities in the area (e.g. Koukouras *et al.*, 1998; Voultsiadou *et al.*, 1987). Another major problem with species like sponges and corals is that their economic value increases as they become less abundant, this leading to more intensive harvesting. Such species may not necessarily become "economically extinct" before their local or regional extinction, as is assumed for fish stocks (see Dulvy *et al*., 2003).

This review shows that historical information, though often fragmented and sometimes inconsistent, is sometimes the only source available to estimate long-term population trends, especially for species that are commercially exploited for centuries. Following historical data on coral, sponge and monk seal population status and distribution, for instance, we can reconstruct the condition of marine ecosystems in past times. Interestingly, if one could go back 2,000 years in time and dive in the Mediterranean waters, a rather different picture of the sea bottom and coastal zone would be witnessed: extended red forests of robust and tall *C. rubrum* colonies (especially in the western basin, see Tsounis *et al*., 2010), dense populations of black bath sponges in the eastern basin and large herds of seals lying fearless on sandy beaches. Thus, we could argue that the major extinction that has taken place in the Mediterranean is that of the physiognomy of the marine ecosystem as a whole.

5.3 Conservation preventing extinction

The eastern Mediterranean basin and most specifically the Aegean archipelago and its adjacent waters preserve important core zones which support specific Mediterranean features that have almost disappeared from other areas of this basin (e.g. *M. monachus*, *P. phocoena*). However, there is an obvious lack of adequate and efficient marine conservation in the Mediterranean, and particularly in the eastern and southern areas, possibly attributed to the lack of scientific spatial data in the region as well as to the socio-economic, political and cultural context (see Giakoumi *et al*., 2012 and references therein).

Over the last years, the urgency for the establishment of networks of marine reserves, high seas MPAs and 'Marine Peace Parks' in a pan-Mediterranean scale has been underlined by researchers (e.g. Coll *et al*., 2012), scientific commissions (e.g. CIESM, 2011), NGOs (e.g. Greenpeace, 2006; OCEANA, 2011), and Agreements (e.g. ACCOBAMS) (see Giakoumi *et al*., 2012). Several areas of the Greek seas have been included in such proposals (i.e. Thermaikos Gulf, Thracian Sea, Northern Sporades, Saronikos Gulf, Eastern Ionian and Gulf of Corinth, Southwest Crete/Hellenic Trench, Dodecanese) since they host important populations of marine mammals, sea turtles, large pelagic fish (including sharks), as well as unique environments and communities, e.g. upwelling areas, offshore banks, seamounts, coralligenous beds and deep sea corals, mud volcanoes, cold seeps and brine pools with interesting microbial communities (OCEANA, 2011 and references therein).

A major impediment to marine conservation is the ineffective management and surveillance of MPAs: several cases are tuning to be 'paper parks', where no management measures have yet been implemented (Abdulla *et al*., 2008). On the other hand, established MPAs have proved successful in recovering and preserving certain features of the Mediterranean marine environment and often benefit a broader geographic sector than the strict area of protection (PISCO, 2007). Such an example is the appearance of bath sponges in high abundances in areas associated with MPAs in the Aegean Sea, probably due to the protective measures facilitating colonization by larvae and growth of young sponges.

The absence of scientific data noted here should not be used as an excuse for no protection or management on a precautionary basis, particularly for marine species and habitats (Bussoletti *et al*., 2010). For instance, the lack of habitat maps in Greek waters has severely contributed to a consecutive ongoing degradation even of priority habitats (e.g. sea-grass meadows and coralligenous beds) and supporting diversity, in spite of the existing, relevant national legislation.

The lack of environmental awareness constitutes an added, a potential threat for vulnerable species. For example, despite the legislative framework for the commercial exploitation of threatened elasmobranch species, large sharks (e.g. *Cetorhinus maximus*) caught as bycatch have been reportedly sold in Greek fishmarkets (Megalophonou, 2009). Information campaigns could raise environmental awareness of fishermen, fish merchants, relevant authorities and consumers who should avoid further exploitation of threatened species. Both cases illustrate that the existence of legislative frameworks does not always guarantee protection of species/habitats and that further actions must be taken for regulation enforcement.

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