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Regional Activity Center for Specially Protected Areas

Fisheries conservation and vulnerable ecosystems in the Mediterranean open seas, including the deep seas

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Executive summary

The most important negative consequence of fishing activities is the degradation of marine ecosystems by the removal of target or non-target species and by physical disturbance inflicted by some fishing gear. Essential Fish Habitats (EFHs) are those habitats necessary for the feeding, refuge or reproduction of the species; and Sensitive Habitats (SHs) consist of areas with endemic species, high biodiversity or high productivity and vulnerable to fishing practices. The degradation of ecosystems by fishing indirectly affects the commercial species if the habitat is no longer suitable for these species. In this context, there is a need to regulate fishing activities to reduce ecosystem degradation by establishing an Ecosystem Approach to Fisheries (EAF), which considers not only the protection of target species, but the ecosystem as a whole. Within the EAF framework the Precautionary Approach considers the most restrictive measures for fisheries management (including establishing areas closed to fishing, or Marine Protected Areas) against a general lack of knowledge on the functioning of many ecosystems that sustain fisheries resources.

Jurisdictional waters in the Mediterranean are defined as lying up to 12 nautical miles from the coast in most countries; most Mediterranean waters correspond to international waters, or high seas. The Mediterranean high seas contain a high diversity of habitats, both pelagic and demersal. These habitats are poorly known compared to the coastal and continental shelf ecosystems, which are more easily surveyed. The protection of fauna in the Mediterranean high seas is important for fisheries and ecosystem conservation because organisms can determine the healthiness of an ecosystem. Sessile benthic fauna play an important role as habitat structuring organisms that provide a refuge for many marine species (e.g. cold coral reefs, deep sea sponges, crinoidea beds). Deep bottoms consist of wide extensions of soft sediments interrupted by geological features like submarine canyons, brine pools, seamounts, hydrothermal vents, cold seeps and mud volcanoes, that create a special habitat that harbours high diversity and endemism; many of these habitats have been only recently discovered and must be protected according to the Precautionary Approach. Demersal fisheries operating in the Mediterranean high seas can be summarized as follows: bottom trawling, bottom longline, and gillnet. Deep sea fisheries currently operate on continental shelves and some slopes, down to below 800m. Bottom trawling is a highly damaging practice that was banned in 2005 in bottoms deeper than 1,000m, aiming to protect the vulnerable deep sea fauna.

Of the benthic habitats in the Mediterranean high seas, the components most vulnerable to fishing are coralligenous facies, the crinoidea *Leptometra phalangium,* and the cnidaria *Funiculina quadrangularis* and *Isidella elongate*, facies of sessile organisms that have been detected on continental shelves and the shelf break in the western basin, although the location and extent of these habitats is still poorly known. In the deep seas there are several areas with considerable abundance of highly vulnerable cold coral reefs, mostly found on continental slopes, seamounts and on the walls of submarine canyons (e.g. off Cape Santa Maria di Leuca, or in numerous submarine canyons and seamounts scattered throughout the Alboran Sea). Several abyssal plains, that harbour poorly known and vulnerable deep sea fauna, are located throughout the Mediterranean basin, with the deepest grounds found in the central basin (e.g. the Calypso depth in the Ionian Sea, SW of Greece). Other geological features might be vulnerable to fishing since they are hotspots of diversity and are habitats of vulnerable fauna like cold corals. The massive Eratosthenes Seamount in the eastern basin (south of Cyprus) and numerous scattered seamounts in the Alboran Sea and the south Tyrrhenian, cold seeps, brine pools and hydrothermal vents are mostly found in the eastern Mediterranean basin (south of Crete and Turkey, and near Egypt). The western Mediterranean basin harbours numerous submarine canyons that are EFHs for red shrimp, like numerous canyons in the Gulf of Lions that sustain important fisheries of red shrimp, Norway lobster, hake, monkfish, among other important commercial species; otherwise, the hake nursery areas are mainly located on wide extensions of the continental shelves or banks, especially the south of Sicily, the central Adriatic in the Jabuka Pit, and the Thracian Sea, whereas hake spawning grounds seem to be located on the shelf break and slope canyons, the Gulf of Lions being the clearest example.

The large pelagic species that inhabit the high seas: mainly bluefin tuna, swordfish, and albacore, and also pelagic sharks (short fin mako, blue shark and porbeagle) are of high conservation interest and have long been overexploited by pelagic fishing gear. The main fishing gears for large pelagics are purse seines and pelagic longlines. Pelagic long lining fleets operate in Mediterranean waters, ranging from local coastal national fleets to large industrial foreign fleets; these are highly mobile, and cover almost the whole Mediterranean basin. Driftnets were banned in the Mediterranean in 2005, although this activity is still practiced. The Mediterranean high sea is also the habitat of the endangered cetaceans and turtles that are a common by-catch of pelagic fisheries and deserve special protection. Important EFHs for large pelagic species are mostly determined by oceanographic features like upwellings or gyres that create productive areas important for feeding and breeding; areas that act as EFHs must be identified to define protection measures for pelagic species. The main spawning areas for bluefin tuna are in the southern Balearic Islands, the Alboran Sea and the Strait of Sicily; swordfish spawns in almost all the Mediterranean area and albacore overlap with bluefin tuna spawning grounds.

Marine Protected Areas (MPAs) help fisheries management by providing local relief from fishing and maintaining undisturbed areas that encourage vulnerable ecosystems. But in order to assess the efficiency of MPAs for fishery purposes, it is essential to have a good knowledge of the ecosystem's components and functioning, and to promote continuous monitoring. In order to select the most suitable areas as candidate sites for MPAs, we need to identify sites by their ecological importance, including uniqueness or rarity, special importance for life history stages of species, importance for threatened, endangered or declining species and/or habitats, vulnerability, fragility, sensitivity or slow recovery of the ecosystem, its biological productivity and biological diversity. Furthermore the establishing of a MPA must carefully consider its location (according to the criteria mentioned above), and its size and connectivity. In the Mediterranean, most MPAs are located around coastal rocky bottoms or islands, neglecting the importance of the high sea ecosystems.

Ecosystems selected as EFHs and SHs that receive fishing impacts in the Mediterranean open seas could be considered as candidate sites for Specially Protected Areas of Mediterranean Importance (SPAMIs). They could represent an essential tool for managing fisheries in the Mediterranean open seas within an EAF and Precautionary Approach; however, these areas might imply the effective restriction of fishing activities, requiring a suitable surveillance system and long-term monitoring. The following 13 sites are considered by the authors as priority areas for conservation regarding fishing impacts in the Mediterranean open seas, including demersal and pelagic ecosystems.

Demersal priority areas

1) Gulf of Lions slope. A demersal ecosystem to protect the spawning areas of several commercial species (including hake, shrimp, monkfish) from demersal fishing activities. Already adopted as a FRA (Fishery Restricted Area) by GFCM.
2) South of Sicily, Adventure and Malta Banks. A demersal ecosystem important as offering hake nursery areas where bottom fishing activities, specially trawling, should be restricted.
3) Thracian Sea. A demersal ecosystem in the Strymonikos Gulf and Samotraki Plateau offering important spawning grounds for hake where bottom fishing activities, mainly trawling, should be restricted.
4) Cold coral reefs (*Lophelia pertusa*) off Cape Santa Maria di Leuca. A SH highly vulnerable to physical disturbance by bottom trawling. Already adopted as a FRA (Fishery Restricted Area) by GFCM.
5) Fosa di Pomo/Jabuka Pit. This important nursery area for hake in the central Adriatic should be protected from demersal fishing activities, mainly trawling.
6) Eratosthenes Seamount. An important SH vulnerable to bottom fishing activities. Already adopted as a FRA (Fishery Restricted Area) by GFCM.
7) Nile hydrocarbon cold seeps. A SH, being a unique environment in the eastern Mediterranean basin that needs to be protected from harmful bottom fishing activities. Already adopted as a FRA (Fishery Restricted Area) by GFCM.
8) Bottoms below 1,000m. Habitats of poorly known and vulnerable fauna that could be protected. Fishing using towed gear has been prohibited in this area by GFCM.
9) The Alboran Sea Seamounts. This SH (this area contains cold coral reefs and submarine canyons), highly vulnerable to bottom fishing, could be protected.

Pelagic priority areas

10) South of the Balearic Islands. An important spawning area for bluefin tuna in the Mediterranean, as well as an important area for cetaceans and sharks; this area could be protected from pelagic fishing activities.
11) The Strait of Gibraltar and the Alboran Sea. An important migratory route for bluefin tuna and cetaceans; pelagic fishing could be banned in this area.
12) North of the Levantine Sea. An important bluefin tuna spawning area in the eastern Mediterranean, thus should be protected from pelagic fishing.
13) The Straits of Sicily. Proposed as a Protected Area for pelagic species as it is an important migratory route for tuna-like species.

Acronyms

ABNJ	Area Beyond National Jurisdiction
ACCOBAMS	Agreement on the Conservation of Cetaceans in the Black Sea, the Mediterranean Sea and the Contiguous Atlantic Area
ADRIAMED	A regional FAO project, “Scientific Cooperation to Support Responsible Fisheries in the Adriatic Sea”
CBD	1992 Convention on Biological Diversity
CIESM	Commission Internationale pour l’Exploration de la mer Méditerranée
CIHEAM	International Centre for Advanced Mediterranean Agronomic Studies
CMS	Convention of Migratory Species (UNEP)
COPEMED	A regional FAO project, “Coordination to Support Fisheries Management in the Western and Central Mediterranean”
EAF	Ecosystem Approach to Fisheries
EASTMED	A regional FAO project: “Sustainable Fisheries Policies and Strategies in the Eastern Mediterranean”
EBFM	Ecosystem Based Fisheries Management
EBSA	Biologically Significant Area
EEZ	Exclusive Economic Zone
EC	European Commission
EFH	Essential Fish Habitat
EU	European Union
FAO	Food and Agriculture Organization (United Nations)
FRA	Fishery Restricted Area (GFCM protection figure)
GFCM	General Fisheries Commission for the Mediterranean
ICCAT	International Commission for the Conservation of Atlantic Tunas
IUCN	International Union for the Conservation of Nature
IUU	Illegal, Unreported and Unregulated
MAP	Mediterranean Action Plan
MCS	Monitor, control and surveillance
MEDFISIS	A regional FAO project, “Mediterranean Fishery Statistics and Information System”
MEDITS	An international bottom trawl survey in the Mediterranean
MEDSUDMED	A regional FAO project, “Assessment and Monitoring of the Fishery Resources and the Ecosystems in the Straits of Sicily”
MPA	Marine Protected Area
RAC/SPA	Regional Activity Centre for Specially Protected Areas
RFMO	Regional Fisheries Management Organization
SAC	Scientific Advisory Committee (GFCM body)
SAP	Strategic Action Plan

SCMEE	Subcommittee on Marine Environment and Ecosystems (GFCM body)
SCRS	Standing Committee on Research and Statistics (ICCAT)
SH	Sensitive Habitat
SPAMI	Specially Protected Area of Mediterranean Importance
STECF	Scientific, Technical and Economic Committee for Fisheries (EC body)
TAC	Total allowable catch
TROM	Target Resource-Orientated Management
UNCLOS	United Nations Conference on the Law of the Sea
UNEP	United Nations Environment Programme
VME	Vulnerable Marine Ecosystem
VMS	Vessel Monitoring System
WPC	World Parks Congress
WSSD	World Summit on Sustainable Development
WWF	World Wide Fund for Nature

1 Introduction

1.1 Importance of marine ecosystems for fisheries

The habitat of an organism can be defined as the place where it lives and which provides food, shelter and living space (Chabanet *et al.* 2005). A habitat must be defined in relation to the species and populations of interest; potential habitats for a species vary with respect to both quality and quantity of available resources (food, refuge, etc.), predation risk, or resource requirements by organisms from the same or different species leading to competitive interactions. The question is: what habitat features are relevant for the organisms and what are the ecological functions provided by these features which are to be measured and, ultimately, protected (Garcia-Charton *et al.* 2000). The concept ‘habitat’ encompasses not only the substratum (e.g. rock, sand, for demersal species; oceanographic features like fronts, upwellings, gyres for pelagic species), but also habitat ‘formers’ (e.g. coral reefs, seagrass meadows, gorgonians, vermetid reefs, maërl beds, or macroalgae) (Fluharty 2000). Moreover, habitat ‘determiners’, i.e. organisms able to modify the physical structure of a habitat by their individual activity (e.g. grazing, scratching, scavenging), should be considered.

Marine ecosystems from fishing grounds should be treated as a whole, from the fishery that is operating on them to the commercial species targeted by the fleet, as well as communities of non-target species and habitats that support commercial species and fishery activities (Christensen & Pauly 1998, Charles 2001, Hart & Reynolds 2002). There is a tight link between these three compartments that constitute ecosystems from fishing grounds; one cannot be understood in isolation. However, we underline the importance of increasing our knowledge of marine communities and habitats in order to protect them suitably (de Juan *et al.* 2007).

Fishing activities worldwide frequently drive the overexploitation of stocks; however, the most important negative consequence of fishing is the degradation of ecosystems (Auster *et al.* 1996, Thrush & Dayton 2002) that additionally can indirectly affect the commercial species if the habitat is no longer suitable for these species (Turner *et al.* 1999, Kaiser *et al.* 2002). If the density of target species declines as a consequence of ecosystem degradation, a higher fishing effort would subsequently be necessary to exploit that resource, and, in this context, it has been widely accepted that fishing has to be managed to reduce the degradation of marine communities and habitats (Ludwig *et al.* 1993, Browman & Stergiou 2004, Frid *et al.* 2005).

Article 6.8 of the Code of Conduct for Responsible Fisheries (FAO 1995a) states:

> *All critical fisheries habitats in marine and fresh water ecosystems, such as wetlands, mangroves, reefs, lagoons, nursery and spawning areas, should be protected and rehabilitated as far as possible and where necessary. Particular effort should be made to protect such habitats from destruction, degradation, pollution and other significant impacts resulting from human activities that threaten the health and viability of the fishery resources.*

Furthermore the Valencia Declaration (World Conference on Marine Biodiversity, 11-15 November 2008[1]) states that, *inter alia*:

- *Ecologically coherent networks of marine protected areas be developed at an urgent and accelerated pace based on existing scientific data and understanding*
- *Mechanisms be established to enhance cooperation between scientists, governments and relevant organizations to identify and protect ecologically and biologically significant areas based on the scientific criteria adopted by the Parties to the Convention on Biological Diversity for the open ocean and deep seas.*

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[1] http://www.marbef.org/worldconference/

1.1.1 Essential Fish Habitat

"Essential Fish Habitat" (EFH) refers to those waters and substrates necessary to fish for spawning, feeding or growth to maturity (Benaka 1998); to protect a specific organism it is necessary to protect those habitats that maintain the species at any life stage (Engel *et al.* 1999, Schmitten 1999, NRC 2002).

With the adoption of the Sustainable Fisheries Act in 1996 (Fluharty 2000), significant new opportunities and challenges to protect the habitats of marine fish emerged, through the Magnuson-Stevens Fishery Conservation and Management Act. In this Act, EFH was first defined in terms of an "area" but then was expanded and clarified to refer to "waters and substrates" including also the biological communities living there.

Ardizzone (2006) stated that an EFH is a habitat identified as essential to the ecological and biological requirements for critical life history stages of exploited fish species, and which may require special protection to improve stock status and long-term sustainability. Therefore, the habitat must be identified as the physical space where individuals of a critical phase of a species are concentrated:

- Nursery grounds could be considered as those areas where the highest concentrations of recruits are found
- Spawning areas and seasonal areas could also be considered as areas or periods of concentrations of mature females.

1.1.2 Sensitive Habitats

"Sensitive Habitats" (SHs) are habitats that are highly vulnerable, or support organisms that are of interest because of their rarity, e.g. seagrass meadows, maërl beds, sponge cover (Ardizzone *et al.* 2000, Hall-Spencer & Moore 2000). A SH consists of complex ecosystems with endemic species, high biodiversity or high productivity. This definition includes fragile habitats that are recognised internationally as ecologically important and which support important assemblages of commercial and non-commercial fish species and which may require special protection (e.g. *Posidonia oceanica* beds, Ardizzone 2006).

The GFCM (2008a) defines SHs as those habitats that are:

- Essential to the ecological and biological requirements of at least one of the life stages of the species

- Crucial for the recovery and/or long-term sustainability of the marine biological resources and assemblages to which the priority species belongs

- Any other habitat of high biodiversity importance potentially impacted by fisheries activities

- Any other habitat of high biodiversity importance potentially impacted by climate change.

1.1.3 Need to regulate fishing activities from an ecosystem perspective: Ecosystem Approach to Fisheries (EAF)

Fisheries management aims to minimise the negative effects of fishing on natural populations and ensure fisheries resources for future generations (FAO 1995a, 2003b). Decision-making in fisheries management has been focused on achieving maximum sustainable yield, i.e. maximum catch without compromising the survival of the stocks. However, the general picture of the world's marine resources is one of overexploitation with a continuous decreasing trend for many commercially exploited stocks (Dayton 1998, Pauly *et al.* 1998, Pitcher 2001). In this context, management of the world's fisheries has been reconsidered over the past decades, and both scientists and stakeholders accept the importance of protecting the habitats where exploited species live in order to ensure their survival (Pauly *et al.* 2002, Browman & Stergiou 2004). Management has thus begun to incorporate approaches for the protection of spawning grounds, nursery areas, and in general EFHs for fish species of commercial interest. An example is the closure at specific times of year of areas considered as being crucial for the species, such as recruitment periods; this has been established for decades now and represents the first step towards protecting fish habitats (Dinmore *et al.* 2003, Micheli *et al.* 2004). But only recently have management plans been widened to see the ecosystems as a whole, which have to be protected to ensure the resilience and maintenance of the marine resources, the communities and their habitats (Agardy 2000, Murawski *et al.* 2000).

One of the consequences of the adoption of the Code of Conduct for Responsible Fisheries (FAO 1995a) was the development of the Ecosystem Approach to Fisheries (EAF), also known as Ecosystem Based Fisheries Management (EBFM) or by other similar names. The official starting of EAF was the Reykjavik Declaration after the Conference on Responsible Fisheries in the Marine Ecosystem (Reykjavik, October 2001). Many documents have been published on that matter (the most fundamental are FAO 2003a, Garcia *et al.* 2003, Sinclair & (eds.) 2003). This is not the place to introduce EAF extensively, but it represents a new and integrated way to manage fisheries after the failure of traditional TROM (target resource-orientated management) in many fisheries. The EAF may help improve management actions in that it takes a wider view than the target species approach. However, no standard procedures to identify and protect important fish habitats have yet been implemented in European waters, including the Mediterranean.

Fishing activities sustain an important fishery sector that must be included in management actions and consulted for decision-making. The agreement of this sector is of great importance for the success of any action (IMEDES-COPEMED 1999, Guenette *et al.* 2000, Charles 2001). Concurrently, the populations of targeted species must be controlled (i.e. overall biomass, average size, recruitment), as they are what sustains the fishery; most importantly, communities and habitats that maintain this resource must be included in any management action plan (NRC 2002). Thereafter, implementation of suitable management plans has to be carried out along with investigation of potentially altered ecosystems to design the most appropriate measures and avoid their degradation.

1.2 MPA as a fishery management tool

It is widely accepted that in order to achieve biodiversity conservation and the recovery of species populations, an overall reduction of the trawling effort has to be made, involving the closure of areas to fishing, by setting up Marine Protected Areas (MPAs), the most restrictive measure (Fogarty 1999, Lubchenco *et al.* 2003). Existing studies indicate that networks of well-managed MPAs can make ecosystems more resilient to external threats, e.g. climate change or fishing, can protect valuable habitats, and can support the species that use these habitats for feeding or breeding (Parnell *et al.* 2006). MPAs are an essential tool for marine conservation in that they are designed to protect pristine and sensitive areas from anthropogenic activities, and to protect altered communities from further degradation (Allison *et al.* 1998, Sainsbury & Sumaila 2003).

1.2.1 <u>Background</u>

In recent decades, MPAs have been set up around the world at a rapid rate (Lubchenco *et al.* 2003). Some offer protection to pristine natural communities (Kelleher 1995), while others attempt to halt further deterioration of SHs, or serve as fisheries management tools for long-term sustainability of fisheries. MPAs have proven to be effective in fisheries rebuilding in adjacent areas around the world (Roberts *et al.* 2001), including the Mediterranean Sea (Goñi 1998, Sanchez Lizaso *et al.* 2000, Francour *et al.* 2001). However, the use of MPAs to protect habitats from fishing (known as Fishery Restricted Areas, or FRAs, in the terms of the GFCM) is not common. In the Mediterranean, most marine reserves set up to protect ecosystems from any sort of anthropogenic impact have been located in coastal rocky bottoms or islands (Francour *et al.* 2001), with a few exceptions that include soft bottoms protected from trawling on continental shelves (Pipitone *et al.* 2000, Pipitone *et al.* 2004).

The benefits of MPAs can be summarized as, first, they maintain undisturbed areas which increase the resilience of ecosystems, and second, they provide local relief from fishing to some species and habitats and maintain high biomass and diversity of target and non-target organisms (Dugan & Davis 1993, Micheli *et al.* 2004). Among the ecological effects of MPAs we highlight: reserve effect (increased abundance, mean size and age); fish movement and connectivity (protection of dispersal and migratory patterns); density dependent emigration (spillover). MPAs could become repositories of large super-fertile mother fish, laying large, healthy eggs that can restock the oceans. Moreover, these protected areas must allow increases in the complexity of the ecosystem, and as the most vulnerable organisms are generally slow-growing species that need a long recovery time (e.g. sponges, corals, chondrichthyans), the complete recovery of ecological interactions may require decades (Diamond 1975, Allison *et al.* 1998, Ward *et al.* 1999).

Over the last few years many international organisms have recalled the importance of MPAs as a management tool for protecting and restoring ecosystems; amongst these the Bergen Declaration (Declaration 2002) calls for setting up networks of Marine Protected Areas by 2010. The IUCN has called for the development of networks of Marine and Coastal Protected Areas, which protect at least 20% of each habitat type, by 2012. MPAs provide an alternative to conventional fisheries management tools, especially when these tools cannot be implemented effectively (Agardy 1994, Botsford *et al.* 1997, Bohnsack 1998, Lauck *et al.* 1998). Creating an MPA is often considered as an application of the Precautionary Principle against the various sources of uncertainty in the management of marine resources. For example, uncertainties arise from the natural variability of ecosystems, the impacts of various anthropogenic activities on these ecosystems (Lauck *et al.* 1998), and the socioeconomic system (Sumaila & Charles 2002).

1.2.2 Criteria for setting up MPAs for fisheries management purposes

The effects of MPAs have not always been positive, and each situation must be carefully analysed, including the size of the Protected Area, the effort allocation, and the ecology of the community (Roberts & Polunin 1991, Roberts *et al.* 2001). A small Protected Area in the middle of a fishing ground can be subject to limited recovery and still be highly influenced by fishing in the surroundings. These areas should be large enough to provide a structured habitat and eliminate the negative influences of fishing on nearby fishing grounds (Dugan & Davis 1993, Allison *et al.* 1998).

The most difficult concept for planning suitable MPAs is the dispersal capacity of marine organisms and the inexistence of borders in the aquatic environment, which imply the need to carefully analyse each particular situation and define the appropriate size of each Protected Area. Sources and sinks of individuals must be investigated, considering larval export, persistence of species inside the reserve, and existence of reserve networks (Dayton *et al.* 1995, Lockwood *et al.* 2002). Overall, it is emphasised that several issues must be addressed to appropriately define a MPA: what is its goal, what human activities are restricted, and the degree of restriction of these activities (Allison *et al.* 1998).

Main characteristics to be taken into consideration when designing MPAs for fishery management purposes:

Location: Priority conservation areas, which are equivalent to the Ecologically or Biologically Significant Areas (EBSAs) described in the criteria adopted by the 2007 Convention on Biological Diversity (Sharma *et al.* 2007). As detailed in the CBD report (UNEP (DEPI)/MED WG. 330/Ref.; Report on the expert workshop on ecological criteria and biogeographic classification system for marine areas in need of protection: UNEP/CBD/EWS.MPA/1/2), such areas can be identified using the criteria of: uniqueness or rarity; special importance for life history stages of species; importance for threatened, endangered or declining species and/or habitats; vulnerability, fragility, sensitivity or slow recovery; biological productivity; biological diversity; and naturalness.

Size of MPA: Ballantine (1991), a pioneer of MPAs for fishery purposes, proposes for New Zealand that 10% of their marine ecosystems should be protected. Agardy (2003) relates MPA size to specific objectives related to the biology of the species inhabiting the area, biomass, and fishing mortality. The GFCM & RAC/SPA (UNEP-MAP-RAC/SPA 2007) workshop on MPAs noted that “The size and connectivity of MPAs have been recognized as key issues regarding fishery sustainability. MPA size depends on the mobility of the target species, and protection of 20% of fishing grounds has been considered a sound reference point to have a real effect on the stocks”.

Connectivity: An ecologically representative network of MPAs should incorporate the full range of known biodiversity in protected sites, including all habitat types, with the amount of each habitat type being sufficient to cover the variability within it, and to provide duplicates (at least) to maximize potential connectivity and minimize the risk of impact from persistent large-scale and long-term effects (Balmford *et al.* 2005). Taking into account connectivity between sites will require consideration of how far populations are connected by adult and larval dispersal, as well as an understanding of the differing dispersal mechanisms for different species within a given site. Ensuring that biogeographic units are well represented within an overall system of Protected Areas helps ensure that the full range of marine biodiversity and ecosystem processes will also be protected, and it is often the best that can be achieved given the current state of knowledge (UNEP-WCMC 2007; GOODS, Biogeographic Classification, UNESCO 2009).

1.3 Mediterranean fisheries and MPAs

1.3.1 Fisheries in the Mediterranean

Fishery resources in the Mediterranean are diverse and sometimes highly migratory; catches are usually low, with marked seasonal difference; and they have been long considered overexploited (Martin 1991). Multispecies catch impedes the designing of management actions, in that it requires a multispecies approach (Caddy 1993). Furthermore, the main problems linked with fishery management in the Mediterranean are due to the large number of countries involved and to a general lack of cooperation in fisheries management. Much of the surface area of the Mediterranean is international water, since most countries only control the area within 12 miles of the baseline (jurisdictional waters), which hampers the regulation of fishery activities in international areas not far from the coast. The jurisdictional area is controlled by each country, although it is subject to European legislation for the European countries. There are three international fisheries commissions: GFCM (General Fisheries Commission for the Mediterranean) is an institution involving 24 countries and linked to FAO, the EU for the Mediterranean European countries, and ICCAT (International Commission for the Conservation of Atlantic Tunas), are the only organisations that can develop actions involving more than one country and make compulsory management recommendations.

The largest difference from other geographical areas is the lack of industrial fishing, with bigger vessels where catches are processed (Demestre *et al.* 1987, Martin 1991). Depending on the target species, fishing is conducted with one specific gear type in a selected fishing ground. The narrowness of the Mediterranean continental shelves means that most fishing grounds are relatively close to the coast (Demestre *et al.* 1988, Sbrana *et al.* 2002).

Many fishing gear are used in the Mediterranean; Bas (2002) describes near 40; however, most are coastal or artisanal and only a few have relevance on the high seas. These are:

- Bottom otter trawl. Hake (*Merluccius merluccius*) and deep shrimps (i.e. *Aristeus antennatus*, *Aristomorpha foliacea*, *Plesionika* spp.) are the main target species. Usually the catch is highly multispecies (i.e hake as target species may constitute 15% of the catch). In the case of the red shrimp (*A. antennatus*) fishing gear can reach depths of 800 m in the Western Mediterranean
- Demersal longline and gillnets. Large hake is the main target. They can operate in canyons and rocky bottoms where bottom trawl can not
- Pelagic longline. Swordfish and pelagic sharks are the main targets
- Pelagic trawling, banned in several countries (i.e. Spain and Greece)
- Tuna purse seine. The only target is bluefin tuna; its purpose is to catch them alive to move them (using carriers) to cages for fattening

- Driftnets. Any pelagic, highly migrant, species is a target of this gear (tunas, swordfish, sharks) due to the very high catch of protected or non-target species (cetaceans, turtles, birds). Driftnet fishing was prohibited by ICCAT and GFCM in 2003. However this practice (often under different names) is far from having been eradicated in the Mediterranean.

1.3.2 Current legislation in the Mediterranean

Organisms controlling legislation: at national level by each country within 12 nautical miles; the EU for European countries; GFCM and ICCAT for member countries. Territorial waters lie within 12 nm of the coast (with the exception of Greece and Turkey in the Aegean Sea, with 6 nm of territorial waters); this results in a high proportion of high seas. Several countries have claimed an Exclusive Economic Zone; and Algeria, Malta, Spain and Tunisia have claimed Fishing Zones); however, there is not a consensus throughout the Mediterranean basin. Moreover, all the agreements or plans that have emerged have not always been supported by all the countries (Cacaud 2005b). All these factors make the management of fishery resources and ecosystems beyond national jurisdiction highly complicated (See Table 1 for a detailed description of the claims).

Fishing activities in the Mediterranean are regulated by controlling the fishing effort (i.e. engine power, fishing hours, seasonal closures), size of net and minimum landing size and total allowable catch (TAC) for large pelagics (ICCAT).

Effort measures

- TACs and quotas
- Number of boats
- Fishing time (hours per day, days per week, per year, temporal closures, etc.)
- Size or number of items of gear (net length, number of hooks, etc.)
- Fishing power (engine power, tonnage, etc.)
- Technological progress

Technical measures

- Minimum landing size
- Gear characteristics (material of nets, type of mesh, minimum mesh size, hook size, etc.)
- Gear (forbidden, permitted)

Fishery restrictions

- Protected Areas, spatial closures, temporary closures

Lleonart (1999) proposed several management actions that are still pending:

i. Fisheries monitoring should be developed. Standardised and routine collection and gathering of data (including discards) should be implemented
ii. Promote international assessments starting with the main, and shared, stocks
iii. Later, even national stocks could be assessed by international bodies
iv. Mediterranean fisheries at this moment need to implement both adaptive and precautionary management
v. Use management tools (economic, ecological and technical) that are easy to implement and control. Avoid redundancy of management measures
vi. Develop reference points to detect and prevent recruitment overfishing
vii. Regionalise management when possible, taking into account market and border effects
viii. Any change to be introduced in the fishing policy should be clearly addressed to remove fishing mortality, improve selectivity or protect (or recover) ecosystems
ix. Special attention should be paid to the technological progress. In order to avoid increasing fishing mortality, technological improvements should be analysed and compensated for by decreasing the effort
x. Develop and implement pilot management projects
xi. Analyse different management strategies.

1.3.3 MPAs for fishery purposes in the Mediterranean

For Mediterranean fisheries, with their multispecific catch, seasonal activity in fishing grounds, and numerous countries involved, with a large area of international water, FRAs (Fisheries Restricted Areas, the GFCM protection figure) can be a feasible tool to regulate fishing activities within an EAF context.

There are different types of marine reserves; a complete list is included in Annex 1. However, the important protection figures with regard to this report are:

- Marine Protected Areas, with conservation/ecological purpose
- Marine Managed Areas, designed for the sustainable use of natural resources, and with a social purpose
- Fishery Restricted Areas, designed to protect marine ecosystems from the impact of fishing activities
- SPAMI: the 1995 Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean provides for making a list of Specially Protected Areas of Mediterranean Importance; this list includes sites which "are important for conserving the components of biological diversity in the Mediterranean", "contain ecosystems specific to the Mediterranean area or the habitats of endangered species", or "are of high interest at the scientific, aesthetic, cultural and educational levels". When the proposal is located in the high seas, it must be made by two or more neighbouring Parties and with the consensus of the Parties at their regular meetings (UNEP-MAP-RAC/SPA 1995, Cacaud 2000).

In general MPAs have been sited at intrinsically ecologically rich places based more on opportunistic human factors than on relevant ecological and/or socioeconomic features, resulting in a very heterogeneous pool of small reserves along the coast and a number of very large open sea reserves within the EEZ countries (UNEP-MAP-RAC/SPA 2007, Ojeda-Martínez *et al.* 2009).

There are now 649 SPAs and 121 MPAs in the Mediterranean basin (Annex 2). It is important to state that there is a strong heterogeneity of the structures referred to as "MPAs" by the various countries. In addition there is the risk of duplication insofar as the same geographical surface can be quoted several times, being referred to, with different surface areas, in several types (UNEP-MAP-RAC/SPA 2007).

1.4 The Mediterranean high seas

The Mediterranean high seas can be defined in two ways:

i. The seas lying outside the national jurisdiction (usually, but not always, 12 nm from the baseline). Using this definition, the Mediterranean high seas encompass part of the continental shelves, the continental slope and the deep sea, as well as the pelagic ecosystems off the 12 nm limit (6 in Greece and Turkey)

ii. The seas outside any kind of jurisdictional zone, not only territorial waters but also economic zones (present or under discussion in Morocco, Tunisia, Egypt, Cyprus, and Syria) and ecological and fisheries protection zones (France, Spain, Libya, Croatia). Using this definition, the high seas area are considerably reduced.

This report uses the first definition of the high seas.

The continental shelves, which are relatively narrow in the Mediterranean basin, continue as continental slopes; the slopes can be cut into by submarine canyons or deep troughs with depths greater than 200 metres. The slope finishes in abyssal plains, wide extensions of deep seabed (Bas 2006). Throughout the deep seas there are also the long mid-ocean ridges, which have a very complex topography, including seamounts, mud volcanoes, hydrothermal vents, etc. (Erickson 2003). Most of the continental shelves and slopes are composed of sand or mud, whereas much of the abyssal plains from the deep oceans is covered by fine mud. However, within these habitats there is a mosaic of patches of different habitat types, often very different from the surrounding area, increasing the diversity of the deep seas (Hall 2002). These patches generally include the high-vulnerability species that are typically absent from the wider areas, thinly scattered elsewhere and densely developed in rare, small areas (Thrush & Dayton 2002, Sardà *et al.* 2004, Koslow 2007). Many of these patches found in the deep seas are characterised as SHs or EFHs (Koslow *et al.* 2000b).

A large part of the high seas corresponds to pelagic habitats, characterized by oceanographic features (i.e. currents, fronts, upwellings), that harbor populations of pelagic species, including large migratory fish.

The Mediterranean basin has the following proportions, the high seas representing an important percentage of the basin:

- < 200 m: 504,816 km^2, 20% of the total area
- 200 to 1000 m: 559,284 km^2, 22.2% of the total area
- >1000 m: 1,458,976 km^2, 57.8% of the total area

1.4.1 Deep sea habitats

Waters deeper than 1,000 m cover about 60% of our planet and many new deep sea habitats have been discovered in the last three decades (e.g. hydrothermal vents, cold seeps, cold water coral reefs). Some of these habitats, such as seamounts (Koslow *et al.* 2000a) and canyons (Sarda *et al.* 1994) have been identified as hotspots of biological production. Even so, these ocean depths remain virtually unknown to us, and this lack of knowledge is one of the main reasons why these ecosystems are highly vulnerable to exploitation (Briand 2003, Roberts *et al.* 2003). The Mediterranean deep seas present a high diversity of habitats because of the geological history (Bianchi & Morri 2000). There is faunistic renewal and a high rate of endemism at the abyssal stage, which corresponds to the plain that starts at about 2,000 m (Bellan-Santini 1985, Laubier & Emig 1993). Investigations of the Mediterranean deep sea fauna are at a very early stage: below 1,000 m, where systematic sampling has been extremely limited, most faunal groups remain largely unknown, and there are basins in the eastern Mediterranean and in southern waters where effectively nothing is known about deep sea biology (Briand 2003). Our knowledge of deep megafaunal communities is mainly limited to the bathymetric range over which commercial fishing operates usually down to 800 m; below this range we have only fragmentary data. This highlights the importance of protecting deep sea habitats using the Precautionary Approach principles (Tudela 2004). Taking this into account, in its Recommendation GFCM/2005/2 the GFCM prohibits the use of towed dredges and trawl fisheries at below 1,000 m depth.

1.4.2 Fisheries in the high seas

Most of the Mediterranean's living resources are exploited on the continental shelf, where a high variety of species and biocenoses occur and many fishing techniques and related activities have long been carried out. The exploitation of deep sea organisms started only in the first few decades of the last century, due to the development of the technology for prospection in deep waters. Though fisheries down to a depth of 700 m have been common since the middle of the last century in the Mediterranean Sea, the deep sea bottoms down to 1,000 m remain untrawled, although these can be indirectly affected by fishing activities (e.g. marine debris originated by fishing and waste from vessels). However, the trawl bottom fishery currently goes down to almost 1,000 m, as the narrowness of the shelf, crossed by numerous submarine canyons, brings the deep depths to within a few miles of the coast (Sarda *et al.* 2004).

Pelagic fisheries in the high seas mainly target large pelagic species, like the bluefin tuna that has been largely overexploited; however, this fishery has important indirect effects due to the by-catch capture of vulnerable species like cetaceans and sharks (Tudela 2004). This fishery is carried out in international waters by both Mediterranean and foreign fishing fleets, which hampers the control of catch and by-catch and their regulation.

1.4.3 MPAs and the high seas

Recent attention has focused on the previously ignored high sea areas; several workshops have dealed with the importance of a network of high sea MPAs, as the following statements show:

> Convention on Biological Biodiversity (CBD CoP7, Kuala Lumpur, 2004): *The establishment and maintenance of marine and coastal protected areas that are effectively managed, ecologically based and contribute to a global network of marine and coastal protected areas, building upon national and regional systems, including a range of levels of protection, where human activities are managed, particularly through national legislation, regional programmes and policies, traditional and cultural practices and international agreements, to maintain the structure and functioning of the full range of marine and coastal ecosystems, in order to provide benefits to both present and future generations, stressed the importance to address the protection of the biodiversity beyond National jurisdiction, and agrees that there is an urgent need for international cooperation and action to improve conservation and sustainable use of biodiversity in marine areas beyond the limits of national jurisdiction, including the establishment of further marine protected areas consistent with international law, and based on scientific information, including areas such as seamounts, hydrothermal vents, cold-water corals and other vulnerable ecosystems; the CoP7 invites the Parties to raise their concerns regarding the issue of conservation and sustainable use of genetic resources of the deep seabed beyond limits of national jurisdiction and to identify activities and processes under their jurisdiction or control which may have significant adverse impact on deep seabed ecosystems and species*.
>
> The Malaga Workshop on High Seas Protected Areas (January 2003) *stressed, inter alia, that the scientific knowledge of the high seas, especially the one of the deep sea, needs to be raised.*

In spite of the scattered nature of the biological information so far available, it is known that the Mediterranean basin contains many key geomorphologic structures, such as canyons, seamounts, mud volcanoes, deep trenches, etc. that are expressed in a distinctive biodiversity makeup in other regions in the world, as recent findings have indeed confirmed (including the presence of chemosynthetic trophic webs). Moreover, within an oligotrophic region like the deep Mediterranean, the functioning of relatively high productive areas, such as canyons and upwellings, which are crucial for maintaining certain levels of relatively high productivity, is of particular significance. The unique deep sea communities in the Mediterranean reinforce the importance of restricting, in a precautionary spirit, the impact of human activities on these fragile, not very resilient habitats (WWF/IUCN 2004), setting up MPAs being one of the most effective tools for implementing a precautionary approach.

1.4.4 Proposals of MPAs embracing the Mediterranean high seas

Already adopted:

i. The Pelagos sanctuary for the Mediterranean Marine Mammals (Corsican-Ligurian-Provençal basin) is one example of an off-shore Protected Area also useful for other large pelagic species (Notarbartolo-di-Sciara *et al.* 2008)

ii. In 2005 the GFCM (Reccomendation GFCM/2005/1) adopted a recommendation to prohibit towed gear below 1,000 m

iii. In 2006 the GFCM (Reccomendation GFCM/2006/3) decided on protection from towed gear (dredges and trawl nets) in 3 deep sea sites comprising Mediterranean high seas:

    a. the deep-water coral reefs in the Ionian Sea (*Lophelia* reefs off Cape Santa Maria di Leuca)
    b. the chemosynthesis-based cold seep ecosystem near the Nile Delta
    c. the Eratosthenes seamount, off Cyprus.

    In order to protect these sites the GFCM created a new legal category, “Deep-sea fisheries restricted area”. The GFCM recommends that members call the attention of the appropriate authorities to protecting these sites from the impact of any other activities jeopardizing conservation of the features that characterize these particular habitats. The demersal ecosystem of the Alboran Sea was proposed at the same meeting but was not endorsed by the Subcommittee on Environment and Ecosystems. The GFCM name for this protection figure is FRA (Fishery Restricted Area)

iv. In 2009 a FRA proposal of the slope in the Gulf of Lions was adopted, with some temporal restrictions (Recommendation GFCM/33/2009/1).

GFCM proposals included as additional information in electronic format.

Figure 1: Location of the Fisheries Restricted Areas adopted by the GFCM (red rectangles). White line represents the prohibition of towed dredges and trawl nets below 1.000 m

Other proposals:

v. A proposal for a FRA was presented to the SCMEE in 2005. According to the report of the meeting[2]:

   The information provided by the "fact sheets" of the Alboran Sea seamount proposal was not considered sufficient to justify the conservation issues put forward by the proposal. Nevertheless, the SCMEE considered important that this deep sea habitat initiate steps towards more effective conservation procedures. The first step to undertake this task is to collect data and references that testify to the uniqueness and the high diversity of this particular ecosystem

vi. In 2007 a proposal to adopt the Cap de Creus canyon as a FRA was rejected by the SAC (Scientific Advisory Committee) because it was argued that the zone proposed lies inside Spain's Fishery Protection Zone, although it is outside the territorial waters. According to the report[3]:

   60. *The EC delegate noted that, aside the issue of procedure, scientific information on the deep sea corals aggregations for the above mentioned proposed FRA, could have been collected outside the concerned area and, that most of the area was already covered by the Recommendation GFCM/2005/1 prohibiting the use of towed nets and dredges beyond 1 000 metres.*

   61. *The Spanish Delegate further informed the Committee that his Government was about to present a joint proposal from the Ministry of Environment and the Ministry of Agriculture and Fisheries to the European Commission to protect the Cape of Creus canyon head and the surrounding area identified as "Spanish proposal for a Marine Protected Area off the Cape of Creus"*

vii. Greenpeace's (Greenpeace 2004) proposal for considering setting up marine reserves includes: the Alboran Sea, a number of seamounts in the western Mediterranean, the waters surrounding the Balearic Islands, the Gulf of Lions, the Algerian stretch, the Carthagian stretch, the Ligurian Sea, the Central Tyrrhenian Sea, the Strait of Messina, the Sicily Strait, the Maltese Slope, the Medina Ridge, the Gulf of Sirte, the Libyan Headland, the Upper Adriatic, the Pomo/Jabuca Trench, the Otranto Channel, the Hellenic Trench, the Olimpi mud field, the Saronikos Gulf, the Northern Sporades Islands, the Thracian Sea, the Limnos-Gökçeada area in the north-eastern Aegean, a stretch between Crete and Turkey, the Central Levantine Sea, the Anaximander Mountains, the Cyprus Channel, the Eratosthenes Seamount, the Phoenician coast, and the Nile Fan

viii. The tuna sanctuary in the southern Balearic Islands, proposed by WWF to the IUCN World Conservation Congress (Barcelona, 2008), was initially endorsed (WWF 2008)

ix. A proposal for 16 Zones of special interest for a cetacean conservation sanctuary (including both SCIs – Sites of Community Importance – and SPAMIs) along the Iberian Peninsula (Raga & Pantoja 2004).

1.5 Compatibilities and complementarities between different existing criteria for establishing MPAs in the open seas, including deep seas, as well as for fisheries management purposes

Criteria for choosing areas to be put on the SPAMI List are defined by the Protocol on Specially Protected Areas and Biological Diversity in the Mediterranean, including for areas that are partially or wholly located in zones outside national jurisdiction.

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[2] http://www.cmima.csic.es/pub/scmee/Subcommittee_2005/SCMEE_report_2005.pdf

[3] ftp://ftp.fao.org/docrep/fao/010/a1579b/a1579b00.pdf

RAC/SPA has further elaborated operational criteria for identifying potential SPAMIs in areas outside national jurisdiction, compatible with the Barcelona Convention Protocol (Annex 3). They follow the general principles established by the Protocol's Annex I for drawing up the SPAMI List. They also meet the general SPAMI features required by that Annex: basic criteria; regional value requirement; science/educational interest; other favourable characteristics and factors. They also take into account (i) other relevant ecological criteria like those elaborated within the CBD framework for identifying Ecologically or Biologically Significant Areas (EBSAs) in areas lying outside national jurisdiction (ABNJ) in need of protection, and (ii) a set of criteria for identifying habitats of particular importance for Mediterranean fisheries, taking into account in particular the new orientations promoted within the GFCM framework for setting up Fishery Restricted Areas, including in ABNJ. Legal implications and possible geopolitical issues that might constrain the establishing of SPAMIs in areas outside national jurisdiction were also considered.

1.6 Importance of establishing networks of SPAMIs embracing the Mediterranean high seas

Identifying high sea habitats is a priority for the EU Common Fisheries Policy for the Mediterranean, since in the Proposal for a Council Regulation concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea and amending Regulations (EC) No 2847/93 and (EC) No 973/2001, it states:

> *Exploitation of deeper fishing grounds calls for a more cautious approach, however, because of the low productivity of such biological systems, which makes deepwater fish more vulnerable to fishing, and the presence of important but not yet well identified habitats.*

Echoing the implementation plans adopted in 2002 by the world's nations at the World Summit on Sustainable Development (WSSD), the 2003 World Parks Congress in Durban recommended that "networks of MPAs should be extensive and include strictly protected areas that amount to at least 20-30% of each habitat." Currently, fully MPAs of all kinds, whether coastal and pelagic, cover less than one per cent of the Mediterranean Sea, far from the WPC recommendation. The situation is significantly worse concerning the Mediterranean high seas, where only the Pelagos Sanctuary for Mediterranean Marine Mammals and the GFCM-designated areas off-limits to bottom trawling enjoy formal protection (Abdulla 2004, Greenpeace 2004).

Specially Protected Areas of Mediterranean Importance (SPAMIs) are declared within the framework of the Barcelona Convention Protocol on Specially Protected Areas and Biological Diversity in the Mediterranean, and may be established in the high seas. RAC/SPA launched an initiative, in conjunction with the European Commission, to promote the establishing of a representative ecological network of MPAs in the Mediterranean, including high sea sites. The first phase of the initiative included a feasibility assessment to identify, on the basis of currently available information, Mediterranean Areas Beyond National Jurisdiction (ABNJ), which may qualify as SPAMIs.

However, first it was necessary to know what to protect and where these areas are located. Such information is necessary to help implement marine spatial planning strategies in support of integrated ecosystem-based management approaches, and provide expert advice on identifying ecologically and biologically significant areas and vulnerable marine ecosystems.

2 Vulnerable habitat/features in the Mediterranean open seas relevant to fisheries

Habitats vulnerable to fishing activities in the Mediterranean open seas will include those habitats that can be characterised using the definition of a SH/EFH. These include faunal assemblages and geological and oceanographic features which can be relevant for fisheries such as habitat-structuring fauna, complex geological features, or oceanographic features (upwellings that increase nutrients) that create suitable conditions for many marine organisms (including those of great commercial interest).

The conservation of fauna in the Mediterranean open seas can be important because of its commercial interest as target species and by-catch for fisheries (e.g. hake, mullet, angler-fish, tuna, cetaceans) (Politou *et al.* 2003, D'Onghia *et al.* 2004, Massutì *et al.* 2008); non-target organisms are also important in that they frequently determine the healthiness of an ecosystem (Dayton *et al.* 1995). Benthic invertebrates can act as habitat-structuring organisms that provide important habitats for many species, and that are generally highly vulnerable to many fishing practices (e.g. SH) (de Juan *et al.* 2009).

Bottom trawling takes place on soft bottoms (composed of fine mud/sand) from continental shelves and slope (Demestre 2006), although some geographical accidents might be of importance for fishing, maintaining a high biomass of commercially important species (i.g. canyons, trenches, etc.) (Company *et al.* 2008). These structures can be benthic hotspots within an otherwise homogeneous extension of soft sediment; this increases the diversity and resilience of deep sea ecosystems. Most of these habitats are vulnerable to fishing activities; it is necessary to know their location, extent and ecology to protect them from degradation.

Otherwise, pelagic species are largely influenced by oceanographic features that create good conditions for feeding, spawning or growth. Therefore, it is important to know the location of important oceanographic features for pelagic species, as well as their role as EFHs for these species, to allocate and demarcate those areas that need protection. Identifying EFHs for large pelagic species is undoubtedly a challenging task due to their highly migratory nature, both in terms of area and depth. As top predators, their role in pelagic ecosystems is highly important. As open sea pelagic species, tuna and tuna-like species cannot be associated with the typical features of fish habitats. Their habitats should be defined by oceanographic features, such as temperature range, salinity, oxygen levels, currents, fronts, shelf edges and specific food chain. Therefore, for defining relevant habitats for these species hotspots must be identified in relation to the main spawning grounds or juvenile concentration areas (Ardizzone 2006).

A detailed description of the most relevant SH/EFHs located in the Mediterranean open seas appears below (summarised in Table 2).

2.1 Faunal assemblages

2.1.1 Benthic fauna from continental shelves and slope

Most Mediterranean fisheries frequent the continental shelves and slopes, concentrating around highly productive areas, including areas considered as SHs, which are usually highly vulnerable to fishing activities (Ardizzone 2006). These SHs are of importance for the survival of many demersal species of commercial interest, as they increase the complexity of the habitat providing refuge and food source (Thrush & Dayton 2002). In the Mediterranean open seas we can define the following SHs:

i. *Funiculina quadrangularis*

On the shelf edge and the upper slope throughout the Mediterranean, the bathyal mud is often covered by the facies of the cnidarian *F. quadrangularis*. These sessile filter feeder organisms increase the three-dimensional complexity of soft bottoms, and can contain abundant populations of some commercial crustaceans such as *Parapenaeus longirostris* and *Nephrops norvegicus* (Bellan-Santini *et al.* 2002).

ii. *Leptometra phalangium*

Crinoidea beds composed by *L. phalangium* appear on the deep continental shelf and shelf-break in the western Mediterranean. This species is a suspension-feeder organism that inhabits high hydrodynamic areas with a high input of organic matter and plankton. The presence of *L. phalangium* enhances habitat heterogeneity by developing three-dimensional communities, allowing consistent species richness and high rates of primary and secondary productivity (Ardizzone 2006). Crinoidea beds host a well defined assemblage of demersal organisms characterised by a high abundance of spawners of commercially important species, e.g. red mullet *Mullus barbatus,* hake *Merluccius merluccius,* blue whiting *Micromesistius poutassou* and *Trisopterus minutus capelanus* (Bellan-Santini *et al.* 2002).

iii. *Isidella elongata*

On deeper grounds over the bathyal mud the gorgonian *I. elongata* appears*;* this species is generally found on compact mud substrates between 500 and 1,200 m down on the base of the continental slope and bathyal plain, though the slope of the bed must not be greater than 5% (Bellan-Santini *et al.* 2002). Some commercial fishes and decapods (e.g. *Merluccius merluccius*, *Micromesistius poutassou*, *Parapenaeus longirostris* and *Aristaeomorpha foliacea,* as well as the economically important red shrimp *Aristeus antennatus*) are found in abundance in these habitats. This highlights the importance of protecting areas with high concentrations of this species.

iv. Coralligenous facies

These facies can include sessile emergent suspension feeders such as bryozoans (between 30-100 m depth), gorgonians *Eunicella* sp. and *Paramuricea* sp. (10-90 m depth; *Eunicella* sp. can reach 150m), or sponges (Bellan-Santini *et al.* 2002, Ballesteros 2003, Micheli *et al.* 2004). All these communities create three-dimensional structures on the seabed, either by forming reef structures or as coral meadows, and increase secondary production, originating important habitats for demersal species.

Coralligenous buildups are common all around the Mediterranean coasts, with the possible exception of the coasts of Lebanon and Israel. According to Laborel (1961) the best developed formations are those found in the Aegean Sea, although the best studied banks are those of the northwestern Mediterranean.

<u>Coralligenous: maërl</u>

Coralligenous communities in the Mediterranean have been found from 20 m to 120 m down in coastal detritic bottoms. At the greatest depths the coralline red algae are dominant, growing in low light conditions where other algae cannot grow (Ballesteros 2003, Barbera *et al.* 2003). These facies represent an important SH, consisting of hard bottoms composed of red algae, which are structurally and functionally complex habitats that support a rich biodiversity and create important habitat structures, and many of these habitats can be considered as EFHs for demersal species of commercial interest (Ordines & Massuti 2008). Maërl facies can be associated with Phucophycea Laminarial species (between 30 and 100 m); *Laminaria* sp. also creates important three-dimensional structures (Ordines & Massuti 2008, Bellan-Santini *et al.* 2002).

2.1.2 Benthic fauna from the deep sea

Often considered a highly homogeneous extension with low diversity, the deep Mediterranean Sea contains areas that sustain high diversity and high endemism rates, and that could be characterised as benthic hotspots. The peak of abundance and biomass of deep sea fauna can be found around 1,000 m, and 1,500 m would correspond to a transition zone were the main faunal change has been observed (D'Onghia *et al.* 2004).

Deep seas are habitats of several species of commercial interest (Cartes *et al.* 2004b): red shrimps (mainly *Aristeus antennatus* but locally also *Aristeomorpha foliacea*), and Pandalid shrimps *Plesionika* sp. The red shrimp *A. antennatus* is of great economic importance and is present in the entire Mediterranean Sea (except the Adriatic and the Black Sea), distributed locally from 100-200 m to 3,300 m down (Sarda *et al.* 2004); however, the highest abundance is concentrated from 400 to 800 m, where the fishing takes place. The fish are very diverse at these depths, and the commercial species are mainly represented by *Merluccius merluccius* and *Phycis blennoides*, among others. Fish biomass strongly decreases from 200 m to 800 m; however, from 800 m to 1,800 m important fish biomasses are present again (Mytilineou *et al.* 2005a). Given the importance of deep sea areas for red shrimp juveniles and for the reproduction of many fish species, exploitation here would probably entail negative impacts on shallower ecosystems above and beyond the rapid depletion of particularly vulnerable deep sea megafauna communities.

Non-target deep sea invertebrates might be very important as habitat-structuring organisms, i.e. sessile emergent suspension feeders (Gili & Coma 1998). These habitats meet the characteristics of SHs, and many megafaunal species are more abundant around structures provided by the wider epibenthos, making patches of emergent and sessile fauna into “islands of biodiversity” within an otherwise relatively barren seabed (Koslow 2007). That includes higher biomass densities of some commercial fish species and, perhaps particularly, of juveniles of some species which may obtain shelter from predators by living among the structures provided.

The principal SHs in the Mediterranean open seas are:

i. Cold coral reefs

These facies appear below 200 m, generally within a narrow zone of steep rocky areas in the shelf break, canyons, as well as similar areas on ridges and seamounts, with strong currents and a steep slope preventing sedimentation (Bellan-Santini *et al.* 2002, Freiwald *et al.* 2004). Cold water corals are the most three-dimensionally complex habitats in the deep ocean, providing niches for many species (Roberts *et al.* 2006b). Mediterranean deep sea coral mounds are represented by colonies of the scleractinian *Lophelia pertusa* and *Madrepora oculatat.* The diversity of taxa associated with the *L. pertusa* reefs is around three times as high as that of the surrounding soft sediment seabed, indicating that these reefs create biodiversity hotspots and increased densities of associated species, representing a EFH for many species (Tursi *et al.* 2004, Taviani *et al.* 2005). These communities are poorly known in the Mediterranean, highlighting their conservation interest (Bellan-Santini *et al.* 2002).

ii. Deep sea sponges

Hexactinellidae sponges generally live at bathyal depths. Most sponge species produce only small and often encrusting growths which should be little affected by fishing. However, other species can grow to considerable size, with an erect form that exposes them to physical impacts (WWF/IUCN 2004). Some of the larger “vase” sponges have characteristics similar to the cold coral reefs, thus increasing diversity in the deep seas (Maldonado & Young 1998).

2.1.3 Chondrichthyans

The chondrichthyan fish fauna in the Mediterranean Sea is relatively diverse, with an estimated 80 species, including demersal and pelagic species (approximately 7% of total living chondrichthyans) (Compagno *et al.* 2001, Serena 2005a). The Mediterranean region is known to be an important habitat for chondrichthyans and is thought to provide unique breeding grounds for emblematic species such as the white shark *(Carcharodon carcharias)* and thornback ray *(Raja clavata)* (Abdulla 2004). Available evidence indicates that chondrichthyans in the Mediterranean are generally declining in abundance, diversity and range and possibly face a worse scenario than populations elsewhere in the world. This decline can be attributed to a number of factors, including their life history characteristics in combination with the semi-enclosed nature of the Mediterranean Sea and the intense fishing activity throughout its demersal and pelagic waters; effects of habitat loss; environmental degradation; and pollution (Stevens *et al.* 2000). Their biological traits (i.e. slow-growing, late maturity, low fecundity and productivity, long gestation periods) result in low reproductive potential and low capacity for population increase for many species; such characteristics limit their capacity to sustain fisheries and recover from decline (Camhi 1998, Burgess *et al.* 2005).

2.1.4 Large pelagic species

Of the large migratory fish, three species are characteristic in the Mediterranean: bluefin tuna (*Thunnus thynnus*), swordfish (*Xiphias gladius*) and albacore (*Thunnus alalunga*). Other species with no direct commercial interest, but that are vulnerable to fishing activities, are cetaceans and turtles (Ardizzone 2006, WWF 2006).

i. Bluefin tuna (*Thunnus thynnus)*

The most relevant species of conservation interest, bluefin tuna presents the widest geographical extension among the large pelagics, inhabiting the North Atlantic Ocean from Newfoundland to Brazil, and from Norway to the Mediterranean and Cape Blanc at 20º N latitude on the West African coast (Ravier & Fromentin 2001, Fromentin & Powers 2005). Adult bluefin tunas migrate to the Mediterranean for spawning; mature specimens are reported in most Mediterranean areas, the only exception being the Gulf of Lions and the northern Adriatic Sea. Spawning usually takes place from late May to July, with a peak from June to July. Larvae are found in most of the Mediterranean surface waters, with a major concentration in areas where gyres and fronts are present, particularly in the second part of the summer. Juvenile bluefin tunas are found mostly in coastal areas over the continental shelf, whenever a proper food chain is present (WWF 2006).

ii. Swordfish (*Xiphias gladius*)

The spawning activity of the Mediterranean swordfish appears strictly related to climate and oceanographic features. Observation at sea confirms that the presence of a surface layer of about 22°C or over is sometimes enough to induce spawning even for a short period. Usually spawning takes place from the second half of May to July, but in some years spawning was reported even in late April or up to the first week of September, due to climate influence; the peak is always from June to July. Swordfish larvae are found in most Mediterranean surface waters, moved by surface currents, particularly in the second part of summer. Swordfish juveniles are also found in most of the Mediterranean Sea, either close to the coast or off-shore, particularly from late August or the beginning of September to December (WWF 2006).

iii. Albacore (*Thunnus alalunga*)

Albacore spawning usually occurs in late summer, from the last part of June to the first part of September, with small yearly variations due to the influence of climate and oceanographic factors.

iv. Turtles

The loggerhead turtle (*Caretta caretta*), green turtle (*Chelonia mydas*) and leatherback turtle (*Dermochelys coriacea*) are the most common species of marine turtle in the Mediterranean, though only the former two are known to nest on Mediterranean beaches (Tudela 2004); these three species are endangered (UNEP/IUCN 1990). In the case of the loggerhead, an additional contingent of individuals of Atlantic origin is known to migrate into the western Mediterranean across the Gibraltar Strait during the first half of the year to nest (Camiñas 1997).

v. Cetaceans

About 17 different cetacean species have been reported in Mediterranean waters, some of them being only occasional visitors from the Atlantic (Duguy *et al.* 1983). They range in size from the small common (*Delphinus delphis*) and striped (*Stenella coeruleoalba*) dolphins to the large whales such as the sperm whale (*Physeter catodon*) and the fin whale (*Balaenoptera physalus*) (Tudela 2004). A specific Action Plan for the Conservation of Cetaceans in the Mediterranean Sea was adopted under the auspices of the Barcelona Convention in 1991 (Notarbartolo di Sciara 2002). ACCOBAMS, an agreement signed by most Mediterranean countries, was created as a tool for the conservation of cetaceans in the Mediterranean and Black Seas (www.accobams.org).

vi. Monk seals

Monachus monachus is a highly endangered species that needs to be protected from any fishing impact, i.e. accidental catches; populations in the Mediterranean have been minimised, the Greek and Turkish islands and the Western Sahara coast being their last refuge (Cebrian & Vlachoutsikou 1992, Borrell *et al.* 1997, Forcada 2000).

2.2 Geological features

The 1,000 m isobath defines two differentiated basins in the Mediterranean, western and eastern, separated by the Sicily channel. The western basin includes the Balearic, Alboran and Tyrrhenian Seas. The eastern basin includes the Ionian and Levantine Seas. Some relatively minor spots of depths below 1,000 m are the Chella, Pantelleria and Linosa troughs, in the Sicily channel, the south Adriatic basin and some smaller spots in the northern Aegean Sea. The eastern basin is deeper than the western. In the latter, only the central Tyrrhenian goes down further than 3,000 m, and no depths greater than 4,000 m exist. In the eastern basin almost half the Ionian Sea and some parts of the Levantine are below 3,000 m, with some spots below 4,000 m. The deepest point, known as the Calypso deep, is in the Ionian Sea and goes down to 5,267 m (Bas 2006).

Shelves, the best areas for trawl fishing, are generally narrow, the widest ones being located in the central Mediterranean, i.e. the north Adriatic, the east of Tunisia (including the Gulf of Gabès) and the south of Sicily. In the western Mediterranean only the Gulf of Lions and some parts of the Iberian Peninsula, zones around the Balearic Islands, the northern Tyrrhenian (around Elba Island) and some other small zones present relatively wide shelves. In the Aegean and Levantine Seas the shelves are very narrow.

The slope shows numerous trenches or canyons; the canyons in the Mediterranean are of major importance from the fishery point of view, in that they create productive areas (Demestre & Lleonart 1993, Cartes *et al.* 1994).

Below is a description of the most relevant geological features identified in the Mediterranean open seas:

i. Highly productive mud extensions: soft bottoms on the continental shelves and slopes

These habitats are composed of sediments with a variety of grain size: from gravel, biogenic detritus (e.g. shell fragments) or coarse sand, to fine sediment (i.e. silt and clay). Ecosystems composed of muddy-sand habitats have been neglected as being highly homogeneous extensions with low diversity and thus of no conservation need. However, many studies have shown that they can be highly complex, with infaunal structures and emergent biogenic formations that increase habitat structure, maintain complex trophic interactions, and harbor relatively high diversity (Ball *et al.* 2000, Hall 2001, Pearson 2001). From an anthropogenic perspective, soft bottoms are of paramount importance as habitats where most commercially exploited species live, like hake, red mullet, angler-fish, Norway lobster or sole that support economically important fisheries (Turner *et al.* 1999, Kaiser *et al.* 2002, de Juan *et al.* 2007).

Banks are undersea elevations rising from the continental shelf (composed of soft sediment) with summits less than 200 m below the surface (this definition can include the low seamounts that present a flat top). Many banks are local prominences on continental shelves. Similar elevations with tops more than 200 m below the surface are called oceanic plateaus; some banks provide favorable conditions for marine life and are therefore important fishing grounds, e.g. the Newfoundland Grand Banks (Stewart 2002).

ii. Canyons

Canyons are relatively narrow, deep furrows with steep slopes, cutting across the continental shelf and slope, with bottoms sloping continuously downward, that form part of the drainage system of the continental margins (Stewart 2002, Sarda *et al.* 2004). They play an important role in transporting terrigenous debris from the coastal waters to the deeper grounds, making the organic carbon content higher than in surrounding areas (Canals *et al.* 2006), and being important EFHs. Great accumulations of sediment and detritus have been observed on the floor of several such canyons (Gili *et al.* 1999). Otherwise, the canyons function as chimneys facilitating the rising of deep waters, and consequently nutrients, to the surface, which helps to create a special habitat characterized by a great density and diversity of benthic and pelagic fauna, exceeding that for other habitats along the continental shelf and slope (Gili *et al.* 2000, Jordi *et al.* 2005).

Characteristic benthic assemblages, endemic species and high macro and meiofaunal biomass have been found in canyons. Vertical displacement of fauna, even of commercial interest, such as *Aristeus antennatus* and *Aristeomorpha foliacea,* has been detected (Company *et al.* 2008). These habitats can act as an ecological refuge for many bathyal species. They are generally unsuitable for trawling and represent sheltered sites for species during sensitive phases of their life cycle or for species well adapted to unstable environments. These submarine features are viewed as hotspots of species diversity and endemism (Gili *et al.* 1999), likely to play an important role in structuring populations and life cycles of the planktonic fauna (Gili *et al.* 2000) and the benthic megafauna fishery resources dependent on them (Stefanescu *et al.* 1993, Cartes *et al.* 1994, Acosta *et al.* 2003).

iii. Seamounts

When submarine volcanoes do not rise above sea level they become these isolated undersea volcanic structures called seamounts: elevations rising from the sea floor and with a small summit area (Erickson 2003). Seamounts can be higher than 1,000 m above the surrounding seafloor, supporting unique and valuable habitats. They generally show high biodiversity and high rates of endemism, supporting biologically unique and valuable habitats (de Forges *et al.* 2000), and may act as refuges for relict populations or become centres of speciation (Galil & Zibrowius 1998). Seamounts influence the productivity of the waters above them, and the overlying waters can even become focal points for surface-dwelling species and sea birds.

iv. Hydrothermal vents

Hydrothermal vents expel hot water and other chemical compounds associated with submarine volcanic activity; they harbor communities of the strange organisms inhabiting the extreme conditions around the vents, and production is sustained by chemosynthetic bacteria. Hydrothermal vents have been described as deep sea oases as regards high primary production compared to the surrounding abyssal plain (Herring 2002, Erickson 2003). However, most of the known hydrothermal sites in the Mediterranean are in shallow coastal waters, less than 200 m depth, and no extant vent-specific fauna have been described in Mediterranean sites (Briand 2003). There is little diversity of fauna within the sediment at the vents; however, a high diversity of epifauna has been reported, and the vent sites are areas of settlement for exotic thermophilic species (Tunnicliffe *et al.* 1997, Dando *et al.* 1999, Morri *et al.* 1999).

v. Cold seeps

Seepage of cold fluids, enriched in sulfide, methane, hydrocarbons, as well as nutrients is common in both active and passive margins in the deep seas (generally associated with deep mud volcanoes). These are known to sustain exuberant deep sea, chemosynthesis-based communities, usually dominated by bacterial mats, bivalves (mussels and clams) and tube worms, both metazoans associated with endosymbiotic chemo-autotrophic bacteria (Sibuet & Olu 1998, Briand 2003, Tunnicliffe *et al.* 2003). Circulating fluids percolate through the seafloor, precipitating calcium carbonate, releasing gas and supporting benthic organisms (Coleman & Ballard 2001). Analysis of cold seeps has revealed that they comprise hard deposits of calcium carbonate and that there are benthic organisms surrounding these structures (similar to those surrounding hydrothermal vents, clams and polychaetes) that are probably chemosymbiotic.

vi. Mud volcanoes

Mud volcanoes are geological structures where mud and fluid seep through the seafloor. Mud volcanoes are composed of mounds of remobilized sediment formed in association with cold seeps (Dimitrov 2003); large quantities of methane are commonly released from their surfaces, with bacteria producing chemoautotrophy and many endemic accompanying species. Mud volcanoes usually develop above rising blobs of salt or near ocean trenches (Coleman & Ballard 2001, Erickson 2003). The discovery of bivalve thanatocenoses in samples cored on the Napoli mud volcano at 1,900 m depth in the eastern Mediterranean Sea, with dead shells attributed to *Myrtea* sp. (Lucinidae) and *Vesicomya* sp. (Vesicomyidae), demonstrated dense living chemosynthesis-based communities (Briand 2003). The community appears as mainly composed of bivalves belonging to four families (Lucinidae, Vesicomyidae, Mytilidae and Thyasiridae) and pogonophorans (Annelida Siboglinidae) including a big vestimentiferan worm.

vii. Brine pools (hypersaline basins)

Brine pools, or hypersaline anoxic basins, are extreme habitats, associated with tectonically active zones in the deep sea (Briand 2003). The deep hypersaline anoxic basins of the eastern Mediterranean Sea are unique environments created by the flooding of ancient evaporites from the Miocene period, located at great depths (more than 3,300 m). In these environments salinity increases sharply with depth, whereas the concentration of dissolved oxygen drops rapidly to zero. The sharp density difference between brines and the upper normal deep seawater acts as a barrier to oxygen exchange between water and brine. Several reports indicate that the seawater-brine interface is a very stable physical configuration (Henneke *et al.* 1997), and a great diversity of microorganisms has been detected along the seawater-brine gradient compared to other anoxic marine hypersaline lakes that have been more largely studied (Eder *et al.* 2002), showing a highly complex structure and a very great abundance of newly described prokaryotic taxonomic groups, particularly in the interface.

viii. Abyssal plains

Deep sea organisms located in the abyssal plains are highly vulnerable fauna due to their life history characteristics (slow growth and slow metabolic rate) and the fact that these fauna are not influenced by high natural disturbance events. In spite of the small size of the Mediterranean basin, it contains a large surface area that is deeper than 1,000 m; the Levantine Sea holds the deepest parts of the Mediterranean, and its being isolated from the Atlantic deep seas by bathymetric barriers makes its deep sea fauna unique (Galil 2004). This area is of high conservation interest as an area encompassing numerous habitats described as SHs (i.e. seamounts, cold seeps, brine pools). These areas, although not directly affected by bottom fishing (due to the 1,000m ban), can be indirectly affected by anthropogenic activities like pelagic fishing that cause accumulation of debris and waste in these otherwise undisturbed habitats (Laist 1987, Katsanevakis *et al.* 2007).

2.3 Oceanographic features

The Mediterranean basin is dominated by an inverse estuarine circulation, which is fed by an inflow of surface water from the Atlantic. As it spreads throughout the whole basin this water becomes heavier because of excessive evaporation and the cooling effect which is a feature of the Mediterranean. Some of the inflow then flows back into the Atlantic as intermediate water, while the rest is transformed into deep water in the eastern and the western Mediterranean (Astraldi *et al.* 1999).

The Atlantic current through the Mediterranean determines most of the oceanographic characteristics of the basin, important for the productivity of habitats; the Atlantic current enters through the Gibraltar Strait and makes two anticyclonic gyres in the Alboran Sea. Then it continues parallel to the Algerian coast; a branch of this current goes northwards and another enters the Tyrrhenian basin and comes out via the Corsica channel giving rise to the Ligurian-Provencal current, with a strong cyclonic gyre present in the Ligurian Sea. The Gulf of Lions presents powerful general circulation along the continental slope, the formation of dense water both on the shelf and off-shore, seasonal variation of stratification and the extreme energies associated with such meteorological conditions (Millot 1990). The Ligurian-Provencal current continues through the Catalan Sea, reaches the Alboran Sea and proceeds to the Atlantic through the lower part of the Strait of Gibraltar (Send *et al.* 1999).

The Atlantic current in the eastern basin is very weak and becomes progressively thinner; a branch to the north describes a gyre in the centre of the Ionian Sea, and a branch of it enters the Adriatic Sea and returns to the Ionian Sea after a few gyres in the Adriatic. In the Levantine basin the Atlantic current runs between numerous existing gyres, reaching the Syrian coast, where it splits, with one branch moving to the Turkish coast and other to Lebanon. The gyres in the central-eastern Levantine basin are stable and permanent (Manca *et al.* 2004, Millot 2005, Bas 2006).

There are other secondary physical processes of importance (most derived from the Atlantic current) that determine high productive areas important for holding high biomass of many species:

i. Cascades

Cascades along continental slopes are important for deep seas as providers of nutrients, as evidenced in Company *et al.* (2008): the formation of dense shelf waters and their subsequent downslope cascade, a climate-induced phenomenon, affects the population of the deep sea shrimp *Aristeus antennatus*. Strong currents associated with intense cascading events correlate with the disappearance of this species from its fishing grounds, producing a temporary fishery collapse. Despite this initial negative effect, landings increase between 3 and 5 years after these major events, preceded by an increase of juveniles. The transporting of particulate organic matter associated with cascading appears to enhance the recruitment of this deep sea living resource, apparently mitigating the general trend of overexploitation. Because cascading of dense water from continental shelves is a global phenomenon, its influence on deep sea ecosystems and fisheries worldwide could be greater than previously thought.

ii. Upwellings

Upwelled water from the bottom provides colder water than water normally found on the surface, and is richer in nutrients. The nutrients fertilize phytoplankton in the mixed layer, which are eaten by predators following the trophic chain to larger predators (e.g. tuna). As a result, upwellings are productive waters that support the world's major fisheries (Stewart 2002).

Important upwellings can be detected in the Alboran Sea, in the Gulf of Lions, and the Sicily Strait.

iii. Fronts

If the sharp interface between two water masses reaches the surface, it becomes an oceanic front, which has properties that are very similar to atmospheric fronts (Stewart 2002). For example, the current descending the Catalan coast and that from the Balearic basin generate slope saline fronts, a highly productive separation between shelf and slope that enriches the central Catalan Sea, with important vertical migrators (and small pelagics) (Bas 2006). These are also important as areas of current convergence, of great productivity and consequently the presence of large pelagics and cetaceans. Another important front in the Mediterranean is generated by the current that runs from Spain to Algeria, the Almerian-Oran front (Tintore *et al.* 1988, Millot 1999).

iv. Eddies

Mesoscale eddies are turbulent or spinning flows on scales of a few hundred kilometers; they mix fluids in the horizontal layer increasing productivity (Stewart 2002). The important eddies and fronts detected in the Mediterranean are in the Alboran Sea, in the Algerian basin, in the central Tyrrhenian Sea, the south Ionian Sea and the central Levantine basin (Millot 1999).

v. Gyres

Gyres are wind-driven cyclonic or anticyclonic currents of almost ocean basin size (Stewart 2002). The gyre enriches the area's superficial waters and produces a major concentration of large migrators such as tunas and swordfish, plus, frequently, cetaceans; cyclonic gyres create productive processes. Many gyres are created through the Mediterranean basin by the Atlantic current; in the Alboran Sea there is a quasi-permanent anticyclonic gyre in the west and a more variable circuit in the east (Millot 1999).

3 Identification of vulnerable ecosystems in the Mediterranean open seas

The information available on Mediterranean ecosystems in the open seas, including the deep sea, is very partial and fragmentary; much of the information is recorded as unofficial literature. Moreover, traditionally, scientific studies have been done in the western basin, creating an important bias in the available information. This report focuses on those habitats considered as "emblematic" in the Mediterranean open seas for which there is information available in scientific publications (Table 3 and 4).

3.1 Sensitive Habitats

The protection of SHs that are hotspots of diversity is necessary for indirectly protecting species of commercial interest following the directives of an EAF, such as:

3.1.1 Coralligenous facies: maërl

These habitats have been detected on continental shelves mostly in the western Mediterranean basin; however, this might reflect the fact that most of the available data comes from studies done in the western basin. The coralligenous facies in the eastern Mediterranean are poorly known, which may be related to the greater depth at which the coralligenous develops in this area (not reachable by scuba diving). The main distribution of the coralligenous is well known on a wide scale: it is common all around the Mediterranean coasts, with the possible exception of Lebanon and Israel; however, these assemblages rarely exceed 120 m depth, and few of them are located in the high seas (Ballesteros 2003).

3.1.2 *Leptometra phalangium* beds

Several areas have been detected in the Mediterranean open seas with concentrations of *L. phalangium* (Bellan-Santini *et al.* 2002):

i. Along the Iberian Peninsula coasts, most Leptometra beds have been found along the shelf edge of the Ebro Delta–Castelló region, with a permanent Liguro-Provençal current that favours the presence of this facies, in the shelf break that occurs at depths of around 150 m
ii. In the northern Ligurian Sea the shelf break off La Spezia, Portofino and Savona is colonized by high density *L. phalangium* beds.

3.1.3 Cold coral reefs

Areas with considerable deep sea coral in the Mediterranean open seas have been detected on continental slopes in several locations, mostly in the western basin. The higher concentrations of deep sea corals detected in the western Mediterranean might reflect the historically more intensive research done in this area (Ballesteros 2003, UNEP-MAP-RAC/SPA 2003a, Greenpeace 2004).

i. Living and dead colonies of *Lophelia pertusa* and *Madrepora oculata* are widespread within an area of about 900 km^2 south of Cape Santa Maria di Leuca, between 200 and 1,100 m deep on a gently dipping shelf and characterized by complex seabed topography (Taviani *et al.* 2005). These coral banks represent a unique example of living deep sea coral mounds in the Mediterranean basin, highlighting the importance of their protection. They have been protected by GFCM since 2006
ii. In 2003, Maltese scientists discovered a second living, healthy deep water coral bank, with *Lophelia* and *Madrepora*, at a depth of 390-617 m, some 20-40 km off the southern coast of Malta. This may also be a large reef, making this the second such bank known to date in the Mediterranean
iii. In the Algerian strech
iv. In the Ligurian Sea and western side of Corsica
v. In the Otranto Channel
vi. In the Alboran Sea on the walls of submarine canyons

vii. In the Gulf of Lions and in its submarine canyons
viii. In the Tyrrhenian Sea
ix. In the Strait of Sicily.

3.1.4 *Isidella elongata* beds

Facies of *I. elongata* have been identified in several areas of the western Mediterranean (Bellan-Santini *et al.* 2002):

i. Areas of high density of *Isidella elongata* have been reported on the continental slope off N and S Eivissa Island, and on the continental slope off the Ebro Delta
ii. In Italy, the most important areas are located in front of the main capes (Civitavecchia, Tor Vaianica, Anzio) where the bottom is steeper; in the northern Tyrrhenian Sea (south Tuscany) they occur around the Giglio Island and between the Elba and Montecristo islands; in the southern Ligurian Sea (north Tuscany) they are mainly present north of the Island of Elba; hotspot areas are found on the western side of Capraia Island and off the Livorno coasts.

3.1.5 *Funiculina quadrangularis* beds

F. quadrangularis facies have almost completely disappeared from the trawlable bottoms of most Mediterranean areas, with the exception of a few known areas (e.g. Malta bottoms) (Sarda *et al.* 2004).

3.1.6 Abyssal plains

The deepest grounds occur in the eastern Mediterranean basin: the Cretan Sea (1,500-3,850 m) and Rhodos Basin (2,300-3,850 m), where species of vulnerable (*Hexanchus griseus, Centrophorus* spp., and *Centroscymnus coelolepis*,) and non-vulnerable (*Galeus melastomus* and *Etmopterus spinax*) sharks have been recorded, together with the teleost fishes *Chalinura mediterranea* and *Lepidion lepidion* (Briand 2003). These habitats also harbour other highly vulnerable fauna, such as deep sea gorgonians, vase sponges, etc., which create important nutrient fluxes (Gili & Coma 1998).

i. The area surrounding the Calypso depth, the deepest part of the Mediterranean (5,267 m depth, south-west of the Peloponnese in Greece), contains numerous cold seeps (WWF/IUCN 2004)
ii. The south-eastern Levantine Sea (Galil 2004)
iii. The Tyrrhenian bathyal plain; it is spotted by seamounts that rise from the bathyal plain (Sarda *et al.* 2004)
iv. The Alboran abyssal plain
v. The vast area known as the Algerian-Balearic Basin, bounded by the 2,600 m isobath (Acosta *et al.* 2001)
vi. The Ionian abyssal plain, divided by Medina plain (4,100 m), Sirte plain (3,800 m) and the Herodotus trough that is a narrow depression (3,000-3,500 m)
vii. The Herodotus abyssal plain, directly adjacent to the Eratosthenes Seamount, is a deep (approximately 2,800-3,000 m) depression
viii. The Hellenic trough, 3,000 m.

3.1.7 Seamounts

Several seamounts of different sizes and heights are known in both the western and the eastern basin of the Mediterranean (WWF/IUCN 2004, Ardizzone 2006). The Mediterranean Sea harbours some impressive seamounts, whose biodiversity values are still poorly known, in the Alboran Sea, in the eastern Tyrrhenian Basin, to the south of the Ionian abyssal plain and in the Levantine seas.

i. In the Cyprus basin, off the south coast of Cyprus and west of Israel, lies the massive Eratosthenes Seamount, extending from the seafloor to 800 m of sea surface (Varnavas *et al.* 1988, Galil & Zibrowius 1998, Ballesteros 2003, Galil 2004). This area has been under protection (towed gear forbidden) as a FRA (fishery restricted area) by the GFCM since 2006
ii. The south Tyrrhenian harbours a high density of seamounts (including hydrothermal vents and cold seeps) (Dando *et al.* 1999). One example is the Marsili Seamount in the Tyrrhenian Basin at ~450-500 m depth
iii. South of the Eivissa and Formentera Islands, on the slope, is the Mont dels Oliva and Mont Ausias March and Emili Baudot Seamounts. South of Menorca Island are two other seamounts: Mont Colom and Mont Jaume I (Acosta *et al.* 2001). In the Valencia trough (a 150 m depression separating the continental margin from the Balearic Island platform), there is a string of buried and partially buried seamounts (Barone & Ryan 1987)
iv. In the Alboran Sea, there are numerous seamounts rising between 400 m and 1,800 m above the adjacent bathyal plain with a maximum slope of 1,800 m between the top and the base of the southernmost seamount (WWF/IUCN 2004)
v. In the Medina Ridge (Malta), there are several seamounts, including the Epicharmos and Archimedes Seamounts
vi. Off the coast of Lybia, there is the Herodotus Seamount.

3.1.8 Cold seeps

Several cold seep communities have been located and described in the open seas of the eastern Mediterranean Sea:

i. South of Crete and Turkey (in the Olimpi field and Anaximander mountains, respectively), on mud volcanoes or along faults associated with a high flux of methane (Camerlenghi *et al.* 1992, Charlou *et al.* 2003) and observed from 1,700 to 2,000 m (Olu-Le Roy *et al.* 2004)
ii. Hydrothermalism has been observed on the peak of Marsili Seamount in the Tyrrhenian Basin at ~450-500 m depth (Uchupi & Ballard 1989), with some evidence of chemosynthetically-based communities associated with cold hydrocarbon seeps
iii. Shells belonging to families that typically harbour chemoautotrophic symbionts and are found in cold seeps elsewhere were collected from the top of the Napoli Dome on the Mediterranean Ridge at depths of ~1,900 m (Corselli & Basso 1996)
iv. Cold seeps in the south-eastern Mediterranean near Egypt and the Gaza Strip at depths of 500-800 m (Coleman & Ballard 2001), Nile Cold Seep. The area has been under protection (towed gear forbidden) as a FRA (Fishery Restricted Area) by the GFCM since 2006.

3.1.9 Mud volcanoes

Mud volcanoes and fluid seeps have been found in a number of different environments in the eastern Mediterranean Sea. Most have been found on the Hellenic Arc (the Mediterranean Ridge) and within the Anaximander Mountains (Woodside *et al.* 1998), but they have also been found from Sicily (Holland *et al.* 2006) to the Nile Deep Sea Fan (Mascle *et al.* 2006).

i. South of Crete along the Mediteranean Ridge at about 2,000 m depth (Olimpi mud field) and south of Turkey between 1,700 and 2,000 m depth (Anaximander mud field), high methane concentrations have been measured (Corselli & Basso 1996), allowing the Amsterdam (at 2,032 m depth) and the Kazan (at 1,707 m depth) mud volcanoes to be detected (Zitter *et al.* 2003)
ii. North of Egypt near the Nile Delta, near Egypt and the Gaza Strip, mud volcanoes have been detected at depths of 500-800 m, probably related to the cold seeps also described in this area (Coleman & Ballard 2001, WWF/IUCN 2004).
iii.

3.1.10 Brine pools

Recently, five hypersaline basins were discovered in the eastern Mediterranean Sea, all below a depth of 3000 m: the Bannock, Urania, Discovery, Atalante and Tyro basins (Lampadariou *et al.* 2003, WWF/IUCN 2004); the Urania basin presents the highest concentration of sulphide in the earth's aquatic environments. These unique environments have been isolated from the global ocean for millions of years, and represent unique deep sea environments.

3.1.11 Hydrothermal vents

Known hydrothermal vents occur in shallow waters (< 100 m), associated with volcanic arcs such as the Hellenic Volcanic Arc (Dando *et al.* 1999, WWF/IUCN 2004).

i. In Italy: the Tyrrhenian basin and around the islands (Stromboli, etc.) down to Sicily; mostly between Cape Palinuro and Sicily, associated with several seamounts, Palinuro, Poseidone, Marsili, Glauco, Eolio (Dando *et al.* 1999)
ii. In the Aegean: along the volcanic arc at Euboea, around the islands
iii. Also along the Turkish coast.

3.2 Essential Fish Habitats

In the Mediterranean open seas, EFHs correspond to areas that are important for the survival of species of commercial interest associated with the seabed, for demersal species, or pelagic species associated with oceanographic features.

3.2.1 Demersal species

EFHs for demersal species can either correspond to habitats previously described as SHs because of their vulnerability, such as coralligenous biocenoses, crinoidea beds, and deep sea corals, or to highly productive muddy areas. The most relevant demersal species from a fisheries point of view are the hake *Merluccius merluccius*, the shrimps *Aristeus antennatus, Aristaeomorpha foliacea, Parapenaeus longirostris* and *Plesionika* sp., and the Norway lobster *Nephrops norvegicus* (Cau *et al.* 2002, Dimech *et al.* 2008); in the present report these species are the reference species for identifying important EFHs in the deep seas. Protecting important EFHs based on the occurrence of hake and shrimp (as key species) will allow other demersal species and assemblages to enjoy protection.

Hake *M. merluccius* EFHs are generally on soft bottoms, overlapping with Norway lobster *N. norvegicus* habitats. The shrimp *A. antennatus*, *A. foliacea*, *P. Longirotris* and *Plesionika* sp. are mainly targeted in submarine canyons where the highest densities are found; other areas with an abundance of shrimp might overlap with EFHs defined for hake.

3.2.1.1 Hake nursery areas

i. In the Strait of Sicily the general spatial pattern showed that hake occurs at any life stage in two distinct geographical areas, the Adventure and Malta Banks. Two nursery areas were identified on the eastern sides of the Adventure Bank and the Malta Bank respectively, at depths ranging mainly between 100 and 200 m, whereas the highest abundance of juveniles was detected in shallower bottoms on both the Adventure and the Malta Banks; mature females were mainly found in two areas sited upstream and west of the nurseries on both Banks (Fiorentino *et al.* 2003)
ii. The Castellon-Valencia shelf and the Ebro and Rhone deltaic areas are important areas for hake, among other demersal species, since these areas are composed of productive muddy bottoms with influences from rivers (Palomera *et al.* 2007)
iii. The Jabuka Pit (Fossa di Pomo) area is a depression located in the central Adriatic with a maximum depth of 256 m, and is a critical nursery area for hake (Froglia & Gramitto

1995a, Froglia & Gramitto 1995b). Its special characteristics make it the most important fishing ground for trawling fleets targeting hake and Norway lobster in the Adriatic, and important for purse seining pelagic fisheries (Tudela 2003)

iv. High densities of hake juveniles have been shown between 100 and 200 m in the Otranto Channel, on the western side of the Taranto Gulf and along the Calabrian coasts. Shrimps in the Otranto Channel and Taranto Gulf generally overlap with hake

v. The Samothraki Plateau and Strymonikos Gulf, around 180 m depth, are important nursery areas for hake (Kallianiotis *et al.* 2004).

3.2.1.2 Hake and shrimp spawing areas

A refugium of spawners of hake and blue and red shrimp (*A. antennatus* and *A. foliacea*) (among other important commercial species like monkfish, blue whiting and Norway lobster) has been recently detected in the eastern part of the slope of the Gulf of Lions by means of trawl surveys (Massuti *et al.* 2008) confirming indirect evidence of the presence of a stock of spawners through VPA (Virtual Population Analysis). In order to protect this spawning ground it was declared a FRA (Fishery Restricted Area) by the GFCM (Recommendation GFCM/33/2009/1).

3.2.1.3 Shrimp nursery areas

The main species of commercial interest is *A. antennatus*; the other deep sea shrimp of high commercial value (*A. foliacea*) occurs in similar fishing grounds; thus all the species will benefit from similar protection. *A. antennatus* is exploited throughout the entire Mediterranean basin at deep water depths between 200 and 1,000 m, depending on the location. The general trend shows a situation where stocks are not yet overexploited, but have a tendency to under-optimum exploitation (because of the high turnover rate and the fact that much of the stock is distributed through bathyal depths that are not accessible to fleets (Demestre & Lleonart 1993, Sardá & Maiorano 2008). Mature females are generally caught on the upper slope (400-700 m), and nursery and recruitment grounds might be located below 1,000 m (Sarda 1998). If fishermen start to exploit the grounds below 1,000 m, this species may rapidly present symptoms of overexploitation due to juveniles being captured.

Several submarine canyons cross the continental slope of the western and central Mediterranean (Reyss 1971). Submarine canyons are an important geomorphological feature of the western basin and are of great importance for shrimp fisheries (Company *et al.* 2008). Amongst all the canyons in the Mediterranean basin several areas are highlighted:

i. The slope from the Ionian Sea presents several submarine canyons (D'Onghia *et al.* 1998), and the north-western Ionian is geomorphologically divided by the Taranto Valley, an impressive NW-SE canyon exceeding 2,200 m

ii. Some submarine canyons are located along the Calabrian and Sicilian coasts. At some periods of the year, deep water red shrimps can be caught together with coastal species on the continental shelf at the top of the Roccella Ionica and Caulonia canyons

iii. An intricate network of submarine canyons starting at around 130 m characterizes the Gulf of Lions (e.g. Cap de Creus canyon, Lacaze-Duthiers canyon). Most shelf water is funneled towards the narrowing canyon, greatly enriching these areas and sustaining important shrimp fisheries (Sarda *et al.* 2004, Canals *et al.* 2006)

iv. North of the Mallorca and Menorca islands, the continental slope is steep and we find several canyons (Menorca and Cabrera canyons) (Acosta *et al.* 2003).

Moreover, the Pomo/Jabuka Pit is an important habitat for *Parapeaneus longirostris* and *Nephrops norvegicus* (Adriamed website[4], Vrgoč *et al.* 2004).

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[4] http://www.faoadriamed.org/html/Species/ParapenaeusLongirostris.html

3.2.2 Pelagic species

The most important large pelagic species for Mediterranean high seas fisheries are: bluefin tuna (*Thunnus thynnus*), swordfish (*Xiphias gladius*), albacore (*Thunnus alalunga*). Pelagic species of conservation interest are cetaceans and turtles that can be affected by fishing (by-catch or incidental catch, Greenpeace 2004), and would benefit from fishery restrictions imposed for the large pelagic fisheries. Pelagic sharks are important in both approaches, as fishing targets or commercial by-catch (*Lamna nassus*, *Isurus oxyrhynchus* and *Prionace glauca*) or as endangered species (*Cetorhinus maximus*) (Serena 2005b).

3.2.2.1 Bluefin tuna

i. The most relevant spawning areas are located SW of the Balearic Sea. The Balearic region is considered a transitional zone between the Mediterranean and Atlantic waters. In summer, coinciding with the Atlantic bluefin tuna's spawning peak, surface waters of recent Atlantic origin reach the Balearic Islands; the interaction between both water masses, as well as their interaction with the island topography, results in a complex hydrodynamic situation characterized by strong geostrophic circulation and intense frontal systems, increasing productivity (López-Jurado *et al.* 1995, García *et al.* 2003)
ii. The Alboran Sea has good oceanographic conditions for bluefin tuna (two anticyclonic gyres and the Atlantic current) (Bas 2006); moreover, in the Alboran Sea, the Almeria-Oran front creates high productivity. This area is an important migration route for bluefin tuna
iii. The Algerian basin presents numerous channels on the slope that favour an important biomass of exploitable species. The Atlantic current on the surface generates nutrient-rich waters favouring the presence of large pelagic species, including bluefin tuna (Bas 2006)
iv. In the southern Tyrrhenian to western Sicily, the presence of a large anticyclonic gyre coincides with the spawning ground of this species (Bas 2006)
v. In the Ionian basin, fishing is favoured by two wide areas, first the area between the south of Sicily, Malta and the large slope after the Strait of Sicily (highlighting the importance of the Strait of Sicily); the other area comprises the wide Gulf of Gabes shelf between the eastern Tunisian coast and the western part of Libya. Large migratory species provide an important fishery in this area. The important anticyclonic gyre in the Taranto Gulf coincides with albacore, bluefin tuna and swordfish fishing (Bas 2006).

3.2.2.2 Swordfish

It is supposed that swordfish spawn in most of the Mediterranean Sea and mature specimens have been reported more or less everywhere in late spring and summer, but the major spawning activity seems to take place in the area around the Alboran Sea, the Balearic Islands, close to the south-western part of Sardinia, in the central and southern Tyrrhenian Sea, in the Strait of Messina and in the surrounding western Ionian Sea, in the Strait of Sicily and in the central Mediterranean between Malta and the Pelagie Islands, in the southern Adriatic Sea, in the eastern Ionian Sea, in the Aegean Sea and around the islands of Crete and Cyprus (Tserpes *et al.* 2001, Bas 2006).

3.2.2.3 Albacore

Few spawning areas are known so far: the south-eastern Tyrrhenian Sea, the Strait of Messina, the Ionian Sea, the southern Adriatic Sea and the Balearic area (Arrizabalaga *et al.* 2002, de la Serna *et al.* 2003, Ardizzone 2006).

4 Fisheries in the Mediterranean open seas

In a worldwide context the deep seas are considered (among other definitions) as the marine environment that extends downwards from the continental shelf break, i.e. waters deeper than 200 m to a maximum depth. Deep sea fisheries currently only operate at depths of less than 1,000 m in the Mediterranean, but this might exploit many SHs; i.e. seamount fisheries could be exhausted in as little as three to four years (Johnston & Santillo 2004). The potential fishing interest of the currently unexploited bottoms below 1,000 m (towed gear banned by GFCM, 2005) is very limited. This is so because the overall abundance of crustacean species is considerably lower, and fish communities are largely dominated by fish either not of commercial interest (like the smooth head *Alepocephalus rostratus*) or rather small (such as the Mediterranean grenadier *Coryphenoides guentheri*). If these species ever became of economic interest and if trawlers were able to reach the deeper areas, then the ecosystem could be rapidly deteriorated by fishing.

Pelagic fishing in the Mediterranean open seas, targeting large pelagic species (exceptionally targeting small pelagics, e.g. anchovy and sardine, in the Adriatic Sea), is the only form of industrial fishing; it takes place mainly in international waters (high seas) and even non-Mediterranean countries can be involved (Cacaud 2005a).

Most information on the activity of fishing fleets in the Mediterranean comes from the working group STECF and the GFCM Demersal Working Group, of the Subcommittee on Stock Assessment, and ICCAT for large pelagics, which relates the activity of fleets of member countries. Therefore, there is a lack of reported information on the fishing activity of non-EU member countries (e.g. North Africa) in STECF, although GFCM task 1, and the cooperation projects (Medfisis, COPEMED II, ADRIAMED and EASTMED), are working in this direction.

4.1 Demersal fisheries

Demersal fisheries in the Mediterranean are mostly concentrated on the continental shelf, down to 200 m. The continental shelves are narrow (thus 200 m is relatively close to the coast) and only a few areas like the Gulf of Lions, the Adriatic Sea and the Gulf of Gabes have wider shelves (CIHEAM 2008). Although traditionally most oceanic fisheries have concentrated in the upper regions of the oceans, there is now a pronounced shift of fisheries from the shallow to the much deeper regions (Merrett & Haedrich 1997, Clark 2001), motivated by the growing number of collapsed fish stocks on the continental shelves, and, in the Mediterranean, by the high value of deep sea aristeid shrimps (WWF/IUCN 2004). Deep sea fishing in the western Mediterranean has become relatively important since the 1940-50's, due to the high commercial value of deep sea shrimps (mainly *Aristeus antennatus* and *Aristaeomorpha foliacea*) (approx. 400 m to 800 m), as well as hake (*Merluccius merluccius*) that is harvested by trawlers and bottom longliners. Other important exploited crustaceans in deep seas are the Norwegian shrimp (*Nephrops norvegicus*), *Plesionika* sp. (Sarda 1998) and *Parapenaeus longirostris* that however will benefit from protection measures adopted for hake and red shrimp. Fishing grounds that lie outside coastal state jurisdictions present regulation problems that should be addressed by the Regional Fisheries Bodies or international organizations.

An impressive number of gear are used in the Mediterranean for demersal fishing. Each one has a number of local variants, even inside each country. Most of them are only used for artisanal or coastal fishing, or their use in open seas or deep fishing is incidental.

Demersal fisheries operating in the Mediterranean open seas are:

- Bottom trawling (for shrimp and hake)
- Bottom longline (for hake)
- Gillnet (targeting hake).

It should be taken into account that, although hake and shrimp are usually the main target species, these fishing gear catch other commercial species.

4.1.1 Bottom trawling

In many countries of the Mediterranean the trawl fleet is modern, well equipped, and able to fish not only on the continental shelves but also on the slope down to approx. 800 m. Usually the engine power is excessive, not only in relation to national regulations (power can exceed 4 times the legal value) but also disproportionate for a reasonable fishing effort. These over-sized vessels are economically sustainable only because of fuel subsidies (tax exemption).

As has been said, the continental shelf is narrow in many places but several important areas with large trawlable grounds exist in the NW Mediterranean (around the Balearic Islands, the Gulf of Lions and the shelf in the area of Valencia), in the North Adriatic, the south of Sicily and the east of Tunisia.

Main target species of bottom trawl in the open seas are hake (*Merluccius merluccius*) and crustaceans (*Aristeus antennatus*, *Aristeomorpha foliaciea*, *Parapenaeus longirostris* and *Nephrops norvegicus*).

Hake. According to FAO FishStat, hake (*Merluccius merluccius*) is one of the main demersal species in the Mediterranean, coming only after the bogue (*Boops boops*) and before the striped Venus clam (*Chamelea gallina*), with a reported annual catch of around 30,000 metric tonnes. Its economic value is high and it constitutes a main target species for the whole Mediterranean. Its distribution is wide (30 to 1,000 m, according to Lloris *et al.* (2005), although usually its lower limit is 400 m) and much of the catch is obtained in deep water (i.e. submarine canyons) and in international water. It is caught using trawl, longline and gillnets.

Shrimp. Aristeidae deep shrimps are a characteristic component of the demersal muddy bottom community on the middle slope, at depths between 400 and 800 m (Cartes & Sarda 1993). The distribution of this species is nonetheless considerably broader, reaching depths of at least 3,300 m (Sarda *et al.* 2004). Towards the end of summer the shrimp shoals tend to break up and move inside submarine canyons, with the shrimp being fished at shallower depths along the margins of the canyons. *A. antennatus* is highly exploited in the western Mediterranean by bottom trawlers fishing on the continental slope down to 800m (along with *A. foliacea*); according to GFCM assessment these species are overexploited and the effort should be reduced (CIHEAM 2008). The nursery grounds of deep water pink shrimp (*Parapenaeus longirostris*) are not so well defined as for hake (outside the submarine canyons). However, it is clear that nurseries of the two species overlap. Any new measure concerning closed areas to protect hake juveniles would also serve to protect juvenile shrimps.

The following fisheries have been described:

i. The trawl fishery in the Gulf of Lions, operated by French and Spanish fleets targeting hake. Both trawls, Spanish and French, catch mainly immature hake. The French fleet exploits the edge and slope of the continental shelf and the canyons off their coasts, from 50 to 200 m (STECF 2004). The trawl fishery overlaps with longlining and gillnetting with the same target (Aldebert *et al.* 1993b, Aldebert & Recasens 1996).

   According to Jadaud *et al.* (2006) the main accompanying species caught by bottom trawl in the Gulf of Lions hake fishery are:

   - European pilchard (*Sardina pilchardus*)
   - European anchovy (*Engraulis encrasicolus*)
   - Soles (*Solea* spp.)

- Striped mullet (*Mullus barbatus*)
- Red mullet (*Mullus surmuletus*)
- Angler (*Lophius piscatorius*)
- Black-bellied angler (*Lophius budegassa*)
- Gilthead seabream (*Sparus aurata*)
- European seabass (*Dicentrarchus labrax*)
- Seabreams (*Pagellus* spp.)
- Blue whiting (*Micromesistius poutassou*)
- Poor cod (*Trisopterus minutus capelanus*)
- Horned octopus (*Eledone cirrhosa*)

ii. In the NW Mediterranean, deep shrimp fishery is of great importance, especially in areas associated with the numerous canyons that cut into the continental shelves (Bas 2006, Company *et al.* 2008)

iii. The Algerian basin has a narrow continental shelf with some canyons, and with the presence of the Atlantic current creating high productivity, there is a large exploitable biomass. However, the continental slope has been exploited by foreign fleets (e.g. Spanish and Italian) targeting *A. antennatus* (Bas 2006)

iv. Trawlers on the Tyrrhenian coast can work up to 700 m depth; these can be bottoms rich in bivalve thanatocenosis and *Leptometra phalangium,* which makes them rich but difficult to trawl over (Bas 2006)

v. The Adriatic Sea is mainly composed of relatively shallow soft bottoms, whose depth increases from north to south, with the Jabuka Pit in the centre, influencing the distribution and catch of species. The contribution of the river Po is also important in the area. The striped Venus clam (*Chamelea gallina*) is the most important demersal resource, exploited by means of hydraulic dredges. Hake and red mullet are the most important demersal species. The densest populations of hake and shrimp (*Nephrops norvegicus*, *Parapenaeus longirostris*, *Aristeus antennatus* and *Aristeomorpha foliacea*) are found in the Jabuka Pit (Vrgoč *et al.* 2004). This fishery extends throughout the whole shelf reaching depths up to 800 m, in the south Adriatic basin

vi. Cape Santa Maria di Leuca in Italy harbours the most important resources in the area, represented by the deep water shrimps (*A. antennatus* and *A. foliacea*) which can constitute up to 58% in weight and 66% in economic value of the total catch (Gallipoli fishery). Other important ground-fish resources here are the hake (*M. merluccius*) (Bas 2006)

vii. In the Ionian Sea, the shelf is narrow in many parts, making trawling difficult. But this fishery is carried out in the Tunisian Gulf and in some offshore fishing grounds

viii. The eastern Tunisian shelves are wide and much exploited by trawlers (though mostly near the coast); in Libya, the slope is not exploited, whereas in Tunisia the slope is exploited for hake (down to 400 m, where rose shrimp and cephalopods can also be exploited) (Bas 2006). South of Sicily, large trawlers operate far out from the coast (and around the Lampedusa and Panteleria Islands), fishing hake, deep water shrimp and red mullet in deep waters. South of Sicily are two large shelves, Adventure Bank and Malta Bank, recognized as hake nurseries (Fiorentino *et al.* 2003, Garofalo *et al.* 2007)

ix. In the Greek Ionian Sea, *A. foliacea* is more abundant than *A antennatus.* However, deep water fisheries (> 500 m) are not yet well-developed in Greece (Politou *et al.* 2003, Mytilineou *et al.* 2005b)

x. Fishing in the Aegean Sea is small-scale and mostly artisanal (Conides 2007); the small size of these vessels does not permit long, distant trips. Important hake nurseries have been identified in the Thracian Sea around 180 m depth (Kallinaniotis com. pers.). Regarding crustaceans, the deep water pink shrimp *Parapenaeus longirostris* is the main deep sea (200-500 m) species (Thessalou-Legaki 2007). The Turkish coast is narrow and the fishing fleet not very developed (Bas 2006)

xi. The Levantine basin is of little interest for demersal fisheries, due to its narrow continental shelves and the low productivity of its warm saline waters. Israel's coast has many canyons where the trawling fleet could develop.

4.1.2 Bottom longline

Small bottom longlines are used by artisanal coastal fishermen at fairly shallow depths, and large ones (over 500 hooks) by modern, powerful vessels. Hake is a frequent (but not the only) target species of bottom longlines. In the Gulf of Lions canyons, Spanish fishers use longlines with alternate sinkers and floats (described in 18th century documents) to reach some meters above the bottom, where the hake live. The longlines are laid between the edge and the slope of the continental shelf between 80 and 400 m. The longline fleet catches large specimens of hake, making a special impact on spawners.
Offshore Italian fleets using bottom longlines exploit demersal resources (mostly hake) on both soft and rocky bottoms, mostly in the southern zones, at depths of 150-400 m.
Bottom longlines are also used in Greece. Adamidou (2007) classified this gear according to hook size as (i) small (operating at depths of 20 to 100 m), (ii) medium (operating at depths of 80 to 180 m) and (iii) large (operating at depths of 200 to 700 m). Most of the target species of small and medium longlines are sparids and groupers (*Epinephelus* spp.). The large ones target mainly hake, dentex (*Dentex dentex*) and groupers.

According to Jadaud *et al.* (2006) the main accompanying species caught by bottom longlines in the Gulf of Lions hake fishery are:

- Rockfish (*Helicolenus dactylopterus*)
- Silver scabbard fish (*Lepidopus caudatus*)
- Conger eel (*Conger conger*)
- Red sea bream (*Pagellus bogaraveo*)
- Fork-beard (*Phycis blennoides*)

4.1.3 Bottom gillnets

Gillnetters targeting hake set their nets between the edge and the slope of the continental shelf between 80 and 400 m.

The French fleets target hake with gillnets on hard bottoms at the edge and slope of the continental shelf and the canyons off their coasts, including the Gulf of Lions, from 50 to 200 m (STECF 2004). Gillnets target large fish (not as large as the Spanish longlines).

According to Jadaud *et al.* (2006) the main accompanying species caught by bottom gillnets in the Gulf of Lions hake fishery are:

- Atlantic mackerel (*Scomber scombrus*)
- Tub gurnard (*Trigla lucerna*)
- Poor cod (*Trisopterus minutus capelanus*)
- Megrims (*Lepidorhombus* spp.)
- Small-spotted dogfish (*Scyliorhinus canicula*)

Gillnets are used in Spain for catching red mullet and hake but this is an artisanal activity and they operate fairly near the coast.

Gillnet fishery targeting hake is an important activity particularly in the northern and central Tyrrhenian Sea, concentrated principally on bottoms from 100 to 200 m depth on sand-muddy bottoms, often close to rocky formations (Cartes & Sarda 1993, STECF 2004).

According to Adamidou (2007) gillnets are used in Greece to catch hake at depths down to 400 m.

4.2 Pelagic fisheries

There are two kinds of pelagic fisheries in the Mediterranean according to the target species: small pelagics and large (migratory) pelagics. These two types of fisheries are totally unlike. The small pelagic fisheries target mainly sardine (*Sardina pilchardus*), anchovy (*Engraulis encracicholus*) and round sardinella (*Sardinella aurita*). These fisheries take place close to the coast in productive areas (e.g. off the Ebro Delta, the Po Delta, the Gulf of Lions) (Palomera *et al.* 2007) and elsewhere (the Aegean Sea, the whole Adriatic Sea, North Africa, Nile Delta, etc.). Currently small pelagics constitute most of the fish production in the Mediterranean, accounting for around 50% of total catch; usually these fishing grounds are located close to the coast, within waters under national jurisdiction, and are therefore outside the scope of this work. The only fisheries for small pelagics located in the high seas are possibly in the Adriatic. Many countries use pelagic trawl to targeting small pelagics, but in some countries (i.e. Spain, Greece) this gear is forbidden.

The large pelagic fisheries constitute a completely different activity. They operate in the open sea (except for tuna traps) with industrial fleets (probably the only really industrial fishing fleets in the Mediterranean), using mainly two gear: longlines and purse seines. Other gear, like lines, are of minor use. Driftnets were banned in the Mediterranean by ICCAT and GFCM in 2005 although they have not yet been completely eradicated. Moreover, coastal cages to fatten tuna are thought to increase fishing pressure, as wild tuna are captured for these cages (CIHEAM 2008).

As concerns fisheries for large pelagic species, the general overview is usually provided by ICCAT (www.iccat.int), where scientists from the countries concerned provide their contribution, taking into account the fact that all the species included in this category (bluefin tuna, albacore, bullet tuna, bonito, swordfish, Mediterranean spearfish, etc.) are shared resources and have a wide distribution (STECF 2004). This body (ICCAT) is responsible for managing tuna fish via a system of TACs.

4.2.1 <u>Longlining</u>

A variety of medium-scale and industrial pelagic long lining fleets operate in Mediterranean waters, ranging from local coastal national fleets to large industrial foreign fleets, whether Korean vessels, flying flags of convenience, or even non-registered fleets. These non-registered fleets are estimated at about 100 units. Surface longline gear, including those used by local Mediterranean fleets, are deployed in large areas and line lengths of 50–60 km (bearing several thousand hooks) are not rare. Longline fleets in quest of their very migratory target fish species are highly mobile, covering virtually the whole Mediterranean basin. A significant part of the catch is taken in international waters, more than 12 miles offshore (Tudela 2004).

i. There is an important Spanish fishery of large pelagics in the western Mediterranean. This fishery is practised mainly in international waters targeting principally bluefin tuna and swordfish as well as other species like pelagic sharks (STECF 2004). The Spanish longline fleet operates from the Strait of Gibraltar (5ºW) to 7ºE near Sardinia, specially in the waters surrounding the Ibiza Channel and Balearic Islands, and from 42ºN to the Algerian coast (Caminas & De la Serna 1995), Alicante being the main port for swordfish. Overall, some 145 Spanish longliners target swordfish in Mediterranean waters. Seventy percent of total yearly effort in this fishery is concentrated in the summer and autumn. By-catch, excluding turtles, accounts for 10% of total landings in weight
ii. Tuna and swordfish fisheries take place from the Ligurian-Provence area to the Balearic Islands, using longlines (mainly French and Italian); however, extra-Mediterranean boats like Korean and Japanese boats can be found here (STECF 2004). The French longline fishery concentrates its activity in the offshore waters in the Ligurian-Provence current
iii. Italian longlining fleets targeting swordfish and albacore are based mostly in Sicily, Puglia, Sardinia, Campania and Liguria (Caminas & De la Serna 1995). These fleets, however, are able to reach much more distant grounds. The bluefin tuna fishery is

carried out mainly by the fleet based in the Strait of Sicily and, more recently, by some vessels based in Ionian harbours. All the tuna longline activities are offshore; minor fishing grounds exist around all the Sicilian islands and along the Ionian coast (STECF 2004). The swordfish fishery has its highest concentration along the Ionian coast and in the Strait of Sicily, and along the North African coast

iv. The Greek National Statistics Service includes longlining in the broad category of "coastal fisheries" and although no specific figures are available, it is estimated that swordfish fishery accounts for over 50% of the total professional fishing effort by Greek fleets in western Greece. The main fleets, with 50% of total Greek production, are based in Kalymos (south-east Aegean) and Chania (Crete). Of the total annual catch, 70% is taken at the peak of the season, from May to September, in an area covering the Aegean Sea, the Ionian Sea and even the Levant Sea (STECF 2004)

v. The Aegean Sea waters have one of the most important large pelagic fisheries that exploit parts of the Aegean, Ionian and Cretan Seas (Tserpes *et al.* 2001). Swordfish comprises the main bulk of the catch, using drifting longlines, with the highest fishing activity in the southern Aegean and eastern Levantine Sea.

4.2.2 Purse seine

The large purse seines targeting large pelagic species operate in the open seas (WWF 2006), whereas the smaller purse seines targeting small pelagics operate in coastal waters.

i. The Spanish fishery takes place in the Mediterranean waters surrounding the Balearic Islands. The activity exploits the concentration of adults in the spawning season. Activity takes place from April to October. This fishery represents about 70 % of total Spanish catch of tuna in Mediterranean waters

ii. The French purse seine fleet is the most important in the Mediternean and exercises its fishing activity during about 8 months, from the end of March to the end of November. Areas frequented by the French purse seiners are: the Gulf of Lions and the Catalan Sea, which are exploited from March to April and from August to November; the Balearic Islands waters which are the main fishery for the big tunas caught from May to July; Libyan and Maltese waters. The Ligurian Sea, which was for 15 years the main fishery area for the French fleet catching small tunas during the summer, was more or less abandoned 10 years ago by the fleet, partly due to the importance of the Balearic Islands. For the last I5 years, the waters of the southern Malta Islands have been exploited (STECF 2004)

iii. The Italian purse seiners concentrate their activity in Italian waters (STECF 2004).

4.2.3 Driftnets

Driftnets are gillnets which are left to drift and which act as passive filters that entangle a wide range of wild organisms, both target and non-target. The large-scale use of this gear has led to the killing of massive numbers of marine mammals and other non-target species in diverse regions. In the Alboran Sea, situated in the western basin of the western Mediterranean, driftnet fisheries have been responsible for many years for the killing of numerous dolphins (*Stenella coeruleoalba*, *Delphinus delphis* and *Tursiops truncatus*) and, to a more limited extent, killer whales *Orcinus orca*, baleen whales *Balaenoptera physalus*, and even monk seals *Monachus monachus*. The Spanish driftnet fleet used to operate on both the Atlantic and the Mediterranean sides of the Strait of Gibraltar following the seasonal migration of the swordfish *Xiphias gladius* (Silvani *et al.* 1999).

In 1992 the European Community prohibited driftnet fishing in the Mediterranean with nets longer than 2.5 km, as did the General Fisheries Commission for the Mediterranean (GFCM) in 1997 under a binding Resolution. A total ban on driftnet fishing of large pelagic species by the EU fleet in the Mediterranean entered into force on 1 January 2002; the same decision was adopted by ICCAT via a binding recommendation in November 2003. GFCM prohibited driftnets for all member countries in 2005. All fishing activities outside this legal framework qualify as IUU (Illegal, Unreported and Unregulated) fishing according to FAO (2001) (Tudela *et al.* 2005).

However, illegal large-scale driftnets are still used in several Mediterranean areas, due to lack of compliance or enforcement (Tudela 2003). In some cases fishermen use gear that are disguised driftnets, like the “melveras” in Spain, “tonnailles” in France or “ferratare” in Italy.

4.3 Enforcement of legislation

The Third United Nations Conference on the Law of the Sea (UNCLOS) referred to the seabed outside the limits of national jurisdiction (the Area); nevertheless, it focused mainly on the mineral resources in these areas, on the assumption that these resources were the only ones of economic interest or consequence. It defines the “resources” of the “Area” as: “all solid, liquid or gaseous mineral resources *in situ* in the Area at or beneath the seabed, including polymetallic nodules”. The negotiators of the UNCLOS could hardly have anticipated the extent of the scientific and technological development that was soon to open up new perspectives on the potential uses of marine biodiversity in areas outside national jurisdiction. It was only later that the potential benefits of marine resources (mainly from a genetic perspective) became known and appreciated outside a specialized scientific community. Today, hydrothermal vents, seamounts and other deep seabed ecosystems rich in genetic biodiversity are being identified and studied with the support of the latest developments in technology, and knowledge of these resources and of their potential uses continues to grow. In this context, FAO is working to develop a set of international guidelines for the management of deep-sea fisheries in the high seas with the aim of protecting vulnerable marine ecosystems and ensuring the sustainable use of their fisheries (FAO 2008).

In general there are no Exclusive Economic Zones (EEZs) in the Mediterranean, only jurisdictional waters limited by 12 nautical miles from the coast in most countries, and some fishery protection areas; therefore, most Mediterranean water exist in international waters or the high seas (CIHEAM 2008). However, some countries have declared EEZs; others have declared ecological or fisheries protection zones (France, Spain, Libya, and Croatia). Those zones are not always accepted at international level.

4.3.1 Demersal fisheries

Since 2005, trawling fishery in the Mediterranean Sea has been banned below 1,000 m. The precautionary prohibition aims to protect the still pristine and unknown deep-water ecosystems. This restricts Mediterranean high seas bottom fisheries to the area between national waters (12 nm from the coast) and the 1,000 m ban, which greatly reduces the trawlable surface in an average deep basin. Moreover, as bottom trawling is mainly controlled by total effort, including licenses, and in some countries daily fishing hours, boats must return to their port of origin every night; thus the distance of fishing from port is controlled (i.e. it is not sensible to go far out from the coast if the fishing hours are restricted). This rigid timetable does not allow the extensive exploitation of fishing grounds far out in the deep seas (Bas 2002).

Nevertheless, there are some problems associated with the control of Mediterranean demersal fisheries; first there is a common failure to respect the regulations; second, as continental shelves are very narrow in some areas, some SHs, such as canyons or seamounts, are still reached by trawlers; third, there are other SHs in shallower areas (deep continental shelf, and shelf break) that are neglected in ecosystem conservation (e.g. coralligenous facies, *Leptometra phalangium* beds). Therefore, trawling activities could also be restricted in these vulnerable areas by establishing well-monitored prohibition measures.

4.3.2 Pelagic fisheries

To date, bluefin tuna is the only species subject to a quota system, TAC, throughout the Mediterranean. This system, established by ICCAT, applies only to its members. In Algeria, an individual quota for highly migratory species was established and set at 500 tonnes per year and per authorized vessel.

However, despite the TAC control, this fishery is difficult to control, first because it operates far out from the coast, second because many non-Community countries are involved; although controlled by TACs, transfer of catch between vessels has been reported. Moreover, a relatively high proportion of the catch is not recorded in auctions since it goes to fattening cages for tuna (FAO 2008). Finally, one of the most important problems is the use of the forbidden driftnets (which moreover catch many vulnerable non-target species, such as cetaceans).

In a more general scope, the United Nations (UN 1995) promoted the "Agreement for the implementation of the provisions of the UNCLOS of 10 December 1982 relating to the conservation and management of straddling fish stocks and highly migratory fish stocks". This agreement sets out principles for the conservation and management of those fish stocks and establishes that such management must be based on the Precautionary Approach and the best available scientific information. The Agreement elaborates on the fundamental principle, established in the Convention, that states should cooperate to ensure conservation and promote the optimum utilization of fisheries resources both within and outside the Exclusive Economic Zone.

4.3.3 Problems related to the regulation of fisheries in the Mediterranean high seas

The Mediterranean is a semi-enclosed sea surrounded by 21 countries. It is characterized by a number of distinctive features with important implications for the conservation and management of fisheries. One of these features is the general restraint shown by coastal states in exercising their rights to extend their national jurisdiction over waters in the Mediterranean. Most of the states have limited their jurisdiction to territorial waters; few have claimed an Exclusive Economic Zone or a fishing zone extending outside these waters, usually to the equidistant line (and if so, not always recognised by the other countries). As a result, the high seas area in the Mediterranean lies much closer to the coast than in most of the planet's other seas and oceans. The existence of a large high sea area requires a high level of cooperation between coastal states to ensure the sustainable utilization of fisheries resources in the Mediterranean, which has proven difficult in the Mediterranean context (Cacaud 2005a). Table 1 presents a summary of the jurisdictional and claims legislation.

In order to ensure compliance with conservation and management measures, in the last decade an increasing number of coastal states and regional fisheries management organizations have established a Vessel Monitoring System (VMS). In particular in EU countries, VMS is compulsory for all fishing vessels of 15 m length. To date, VMSs have been primarily used to monitor the position of fishing vessels operating within waters under national jurisdiction or within the areas of jurisdiction of Regional Fisheries Management Organizations (RFMOs) on the high seas (Cacaud 2005a); however, VMSs could supply a strong tool to promote the enforcement of control measures in the high seas (i.e. setting up MPAs in the high seas).

High seas fishing regulation involves a series of problems, mainly due to being far out from the coast, outside national jurisdiction and surveillance; the following can be highlighted:

i. Main regulating bodies are the EU, GFCM and ICATT, but this only involves member countries, and this implies problems regarding non-member countries enforcing legislation (this will suppose a big issue for restricting specific activities from areas)
ii. Regarding available data on high seas fisheries: much of the detail comes from some countries (Italy) in contrast to others (North Africa), since most information comes from the GFCM
iii. Driftnets: although this practice has been banned in the Mediterranean, driftnet fleets have continued to expand, in some cases taking advantage of gear supplied from reconverted fleets from other countries. This has been reported, despite national legislation banning large-scale swordfish driftnetting in most of those countries (Tudela *et al.* 2005). In addition to the major North African fleet, the other major fleets involved are Italian (about 90–100 vessels still exist), Turkish (45–110 vessels; Ayd *et al.* 2008) and French (46–75; SGFEN/STECF 2001). Much evidence points to other countries also probably being driftnetters, though confirmed official information is not available. Solid legal instruments already exist to tackle the issue of driftnet fishing in the Mediterranean,

especially after the recent total ban issued by ICCAT. Their enforcement should be a priority for the various coastal states and the concerned Regional Fisheries Organizations (GFCM and ICCAT)

iv. Foreign fleets: growing concern about Illegal, Unreported and Unregulated (IUU) fishing in national waters and on the high seas has prompted states to develop and adopt new international fisheries instruments to address this issue and to provide states with a legal basis for taking action against fishing vessels that are undermining international conservation measures agreed in the framework of subregional or regional fisheries organizations or arrangements. Both the FAO Compliance Agreement and the UN Agreement on Fish Stocks require that flag states whose vessels operate on the high seas take measures to ensure that vessels flying their flag comply with subregional and regional conservation and management measures and that those vessels do not engage in any activity which undermines the effectiveness of such measures. These two instruments contain provisions specifying flag state responsibility and duties. They include, *inter alia*, establishing a national record of fishing vessels authorized to fish on the high seas, requirements for the marking of fishing vessels and fishing gear, requirements for recording and reporting information on fishing activities, requirements for the recording and timely reporting of vessel position, implementation of national inspection schemes and subregional and regional schemes for cooperation in enforcement, implementation of national observer programmes, development and implementation of VMS, and regulation of trans-shipment on the high seas (Cacaud 2005a)

v. Worldwide Illegal, Unreported and Unregulated (IUU) fishing: IUU fishing is a major problem, linked to the lack of effective management systems and also to increased commercial pressure on dwindling fisheries resources. The Mediterranean is no exception to this problem. A good example is the extensive use of driftnets, which continues despite their being prohibited in the Mediterranean. The constraints on addressing IUU fishing in a meaningful way are considerable. Financial constraints limiting the frequency and intensity of surveillance operations, for example the use of patrol craft, adequacy of training programs, availability of fisheries Monitoring, Control and Surveillance (MCS) instruments and the lack of an enforceable legal regime on the high seas are all substantial constraining factors. Added to this are societal costs, such as unemployment in the fishing and related industries, that can result (at least in the short term) from the passing and enforcing of laws to reduce the fishing effort (Tudela 2004, Tudela *et al.* 2005). These can be the main problems that face setting up MPAs in the high seas.

5 Fishing impacts on Mediterranean open sea ecosystems

As nowadays the effects of commercial fishing activities on ecosystems are not completely understood, a Precautionary Approach to fishery management should be adopted (FAO 1995b, Lauck *et al.* 1998, Symes 2000), whereby the most conservative measures are considered to ensure the survival of marine resources (Dayton 1998, Hall 1999, Agardy 2000).

To regulate fishing activities via a Precautionary Approach it is widely accepted that an overall reduction of effort has to be made, the closure of areas to fishery activity being the most restrictive measure (Fogarty 1999, Lindeboom 2000). Populations of targeted species must be controlled (i.e. overall biomass, average size, recruitment), since they sustain the fishery, and the importance of the communities and habitats that maintain this resource highlighted (NRC 2002). Implementation of suitable management plans has to accompany investigation of altered ecosystems to design the most appropriate measures and avoid their degradation.

5.1 Demersal fisheries

The Mediterranean deep sea may be among the most heavily impacted deep sea environments in the world. And paradoxically, it is among the least known areas in terms of biodiversity, where a significant loss of biodiversity might be currently taking place before scientists have had a chance to document its existence (Briand 2003, Cartes *et al.* 2004a, Roberts 2008).

Of all the anthropogenic activities that are negatively affecting benthic ecosystems from continental shelves, fishing with towed gear has the strongest negative consequences for these ecosystems (Thrush *et al.* 1998, Gray *et al.* 2006, Kaiser *et al.* 2006). Bottom trawling directly extracts the target organisms from the seabed, and also removes as by-catch a large number of organisms that can be commercialised or returned to the sea as discard. The amount of biomass discarded because it has no commercial value can be very great, being much higher than discard from other gear. Carbonell *et al.* (1998) estimated an average discard of around 27% of biomass caught at depths below 350 m by several Mediterranean countries' fleets. Furthermore, trawling has very low selectivity, since the legal mesh size in the Mediterranean is 40 mm diamond mesh (according to Recommendation GFCM/2005/1). This is much smaller than regulated mesh sizes in the Atlantic (up to 110 mm). The consequence is the capture of small fish, age 0 class, and immature fish for the majority of species, including the main target commercial species.

Moreover, trawling has a series of indirect consequences caused by the scarring of the seabed by the trawling gear and damaging of the benthic fauna that inhabits the seabed, modifying the habitat structure and altering community composition (de Groot 1984, Auster *et al.* 1996, Lindeboom & de Groot 1998). The accumulation of organic matter from discard and damaged fauna alters the ecosystem balance, and numerous studies have observed that scavengers and opportunistic species aggregate in recently trawled areas, attracted by carrion (Ramsay 1997, Groenewold & Fonds 2000, de Juan 2007). Physical structures are strongly modified, and the habitat alteration has consequences for the benthic communities that are tightly linked to this habitat. Ploughing the seabed with towed gear, as well as habitat homogenisation with the elimination of burrows and other sediment structures, can have important negative consequences for organisms that live or seek protection in these habitat microstructures (Thrush *et al.* 2001). Moreover, there is a series of indirect effects, such as increased turbidity, that can have serious negative effects on organisms such as filter feeders that are highly affected by this increase in suspended sediment because their filtering system is blocked (Hill *et al.* 1999).

Amongst the effects of trawling on habitats in the Mediterranean open seas, the following can be highlighted:

i. Gorgonian communities (e.g. *Isidella elongata*) and other sessile organisms are immediately removed from soft bottoms after trawling
ii. Suspension feeders (e.g. *Leptometra phalangium*) are negatively affected by trawling by the increased turbidity

iii. The ecosystem balance can be changed by the supply of organic matter by discard (i.e. shift to scavengers and opportunistic fauna). It will take longer for sedentary organisms to be replaced than for mobile ones, and endemic species could become extinct as a result of the destruction of their habitats (de Juan *et al.* 2007)
iv. Vulnerable ecosystems, like hydrothermal vents or cold seeps, will be highly damaged by either direct contact with fishing gear or the changing of the ecosystem structure (Thrush & Dayton 2002)
v. Vulnerable fauna like chondrychthyans are highly affected by trawling (captures as by-catch or discard) (Carbonell *et al.* 2003) because of their slow growth and late maturity. Species caught in deep sea fisheries are characterized by low productivity, low fecundity, high age at first maturity and high longevity. These species will be more sensitive to exploitation than typical shallow water species, and will only be able to sustain low exploitation rates (Cavanagh & Gibson 2007).

Although trawling on coral reefs has one of the most obvious impacts on benthic ecosystems in the open seas, trawling in the neighbouring bathyal mud bottoms could be equally damaging for these suspension feeders, due to the effects of sediment resuspension and related increased sedimentation, even at depths well below those trawled (WWF/IUCN 2004). A study showed evidence of how sediment resuspension from trawlers working at 600-800 m depth reached a depth of 1,200 m (Palanques *et al.* 2001). Cold water coral colonies can also be very long-lived. Estimates vary, but although a single gorgonian can apparently survive for several centuries, reestablishing a community, following its elimination by gear impact, may require much longer than the lifetime of a single colony.

Seamounts themselves are large masses of rock and their relief itself is not vulnerable to any fishing impact, but they may nevertheless be highly vulnerable because of the possible abundance of coral reefs and large sponges, especially on their flanks. Thus, the vulnerability of seamount ecosystems is largely the same as the vulnerability of other coral and sponge ecosystems, while the ecological roles of corals and sponges on seamounts is not much different from their roles in other areas, though the value of seamount ecosystems may be higher because of their biodiversity and endemism (Barone & Ryan 1987, Acosta *et al.* 2003, Ardizzone 2006).

Most of the effects described above will have consequences for commercial species (like hake and red shrimp) via habitat loss and deterioration, highlighting the importance of an ecosystem approach to management (de Juan *et al.* 2009).

Regarding the deep sea (below 1,000 m), trawling effects would be multiplied due to low fecundity and low metabolic rates in a stable environment like the deep sea, implying high vulnerability for their populations (Sardà *et al.* 2004). Based on the limited knowledge available, it appears that the deep seabed is inhabited by generally slow-growing species that are less dependent on the production pulses that occur closer to the surface. Such species tend to be more specialised feeders, partly because of their morphological and functional adaptations to great depth, low light levels, and low food availability. Their populations will typically have lower densities. As these environments are subject to more constant conditions than the coastal environment, they are presumably more vulnerable to exploitation and other anthropogenic disturbances (Briand 2003). Therefore maintaining the 1,000 m ban for trawl fisheries is of great importance. However, deep slope fisheries that target high-value crustacean species operate out of Spain, Italy, Algeria and Tunisia, fishing down to a depth of 1,000 m in the NW Mediterranean red shrimp (*Aristeus antennatus* and *Aristeomorpha foliacea*) fishery (Tudela 2004). The most impacted fishing grounds in the open seas are located in the western Mediterranean, where the fishery is more developed and trawlers operate from the minimum depth (generally 50 m) to the continental slope and submarine canyons (down to 800 m). The fishing grounds in the Levant Sea generally remain close to the coast and are confined to the continental shelf; possible fishing grounds beyond the continental shelf are almost intact as regards trawling.

The negative effects of bottom fishing by longlining and gillnet mainly affect target species and by-catch. The effects of this fishing activity consist in its impact on target populations (i.e. hake), it being a fishing practice that usually catches the big spawners, and the main long-term effect will be not only the reduction of average population size, but, specially, the removal of large spawners leading to recruitment overexploitation.

5.2 Effects of pelagic fisheries

Pelagic fisheries have direct effects on the target species, tuna, swordfish, and albacore, by fishing around migration routes and spawning areas, which decimates their populations; and indirect effects on non-target species, like chondrichthyans, turtles and cetaceans, through by-catch and incidental catch. However, large pelagics, the object of this fishery, are the group most impacted by this gear (Tudela 2004). The incidence of discarded species is very variable according to gear type, target species, fishing grounds and season.

5.2.1 Effects on target species

i. Bluefin tuna

The case of the bluefin tuna is well known, with a highly overexploited population in the Mediterranean Sea. The amount of adult bluefin tunas has decreased by 80% over the previous 20 years. Huge numbers of juvenile tuna are caught in every season, further compromising the ability of the stock to regenerate; moreover IUU fishing boats are also depleting the stock, and drastic measures are needed to allow the bluefin tuna population to recover (Tudela 2004, WWF 2006).

ICCAT implemented a TAC system to reduce overfishing, limiting bluefin tuna catches from the eastern stock to around 32 000 tons. However, ICCAT experts have estimated that landings have been maintained at well over 50,000 tons there (ICCAT 2005). Thus the present scenario will continue to induce illegal fishing and under-reporting unless there is a significant reduction in fishing capacity. Farming has also contributed to misreporting because this practice makes controlling catches difficult. The last evaluation by ICCAT's Standing Committee on Research and Statistics (SCRS) confirmed that the stock is being overexploited, depicting a dangerous scenario, showing a continuous decrease from the mid nineties in both recruitment and spawning stock biomass (ICCAT 2007). The current stock would therefore be approximately 1/3 that estimated in the early seventies, and if pressure persists it is likely to lead to the collapse of the fishery, at least from the commercial point of view (Mejuto *et al.* 2002, Tudela *et al.* 2005).

Some protection measures to limit the fishing of spawning bluefin tuna have been adopted so far by ICCAT for the whole Mediterranean Sea. These include banning the purse seine fishery in August and prohibiting the use of aircraft in June. A reduction of the total fishing effort during the peak of the bluefin tuna's spawning season (mostly June to July) should work much better than a closed area, because the hotspots vary in time and space. The prohibition on catching immature bluefin tuna should be adopted all over the Mediterranean Sea, with a complete ban during the fall.

ii. Swordfish

In the case of swordfish the likely high exploitation rate and the probable large catch of very small fish are causes for serious concern. According to ICCAT, catches of immature fish may account for as much as 50-70% of total catch (Tudela 2004). The poor quality and simple unavailability of data makes it difficult to assess the status of tuna and swordfish species in the region.

5.2.2 Effects of pelagic fisheries on by-catch species

i. Chondrichthyans

This group has been revealed as especially vulnerable to human exploitation; fishing mortality has resulted from both direct fisheries and high by-catch as a consequence of the use of low-selective gear. In the Mediterranean, only Malta has adopted national legislative measures to protect the white and basking sharks (Tudela 2004), although as many as 33 of them are currently listed in the species annexes to the SPA/BD Protocol of the Barcelona Convention.

Demersal sharks considered as vulnerable include *Hexanchus griseus, Galeus melastomus*, *Centrophorus* spp., *Centroscymnus coelolepis*, and *Etmopterus spinax* (Briand 2003). Other vulnerable demersal species include the sand tiger shark *Carcharias taurus*, white skate *Rostroraja alba* and porbeagle *Lamna nasus* (Camhi 1998); *Galeus melastomus* and *Hexanchus griseus* are among the most common species in the deep sea (Sion *et al.* 2004). Pelagic sharks are a common by-catch of pelagic fisheries: *Alopias* spp. *Carcharhinus* spp., *Prionace glauca*, *Cetorhinus maximus, Heptranchias perlo, Hexanchus griseus, Charcarodon carcharias, Sphyrina* spp., *Galeorhinus galeu;* and Batoidea *Dasyatis violacea, Mobula mobular, Myliobatis aquila, Pteuromylaeus bovines*; or even target species like *Isurus oxyrinchus* and *Lamna nasus.*

Regional protection has only been achieved for the basking shark *(Cetorhinus maximus)*, great white shark *(Carcharodon carcharias)*, and giant devil ray *(Mobula mobular)*. However, fisheries management programs for sustainable catch (both target and by-catch) need to be developed for the main commercial species, which include dogfish *(Squalus acanthias)*, thresher sharks *(Alopias* spp.*)*, makos *(Isurus* spp.*)*, porbeagle *(Lamna nasus)*, and blue shark *(Prionace glauca)* (Abdulla 2004).

There are no Mediterranean pelagic fisheries that target migratory oceanic sharks. However, longline fisheries targeting swordfish and tunas take chondrichthyans as by-catch (ICCAT 2001). Large pelagic species (e.g. *Isurus oxyrinchus*, *Lamna nassus* and *Prionace glauca)* are regularly caught in the Mediterranean, mainly as by-catch in the longline and driftnet fisheries; the most captured species is *P. glauca* (De la Serna *et al.* 2002). Some of these species are landed and marketed (Tudela 2004). Overall, assuming that carcasses of all finned sharks are discarded, over 200,000 tonnes of shark are discarded annually as a result of finning (discard rate of 96%). Blue shark game fishing is also a matter for concern, especially in the Adriatic Sea, where a nursery area is known to exist and large amounts of juveniles are caught. Surface fisheries targeting large pelagics also entail incidental catches of white shark (*Carcharodon carcharias*). Driftnets are still responsible for considerable mortality in pelagic chondrichthyan species, which frequently get entangled in them (Tudela 2004). According to Tudela *et al.* (2005), large pelagic sharks are massively by-caught by the large-scale Moroccan driftnet fleet targeting swordfish that operates in the Alboran Sea.

This group is covered by a protection program by a RAC/SPA Regional Action Plan (UNEP-MAP-RAC/SPA 2003c).

ii. Turtles

International concern about the general decline of the marine turtle population in the Mediterranean led the Parties to the Barcelona Convention to adopt an Action Plan for the Conservation of Mediterranean Marine Turtles in 1989, acknowledging that catches by fishermen are the most serious threat to turtles at sea, and that the conservation of the green turtle deserves special priority.

Mediterranean fisheries have an enormous impact on the local turtle stock: more than 60 000 turtles are caught annually as a result of fishing practices (Tudela 2003, 2004). The problems related to the interaction between fisheries and turtles in the Mediterranean are, to a large extent, common to the different species. However, local features can affect breeding or wintering populations of turtles differently in different areas. Special restrictive fishing measures affecting large pelagic fisheries could be applied in areas described in recent years with big populations of immature and adult loggerheads. Other impacting factors are natural predation on eggs, nesting females and hatchlings, human egg consumption, pollution and sand extraction from nesting beaches, and injuries to adults inflicted by fishing boat engines; the peak fishing season for small boats overlaps with the loggerhead mating season. A 2001 estimate of turtle by-catch yielded an annual rate of 2.4 turtles per fishing boat, the most damaging gear being fishing gear that target large pelagic species. Foreign large-scale longlines and trawlers authorized to fish in Libyan waters are thought to have an impact on turtle populations too (Tudela 2003, Cambié *et al.* in press).

This group is covered by a protection program by a RAC/SPA Action Plan (UNEP-MAP-RAC/SPA 1989).

iii. Monk seals

The impact of fishing practices consists of direct mortality caused by incidental entanglement in fishing gear and deliberate killing by fishermen, and food scarcity related to overfishing and the subsequent depletion of fish populations (Tudela 2004). A third related factor is the trophic limitation triggered by overfishing that encourages seals to prey more heavily on fish trapped in nets, thus increasing seal-gear interaction. The seals appear to be most vulnerable to static gear (stationary nets set on the bottom) and abandoned nets (ghost fishing effect). As much as 23% of seal deaths recorded in the Greek Ionian Islands was due to entanglement (Panou *et al.* 1993).

iv. Cetaceans

The reduction or depletion of food resources, and being incidentally caught in fishing gear or deliberately killed, are recognised as some of the most serious threats to cetaceans in the Mediterranean. Impacting fishing gear ranges from longlines to driftnets and even trawlers. The Action Plan called on all parties to adopt and implement legislation to prohibit the deliberate taking of cetaceans, use of driftnets longer than 2.5 km, and the discarding of fishing gear at sea, and required the safe release of cetaceans caught accidentally. The most impacted species seems to be the bottlenose dolphin (*Tursiops truncatus*) (Tudela 2003). However, of all fishing practices driftnet fisheries are clearly inherently harmful to cetacean populations and a major factor of direct mortality in Mediterranean waters. In the Alboran Sea, the very high by-catch entailed by the Moroccan driftnet fleet poses a great threat to the survival of the last remaining healthy population of common dolphin in the whole Mediterranean (Tudela 2004).

All marine mammals in the Mediterranean are listed in Annex II to the SPA Protocol, and all cetacean species are protected by the UNEP CMS “Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea, and Contiguous Atlantic Area” (ACCOBAMS; www.accobams.org). A joint IUCN-ACCOBAMS effort to assess the conservation status of populations belonging to ten cetacean species regularly occurring in the Mediterranean Sea, for inclusion on the Red List, determined that 60% are threatened (Critically Endangered, Endangered and Vulnerable), and 40% are Data Deficient (Reeves & Notarbartolo di Sciara 2006). Guidelines for establishing in the Mediterranean MPAs for cetaceans were developed by RAC/SPA (Notarbartolo di Sciara 2007).

v. Sea birds

The key feature affecting sea bird populations is mortality rates. Procellariiforms, as well as Pelecaniforms and Laridae species, are generally long-lived and their populations are highly sensitive to changes in survival (Tudela 2004). By-catch by bottom longlines is a significant source of mortality (Tudela report, STECF). Three Mediterranean sea bird species are currently covered by specific Action Plans designed by BirdLife International, approved by the Ornis Committee (EU DG Environment) and endorsed by the Bern Convention Standing Committee. They include Audouin's gull (*Larus audouinii*), the Balearic shearwater (*Puffinus mauretanicus*) and the Mediterranean shag (*Phalacrocorax aristotelis desmaresti*). This group is covered by a protection program by a RAC/SPA Action Plan (UNEP-MAP-RAC/SPA 2003b).

5.3 Proposal of actions to reduce disturbance to ecosystems

The FAO produced several technical documents for RAC/SPA within the framework of the Strategic Action Plan for the Conservation of Biological Diversity in the Mediterranean (SAP

BIO) aimed at “facilitating the national processes for the elaboration of strategic action plans to face the impact of fishing activities on biological diversity” (Tudela 2003). This technical material encompassed a total six documents, assigned to five different “Outputs”, including *Ecosystem Effects of Fishing in the Mediterranean*, by Tudela (2004). National Action Plans are available only for a subset of 10 countries: Albania, Algeria, Croatia, Lebanon, Libya, Malta (2 Action Plans), Morocco, Tunisia, Slovenia (2 Action Plans) and Turkey. Any regional strategy prepared only from the available National Action Plans would therefore inevitably be incomplete and fragmentary given the enormous contribution of EU fleets to the overall effects of fishing on habitats and biodiversity in the Mediterranean (Tudela 2003). Moreover, the EAF can be considered as a “new” approach in Mediterranean waters, as currently proposed management actions lack any consideration of the ecosystem protection element within their main objectives.

One of the most immediate tasks to be undertaken regarding marine environment science should be identifying areas within commercially exploited fishing grounds that could be permanently closed to these activities. Studies on restricting fishery activity worldwide show that protection from fishing leads to rapid increases in abundance, biomass, and average size of exploited species (Castilla & Bustamante 1989, Roberts & Polunin 1991, Pipitone *et al.* 2000, Roberts *et al.* 2001), but much less is known of the recovery of non-target communities and habitats (Dugan & Davis 1993, Babcock *et al.* 1999). Fishery Restricted Areas would act as refuge zones and provide a species source for the recovery of adjacent areas (Allison *et al.* 1998, Manson & Die 2001), and would favour the persistence of habitats and benthic organisms (Dinmore *et al.* 2003).

6 Priority areas for conservation regarding fishing impacts in the open seas

Those ecosystems selected as vulnerable under EFH or SH definitions that receive fishing impacts in the Mediterranean open seas, including the deep sea, should be considered as priority sites for conservation.

The objectives to be achieved by setting up a network of such priority areas in the Mediterranean open seas are the following:

i. These priority sites must be an essential tool for fisheries management in the Mediterranean, since the technical measures that have traditionally been adopted are not sufficient
ii. They must be large enough to provide effective protection measures, as most of those that are located within national waters are too small to be effective on an ecosystem scale
iii. They must imply real and effective restriction on fishing activities (i.e. the Pelagos Cetacean Sanctuary is not specifically limiting fishing activities)
iv. They must include a monitoring program to control functioning in the long term
v. These priority sites must be included in a representative network of national/international and pelagic/demersal areas.

General management failure for Mediterranean marine resources implies the need to urgently adopt an EAF. The Mediterranean open seas, including the deep sea, are still poorly known, which means that the Precautionary Approach has to be applied.

As there is only one open seas protected area embracing also Mediterranean high seas, there is an urgent need to plan and implement protection zones under the SPAMI/MPA criteria; this should be correctly surveyed and scientifically monitored. Within this framework, a consistent, well monitored network of SPAMIs located in the open seas, including the deep sea (comprising both pelagic and demersal ecosystems), may be proposed.

The first step for proposing such areas is identifying those that meet the definition of a EFH/SH (see Sections 2&3). Some of these areas currently undergo some type of fishing impact (see Sections 4&5), and must be managed following EAF directives, whereas other areas are scarcely known and might be impacted by fishing activities, and thus should also be protected under the Precautionary Approach directives. Considering these different stages of analysis, 13 sites are proposed in this document as priority areas for conservation in the Mediterranean open seas, including the deep sea (Table 5), ideally within a network of SPAMIs managed by their concerned countries (countries neighbouring them and/or those eventually having jurisdictional rights over parts of them).

6.1 Gulf of Lions slope

Situation

37.1 NW Mediterranean Sea.

FAO Statistical Areas 37.1.1 (Balearic) and 37.1.2 (Gulf of Lions)

GFCM GSAs: 6 and 7

Environment: Demersal

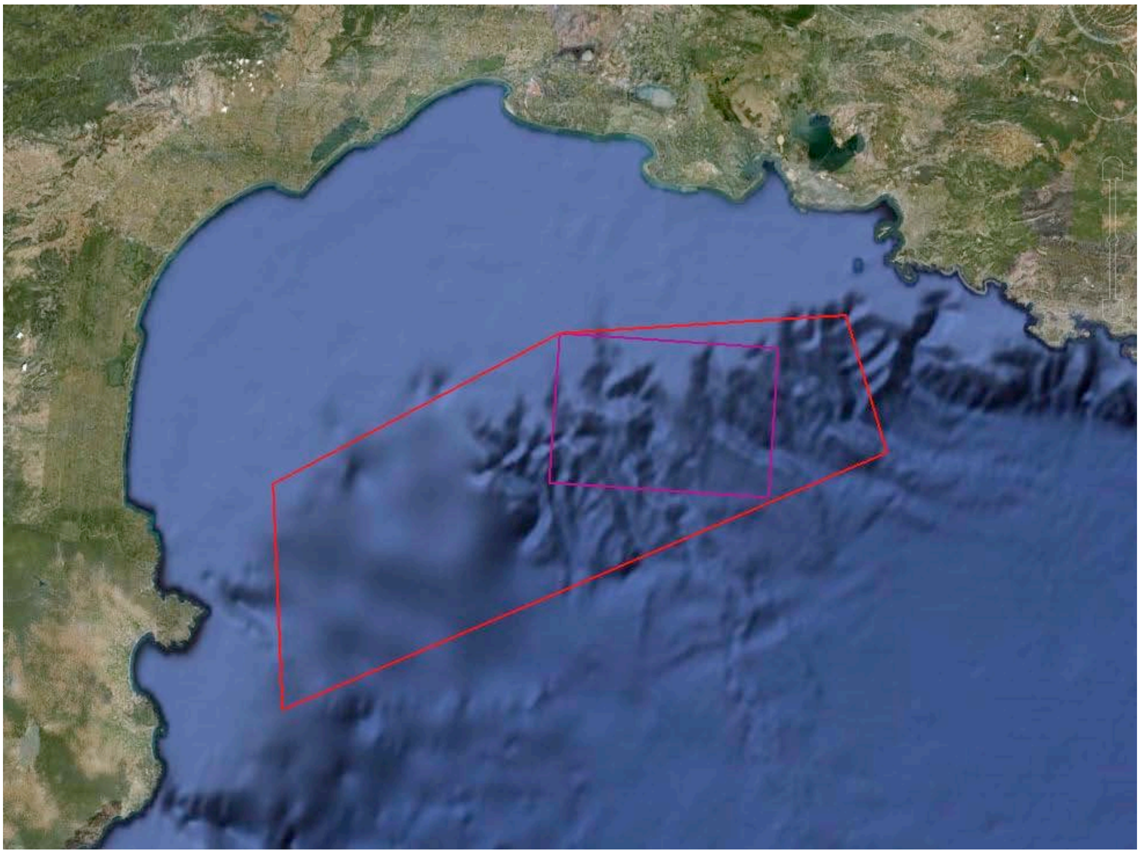
Coordinates

43º05'N	5º12'E
42º47'N	5º21'E
42º07'N	3º35'E
42º37'N	3º30'E
43º00'N	4º20'E

Area: 8,087 km^2

Area proposed at GFCM, 2008: 2,012km^2

43º00N	4º20E
43º00N	5º00E
42º40N	4º20E
42º40N	5º00E



Justification

This area has been identified as a priority area in that it is a spawning area for some important commercial species (i.e. hake *Merluccius merluccius*, monkfish *Lophius* spp. blue and red shrimp *Aristeus antennatus*), and harbours numerous canyons that constitute a refuge for a high biomass of large specimens of these and other species (GFCM 2008b). STECF in 2007 noted that hake is one of the most important demersal target species of commercial fisheries in the Gulf of Lions. In this area, hake is exploited by French trawl, French gillnet, Spanish trawl and Spanish longline (Aldebert *et al.* 1993a, Aldebert & Recasens 1996, Recasens *et al.* 1998). Around 250 boats are involved in the fishery. According to the official statistics, total annual landings decreased from 2,751 tonnes in 2003 to 1,341 tonnes in 2004. This was mainly due to the drop in French trawler landings (from 2,024 t to 1,023 t) and Spanish trawler landings (from 207 t to 101 t) (Cardinale *et al.* 2008). This area also contains cold seeps and deep sea corals on the walls of canyons (Greenpeace 2004); therefore, bottom fishing activities could be eliminated in this area.

A complete dossier (standard sheet) was presented to the SCMEE meeting in 2008 to justify the need for protection of part of the area (GFCM 2008b)[5]. In consequence, a zone where fishing activity is weaker has been endorsed as a Fisheries Restricted Area by the GFCM (Recommendation GFCM/33/2009/1).

Management

Control and limitation of the fishing effort (any type of demersal fishing), and prohibition of demersal fishing within the GFCM FRA rectangle, are recommended.

Priority

Probably the spawning stocks in this area support the commercial fishing grounds of the nearby countries Spain and France. Their exploitation would jeopardize the fisheries through recruitment overexploitation.

[5] Annex 3 of the report: ftp://ftp.fao.org/docrep/fao/meeting/014/aj310e.pdf

6.2 South of Sicily. The Adventure and Malta Banks

Situation

37.2 Central Mediterranean.

FAO Statistical Area 37.2.2 (Ionian Sea)

GFCM GSAs: 15 and 16

The Adventure Bank, located south of Sicily, and the Malta Bank, located between Sicily and Malta, at depths of 100 to 200m

Environment: Demersal

Coordinates

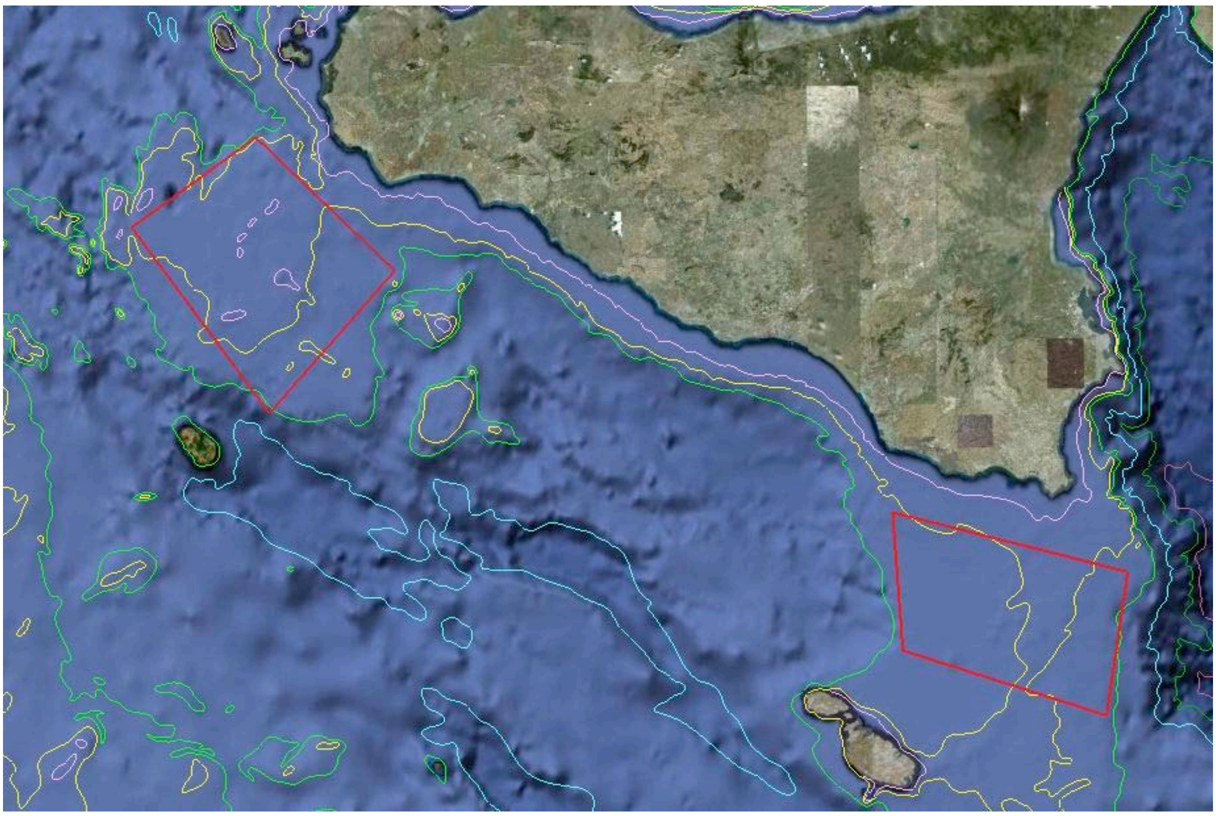
This is a disjoint area covering the two shelves known as the Adventure Bank (GSA 16) and the Malta Bank (or Malta Plateau) (GSA 15, with a small part in 16).

Adventure Bank		Malta Bank	
37º41'N	12º11'E	36º36'N	14º30'E
37º18'N	12º42'E	36º25'N	15º21'E
36º53'N	12º15'E	36º00'N	15º16'E
37º25'N	11º44'E	36º12'N	14º32'E

Area: Adventure Bank: 3,759 km^2

Malta Bank: 3,264 km^2

Total: 7,023 km^2



Justification

These are two important nursery areas for hake. Most of the hake here is caught by bottom trawlers. Along the southern coasts of Sicily, the shelf is widest in the westernmost (Adventure Bank) and easternmost (Malta Bank) sectors (Fiorentino *et al.* 2003). The general spatial pattern in the whole region shows that hake occurs at any life stage at the Adventure and Malta Banks, two areas separated by a wide area where hake is very scarce. Specifically, two areas where the young of the year are highly and almost exclusively concentrated (nurseries) were identified on the eastern sides of both the Adventure Bank and the Malta Bank respectively, at depths ranging mainly between 100 and 200 m (Fiorentino *et al.* 2003, Fiorentino *et al.* 2006, Garofalo *et al.* 2007).

Management

It is recommended that fishing with any towed gear be restricted.

Priority

This area is of high importance for hake.

6.3 The Thracian Sea

Situation

37.3 Eastern Mediterranean.

FAO Statistical Area 37.3.1 (Aegean Sea)

GFCM GSA: 22

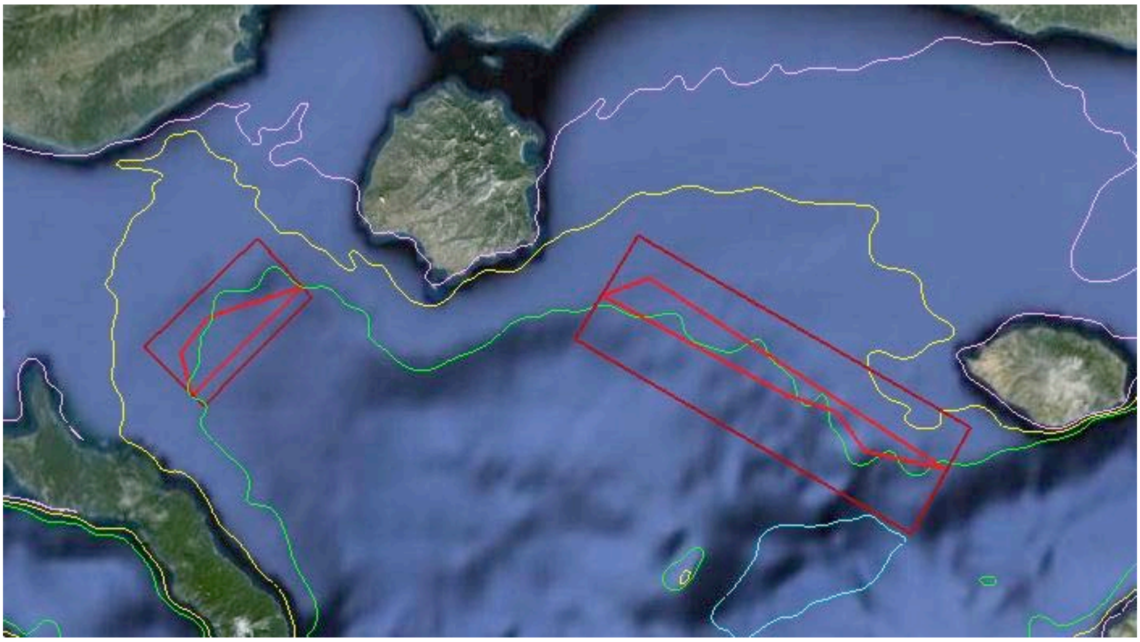
Environment: Demersal

Coordinates

This is a disjoint area covering the two shelves known as the Strymonikos Gulf and the Samotraki Plateau.

Strymonikos Gulf		Samotraki Plateau	
40º33'38"N	24º25'07"E	40º33'00"N	24º53'05"E
40º25'51"N	24º14'48"E	40º34'15"N	24º57'25"E
40º28'52"N	24º13'44"E	40º20'36"N	25º24'57"E
40º31'23"N	24º16'12"E	40º21'54"N	25º17'26"E
		40º24'43"N	25º14'51"E
		40º25'58"N	25º10'07"E

Area:	Strymonikos Gulf:	63 km^2
	Samotraki Plateau:	153 km^2
	Total:	116 km^2



Justification

The Samotraki Plateau and the Strymonikos Gulf are two demersal areas located in the north of the Aegean Sea, around 180 m depth, proposed to protect spawning grounds for hake. In 2008 this area was proposed by the GFCM as a FRA for trawling activities.

This area is considered one of the most productive areas for hake in Greece; research on length frequency distribution indicates that high densities of juveniles are present in this area (Valavanis *et al.* 1998, Kallianiotis *et al.* 2004, Maravelias *et al.* 2007). The proposed area is an important fishing ground for bottom trawlers: approximately 20 artisanal Greek bottom trawlers and an estimated 30 industrial bottom trawlers flying other flags. Bottom trawling activities increase the mortality rates of young individuals of all species in the 180 m isobath area of the Thracian Sea. Furthermore, especially as far as hake is concerned, the nursery and breeding grounds lie mainly in international waters in the Aegean and Thracian Seas (given the fact that Greece's territorial waters extend to 6 nautical miles) and therefore are not protected by any conservation regime.

Buffer area

The areas proposed are rather small and of strange shape. Because of this, establishing buffer areas around the original proposals is suggested. These buffers will make the areas easier to control, avoid boundary problems and enlarge the areas to reasonable protection size.

The buffer area coordinates are:

Strymonikos Gulf		Samotraki Plateau	
40º37'N	24º21'E	40º30'N	24º50'E
40º33'N	24º26'E	40º37'N	24º56'E
40º25'N	24º16'E	40º23.5'N	24º27'E
40º29'N	24º10'E	40º16'N	24º21.5'E

And their surface area:

Strymonikos Gulf:	224 km^2
Samotraki Plateau:	798 km^2
Total:	1,022 km^2

Management

Prohibition of towed gear within the smaller areas, and control and limitation of the effort in the buffer area, is recommended.

Priority

The Thracian Sea in the North Aegean Sea is an important nursery area for hake in Greece.

6.4 *Lophelia* reefs off Santa Maria di Leuca

Situation

37.2 Central Mediterranean.

FAO Statistical Area 37.2.2 (Ionian Sea)

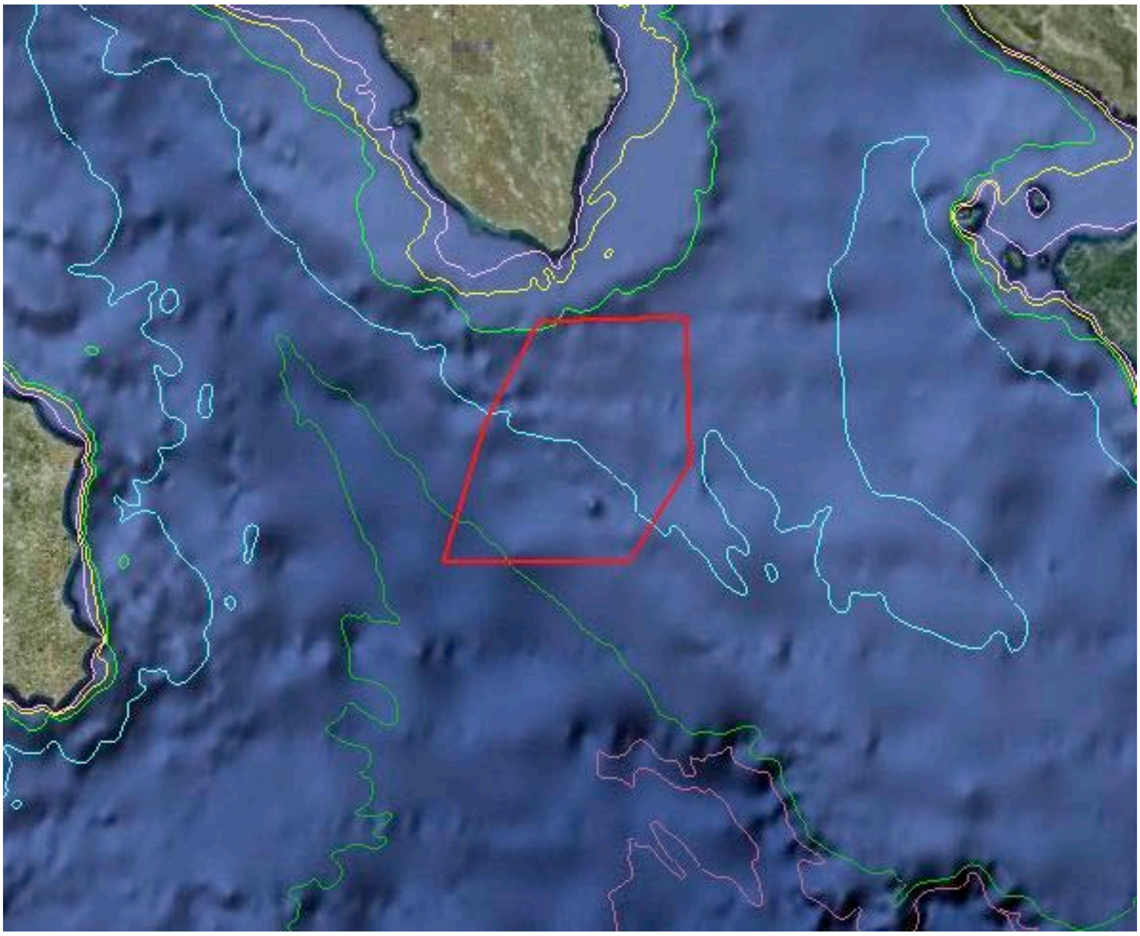
GFCM GSAs: 19

Environment: Demersal

Coordinates

39º27,720'N	18º10.740'E
39º11.160'N	18º04.290'E
39º11.160'N	18º32.580'E
39º22.704'N	18º41.550'E
39º39.789'N	18º40.980'E
39º39.318'N	18º18.684'E

Area: 2,183 km^2



Justification

Cape Santa Maria di Leuca is a demersal priority site in the south-east of Italy, selected because of the presence of *Lophelia pertusa* reefs and other seabed features that need to be protected from bottom fishing. Deep water coral banks dominated by living colonies of *L. pertusa* accompanied by Madrepora were discovered by Italian scientists off the coast of Santa Maria di Leuca (Apulia, Italy) at depths between 425 m and 1,110 m (Tursi *et al.* 2004, Taviani *et al.* 2005). This was an important discovery as, until very recently, this was the only known living large *Lophelia* reef in the Mediterranean. In January 2006, the GFCM declared a FRA for deep sea fisheries off Cape Santa Maria di Leuca and has prohibited fishing with towed dredges and bottom trawl nets specifically to protect the coral banks there. There is a fishery from Gallipolli operating around the area targeting deep water shrimps (*Aristeus antennatus* and *Aristaeomorpha foliacea*) (SCMEE, 2005). Hake is also found in the area (Carlucci *et al.* 2009). The white coral reefs may function as nurseries for many deep water species and centres of extension for the associated fauna, with positive “spill-over” effects on the deep water demersal resources. The GFCM endorsed as a FRA regarding trawling activities (Recommendation GFCM/2006/3) an area demarcated by the following coordinates, covering a surface of 974 km^2.

39º 27.72’ N	18º 10.74’ E
39º 27.80’ N	18º 26.68’ E
39º 11.16’ N	18º 04.28’ E
39º 11.16’ N	18º 32.58’ E

Further information (Tursi, com.pers.) enlarged the area of *Lophelia* presence to the proposed coordinates.

Management

All demersal fishing activities could be restricted in this area due to the high vulnerability of its components.

Priority

Occurrence of SH composed of *L. pertusa* reefs; habitat for hake and red shrimp.

6.5 Fosa di Pomo /Jabuka Pit

Situation

37.2 Central Mediterranean.

FAO Statistical Area 37.2.1 (Adriatic Sea)

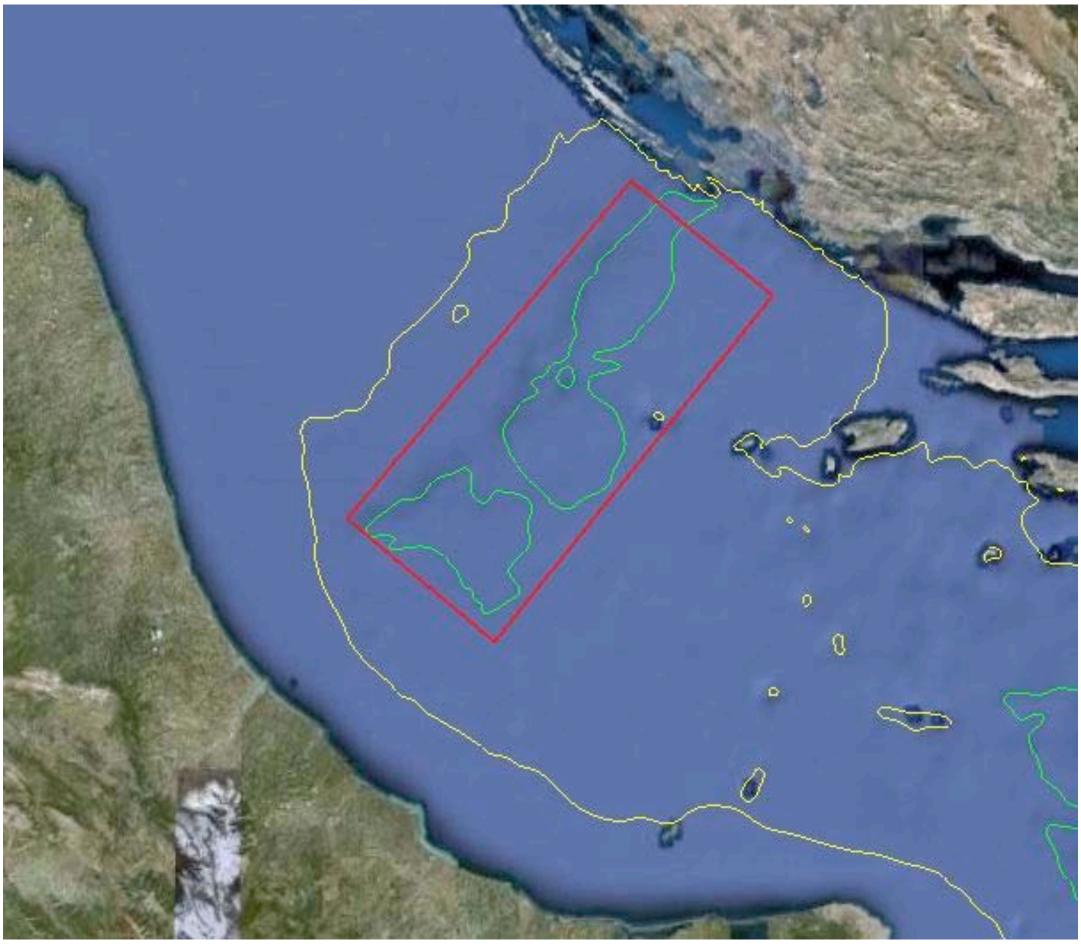
GFCM GSA: 17

Environment: Demersal

Coordinates

43º38'N	15º23'E
43º22'N	15º50'E
42º34'N	14º57'E
42º51'N	14º29'E

Area: 5,481 km^2



Justification

The Jabuka Pit is a bank located in the central Adriatic and proposed as a priority area in that it is an important nursery area for demersal species (AdriaMed 2001, Cardinale *et al.* 2008). Spawning of hake in the central Adriatic occurs throughout the year with two peaks in the winter and the summer; the earliest spawning occurs in the winter in deeper waters down to 200 m in the Jabuka Pit (where the greatest depths in the area are observed). In the summer period, spawning occurs in shallower waters (Jukic-Peladic & Vrgoc 1998).

Management

Effort limitation of any demersal fishing activities, and prospective prohibition in the deeper areas, are recommended.

Priority

This is a very important source area of hake juveniles in the central Adriatic (CIHEAM 2008).

6.6 The Eratosthenes Seamount

Situation

37.3 Eastern Mediterranean.

FAO Statistical Area 37.3.2 (Levant)

GFCM GSA: 26

Environment: Demersal

Coordinates

34º00'N	33º00'E
33º00'N	33º00'E
33º00'N	32º00'E
34º00'N	32º00'E

Area: 10,295 km^2

Justification

The Eratosthenes Seamount is located south of Cyprus and north of the Nile Delta, rising up from the seafloor to 800 m below sea level. Here rare coral species can be found, such as *Caryophyllia calveri* and *Desmophyllum cristagalli* (Varnavas *et al.* 1988, Galil & Zibrowius 1998). No fishing activity is reported in the area. It is probably the most pristine environment in the Mediterranean, and because of this needs protection status to avoid the threats posed by human activities (SCMEE, 2005[6]). This area was endorsed in 2006 as a restricted area for trawling activities (Recommendation GFCM/2006/3).

Management

All demersal fishing activities could be restricted in this area due to the high vulnerability of the seamount ecosystem.

Priority

Because of the unique ecosystem this Seamount maintains, it is included as an area proposal, where bottom fishing activities could be restricted.

[6] http://www.cmima.csic.es/pub/scmee/Subcommittee_2005/SCMEE_report_2005.pdf

6.7 Nile hydrocarbon cold seeps

Situation

37.3 Eastern Mediterranean.

FAO Statistical Area 37.3.2 (Levant)

GFCM GSA: 26

Environment: Demersal

Coordinates

31º30.00'N	34º10.00'E
31º30.00'N	34º00.00'E
32º00.00'N	34º00.00'E
32º00.00'N	33º10.00'E

Area: 4,374 km^2

Justification

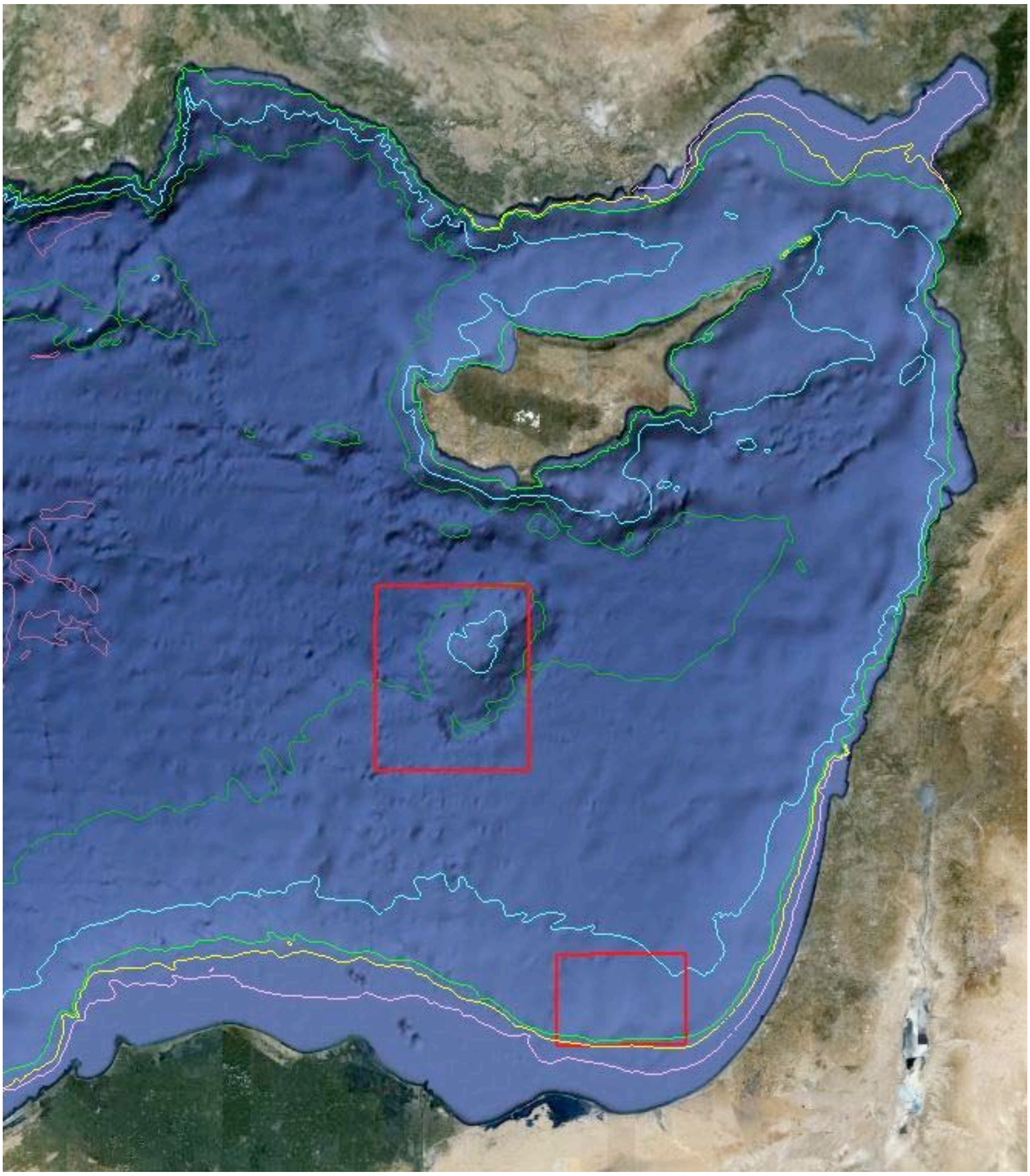
A highly concentrated region of cold hydrocarbon seeps was observed in the southeastern Mediterranean Sea, in front of the Nile Delta, between 300 and 800 m off the continental slope of North Sinai (Egypt) and the Palestinian Authority Gaza Strip (Mascle *et al.* 2000, Coleman & Ballard 2001). The Nile Deep Sea Fan hosts numerous cold seeps, which emit fluids, gases and mud. Compounds contained in cold seep emissions are often capable of supporting diverse microbial metabolisms (Omoregie 2005). The deep waters of the Nile Fan, with their associated submarine canyons and cold seeps, are areas of high biodiversity (Greenpeace 2004). This area was endorsed as a FRA by the GFCM in 2006 (Recommendation GFCM/2006/3).

Management

All demersal fishing activities could be restricted in this highly vulnerable habitat.

Priority

This area harbours the unique cold seep environment (Duperron *et al.* 2007, Dupré *et al.* 2007), highly vulnerable to fishing activities, although not currently exploited by trawling. It is proposed as a demersal priority area for bottom fishing to avoid degradation.



The Eratosthenes Seamount / Nile hydrocarbon seep

6.8 Bottoms below 1,000 m

Situation

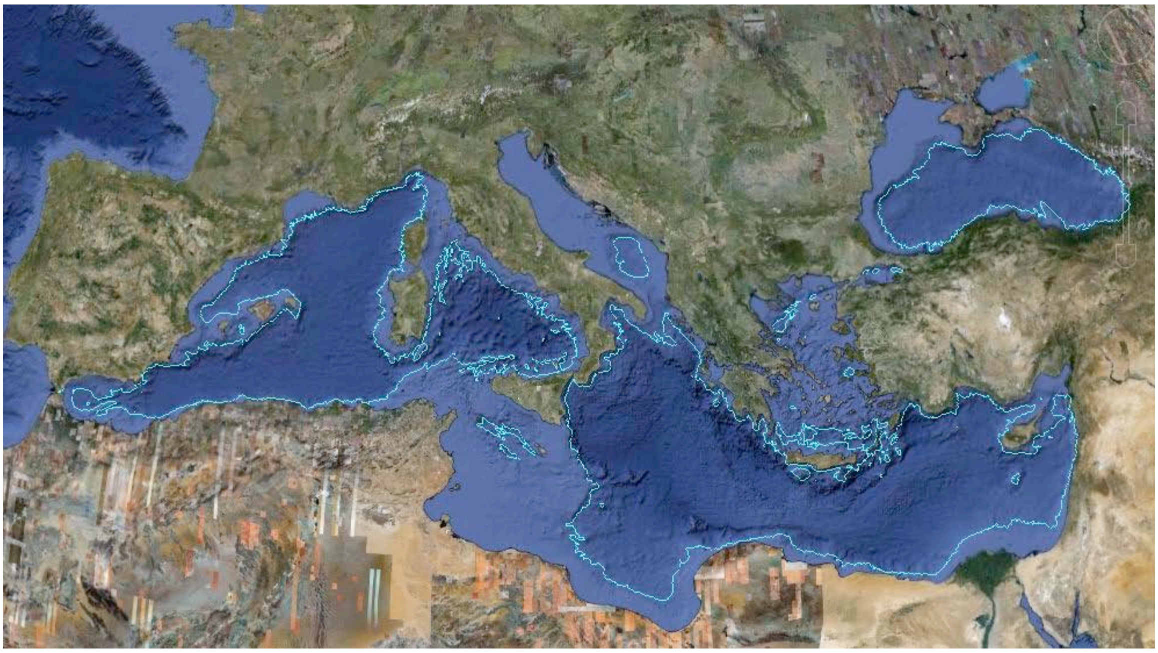
All the Mediterranean

Environment: Demersal

Coordinates

Defined by the 1,000 m isobath. Two large disjoint areas (western and central-eastern) with some “islands” in the South Adriatic and Sicily channel (Pantelleria, Linosa and Malta troughs). Some smaller spots can be found in the Aegean and Tyrrhenian Seas.

Area: Approx 1,459,000 km^2 equivalent to 57.8% of the Mediterranean



Justification

The sea bottom below 1,000 m has been repeatedly described as a highly vulnerable area that harbours unique ecosystems that are poorly known and must be urgently protected. Tudela *et al.* (2004) present a summary of the main information available on the diversity, structure and functioning of Mediterranean deep sea ecosystems and the impact of fishing upon them. Much of the deeper part of the Mediterranean lies within international waters. The deep Mediterranean is quite young compared to the other main ocean basins and is markedly oligotrophic, especially the eastern basin, and dependent on inputs from the pelagic ecosystems above. The Mediterranean basins are therefore not as independent as other deep sea ecosystems. The main threat, especially to sessile organisms, is trawling for deep sea prawns. Discard from the near surface fisheries may favour scavenging species in the deep sea. Pollution may also pose problems for the Mediterranean deep sea (e.g. accumulation of marine waste), and climate change might affect the quality and quantity of food reaching the deep sea. There are a number of extreme environments in the Mediterranean including mud volcanoes and deep sea regions with chemosynthetic communities giving rise to high biodiversity. Brine pools at depths greater than 3,000 m have particular communities. There are also deep sea coral mounds and seamounts which may require protection.

There is a shift towards deeper fisheries in the Mediterranean as fleets expand and move away from the exploitation of existing resources. However, the deep sea resources show low biomass and low diversity of commercial species, and organisms show a conservative ecological strategy of low growth rates and low metabolic rate. These resources cannot sustain heavy fisheries.

Current scientific advice does not support any expansion in the range of depths at which fishing takes place. Some scientists from the NW Mediterranean strongly believe that there should be no fishing at depths greater than 1,000 m, based on the Precautionary Approach.

In this context the GFCM restricted all trawling activities below the 1,000 m isobath (Recommendation GFCM/2005/1): "The Members of the GFCM shall prohibit the use of towed dredges and trawl nets fisheries at depths beyond 1,000 m." It is proposed that this restriction should be reinforced by setting up a protected area for demersal fisheries below the above-mentioned depth.

Furthermore the Valencia Declaration (World Conference on Marine Biodiversity, 11-15 November 2008) stipulates that:

> *Deep-sea fisheries be authorised only where evidence has been gathered to conclusively demonstrate that a stock can be sustainably exploited in full compliance with FAO Technical Guidelines for deep-sea fishing in the high seas.*

Management

It is recommended that the use of any towed gear be prohibited at depths below 1,000 m.

Priority

High.

6.9 The Alboran Sea Seamounts

Situation

37.1 Western Mediterranean.

FAO Statistical Area 37.1.1 (Balearic)

GFCM GSAs: 1, 2 and 3

Environment: Demersal

Coordinates

Alboran Seamounts around the Djibuti Bank

35.9888	-3.68697	36.4307	-3.95989	36.0221	-3.38507
36.3387	-4.12237	36.4282	-3.95166	36.0132	-3.39329
36.3504	-4.12973	36.4243	-3.93853	36.0047	-3.40222
36.3589	-4.13147	36.2866	-3.54118	35.9894	-3.42203
36.3769	-4.12141	36.2855	-3.52751	35.9826	-3.43283
36.3862	-4.10771	36.258	-3.43846	35.9614	-3.4808
36.3998	-4.08782	36.2514	-3.42736	35.9548	-3.50693
36.4181	-4.04382	36.2366	-3.40688	35.9511	-3.53389
36.4231	-4.0273	36.2284	-3.39759	35.9525	-3.58843
36.4279	-4.01149	36.2107	-3.38112	35.9653	-3.64066
36.4306	-3.98202	36.2012	-3.37401	35.9758	-3.66477
36.4307	-3.96727	36.1159	-3.34747	35.982	-3.67613

Bottoms around Alboran Island

35.8429	-3.43867
36.0939	-2.92152
36.1381	-2.81207
36.0186	-2.65757
35.6959	-3.3405
35.8429	-3.43867

Motril Seamount

36.3833	-3.06667
36.4000	-3.00000
36.3500	-2.98333
36.3250	-3.05000

Area

Alboran Seamounts around the Djibuti Bank	2,001 km²
Bottoms around Alboran Island	1,586 km²
Motril Seamount	39 km²
Total	3,626 km²

Justification

The Alboran Seamounts are located between the European and the African continents, in the Alboran Sea, scattered through the whole area with the remains of an old volcano rising 15 m above sea level, part of a mountain crest (Alboran Island, 35º56'20''- 35º56'35'' N, 3º02'10''- 3º01'45'' W) (Templado 1986, Susana Requena com. pers.). Along the canyons of the Alboran Sea are deep water corals (UNEP-MAP-RAC/SPA 2003a). Hake is one of the most important target species for the trawl fisheries in this area; it is exploited in all trawlable areas from the Strait of Gibraltar to the Cape of Gata, including the deep bottom fishing grounds surrounding Alboran Island. Commonly small hakes are caught in shallow waters of about 50 m to 300 m depth, whereas adults reach the maximum depths exploited, 800 m, associated with the *Nephrops norvegicus* fishery (Cardinale *et al.* 2008).

A proposal for a FRA was presented to the SCMEE in 2005. According to the report of the meeting:

"The information provided by the "fact sheets" of the Alboran Sea seamount proposal was not considered sufficient to justify the conservation issues put forward by the proposal. Nevertheless, the SCMEE considered important for this deep sea habitat to initiate steps towards more effective conservation procedures. The first step to undertake this task is to collect data and references that testify the uniqueness and the high diversity of this particular ecosystem".

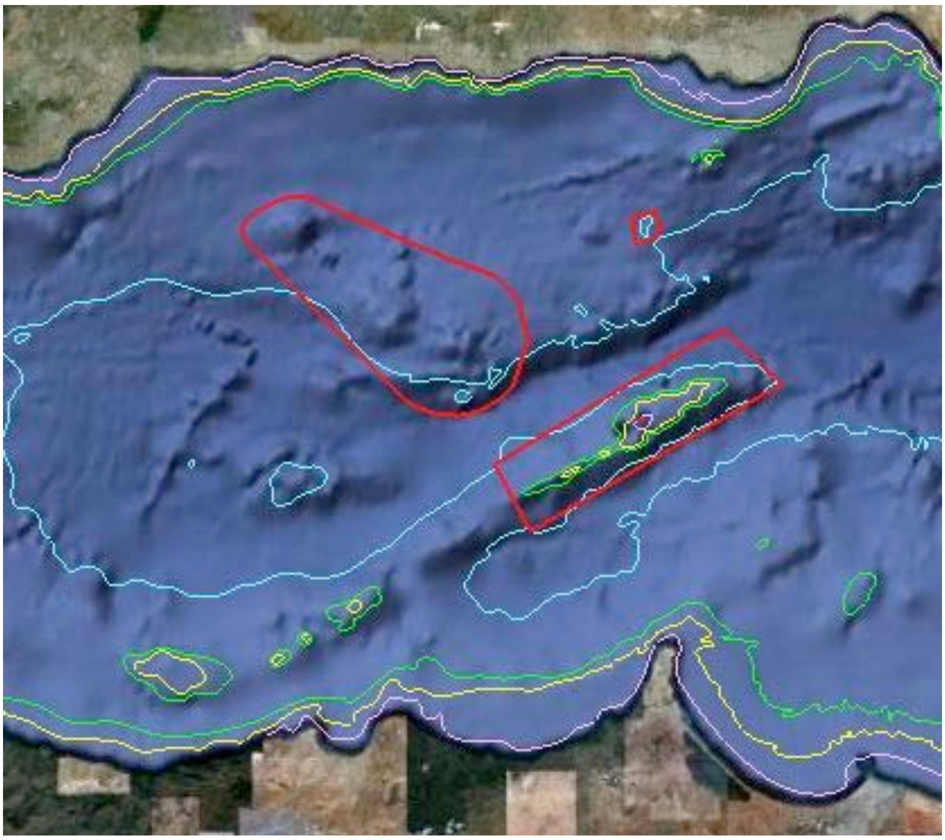
Considering that no new information has been provided to the GFCM, and that the management reasons for protecting this zone are still valid, the part of the proposal corresponding to the international waters is included in this proposal.

Management

The restriction and limitation of any demersal fishing activities should be considered.

Priority

Importance of protecting seamounts, cold coral reefs and canyons SHs.



6.10 South of the Balearic Islands

Situation

37.1 NW Mediterranean Sea.

FAO Statistical Area 37.1.1 (Balearic)

GFCM GSAs: 4 and 5

Environment: Pelagic

Coordinates

40º04’N	4º08’E
40º08’N	5º00’E
38º30’N	5º00’E
37º30’N	3º00’E
37º30’N	0º30’E
39º35’N	0º30’E
39º35’N	2º19’E
Southern Mallorca coastline	
39º45’N	3º28’E
39º55’N	3º49’E
Southern and eastern Minorca coastline	

Area: 84,348 km^2

Justification

The waters surrounding the Balearic Islands are an important spawning area for tuna and swordfish, two over-exploited migratory species. Moreover, this area is important for sperm whales, and the great white shark, a vulnerable species, is also recorded in the area (Greenpeace 2004, Roberts *et al.* 2006a). Historically the waters around the Balearic Archipelago have constituted one of the most important spawning grounds for bluefin tuna in the Mediterranean (Ravier & Fromentin 2001, García *et al.* 2002a, García *et al.* 2002b). Protection of this area is important to protect spawning adults of tuna in key spawning grounds in the form of no-fish zones or sanctuaries, and to avoid the capture of juveniles. These waters are proposed as a sanctuary for large pelagic species by setting up a Protected Area where pelagic fisheries using purse seine and longline could be prohibited. In 2008 WWF proposed the closure of this area to fishing due to its ecological importance (WWF 2008).

Management

Pelagic fishing for tuna and swordfish could be prohibited in this area to reduce the impact on tuna populations and by-catch of cetaceans and pelagic sharks.

Priority

This area is of high priority, being a spawning area for tuna and swordfish, and a concentration area for cetaceans.

6.11 The Strait of Gibraltar and Alboran Sea

Situation

37.1 Western Mediterranean.

FAO Statistical Area 37.1.1 (Balearic)

GFCM GSAs: 1, 2 and 3

Environment: Pelagic

Coordinates

36º10'N	6º01'W
35º40'N	6º00'W
36º32'N	2º00'W
35º34'N	1º35'W

Skirting the coasts of Morocco and Spain and Alboran Island

Area: 29,000 km^2

Justification

The Alboran Sea is an outstanding area for biodiversity in the Mediterranean (Tudela *et al.* 2005), being a transitional zone between the Atlantic Ocean and the Mediterranean Sea (Lloris & Rucabado 1998). The Alboran Sea is a migratory route for many species of tuna, whales, dolphins and turtles, including the internationally protected loggerhead turtle (*Caretta caretta*), from the Atlantic to the western Mediterranean, through the Strait of Gibraltar (Camiñas 1997, Royer *et al.* 2005). Among resident species, the short-beaked common dolphin (*Delphis delphis*) merits particular attention, because its population in the Alboran Sea is the healthiest in the Mediterranean, after a dramatic decline of the species in most of its Mediterranean range (Notarbartolo di Sciara 2002, Roberts *et al.* 2006a) The anticyclonic gyres in this area and the Almeria-Oran front create conditions of high productivity, which are the optimal conditions for large pelagic fish (i.e. tuna and swordfish) (De Metrio *et al.* 2005, Rodríguez-Marín *et al.* 2005).

Management

It is recommended that the pelagic fisheries' fishing effort be limited and controlled, with special attention paid to longlines, and that driftnets be completely eliminated in this area.

Priority

This area is important for large pelagic species, including tuna and swordfish, and presents cetaceans and turtles.

6.12 North of the Levantine Sea

Situation

37.3 Eastern Mediterranean.

FAO Statistical Area 37.3.2 (Levant)

GFCM GSA: 26

Environment: Pelagic

Coordinates

36º41'N	31º08'E
36º03'N	32º19'E
34º42'N	31º56'E
35º09'N	29º40'E

Area: 29,992 km^2

Justification

Bluefin tuna also spawns in the eastern Mediterranean; this has been confirmed since bluefin tuna larvae, as well as albacore and little tunny larvae, have been found in the south of the Anatolian peninsula (Karakulak *et al.* 2004, Oray & Karakulak 2005). This is the principal area for tuna spawning in the eastern Mediterranean (with a permanent population of bluefin tuna), and should be protected from fishing activities that target large pelagic species.

Management

As this area maintains a sedentary population of bluefin tuna, it could be made into a sanctuary by prohibiting tuna fisheries.

Priority

This area is important as the principal area of tuna spawning in the eastern Mediterranean basin.

6.13 The Sicily channel

Situation

37.1 Western Mediterranean and 37.2 Central Mediterranean

FAO Statistical Area 37.1.3 (Sardinia) and 37.2.2 (Ionian)

GFCM GSAs: 10, 12, 13, 14, 15 and 16

Environment: Pelagic

Coordinates

37º40'N	9º41'E
38º41'N	11º28'E
34º32'N	12º28'E
35º35'N	15º03'E

Skirting the Tunisian and Sicilian coasts and the main islands (Malta, Lampedusa, Linosa, Pantelleria, Zembra, Lampione)

Area: 97,639 km^2

Justification

The Sicilian channel between Sicily and Tunisia joins the western and eastern Mediterranean basins, and hosts many species from both areas. It is a highly productive area and represents a biodiversity hotspot within the Mediterranean (Roberts *et al.* 2006a). The Sicily channel is important as a "migrating" area for large pelagic species (Di Natale *et al.* 2005), as well as a spawning area for bluefin tuna (in the southern area). Italian surveys (Piccinetti *et al.* 1996a, b) found bluefin tuna larvae mainly concentrated all around Sicily (the Sicily channel, the southern Tyrrhenian Sea and the northern Ionian Sea). This area is also a spawning area of white shark.

Management

In this area, it is recommended that the pelagic fisheries' fishing effort be limited and controlled, with special attention paid to longlines, and that driftnets be completely eliminated. The southern area is a spawning area for bluefin tuna, and in the future, tuna fishing could be completely banned in this area.

Priority

It represents an important area as a migratory route for large pelagics, including tuna and swordfish.

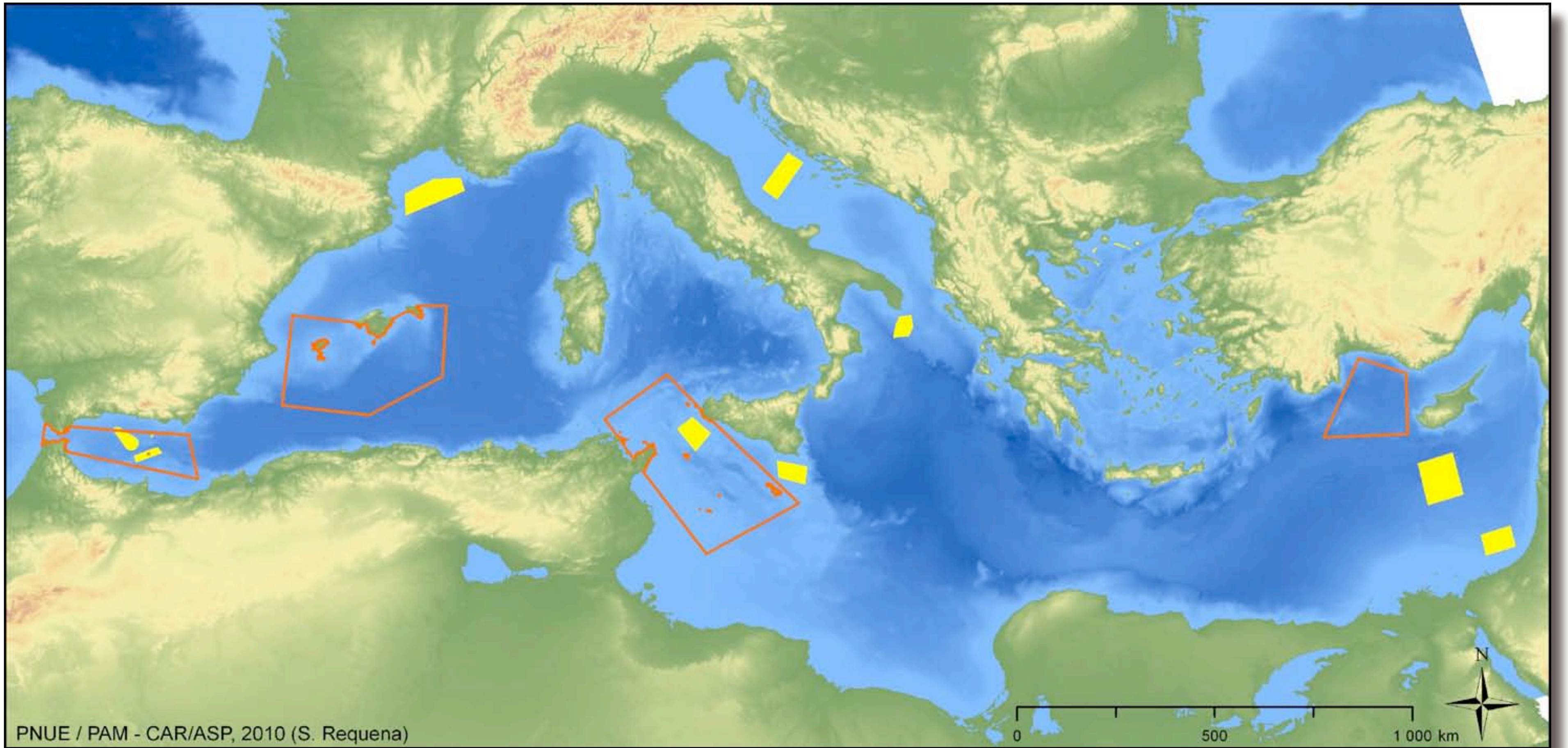


Figure 2: Priority areas regarding fishing impacts in the Mediterranean open seas, including the deep seas (green polygons represent pelagic priority areas and white polygons represent demersal priority areas).

7 Gaps in knowledge and future actions

i. There is a lack of information on Mediterranean deep sea ecosystems (much of the information is dispersed or in the unofficial literature). Moreover, few areas have been intensively studied (western basin: Spain, Italy, France), and many areas lack information (eastern basin and the North African coast).

ii. Many ecosystems located on the continental shelves and slopes are highly vulnerable to bottom fishing; these areas hold the highest intensities of fishing activity (close to the coast), and have been neglected in conservation programs. Included in these areas are the SH coralligenous, crinoidea beds, *Leptometra phalangium*; however, more information is necessary on distribution (their exact location being important).

iii. Most of the unique deep sea environments in the Mediterranean have been discovered only recently, enhanced by the use of newly available techniques (deep submersibles, ROVs). A further increase in our knowledge of Mediterranean deep sea ecosystems, paying special attention to their dynamics and to the influence of anthropogenic impacts on their functioning and structure, is necessary for their effective management.

iv. The proposed priority areas are based on the information available, but more studies should be done to construct a network of SPAMIs embracing the high seas that comprise them, with all the SHs and EFHs represented. A suitable network of SPAMIs in the Mediterranean should imply connectivity between the areas. The proposed list of priority areas comprises a relatively small list of key habitats that should be protected, as it is more feasible to protect a few areas with adequate information, than try to encompass within the SPAMI network all the SHs/EFHs that are vulnerable to fishing impact in the Mediterranean.

v. This report could be considered as a preliminary study of the Mediterranean open sea ecosystems; the authors consider that there is insufficient information about many Mediterranean open sea habitats to propose an exhaustive, complete list of areas that need protection from fishing activities.

vi. Each case study is unique in terms of the ecosystems and the fishery activities operating in them, so every proposed priority area should be considered as an isolated case for which much more information is necessary to suitably protect the ecosystems and monitor possible (negative/positive) changes.

vii. There are several problems regarding the implementation and effectiveness of the proposed areas: there are many countries involved, and if they are declared as open sea SPAMIs they would need a strong surveillance system (e.g. control of fishing vessels by VMS).

viii. The protection measures could be implemented through a well established network of SPAMIs that needs a well managed plan, surveillance and long-term monitoring program. Simultaneously, more effort could be dedicated to investigating open sea marine ecosystems.

8 Tables

TABLE 1. Claims to maritime jurisdiction (nautical miles) by states bordering the Mediterranean Sea. Modified from Cacaud (2005) Table A.1., UN Law of the Sea legislative database[7] and Suárez de Vivero (com. pers.). The Atlantic Ocean, Black Sea, Marmara Sea and Red Sea are excluded.

Country	Territorial sea width	Contiguous zone	EEZ, width (nm from baseline)	Fisheries protection zone (nm from baseline)	Other
Albania	12				
Algeria	12	24		32 and 52 (west and east of ~0º3'W respectively)	
Bosnia and Herzegovina					
Croatia	12				Ecological and fisheries protection zone to equidistant line
Cyprus	12	24	To equidistant line (to the south)		
Egypt	12	24	To the equidistant line		
France	12	24			Ecological protection zone to equidistant line plus a western zone
Greece	6				
Israel	12				
Italy	12	24			Historical bay (inner waters) in the Gulf of Taranto
Lebanon	12				
Libyan A. J.	12			62	Historical bay (inner waters) in the Gulf of Sirte
Malta	12	24		25	
Monaco	12				
Morocco	12	24	To the equidistant line		
Montenegro	12				
Slovenia					
Spain	12	24		To the equidistant line but excluding the Alboran Sea (~2º11'W)	
Syrian A. R.	12	24	To the equidistant line		
Tunisia	12	24	To the equidistant line		
Turkey	6				

The information contained in this Table has been taken from several published or on-line sources, and does not imply the expression of any opinion whatsoever on the part of the authors or UNEP-MAP-RAC/SPA.

7 http://www.un.org/Depts/los/LEGISLATIONANDTREATIES/index.htm

TABLE 2. Description of Mediterranean habitats/features relevant for fisheries as EFHs or SHs

Faunal assemblages	Continental shelf/slope	Coralligenous (maërl) *Funiculina quadrangularis* *Isidella elongata* *Leptometra phalangium*
	Deep sea	Deep sea sponges Cold coral reefs
	Chondrichthyans	Demersal/pelagic
	Pelagic fauna	Large migratory species (bluefin tuna, swordfish, albacore) Turtles Cetaceans
Geological features	Abyssal plains Cold seeps Mud bottoms /Banks Seamounts	Brine pools Hydrothermal vents Mud volcanoes Submarine canyons
Oceanographic features	Cascades Fronts Upwellings	Eddies Gyres

TABLE 3. Identification of marine ecosystems vulnerable to fishing activities in the Mediterranean open seas

Sensitive Habitats	*Leptometra phalangium*	Shelf edge off the Ebro Delta Shelf edge off the Northern Ligurian Sea
	Cold coral	Alboran Sea Algerian coasts Cape Sta. Maria di Leuca (200-1,100m deep) Gulf of Lions and Banyuls/Marseille canyons Ligurian Sea and western Corsica South of Malta Otranto channel Strait of Sicily Tyrrhenian Sea
	Isidella elongata	Continental slope N and S of Eivissa Island Continental slope off the Ebro Delta Northern Tyrrhenian (Giglio, Elba and Montecristo Islands) Southern Ligurian (Capraia islands and Livorno coast)
	Abyssal plains	Alboran abyssal plain Algerian-Balearic basin Calypso plain Hellenic trough Herodotus abyssal plain Ionian abyssal plain (Medina and Sirte plain, Herodotus trough) Tyrrhenian bathyal plain South-eastern Levantine Sea
	Seamounts	Alboran Sea Around the Balearic Islands and in the Valencia Trench Eratosthenes Seamount (south of Cyprus) Herodotus Seamount (off the coast of Libya) Medina Ridge South Tyrrhenian Sea (numerous seamounts)
	Cold seeps	South of Crete (Olimpi field and Anaximander mountain) Marsili Seamount in the Tyrrhenian Napoli Dome on the Mediterranean ridge Nile cold seep between the Gaza Strip and Egypt at 500-800m)
	Mud volcanoes	South of Turkey (Amsterdam, Kazan, Anaximander) South of Crete (Olimpi mud field) Northern Egypt near the Nile Delta
	Brine pools	In the eastern basin below 3,000m: Bannock, Urania, Discovery, Atalante and Tyro
	Hydrothermal vents	South Tyrrhenian Euboea volcanic arc (Aegean) Turkish coast

TABLE 4. Identification of Essential Fish Habitats in the Mediterranean open seas

Essential Fish Habitats	Demersal	Hake (*M. merluccius*)	Adventure and Malta Banks (Strait of Sicily) Castellò-Valencia shelf, and the Ebro and Rhone Deltaic areas Jabuka Pit Otranto channel (west Taranto Gulf) Samothraki Plateau and Strymonikos Gulf Slope of the Gulf of Lions
		Shrimp (*A. antennatus* and *A. foliacea)*	Submarine canyons in the western basin, e.g.: Along the Calabrian and Sicilian coasts Gulf of Lions North of the Balearic Islands Slope of the NW Ionian Sea
	Pelagic	Bluefin tuna	Alboran Sea Algerian sub-basin Anticyclonic Gyre S Tyrrhenian-W Sicily Gulf of Gabes and South Sicily-Malta South of the Balearic Islands
		Swordfish	Aegean Sea, around Crete and Cyprus Alboran Sea Strait of Messina Strait of Sicily South of the Balearic Islands South Sicily-Malta
		Albacore	Balearic area Ionian Sea SE Tyrrhenian-Strait of Messina Southern Adriatic Sea

TABLE 5. List of priority areas for conservation regarding fishing impacts in the Mediterranean open seas, including the deep sea

Priority areas	Justification	Management recommendations	References
Demersal areas: **Gulf of Lions Slope**	Hake spawning area; canyons for red shrimp; SH cold coral reefs and cold seeps	Control of any demersal fishing effort; prohibit fishing in the inner area	Aldebert *et al.*, 1993; Aldebert and Recasens, 1996; Recasens *et al.*, 1998; Cardinale *et al.*, 2008; GFCM, 2008b; Greenpeace, 2004
Demersal sites: **South of Sicily: Adventure and Malta Banks**	Hake nursery areas	Limit and control the effort of any towed gear	Fiorentino *et al.*, 2003; Fiorentino *et al.*, 2006; Garofalo *et al.*, 2007
Demersal areas: **Thracian Sea-** **Samothraki Plateau and Strymonikos Gulf**	Hake spawning grounds	Prohibit towed gear; control the effort in the buffer area	Valavanis, 1998; Kallianiotis, 2004; Maravelias, 2007
Demersal areas: **Santa Maria di Leuca**	SH *Lophelia* reefs	Prohibit any demersal fishing	Tursi *et al.*, 2004; SCMEE, 2005; Tavani *et al.*, 2005; Carlucci *et al.*, 2009
Demersal areas: **Fosa di Pomo/Jabuka Pit**	Hake spawning area; nursery area for demersal species	Control and limit any demersal fishing effort	Jukic-Peladic and Vrgoc, 1998; AdriaMed, 2001; CIHEAM, 2008; Cardinale *et al.*, 2008;
Demersal areas: **Eratosthenes Seamount**	SH seamount	Prohibit any demersal fishing activities	Varnavas *et al.*, 1988; Galil and Zibrowious 1998; SCMEE, 2005
Demersal areas: **Nile cold seeps**	SH cold seeps	Prohibit any demersal fishing activities	Mascle *et al.*, 2000; Coleman and Ballard, 2001; Omoregie *et al.*, 2001; Greenpeace, 2004; Duperron, 2006; Dupre, 2007;
Demersal areas: **Bottoms deeper than 1,000m**	SH, vulnerable deep sea fauna	Prohibit any towed gear	Tudela *et al.*, 2004
Demersal areas: **Alboran Sea Seamounts**	SH seamounts, canyons and cold coral reefs	Control and limit any demersal fishing activities	UNEP-MAP-RAC/SPA, 2003a; Cardinale *et al.*, 2008; Templado, report wwf
Pelagic areas: **South of the Balearic Islands**	Spawning area for tuna and swordfish; area of interest for sperm whale and white shark	Prohibit tuna and swordfish fishing	Ravier and Fromentin, 2001; Garcia *et al.*, 2002a, b; Greenpeace, 2004; Roberts *et al.*, 2006a; WWF, 2008
Pelagic areas: **Alboran Sea and Strait of Gibraltar**	Migratory route for large pelagics, abundance of cetaceans and turtles	Control and limit pelagic fishing (especially longlines). Eliminate driftnets	Camiñas, 1997; Lloris and Rucabado, 1998; Nortabartolo and Sciara, 2002; Roberts *et al.*, 2002a; De Metrio *et al.*, 2005; Rodriguez-Marin *et al.*, 2005; Royer *et al.*, 2005; Tudela *et al.*, 2005

Pelagic areas: **North of the Levantine Sea**	Spawning area for bluefin tuna	Prohibit tuna fishing	Karakulak *et al.*, 2004; Oray and Karakulak, 2005
Pelagic areas: **Sicily channel**	Migratory route for large pelagic species; spawning area for bluefin tuna and white shark	Control and limit pelagic fishing (especially longlines). Eliminate driftnets	Piccinetti *et al.*, 1996a and b; DiNatale *et al.*, 2005; Roberts *et al.*, 2006a;

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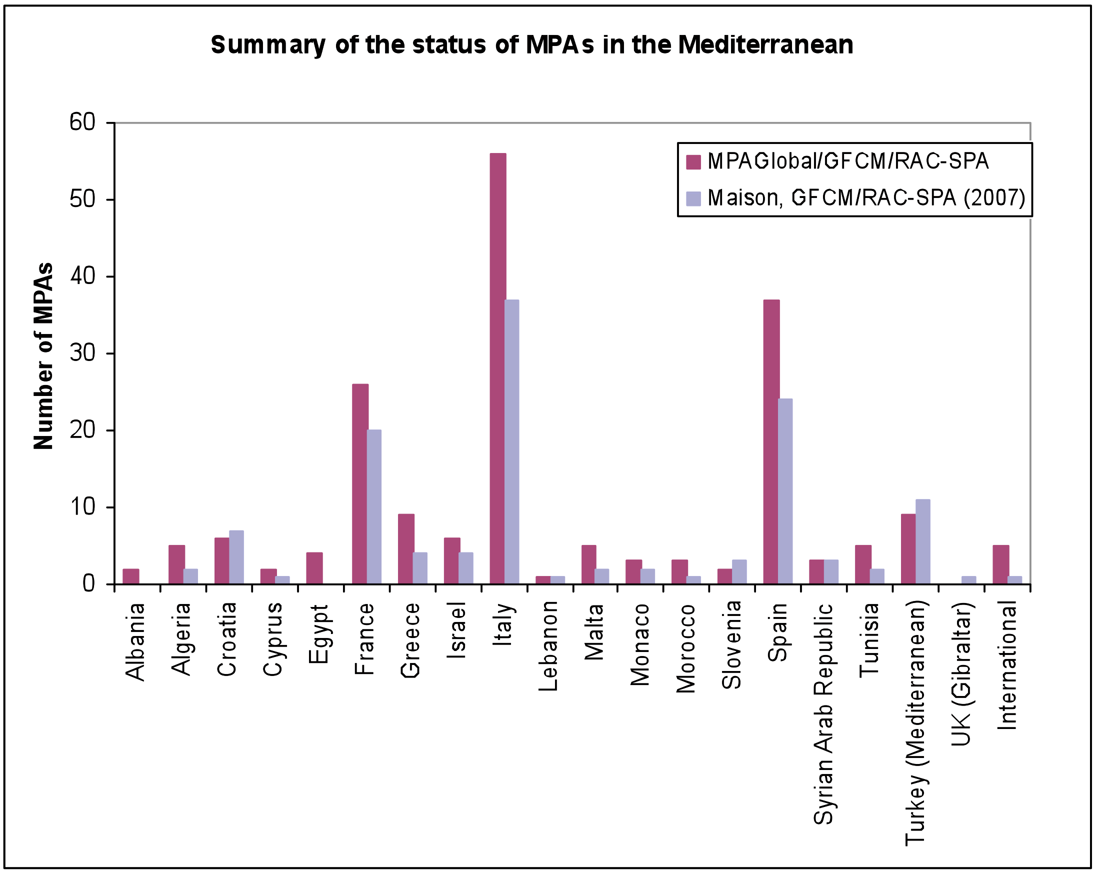
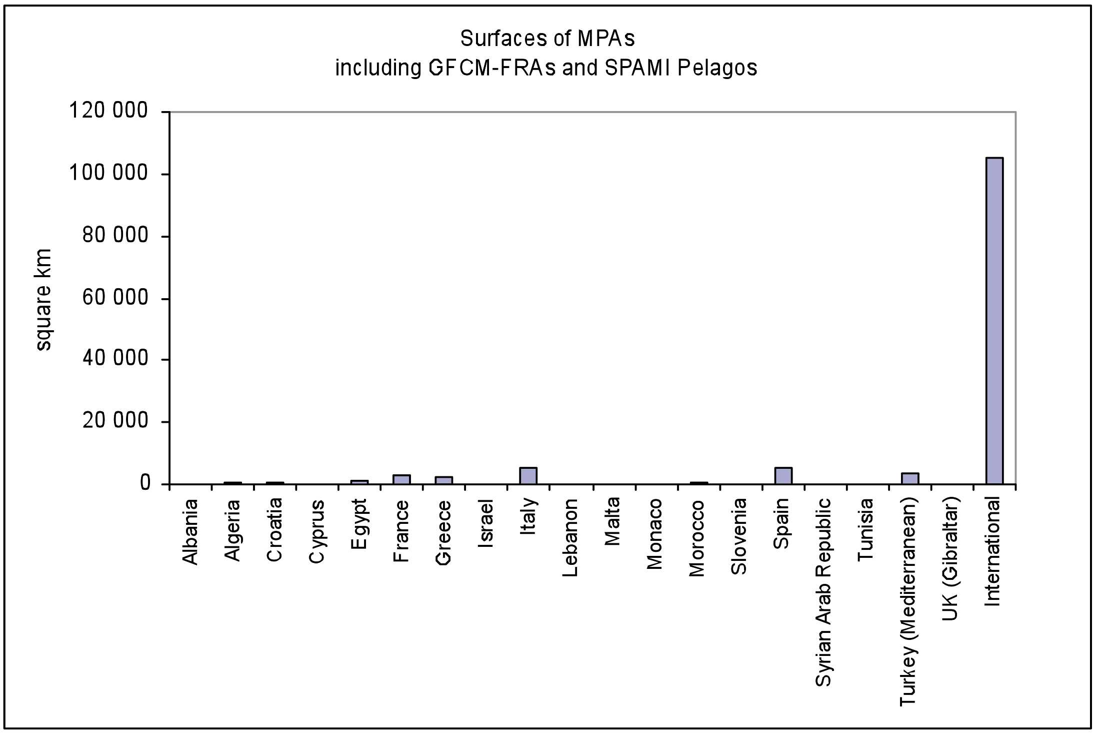
10 Annexes

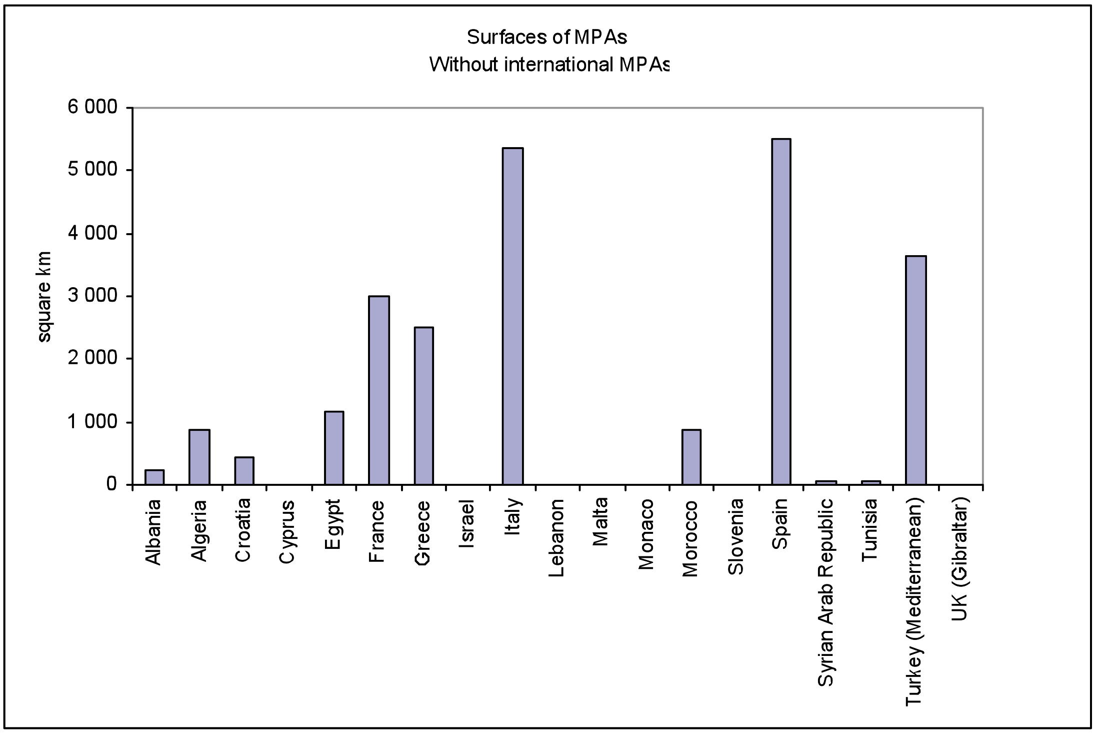
ANNEX 1. Formal designations under national legislation/international convention, of MPAs in the Mediterranean Sea, as appear in Wood (2007).

Aesthetic Forest
Area of Ecological Importance
Area of Ecological Importance/Site of Scientific Interest
Biological Reserve
Bird Sanctuary
Controlled Hunting Area
Core Zone in National Park
Fishery Reserve
Fishing Reserve
Game Breeding Station
Land Acquired by Littoral and Lakeside Conservator
Managed Nature Reserve
Marine Natural Protected Area
Marine Nature Reserve
Marine Nature Reserve
Marine Park
Marine Protected Area
Marine Protected Zone: Aquaculture Concession
Marine Reserve
Marine Reserve / Fishery Reserve
National Forest Park
National Game Reserve
National Hunting Refuge
National Marine Park
National Park
National Park (State Network)
National Park / Natural Marine Protected Area
National Park and Marine Protected Area
National Reserve
Natural Marine Protected Area
Natural Marine Reserve
Natural Monument
Natural Monuments and Landmarks
Natural Park
Natural Reserve
Nature Area of Special Interest
Nature Park
Nature Reserve
No Berthing Zone/No Entry Zone except for Fisheries
No-take Zone
Other Area
Protected Area
Protected Marine Area
Public Maritime Domain
Regional Natural Park
Regional Nature Reserve
Regional/Provincial Nature Park
Regional/Provincial Nature Reserve
Special Marine Reserve
Specially Protected Area
State Nature Reserve
Submerged National Park
Temporary Fishing Reserve
Trawl Ban Area
Zona di Tutela Biologica Marina

ANNEX 2. Existing MPAs in the Mediterranean







Surfaces of MPAs
Without international MPAs
6 000
5 000
4 000
3 000
2 000
1 000
0
square km
Albania
Algeria
Croatia
Cyprus
Egypt
France
Greece
Israel
Italy
Lebanon
Malta
Monaco
Morocco
Slovenia
Spain
Syrian Arab Republic
Tunisia
Turkey (Mediterranean)
UK (Gibraltar)

ANNEX 3. Operational criteria for the identification of potential SPAMIs in areas beyond national jurisdiction

Criteria categories

The proposed criteria are organised in four main categories following the SPA/BD Protocol. The first two emphasize the "per se" value of the area, while the next two address added values related to human interaction with the environment

- **i. - General criteria:** To be eligible for inclusion on the SPAMI List, an area must fulfil at least one of the general criteria set out in Article 8 paragraph 2 of the SPA/BD Protocol. Several of these general criteria can in certain cases be met by the same area, and such a circumstance can but strengthen the case for the inclusion of the area on the List.

- **ii. - Criteria concerning the regional ecological value of the area:** According to the SPA/BD Protocol, regional value is a basic requirement for the inclusion of an area on the SPAMI List. The criteria under this category should therefore allow in-depth assessment of the ecological features of the SPAMI candidate area.

- **iii. - Criteria concerning science/education/aesthetic interest:** The SPA/BD Protocol sets out criteria regarding three main aspects of knowledge benefits which can derive from the listing of an area as a SPAMI

- **iv. - Other favouring characteristics and factors:** They include criteria addressing the mitigation/neutralizing of threats and the opportunity for ecosystem-based management of the protected areas, including the possibility of different levels of community and general public participation in the area management. They are:

    - **Sustainable use criteria:** The criteria listed in this category are intended to assess (i) the threats generated to the marine environment by human activities and the uses of the marine environment and its living resources in the area, and (ii) the importance of the area to human well-being, including the sustainable use of the marine living resources and other ecosystem services

    - **Feasibility criteria:** These criteria are intended to assess the constraints that could be faced in the process of preparing the SPAMI proposal and in enforcing the protection and management measures. These include geopolitical issues, sovereignty conflicts, common use and logistic considerations.

Criteria description

i.- General criteria

An area must meet at least one of the three fundamental criteria below to become a SPAMI embracing zones located outside national jurisdiction
The SPAMI List may include sites which:
- are of importance for conserving the components of biological diversity in the Mediterranean;
- contain ecosystems specific to the Mediterranean area or the habitats of endangered species;
- are of special interest at the scientific, aesthetic, cultural or educational level.

ii. - Criteria concerning the regional ecological value of the area

The SPA/BD Protocol defined the following 5 criteria to assess the Mediterranean regional value of a candidate SPAMI[8]:

- Uniqueness: The area contains unique or rare ecosystems, or rare or endemic species.
- Natural representativeness: The area has highly representative ecological processes, or community or habitat types or other natural characteristics. Representativeness is the degree to which an area represents a habitat type, ecological process, biological community, physiographic feature or other natural characteristic.
- Diversity: The area has a high diversity of species, communities, habitats or ecosystems.
- Naturalness: The area has a high degree of naturalness as a result of the lack or low level of human-induced disturbance and degradation.
- Presence of habitats that are critical to endangered, threatened or endemic species.

Based on these criteria and taking into account the need for harmonization with other currently adopted criteria, in particular those adopted within the framework of the CBD, the following criteria are proposed to identify, in zones located beyond national jurisdiction, areas with a regional ecological value that could be proposed for inclusion on the SPAMI List:

1. Uniqueness or rarity: area contains either (i) unique ("the only one of its kind"), rare (occurs only in few locations) or endemic species, populations or communities, and/or (ii) unique, rare or distinct, habitats or ecosystems; and/or (iii) unique or unusual geomorphological or oceanographic features.
2. Special importance for life history stages of species: areas that are required for a population to survive and thrive.
3. Importance for threatened, endangered or declining species and/or habitats: area containing habitats for the survival and recovery of endangered, threatened, declining species or area with significant assemblages of such species.
4. Vulnerability, fragility, sensitivity, or slow recovery: areas that contain a relatively high proportion of sensitive habitats, biotopes or species that are functionally fragile (highly susceptible to degradation or depletion by human activity or by natural events) or with slow recovery.
5. Biological productivity: area containing species, populations or communities with comparatively higher natural biological productivity.
6. Biological diversity: area contains comparatively higher diversity of ecosystems, habitats, communities, or species, or has higher genetic diversity.
7. Naturalness: area with a comparatively higher degree of naturalness as a result of the lack of or low level of human-induced disturbance or degradation.

iii. - Criteria on scientific, educational, cultural or aesthetic interest

The area presents a particular value for research in the field of natural sciences, including ecosystem, species or genetic biodiversity; or for activities of environmental education or awareness; or for sustainable traditional activities (e.g. traditional artisanal fisheries) historically happening within it; or it contains outstanding natural features or seascapes which may enhance the human perception of the open and deep sea values.

[8] Criteria listed in the Annex 1 (Paragraph B. 2) of the Protocol. However, in addition to the criteria considered in this note, the "Cultural representativeness" is among the criteria recommended by the Protocol for the evaluation of the regional interest of areas to include on the SPAMI List. Since in the High Sea zones of the Mediterranean there are no "environmentally sound traditional activities integrated with nature which support the well-being of local populations", there is no need to include cultural representativeness in this category as a "regional value" criterion for the area being assessed as a feasible SPAMI.

iv. - Other favouring characteristics and factors

Sustainable Use Criteria

Currently, the main uses made of the marine ecosystem services in the Mediterranean areas beyond national jurisdiction are fisheries and navigation[9]. The following criteria are proposed to identify, in zones located beyond national jurisdiction, important areas for the sustainable use of the marine environment and its living resources that could be proposed for inclusion on the SPAMI List.

1. Importance for species exploited by fisheries: areas with essential habitats for important fishery species: these include areas with high concentration of at least one critical phase of a species exploited by fisheries, in particular:

   - Nursery grounds: areas with high concentrations of recruits

   - Spawning areas: areas of aggregation of mature females

2. Sensitivity to human activities: area highly susceptible to ecosystem services degradation by fishing, navigation or other human activities: these include areas having (i) assemblages and/or physical features particularly sensitive to the impact of fishing gear; (ii) high potential for negative interaction between the requirements of the conservation of species/habitats and some human activities; (iii) high value with regard to archaeological wrecked heritage vulnerable to degradation by fishing gears, looting or other; (iv) high value with regard to ecosystem services provision, such as climate change mitigation

Feasibility Criteria

Application of the feasibility criteria must not compromise compliance with existing obligations and commitments under regional and international agreements and conventions to protect biodiversity and designate marine protected areas in the Mediterranean Sea, including in areas beyond national jurisdiction.

1. Legal Status: the area is located in a zone where there are no uncertainties as to the delimitation of maritime boundaries or the solving of such uncertainties can be favoured through a common SPAMI management frame by the concerned countries.
2. Favourable context: the relationship between the concerned countries is favourable for the elaboration and submission of a joint SPAMI proposal[10].
3. Compliance with the provisions of International agreements or Conventions[11].

Feasibility to enforce the protection and management measures having regard to the location and extension of the area.

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[9] Other uses may appear in the future following technological advances mainly concerning energy production (wind; currents; waves), carbon capture and exploitation of non-living resources.

[10] The procedure set out 4 by the Protocol for the establishment of the SPAMI List requires that the SPAMI proposal be made by two or more neighbouring Parties concerned if the area is situated, partly or wholly, on the high sea and by the neighbouring Parties concerned in areas where the limits of national sovereignty or jurisdiction have not yet been defined.

[11] The establishment of a SPAMI on a given area may be challenging because of the restrictions that it could involve to freedom of navigation on the high seas, the right and the modalities of passage through straits used for international navigation and the right of innocent passage in territorial seas, as well as the nature and extent of the jurisdiction of the coastal State, the flag State and the port State.