High Seas Mediterranean Marine Reserves: a case study for the Southern Balearics and the Sicilian Channel

A briefing to the CBD’s Expert workshop on scientific and technical guidance on the use of biogeographic classification systems and identification of marine areas beyond national jurisdiction in need of protection

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Table of Contents

Abbreviations and Acronyms

ABB	Algero-Balearic Basin
AC	Algerian current
AIS	Atlantic Ionian stream
AW	Atlantic water
BC	Balearic current
BFT	Bluefin tuna
CBD	Convention on Biological Diversity
EEZ	Exclusive economic zone
EOW	Eastern Mediterranean outflow water
EU	European Union
FAO	Food and Agriculture Organisation of the United Nations
HERMES:	Hotspot Ecosystems Research on the Margins of European Seas
ICCAT	International Commission for the Conservation of Atlantic Tunas
IUCN	International Union for Conservation of Nature
LIW	Levantine Intermediate water
MAW	Modified Atlantic water
MPA	Marine Protected Area
POPs	Persistent Organic Pollutants
ROV	Remotely Operated Vehicle
SCRS	Standing Committee for Research and Statistics (ICCAT's scientific committee)
SPAMI	Specially Protected Areas of Mediterranean Importance, listed under the SPA protocol of the Barcelona Convention
SST	Sea surface temperature
WMED	Western Mediterranean

Executive Summary

The purpose of the Convention on Biological Diversity (CBD) is to ensure the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of any utilization. It covers all ecosystems, species and genetic resources and states that where there is a threat of significant reduction or loss of biological diversity, lack of full scientific certainty should not be used as a reason for postponing measures to avoid or minimize such a threat. The CBD also underlines the need for its Contracting Parties to cooperate for the conservation and sustainable use of biodiversity in areas beyond national jurisdiction. In 2004 the CBD took a major step forwards by committing to the establishment of a global network of marine protected areas (MPAs) by 2012 as set out in decision VII/28. This decision further specifies that this network should be composed of:

> *comprehensive, effectively managed, and ecologically representative national and regional systems of protected areas that collectively … contribute to achieving the three objectives of the Convention and the 2010 target to significantly reduce the current rate of biodiversity loss .*

The CBD's Programme of Work on protected areas requires States to address the shortfall of marine sites in the global network of protected areas. Progress in areas beyond national jurisdiction, however, is limited by the lack of an overarching global legal framework defining international responsibilities in this domain and the concomitant absence of mechanisms which can be used for the identification, creation and protection of such protected areas.

Individual marine species have complex relationships both with the physical habitats in which they live and with the other species living in them. Hence, holistic protection of marine ecosystems is crucial to the preservation (and restoration) of these complex relationships in the oceans. Marine protection efforts are, therefore, increasingly becoming focused on an ecosystem approach. In turn, the need for a precautionary approach which allows for uncertainties and indeterminacies has also been widely recognised. Such approaches are useful in the protection of high seas areas and areas falling outside national jurisdiction where little may be known about specific features and overall ecosystem function. In such environments there is also a need to act over a large geographical scale since many birds, marine mammals and other species are extremely wide-ranging species. (e.g. Roberts et al. 2006).

It is becoming increasingly accepted that networks of designated marine reserves have an important role to play in the protection of marine biodiversity and in the restoration of degraded marine ecosystems. In order to be effective in this role, the networks should include large scale fully protected reserves in which anthropogenic activities are prohibited. In addition, these networks should be fully representative of the whole range of different ecosystems, habitats and communities found in the oceans. Hence, the organization of a network of marine reserves as recently advocated by the world's nations at the World Summit on Sustainable Development (Johannesburg, 2002), and later by the Convention of Biological Diversity is particularly relevant to the emerging paradigm of marine environmental management based upon marine reserves.

In the above context, this document is aimed at strengthening the case for the establishment of Marine Reserves in two areas in the Mediterranean high seas, the waters surrounding the Balearic Islands and the Sicilian Channel. In doing so it broadly follows the criteria adopted by the CBD for identifying ecologically or biologically significant areas in need of protection in open-ocean waters and deep-sea habitats (COP 9, Decision IX/20) and applies them to the evaluation if the available scientific information.

The Sicilian Channel and the Balearic Islands have some common environmental and oceanographic features. Both areas are characterized by intense geostrophic circulation of water masses. The obstructions caused by the island topography generate mesoscale eddies and convergent fronts (Oray and Karakulak 2005, López-Jurado et al., 1995, Pinot J. et al., 1995; Vélez-Belchí and Tintoré, 2001;García et al., 2003; Alemany et al., 2007). Moreover, both areas have a remarkably complex bottom topography which includes diverse undersea features such as seamounts, escarpments, banks, pockmarks and mud volcanoes. The combination of complex topography with the ocean circulation patterns found in these areas that makes them highly productive and marks them as biodiversity hotspots.

Seamounts provide a good example of biodiverse and biogeographically important features. These are undersea mountains (usually of volcanic origin) rising from the seafloor but reaching a peak below sea level (e.g. Kennish 2001). In the Balearic archipelago, three seamounts can be identified: The Mont Ausias Marc, the Mont dels Oliva and the Emile Baudot. In the Sicilian Channel five volcanic seamounts have been described: Tetide, Anfitrite, Galatea, Cimotoe and Graham. These locations are of scientific interest because they appear to support unique biological communities such as those based upon the colonies of white coral (dominated by the scleractinians *Lophelia pertusa* and *Madrepora oculata*). In addition, the local water circulation patterns induced around the seamount summits, together with the rocky substrata, provide ideal conditions for complex epifaunal assemblages such as corals, crinoids and sponges. These communities represent sensitive habitat of high biodiversity value. They include, for example, colonies of the coral *Isidella elongata*, colonies of the cnidarian *Funiculina quadrangularis* and *Leptometra* beds on the deep shelf. All of these habitats are highly susceptible to the impacts of ground contacting trawling gear.

Seamounts also feature in the life cycles of a wide range of different species. These include some of high commercial importance (and which are currently overexploited). The eastern stock of Atlantic Bluefin tuna (*Thunnus thynnus*) migrate annually from the Atlantic Ocean into the Mediterranean Sea through the Strait of Gibraltar in order to spawn. The waters off the Balearic archipelago (i.e. south of the archipelago above the Emile Baudot seamount) and the Sicilian Channel, are two of the most important known spawning grounds for the species in the Mediterranean basin. Other pelagic species that also reproduce in these waters include Albacore (*Thunnus alalunga*) and Dolphinfish (*Coryphaena hippurus*), small tuna such as Frigate (*Auxis* sp)., little tunny (*Euthynnus alleteratus*), Atlantic bonito (*Sarda Sarda*) and skipjack tuna (*Katsuwonus pelamys),* Other large large scombroids such as Swordfish (*Xiphias gladius*) (e.g. Alemany et al., 2006) and small pelagic species anchovy (*Engraulis encrasicolus*) and round sardinella (*Sardinella aurita*) also spawn in these waters To an extent, the hydrological features influence spawning egg and larval dispersal and also recruitment processes. Overall, the mesoscale hydrographic features produced by the interaction between island topography and water masses, such as fronts and eddies, increase local productivity and retention (Bakun 2006), and the spawning strategies of tuna are adapted to release eggs near these areas.

Both the Balearic Islands and Sicilian Channel include habitat required for the survival and recovery of various endangered or threatened species (i.e. breeding grounds, spawning areas, nursery areas, juvenile habitat). The Mediterranean sperm whale sub-population is listed on the IUCN red list of threatened species and recently classified as Endangered (E) (Reeves and Notarbartolo 2006). The predominance of sperm whales around the southern continental shelves of the Balearics is due to the depth and the topography of this region being conducive to successful foraging. Other species listed as endangered include the striped dolphin, the common dolphin, and loggerhead turtles. The Pelagian Islands of Lampedusa and Linosa are the last known nesting sites of the loggerhead turtle in Italy.

Seabed pockmarks are another biologically important geomorphological feature. These are defined as “circular to ellipsoidal shallow craters typically 30-40 m in diameter and 2-3 m deep which occur as isolated depressions, in groups or in association with larger structures (Uchupi et al. 1996). The importance of pockmarks lies on the existence of cold seep type communities which are the home to unique chemosynthesis-based communities (not relying on photosynthetic production). These communities are dominated by bacterial mats and particular species of bivalves and tubeworms that are associated with endosymbiotic (chemo-autotrophic) bacteria. (Cartes et al., 2004).

Finally, in shallower waters, red algae concretions are arguably among the most complex and diverse communities of the Mediterranean Sea. They are related to a number of vulnerable habitats and are of great biological interest. Coralligenous beds are comprise a habitats strongly associated with gorgonian gardens, sponge fields and aggregations, caves and grottos, etc. Various species that are characteristic of coralligenous formations, such as red and yellow gorgonians, suffer serious damage due to frequent underwater dives in certain areas. Some species that live in association with coralligenous beds are considered threatened or endangered in the Mediterranean Sea, including the algae *Chondrymenia lobata*, *Halarachnion ligulatum*, *Halymenia trigona*, *Platoma cyclocolpa*, *Nemastoma dichotomum*, *Ptilophora mediterranean*, *Schizymenia dubyi* and *Laminaria rodriguezii*, as well as some associated molluscs like the date mussel (*Lithophaga lithophaga*), echinoderms like the longspined sea urchin (*Centrostephanus longispinus*), and fish such as *Sciaena umbra* and *Umbrina cirrhosa* (BARCOM 1995).

Although the Mediterranean environment has long supported a diversity of activities from early in human history, in recent years anthropogenic pressures have intensified. Fishing, pollution, tourism, and coastal development are recognised as the main drivers of biodiversity changes, along with the exacerbating effects of climate change. The presence of important morphological features associated with high biodiversity (e.g. seamounts) and the threat of damage to vulnerable habitats and species as a result of human activities makes these areas high priorities for inclusion in any future comprehensive and fully representative network of MPAs for the Mediterranean basin.

1. Introduction

Particularities of High Seas in the Med

The Mediterranean basin is located in the temperate zone of the Northern Hemisphere between 30 and–45ºN and has a marked seasonal cycle The Mediterranean is considered to be an oligotrophic sea and annual evaporation exceeds rainfall (Hopkins, 1978; Lacombe *et al.,* 1981). The Mediterranean Sea is an important ecological region with a high environmental diversity at both regional and local scales. Its waters host a high level of biodiversity with numerous endemic species, and it also has areas critical to the reproduction of pelagic species (Abdulla *et al.,* 2008).

The wide variety of habitats in the Mediterranean Sea results in an unusually high biodiversity for a temperate sea (Bianchi 2007). This high biodiversity comprises a wide range of species, from those of boreal Atlantic origin to those that are more typical of temperate and subtropical waters (Sará, 1985).

It has been estimated that around 26.6% of the total Mediterranean marine fauna (4238 species: Fredj *et al.,* 1992) are endemic. In the case of macrofauna these endemic organisms appear to be uniformly distributed through all the deep Mediterranean Basins.

A Representative Network of Marine Reserves for the Mediterranean

In 2006 Greenpeace published a proposal for a regional network of large-scale marine reserves with the aim of protecting the full spectrum of life in the Mediterranean (Greenpeace 2006). The network of candidate sites is made up of 32 different areas stretching from Alboran Sea in the west to the Phoenician coast in the east. Both the Balearics and the Sicilian Chanel were identified as areas to be protected within the network which was drawn up with the help of experts and used a variety of data sets including distribution of species, areas important for key life stages e.g. spawning grounds, important habitats such as seamounts and sites previously identified as priority sites for protection such as SPAMIs. The key principles of marine reserve networking were applied to the network design, ensuring that it is representative of the full range of habitats found in the Mediterranean Sea, has different habitat types replicated through the network, has sufficient levels of connectivity and is made up of sites that are sufficiently large to be viable. The total coverage of the network amounts to 40% of the Mediterranean.

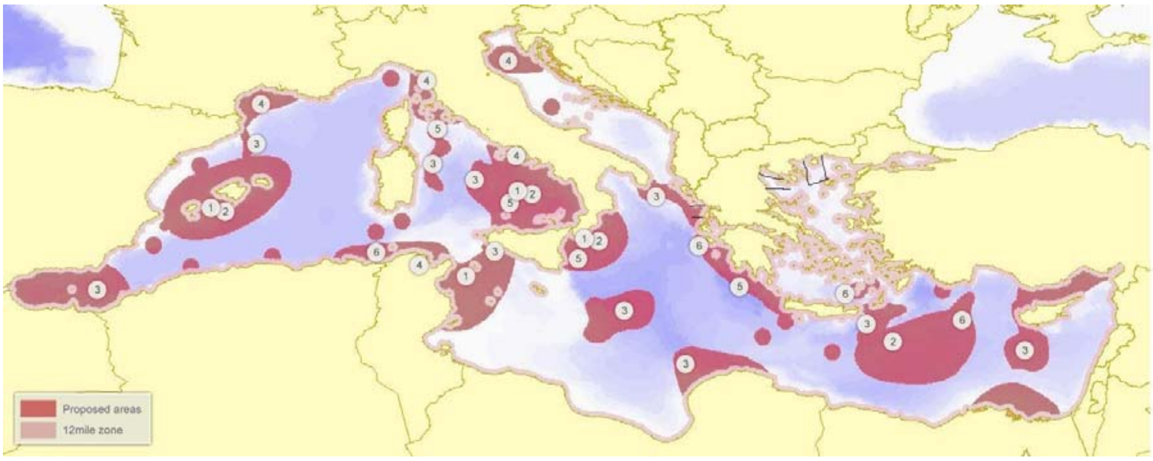


Fig. 1. Map showing Greenpeace's proposal for a network of marine reserves for the Mediterranean.

In May 2008 WWF published a proposal, supported by Greenpeace, to permanently close the waters surrounding the Balearics to fishing in order to protect the tuna spawning grounds. The report, *Spatial management to support recovery of the Atlantic bluefin tuna in the Mediterranean*, lays out the evidence for the continued importance of Balearic waters as a spawning ground for bluefin tuna and other large pelagics as well as setting out the political arguments. On the basis of the scientific evidence presented it also sets out the geographical boundaries for the area as presented in figure 2.

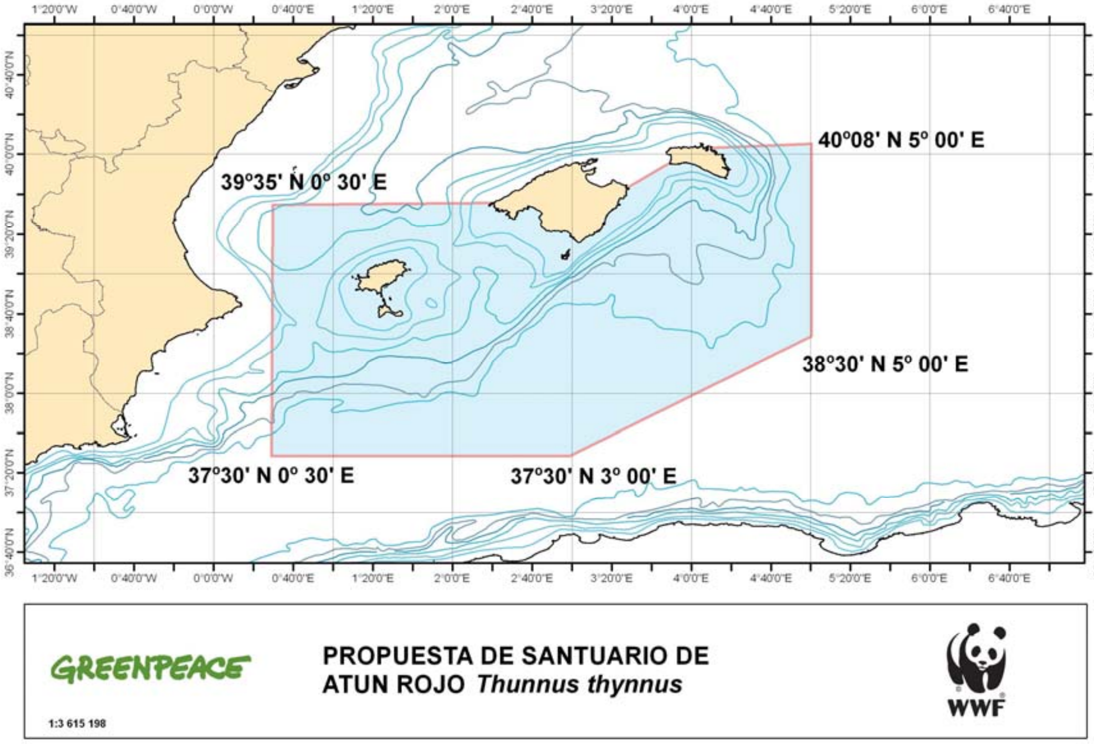


Fig. 2. Area proposed as a no-take marine reserve to protect the Balearic spawning grounds of the bluefin tuna.

Almost half of the currently designated MPAs in the Mediterranean are in the western part – 40 out of 94. However all of these are coastal with the exception of the Pelagos Sanctuary. The Pelagos Sanctuary is large-scale and covers 3.4% of the total surface of the Mediterranean Sea, however it confers little in the way of real protection. In total only 220.0 km2 or 0.01% of the Mediterranean Sea has been set aside as no-take areas and none of this is on the high seas (Abdullah et al. 2008).

The Balearic Archipelago is one of the richest European regions in terms of marine animal species diversity and is characterized by wide range of ecosystem types (e.g. maërl beds, *Leptometra* beds soft red algae communities, *Posidonia* meadows, etc) (Aguilar *et al.,* 2007) Some of these communities are rare considered on a European scale.

The Sicilian Chanel joins the west and east Mediterranean basins and hosts many species from both areas. It is highly productive and considered a biodiversity hotspot within the Mediterranean. Seamounts and deep-sea corals are found close to Sicily and the area is important to both fin and sperm whales as well as the great white shark.

Aim of this report

The aim of this report is to strengthen the case for the establishment of high seas marine reserves in the waters surrounding the Balearic Islands and the Sicilian Channel by identifying and compiling the scientific information available on the ecosystems found in these areas and then evaluating this information according to the criteria adopted by the CBD.

2. Existing research on the areas and availability of information

Current research

The Balearic Islands and the Sicilian Channel have both been subject of systematic research over a period of decades at both a national and international level. In the case of the Balearic Islands, the IEO(Spanish Oceanographic Institute – Balearic Research Centre) and IMEDEA-CSIC (Mediterranean Institute for Advanced Studies - University of the Balearic Islands) are the main Spanish research bodies with projects which embrace a wide range of disciplines (e.g. fisheries, conservation, oceanography, marine ecology, etc.). In the case of the Sicilian Channel, the ICRAM (Central Institute for Technical and Scientific Marine Research) is the main Italian research body. For both areas several Conservation Action Plans are being implemented involving National and Regional government as well as local, regional and national organizations.

At International level, CISEM (the Mediterranean Science Commission) is a relevant research body with more than 2000 marine scientists from 23 countries participating. In addition, both areas have been subject of research under various EU and Global Programmes. A selection of the most relevant are show in the table below.

Project	Funds	Aim	Main partners
MARFISH: Causes and consequences of changing marine biodiversity - a fish and fisheries perspective	Sixth EU Framework Program (2002 - 2006)	• Detect and identify mechanisms of large-scale and long-term change in biodiversity of fish and other exploited species (e. g., scallops, lobsters) • Predict consequences of changes in biodiversity of fish and other exploited communities on ecosystem functioning and human societies	MarBEF EU Network of Excellence
GLOBEC CLIOTOP	International Geosphere-Biosphere Programme IGBP	• The impact of climate change on top predators.	Scientific Committee on Oceanic Research (SCOR)
HERMES: Hotspot Ecosystems Research on the Margins of European Seas	Sixth EU Framework Program (2005 to 2009)	• Investigate Europe's deep marine ecosystems and their environment.	50 partners including 9 small companies, from 17 European and neighbouring countries.
BIOMARES	Fifth EU Framework Program (1998-2002).	• Aimed to establish a network of research sites and a series of indicators for biodiversity as the basis for long-term and large-scale marine biodiversity research in Europe	21 partners
BIOFUSE	Sixth EU Framework Program (2002 to 2006)	• Quantify the relationship between biodiversity and the functioning and stability of ecosystems with variable regimes of diversity and disturbance	MarBEF EU Network of Excellence 20 partners
MEDSURMED	Italian Ministry of Agriculture, Food and Forestry Policies	• Assessment and Monitoring of the Fishery Resources and the Ecosystems in the Straits of Sicily	FAO and representatives of Italy, Tunisia, Malta and Lybia

Gaps in current knowledge and areas for further research on the region

The Mediterranean Sea is one of the best researched. However, there are gaps of knowledge, since most of the research has been conducted responding to European interests and mainly concentrated on coastal resources. In that sense, the southernmost part of the areas proposed have received far less attention. In addition, the bulk of the research on the area has been focused on commercially valuable species. In recent years there has been more research carried out on the deep sea areas with many new discoveries. Such research has the potential to change our appreciation of their value. For many parts, the, existing information consists only of oceanographic information and there are important gaps in our understanding of the existing ecosystems. In consequence, the current report reflects such gaps.

3. Southern Balearics

3.1 Area description

One of the main features of the western Mediterranean Basin is the Balearic Promontory. It is located in the northeast of the Iberian peninsula and along this promontory are located the Balearic Islands of Ibiza, Formentera, Dragonera, Mallorca, Cabrera and Menorca. The whole promontory is 348 km length, 105 km wide and from 1000 to 2000 m high from surroundings basins (Acosta *et al.* 2004)

The Balearic Islands represent the natural limit between two sub-basins of the Western Mediterranean (WMED), the Algerian (located in the southern part) and the Balearic basins (in the north).

3.1.1 Main topographic features

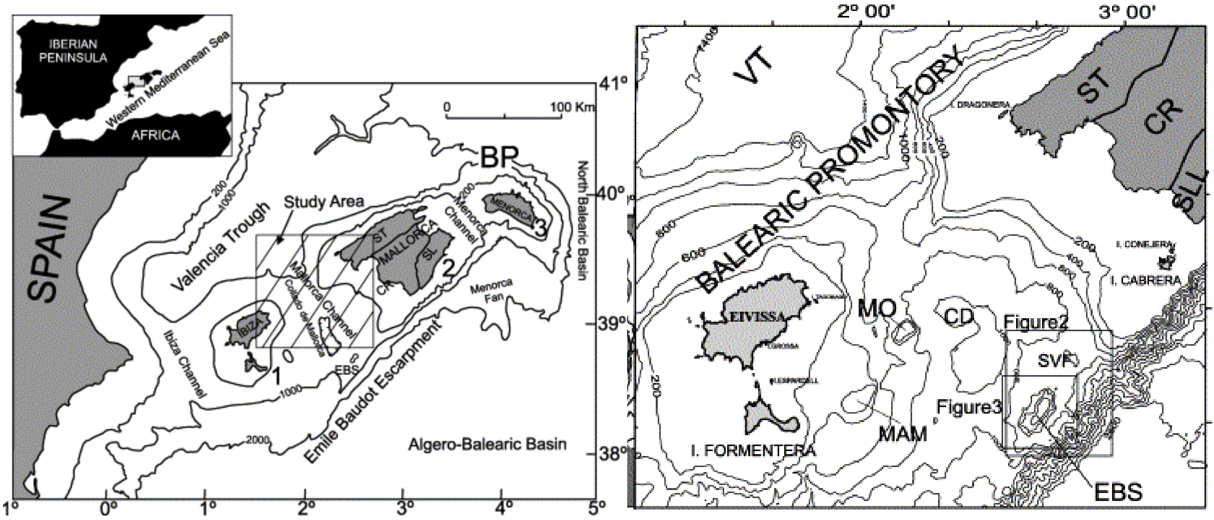
The Balearic Promontory is a major feature of the Mediterranean Basin with a very complex tectonic history. (Sábat *et al.*, 1995, Acosta *et al.,* 2002). The Balearic Islands of Ibiza, Formentera, Dragonera, Mallorca, Cabrera and Menorca are located along this promontory which is 348 km long, 105 km wide and elevated from between 1000 to 2000 m above the surrounding marine basins. (Acosta *et al.,* 2001a, 2002, 2004). The Balearic Islands represent the natural boundary between two sub-basins of the Western Mediterranean (WMED): the Algerian sub basin (located in the southern part) and the Balearic basin (located to the north). The Balearic shelf can be divided into two: the Mallorca – Menorca shelf to the east reaching up to 200m depth and the smaller Ibiza- Formentera shelf to the west, (up to 800 m depth). The sediments of the Balearic shelf are mainly biogenic sands and gravels with a high percentage of carbonates (77– 84%) and up to seven lithofacies have been identified at different depths and with different communities (Acosta *et al.,* 2002 Alonso *et al.,* 1988; Fornós and Ahr, 1997).

The Ibiza and Formentera shelf varies in width and slope. The shelf width is 2km with a slope of 4.11° to the east of Formentera, ranging up to to 25 km width with a 0.37° slope on the west side of the island (Acosta *et al.,* 2002). The Mallorca-Menorca shelf breaks at an average depth of 139 m (Amblas *et al.,* 2004). The coastline is predominantly rocky, while immediately offshore there are generally sandy bottoms with sea-grass meadows. In northern and southern Mallorca, however, embayments enlarge the shelf area and increase the presence of muddy-sand bottoms. The channels between Mallorca and Menorca and between Mallorca and Cabrera, where the maximum depth is 100 m, also effectively enlarge the continental shelf. The continental slope is steep, with an absence of submarine canyons, and the morphology is determined by emergent geological structures (Acosta *et al.,* 2001a, 2004) rather than by the input of sediment from the continental shelf.

At its deepest, the Balearic Sea can reach depths of 3000 m. Between Formentera and Mallorca a Central Depression reaches over 1000 m in depth. To the southeast of this lies the extensive SW Mallorca submarine Volcanic field which includes the Emile Baudot

Seamount and is around 500km^2 in area (Acosta *et al.*, 2001a; 2002). Two volcanic seamounts lie to the immediate east of Ibiza: Mont dels Oliva and Mont de Ausias Marc (Canals *et al.,* 1982). The Algero-Balearic Basin, (ABB) to the south of the promontory is the largest feature of the physical geography of the Western Mediterranean Basin. It covers an area of 240,000km^2 and includes the Balearic Abyssal Plain which lies to the east of Menorca (Acosta *et al.,* 2002). The ABB is bounded by the 2600 m isobath but reaches maximum depths of 2800 m (Acosta *et al.,* 2002). (See Figure 3)

Fig. 3. Bathymetry of the Balearic Promontory



NOTE: Contours of both maps are in meters

NOTE: AS = Alboran Sea; BP= Balearic Promontory; C= Corsica; CI = Columbretes Islands; CD = Central Depression; EBE= Emile Baudot Escarpment; EBS = Emile Baudot Seamount; F = Formentera; I = Ibiza; LB = Ligurian Basin; M= Menorca; MA= Mallorca; MAM= Mont Ausias Marc; MO= Mont dels Oliva; NB–PB = North Balearic– Provenc_al Basin; S = Sardinia; SB–AB = South Balearic–Algerian Basin; SBP= South Balearic Plateau; SVF= Southwest Volcanic Field; VT=Valencia Trough; ST = Serra Tramuntana, SLL= Serra Llevant, CR = Central Rift

SOURCE: Acosta et al., 2004 .

3.1.2. Currents and nutrients circulation system.

The Mediterranean Sea is considered to be a semi-closed ocean area with limited water exchange with the Atlantic Ocean through the Strait of Gibraltar. The water exchange takes place through a stratified circulation system. Atlantic water (AW) of relatively lower salinity enters via the Strait of Gibraltar at the surface and is exchanged with higher salinity Mediterranean water that flows into the Atlantic in a layer underneath the influent current. The Algerian sub-basin, therefore, receives new surface water from the Atlantic and its circulation dynamics are mainly driven by the density gradients caused by temperature and salinity differences. The Balearic sub-basin contains AW that has remained longer in the Mediterranean and which is of higher salinity. Dynamics are affected by atmospheric (mainly wind) forcings, (Hopkins 1978) making the Balearic region a transition zone where two important water masses with different physical, chemical and biological properties meet (Garcia *et al.,* 2006).The area is characterized by the intense density driven (geostrophic) circulation of water masses. Mesoscale eddies and convergent fronts arise as a result of the interactions of the circulating water with the obstructions posed by the islands (López-Jurado *et al.,* 1995, Pinot *et al.,* 1995, 2002). As a result, the hydrodynamics differ markedly between the areas of sea to the north of the Balearics and those to the south (López-Jurado *et al.,* 2008).

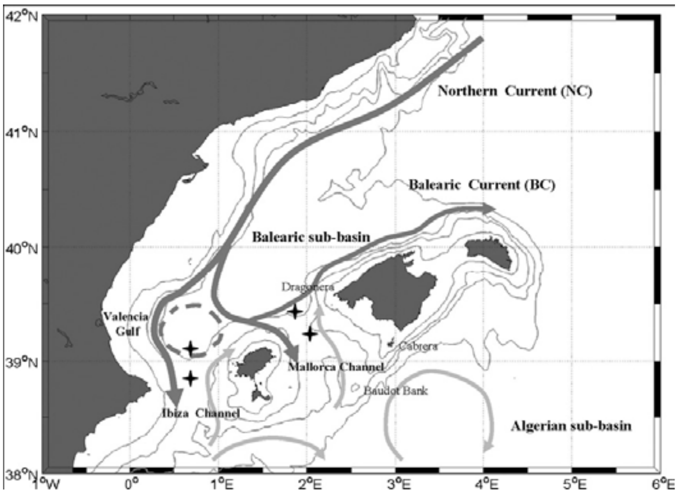


Fig. 4. The Balearic Islands and the major currents characterizing the regional circulation.
(SOURCE: López- Jurado *et al*., 2008)

Hydrodynamics in the Balearic area are very complex with several mesoscale features (e.g. eddies, fronts, etc). The southern area, in particular, generates regular anticyclonic eddies due to the bottom topography. Hence, this area effectively represents a convergence zones and, therefore, a strong retention zone (e.g. Pinot *et al.,* 2002; Millot 2005; Lòpez- Jurado *et al.,* 2008). The southern area is also influenced by the instability of the Almeria-Oran front and by mesoscale features generated from the Algerian current (AC) (Millot 2005). Blocking conditions can also be caused by the presence of large gyres located to the south of Ibiza and Formentera Islands. These gyres damp circulation through the channels and divert Atlantic surface waters towards Cabrera (south of Mallorca) and the Menorca Islands (Font *et al.,* 2004). In this area, very high salinity values (up to 38.6‰.) can be found in the intermediate layer. During the summer, the circulation of surface waters causes water of recent Atlantic origin to reach the Balearic Islands as eddies separated from the main current of Atlantic water that enters the Mediterranean through the Strait of Gibraltar. This is due to the instability of the Almeria-Oran front. Additionally, according to Acosta *et al.,* 2001b (Lòpez -Jurado personal communication) more recent measurement of the southerly flowing bottom currents suggest the presence of a cyclonic gyre towards the east of the channel. This gyre could reach a width of some 500m and could block the flow of the Mediterranean Intermediate Water. The surface waters forming the Balearic Currents (BC) are all of Atlantic origin but some are more recent Atlantic origin, i.e. have different residence times in the Mediterranean.

The presence of both new and older AW in the channels gives rise to ocean fronts that affect the ecosystem dynamics in the area. Moreover, the Mallorca and Ibiza channels play an important role in the regional circulation of this area and their topography conditions the water exchange between these two sub-basins (Pinot *et al.,* 2002). Inter-annual variations in the different water masses, as well as in their characteristic values, depths, thicknesses and areas of influence have been observed in this region (Pinot *et al.,* 2002; López-Jurado *et al.,* 2008;) These conditions influence the eventual formation of mesoscale structures and hence the regional circulation. This large scale situation defines the Balearic Archipelago, and particularly its southern part, as a convergence area, and therefore as a strong retention zone. There are high concentrations of nutrients due to the presence of fronts and mixing zones associated with reefs, canyons, seamounts and islands (Hyrenbach, 2000) that constitute physical obstacles for water masses.

3.2 Topographic Features of Remarkable Biological relevance

3.2.1. Seamounts

Seamounts rising from the seafloor support a diversity of important habitat types including maerl beds and deep sea coral communities (see: Santillo and Johnston 2003, Cartes et al., 2004) In addition seamounts support other complex benthic communities and serve as important habitat for many commercial fish species. Due to the way in which seamounts modify current regimes, rocky seamount substrata provide ideal conditions for attached epifauna such as corals, crinoids and sponges. Some deep sea corals and sponge fields may be thousands of years old and can form highly complex structures (Richer de Forges et al., 2000).

Multi-beam mapping surveys have identified three seamounts in the Balearic region: The Emile Baudot Seamount is located along the crest of the Emile Baudot Escarpment west of the Cabrera canyon and to the south of the Emile Baudot Escarpment (38°42'N and 002°20'E.). Of volcanic origin, this seamount rises more than 500m above the seafloor in waters of 650m depth and is flat-topped. The Mont Ausias Marc (northeast of Formentera) (38º.44'N and 001º.48'E.) rises from a depth of 300m and its summit lies at less than 125m depth**.** The Mont dels Oliva seamount is located east of Ibiza Island (38º.57'N and 002º.00'E) and rises from around 600 to a summit at 300m depth. (Acosta *et al*., 2001a, 2004). Like the Mont Ausias Marc, this seamount is of tectonic rather than volcanic origin. (Acosta *et al*., 2004).

Very little information has been published regarding the benthic communities that inhabit these seamounts (J. Acosta pers.commun). Nonetheless, a recent ROV survey of the three seamounts identified nearly 300 species living there. Rhodolith beds found on these mounds and seamounts reached down to 140-150 meters depth, although the most important ones were between 80m and 120m. The formations were particularly common over the top of Ausias Marc, but could also be found on Emile Baudot. Three forms of coralligenous beds were detected: (i) large bio-concretions, (ii) "cobbled" bio-concretions and (iii) thin sheets and small patches (see Aguilar *et al*., 2007).

Seamounts are particularly vulnerable to fishing and other human activities (Morato *et al.,* 2005, Stocks, 2004). The limited fixed habitat, the extreme longevity of many species (of the order of 100 years and more) and the apparently limited recruitment of organisms between seamount systems all compound the uncertainty of recovery from trawling activity which sweeps away the benthic epifaunal community as bycatch (Richer de Forges et al., 2000)

3.2.2 Pockmarks

Sea floor pockmarks are elliptical shallow depressions in the sea floor, 2-3m in depth and typically around 30-40m in diameter. They may be isolated features, occur in groups or be associated with other seafloor features. The importance of pockmarks lies on the possible existence of cold seep type communities which are the home to unique chemosynthesis-based communities (not relying on photosynthetic production).

Surveys carried out in the Ibiza Channel and on the east side of the Ibiza-Formentera platform have shown variously sized pockmarks to be present in these locations. (Acosta *et al*., 2001b). It is thought that these pockmarks have been formed by the escape of gases and water from an underlying hydrothermal field (Acosta *et al.* 2001). Large pockmarks on the seafloor of the Mallorca channel (Acosta *et al.* 2004) are attributed to venting of gases associated with the volcanic fields lying between Mallorca and Ibiza Islands and the northwards to Valencia Trough.

3.2.3 Volcanoes

Acosta et al. (2001a) have recently described a volcanic field in south Mallorca, located southeast of the Central Depression and in the vicinity of the Emile Baudot Seamount. The field includes some 118 cone-shaped volcanic structures varying from 8-501m elevating above the seafloor and with diameters of between 0.14 and 1.7km. These are though to be of igneous origin based on a sample of basalt recovered in an earlier survey of the area (Acosta *et al*. 2004b).

3.2.4 Submarine Canyons and Ridges

These geographical/geological features are considered to be key to biological and ecological processes in the Mediterranean basin. They channel energy and matter from coastal areas to the deep-sea, and also create local upwellings that are important in the life-cycles of many pelagic fish and of marine mammal species. Two main canyon systems have been identified on the continental slope of Mallorca-Menorca (Acostal *et al*., 2002), the Menorca Canyon System (MC) and the Mallorca-Cabrera canyon Biological communities linked to deep sea corals *Lophelia pertusa* and *Madrepora oculata* are present on the flanks of the canyons.

The Balearic and the Algerian basins are separated by a submarine ridge at ca.600m beneath the Mallorca channel between the islands of Ibiza and Mallorca (Acosta *et al.,* 2004b).

3.3 Rare, vulnerable and highly productive habitats present on the Southern Balearics High Seas.

The Balearic Islands are the location of rare, sensitive, vulnerable and highly productive deep water habitats which require conservation and protection. Continental slopes exhibit a mosaic of habitats with mixed soft and hard bottom faunal communities, although much of the slope seabed is covered by soft sediments (Pérès, 1985; Thistle, 2003). Maërl and Coralligenous beds have been described as areas of high diversity and two of the most productive marine ecosystems in temperate regions (Martin *et al.,* 2007). Both soft red algae and maërl beds are important for carbonate production on the Mallorca–Menorca shelf. In the clear waters off Balearic Islands these communities cover large and deep areas (up to ~80 and ~90 m, respectively) of the sea bottom (Ballesteros, 2003, 2006).

Deep-sea white coral assemblages (*Madrepora oculata*, and *Lophelia pertusa*) at the hard-bottom of the Balearic region are characterized by high-local productivity (Cartes *et al*., 2004) *Leptometra* beds in shelf-break high hydrodynamic areas with a high input of organic matter and plankton. enhances habitat heterogeneity by developing three-dimensional communities, thus allowing high rates of primary and secondary production (Massuti and Ordinas, 2006).

3.3.1 Shallow shelf habitats

Maërl

Maërl grounds have a high diversity and also support a high level of macro-benthic secondary production,. This, in turn, may be important for species which are commercially exploited. These communities have a low rate of turnover (50-75 years lifespan). They are home to a number of economically important species (fishes, cephalopods, crustaceans). This habitat is subject to different anthropogenic stresses in particular the excessive sedimentation and damage from trawling. The latter results in fragmentation, dispersing of rhodoliths, and modification of the biological community. (Barbera *et al.,* 2003).

Maerl bottoms are widespread along all Balearic coasts between 20-90m depth. The beds are mainly built up of red algae of the family Corallinacea (BALAR0502), The brown alga *Laminaria rodriguezii*, together with various species of echinoderm and ascidian is also found on these bottoms. Some trawl fishing grounds are active over these beds targeting fish associated with them. These include *Serranus cabrilla*, *Scorpaena scrofa*, *Scyliorhinus canicula*, *Pagellus erythrinus*, *Scorpena notata*, *Spicara smaris*, *Octopus vulgaris* and *Loligo vulgaris* (Massuti and Ordinas, 2006). Recently, examples of this type of bottom habitat in relatively undisturbed condition and, therefore, excellent candidates for conservation measures have been discovered southeast of the Cabrera archipelago at 50 to 80m depth). In these areas *Lithothmanion valens* is the dominant species of encrusting red alga (Aguilar *et al.,* 2007).

Soft red algae

Deep-water *Peyssonnelia* beds have a widespread distribution from 40m to 80 m depth on the Balearic continental shelf and have been studied to some degree (Ballesteros, 1994). These beds are mainly comprised of the free-living red alga *Peysonellia squamaria* in the basal layer. Corallinacea are also present, but with very much lower biomass indices. The red algae *Phyllophora nervosa* and *Osmundaria volubilis* comprise the erect stratum. These beds have very high biomass indices, and some commercially important species are more abundant in these sensitive habitats. Management of these habitats therefore needs to take into account the resilience of these habitats and their importance to the life histories of targeted species. (Ordines and Massuti 2008)

3.3.2. Deep Shelf habitats

Crinoid beds

The feather stars *Leptometra* spp.are suspension-feeding organisms which live in shelf-break areas with a high hydrodynamic activity and which have a high input of organic matter and of planktonic organisms. (Flach *et al*., 1998; Lavaleye *et al.,* 2002; Orsi Relini *et al*., 2006). They are found in the deep continental shelf and shelf-break in the western Mediterranean and represent a very important sensitive habitat (SH) (Abelló and Solá, 2006). Individual feather stars are very fragile and vulnerable to demersal trawling (Smith *et al*., 2000; Sánchez *et al.,* 2004).

High densities of *L. phalangium* form crinoid beds which act to shelter small benthic and macroplanktonic organisms. Such beds also appear to act as spawning aggregation areas for some fish species, such as *Mullus barbatus* and *Lepidorhombus boscii*. Recruits of other fish species, such as *Merluccius merluccius*, *Helicolenus dactylopterus*, *Phycis blennoides* and of the octopus *Eledone cirrhosa* ocasionally concentrate in these habitats (Colloca et al., 2004; Orsi Relini et al., 2006).

According to Massuti and Ordinas (2006) *Leptometra* beds (most commonly represented by the species *Leptometra phalangium*) are mainly distributed on the muddy-sand detritic bottoms of S and NE Mallorca and around Menorca, at between 90 and 250 m depth. In contrast to other deep shelf bottoms, these crinoid beds are characterised by a high biomass of invertebrates (mainly *Echinus* spp. and *Stichopus regalis)*. These beds have a possible role in the production of some demersal resources, such as *Merluccius merluccius* and *Mullus barbatus* (Colloca *et al.*, 2004)

White-coral communities

Located at depths of between 300 and 1000m, these benthic communities are dominated by colonies of the scleractinians *Lophelia pertusa* and *Madrepora oculata*. Their current distribution is poorly known, although they appear to have been very common in the Mediterranean at the time of the last glaciation (Arzzidone 2006). These cold-water corals form reefs which support high local biodiversity and productivity. The occurrence of live colonies of *Madrepora oculata* have been reported from the Balearic Islands (Cartes *et al.,* 2004; Tursi *et al.,* 2004).

Gorgonians (Isidella elongate) communities

The octocoral *Isidella elongata* characteristically colonises mud substrates in waters of between 500 and 1200 m. Around the Balearics, high densities of *Isidella sp.* have been reported on the continental slope off N and S Ibiza Island. Areas of both live and dead corals support commercially exploited species. For example, hake (*Merluccius merluccius)*, blue whiting (*Micromesistius poutassou*), deep water pink shrimp (*Parapenaeus longirostris*) and the giant red shrimp (*Aristaeomorpha foliacea*) are more abundant in areas with live corals over this depth range. The red shrimp *Aristeus antennatus*, which is the most important of the commercial species exploited in these habitats appears to be more abundant in areas with dead corals. In general, these octocoralline assemblages have been heavily compromised by trawl fishing. (Arzzidone 2006; Maynou and Cartes 2006).

Tall sea pen (Funiculina quadrangularis) communities

Throughout the Mediterranean, muddy deep shelf edge and upper slope areas support sometimes large colonies of the anthozoan *Funiculina quadrangularis* while other areas support the large brachipods *Gryphus vitreus*. Aguilar *et al.,*(2007) reported *Funiculina quadrangularis* communities along with other cnidarian species (e.g. *Pennatula* spp., *Pteroides griseum*, *Virgularia mirabilis*) on soft bottom substrates at many locations around the Cabrera archipelago. In common with the coral *I.elongata*, sea pen communities appear to have been seriously degraded by bottom trawling at many locations in the Mediterranean (Arzzidone 2006).

Cold-seeps

The recent discovery of sea floor pockmarks in the Ibiza Channel (Acosta *et al.,* 2001b) and in the Mallorca Channel (Acosta *et al.,* 2004b) suggests that cold seep type communities may be a feature of these areas.

3.4 Human activities and threats

3.4.1 Overfishing and impacts of fishing activities

Fishing Activity

According to data provided from the Balearic Parliament (Consellería d'Agricultura i Pesca del Govern Balear), the fishing fleet of the Balearic Islands is mainly represented by artisanal fishing boats (349 fishing boats which use gillnets as the main fishing gear). The second in importance is the bottom-trawling fleet with a total of 55 trawlers with fishing permits in the area. Others include purse seiners and longliners with 12 fishing boats active in each fishery.

BluefinTuna and Swordfish under threat

The bluefin tuna is one of the main target species for the purse seine fleets that operate to the south of Balearic Islands, southwest of Mallorca Island, between Mallorca and Ibiza (WWF 2008, Garcia *et al.,* 2003a, 2004). This is a known spawning area for this species that is now closed to purse seiners and large long-liners during the July spawning period. Long-term over-fishing and mismanagement of bluefin tuna in the Mediterranean has led to a rapid decline and the incipient collapse of the stock. Serious concerns are now attached to the long term survival of this valuable resource species.(ICCAT, 2008, WWF 2008). The Standing Committee for Research and Statistics (SCRS) for ICCAT produces a biannual stock assessment for the species. In 2008 the SCRS made an evaluation from the ICCAT vessel list and estimated a probable catch in 2007 of 47,8000t for the Mediterranean. Combined with a further 13,200t for the East Atlantic the total catch for the stock came to 61,100t. This figure is twice the legal quota which is set at 29,500t and over four times the level of 15,000t recommended by ICCAT's own scientific advisors. As acknowledged by the Committee there is also significant underreporting which is substantiated by markets data (ICCAT 2008a).

The fleet that operates around the Balearic Islands are of French and Catalan origin rather than from the local Balearic fleet.

Swordfish is also known to spawn in these waters and has been similarly over-fished with the fishery taking many large catches of small fish under three years old, many of which have never spawned. The total 2006 catch has been estimated to be around to 14,000 t. ICCAT's SCRS believes that the spawning stock level is less than half that necessary to achieve the ICCAT Convention objective and that its estimates of recent fishing mortality rates are more than twice the amount, which if allowed to continue unabated is expected to drive the spawning biomass to a very low level within a generation (ICCAT 2008b).

Use of Destructive fishing techniques – Bottom Trawling

The trawl fisheries operating around the Balearic Islands target around 104 species (Massuti *et al.,* 1996). Target species include the red shrimp (*Aristeus antennatus*), red mullet (*Mullus surmuletus)*, hake (*Merluccius merluccius*), Norwegian lobster (*Nephrops norvegicus)*, picarel (*Spicara smaris*), blue whiting (*Micromesistius poutassou*), In the Balearic Islands, there are two main fishing grounds where the fleet mainly operates: The Ibiza-Formentera and the Mallorca-Menorca channels (Canals *et al.,* 1982). Exploitation of demersal resources extends from 800m to 1000m depth in some northern areas. On the shelf break and upper slope there are two main target species: the European hake, fished at the shelf break and the beginning of the slope between 120 and 350 m depth, and the red shrimp, which is fished on the upper slope between 550m and 800m depth. Currently, the Mallorca trawl fleet operates in greater depths of water during the summer (Moranta *et al.,* 2008).

Trawling is known to have extremely marked direct impacts on the sea-bottom (Demestre *et al.*, 2000, Tudela 2004). The biological communities found in submarine canyons, cold seeps, cold-water coral reefs, seamounts and brine pools are threatened by uncontrolled bottom trawling fishing (Cartes *et al.,* 2004). Gorgonian communities (e.g. *Isidella elongata*) (which can harbour target species such as red shrimps) and other sessile organisms are immediately removed from soft bottoms by trawling. This changes the associated benthic community . Trawling on *Isidella* spp. communities causes direct impacts on the slope assemblages, by removing the habitat-forming corals. This decreases the species diversity of this habitat and shifts the biological community to one more dominated by benthophagous species (Maynou and Cartes 2006).

As a result of trawling damage, biological assemblages change from those dominated by filter feeders (e.g. sponges, brachiopods such as *Gryphus vitreus*) and low-trophic level predators (gorgonians) towards other communities dominated by deposit feeders and their predators. Trawling may also have a negative impact on colonies of other hard-bottom dwelling and rare corals (e.g. *Lophelia pertusa* and *Madrepora oculata*), living in the deep Mediterranean. Maërl beds in the channel between Mallorca and Menorca and neighbouring areas are also threatened by bottom trawling (Massuti and Ordinas 2006). In addition to the red coralline algae which slowly form the maerl, the beds also support the brown algal species *Laminaria rodriguezii*, which is well represented in the Cabrera archipelago (Aguilar *et al.,* 2007) Trawl fishery bycatch is considered to be the single greatest threat to cartilaginous fish species in the Mediterranean according to the last IUCN Red List assessment results. All species are affected or are potentially affected, although for certain pelagic species such as blue shark (*Prionace glauca*) and makos (*Isurus* spp.) the impacts may predominantly affect specific life stages. The K-selected life history characteristics of most chondrichthyan fishes render them intrinsically vulnerable to fishing pressure since thay mature slowly and produce few young. Populations, once depleted, have little capacity to recover (Cavanagh and Gibson, 2007)

Bycatch

Longline fishing gear is a significant source of seabird mortality through bycatch (Oro *et al*., 2004; Arcos et al., 2008). Turtles are also vulnerable (Aguilar et at., 1995, Tómas et al., 2002), together with sharks (Cavanagh and Gibson, 2007), and cetaceans (see: Notarbartolo di Sciara 2006)). Longline fisheries targeting swordfish and tunas also pose a great threat to susceptible chondrichthyans taken as bycatch in this fishery (ICCAT, 2001).

In addition, cetacean species may be affected by the artisanal fleet operations (Silvani *et al.,* 1992, Reeves and Nortabalo di Sciara, 2006). In the Balearic Islands, the inshore occurrence of bottlenose dolphins coupled with the fact that the local fleet is extensive and mostly operates near the coast, has made interactions between these cetaceans and fisheries particularly common. According to fishermen, interactions are particularly intense in trammel net fishing for red mullet (Mullus surmuletus). Dolphins are held responsible for damaging nets and causing significant losses to the catch. In the past, this has led to the harassment and deliberate killing of dolphins by fishermen (Silvani *et al.,* 1992).

3.4.2. Pollution

Organochlorine compounds have been identified as contaminants of the deep Mediterranean, as evidenced by both the physical detection of xenobiotic chemicals in deep water organisms and the activation of enzymes systems such as the P450 cytochrome system in contaminated organisms which indicate exposure to persistent xenobiotics. Elevated enzyme activity has been detected in deep-sea fish living between 1500-1800m depth,(Porte et al., 2000). Polluting chemicals can contaminate food resources, concentrating in animals at the top of the food chain such as marine mammals, sharks and seabirds. At high levels these chemicals can affect physiological and reproductive functioning. (UNEP MAP RAC/SPA 2003). A number of studies have shown that some Mediterranean elasmobranch fish such as the spiny dogfish (*Squalus acanthias*), have flesh concentrations of mercury high enough to render them dangerous for human consumption. Trace metals and organochlorine residues have been found in the eggs, muscles, liver and kidneys of deep sea sharks such as gulper shark (*Centrophorus granulosus*) and blackmouth catshark (*Galeus melastomus*), also confirming that deepwater species are also being affected by pollution (UNEP RAC/SPA 2002).

In addition to impacts from chemicals entering the Mediterranean Sea from land based sources, large amounts of plastic debris also enter the sea from land based activities and the operation of recreational and commercial fishing boats. Fishing gear, plastics and a variety of unidentified objects were found in many of the areas of the Cabrera Archipelago studied (Aguilar et al., 2007).

3.4.3. Alien Species

Introduced alien species are a major driver of biodiversity loss in the Mediterranean. Six of the eight marine macroalgae known to behave as invasive species in Mediterranean benthic communities have been recorded in the Balearic Islands during the last fifteen years (Hormes *et al.*, 2009). There has been an invasion of the green algae *Caulerpa taxifolia* and *Caulerpa racemosa* which outcompete seagrass species, particularly *Posidonia* meadows (Galil 2007). *Caulerpa racemosa* has not been studied as intensively, as *C. taxifolia*, but it is becoming clear that it may adopt different morphological characteristics in different regions, that it can colonise all types of substrata including rock, sand, mud and dead *Posidonia* meadows, down to 60 m depth. It can interfere with marine coastal biocenoses and its expansion in range, may alter marine habitats. A recent study involving ROV techniques conducted in the National- Maritime Park “Cabrera archipelago” (south of Mallorca Is) showed abundant presence of *Caulerpa racemosa* and the red invasive algae *Lophocladia lallemadi*, particularly in the northern and southern extremities of the studied area (Aguilar et al., 2007)

One of the invasive species that represents the greatest danger to coralligenous beds is *Womersleyella (Polysiphonia) setacea*. This species grows quickly and reduces the amount of light that reaches the constructing algae (Perez *et al.,* 2000) and also diminishes biodiversity in this community (Airoldi *et al.,* 1995). Other invasive species that can affect the growth and development of this habitat are *Lophocladia lallemandii*, *Asparagopsis taxiformis* and *Caulerpa taxifolia* (Aguilar et al., 2007). There is evidence that already degraded habitats can be more easily overwhelmed by invasive alien species. (Galil 2000, Occhipinti-Ambrogi and Savini 2003)

3.4.4 Tourism

Tourism is the main industry in Majorca and Menorca. In 2005 they together received 9.3 million visitors and there are 35,000 leisure boats registered in the islands, amounting to one boat for every 25m of coastline. Many boats anchor without any kind of control over all types of seabed habitat. In particular, frequent diving activities in areas of high ecological value can bring about serious damage from repeated anchoring in coralligenous zones. The increase of human population in coastal regions, particularly during the summer months (Blue Plan 2006) has altered breeding sites of many marine species. Some of these are listed as endangered (IUCN 2007) (e.g. Loggerhead turtle (*Caretta caretta*) and the Balearic shearwater (*Puffinus mauretanicus*). Human disturbance of birds can cause them to abandon their young. In the case of the Balearic shearwater it has been estimated that if disturbances and impacts are maintained at their current level, there is a 50% chance that the species could become extinct within the following three generations (Arcos and Oro 2003). .

3.4.5 Climate Change & Ocean Acidification

Although assessments have been made of the potential impacts of climate change within the various European regions (see: Schroter *et al* 2005), the potential changes in marine systems have not been well characterized to date. In relation to the Mediterranean, sea water temperature and salinity are likely to increase over the whole of the Mediterranean Sea, with variations existing between different regions. Modelling of the impact of such changes suggests that the deep water circulation processes in the Mediterranean Sea could be disrupted, and the intensity of winter convection decreased (Somot *et al.* 2004). Analysis of changes in the Western Mediterranean Deep Water (WMDW) circulation suggests that the WMDW could be highly sensitive to rapid climate change (Frigola *et al.* 2008).

The impacts of anthropogenically driven climate change upon biological systems remain highly speculative. Nonetheless, it is likely that they will be profound. Such impacts could include changes in the natural boundaries of the different biogeographic regions of the Western Mediterranean. Hence, some warm water species could be driven north into areas from which they were previously absent (European Science Foundation 2007). This is supported by the fact that the temperature of the western Mediterranean has been rising for the last 20 -30 years and scientists have already recorded a concomitant increase in the abundance of some thermophilic species, including algae, echinoderms and fish (Allsopp *et al.* 2009). A recent study has also concluded that the Mediterranean Sea, a hotspot of endemism, is under increasing threat from invasions of exotic fish species from further south which are benefitting from global warming by expanding their ranges northwards (Lasram and Mouillot 2009).

Large scale atmospheric variability in the North Atlantic Ocean has been shown to be a major driver of the regional meteorological variations and hydrographic patterns in the Balearic Sea area. In turn these control control the abundance of copepods both directly and indirectly (Fernández de Puelles and Molinero 2007). A 2005 study showed that the increased temperatures experienced in the western Mediterranean during the 1980s led to increases in the numbers of jellyfish. These predated upon zooplanktonic species resulting, among other things, in a strong decrease in copepod abundance (Molinero *et al.* 2005). Changes in the availability of plankton due to climate change are likely to result in significant cascade effects throughout the marine foodweb.

The favoured food of the fin whales *Balaenoptera physalus* inhabiting the Mediterranean is the coldwater euphausid species *Meganyctiphanes norvegica* and the whales' distribution appears to be closely linked to the distribution of their prey (Cotté *et al.* 2009). If environmental conditions become unsuitable for this euphausid, it is not likely to be able to adapt since its scope for northwards movement is restricted by the enclosed nature of the Mediterranean. This will have significant consequences for the fin whales and for other predators (Gambaiani et al. 2009).

The rise of atmospheric CO_2 is also predicted to make the oceans more acidic. As CO_2 is absorbed by the ocean it combines with the water resulting in the formation of carbonic acid, so lowering the pH. As the seawater becomes more acidic so the concentration of calcium carbonate in the form of calcite and aragonite decreases with serious consequences for those organisms that rely on calcification for building their shells and other skeletal structures. The marine species most likely to be affected by this acidification will be small and thin-shelled organisms that use $CaCO_3$. These include calcifying plankton (e.g. coccolithophores), coralline algae, pteropod molluscs and coral polyps (e.g. reef-building scleractinian corals) (see Turley and Findlay 2009).

Climate change and ocean acidification together pose serious threats to maërl and coralligenous beds, as changes in sea temperatures as well as in pH can affect calcification rates of the algae involved in these communities. Several episodes of mass mortality of suspension-feeding animals in large areas of coralligenous beds in the Mediterranean Sea (Ballesteros 2003) have been related to the high temperatures that were reached in these waters (Vacelet 1991).

The impacts of climate change upon migrating bird populations remain unclear. Potential changes in the migration sites and winter grounds for the endangered Balearic shearwater, for example, are poorly documented and understood (Arcos and Oro, 2004). While climate change has been considered to be a determining factor of changes in winter distribution of the species in the Atlantic (Wynn et al., 2007), this has been disputed and remains unresolved (Votier et al., 2008).

3.5 Ecological characterisation against criteria

3.5.1 Uniqueness or rarity

Unique and rare habitats.

There are a significant number of rare or unique habitats in the Southern Balearics that were described in Numeral 3.3. They include m*aërl* grounds and *Peyssonnelia* beds in the shallow shelf; and crinoid beds, white-coral communities, *Isidella elongate* communities and *Funiculina quadrangularis* communities in deeper waters. There are also a number oftopographic features of high ecological potential that require further research and that were described in numeral 3.2. These include the Emile Bardeau, Mont dels Oliva and Mont Ausias Marc seamounts; the southwest volcanic field located south of Emile Bardeau Seamount; and the probable presence of cold seep communities associated with the pockmarks located in the Ibiza Channel and Mallorca channels .

Endemic and rare species

According to Cartes and Sorbes, (1999), 25.4% of bathyal malacostracan crustacean peracarida in the Catalano-Balearic Basin can be considered as endemic. In the Algerian Basin, at depths between 249 and 1622 m, the percentage of endemic species among suprabenthic peracarida was slightly lower than in the Catalan Sea (18.2%: calculated from Cartes *et al.,* 2003). Below 2500-3000 m the number of endemic species is low, particularly in the deep bathyal domain. New sampling programmes are increasingly reporting new endemic taxa in the deep Mediterranean, and the faunal composition of deep-sea communities is far from being completely recognized, especially for small faunal groups (Cartes *et al.,* 2009).

Three species of seabirds are endemic to the Mediterranean region, and one of these, the Balearic shearwater (*Puffinus mauretanicus*), is restricted to the Balearic Archipelago,. The Balearic shearwater is the rarest Mediterranean seabird with an estimated breeding population of only 3300 pairs (Aguilar 1991). The lack of specific knowledge about this threatened shearwater is of particular concern since a good understanding of its biology is important in order to design appropriate conservation strategies (Oro *et al.,* 2009).

3.5.2 Special importance for life history stages

In order to confer adequate protection to the following species special attention will have to be given to the role of the Southern Balearics in their life histories.

Bluefin Tuna

BFT are of considerable commercial importance and the eastern stock of BFT ranges over the eastern part of the Atlantic Ocean, from Iceland to Cape Blanco off the Moroccan coasts. Migration towards the Mediterranean takes place during the reproductive season with spawning mainly taking place in June (Rodríguez-Roda, 1980). BFT appear to exhibit spawning site fidelity in both the Mediterranean Sea and the Gulf of Mexico, the two main spawning areas which have been clearly identified (Block et al., 2005; Teo *et al.,* 2007). Hence, adults born in the Mediterranean Sea return to the western and central areas to spawn.The southern Balearic area is considered one of the most important spawning sites for the species along with others which have been identified in Sicilian waters and in the eastern basin off the coasts of Turkey and northern Cyprus (García *et al.,* 2003; Karakulak *et al*., 2004).

It is thought that the complex hydrodynamic regime which exists around the Balearic Islands, particularly the southern part, resulting from the interaction between the inflowing surface Atlantic water masses (AW) and Mediterranean surface waters (MW), play a key role in the spawning of BFT (García *et al.,* 2003; Alemany *et al.,* 2005, 2006, 2007). Past surveys on BFT spawning behaviour off the Balearic archipelago imply that BFT favours the low salinity (Atlantic waters) and a specific temperature range of (23-25ºC) (Bernal and Quintanilla, 2005; García *et al.,* 2003) making the Balearic Sea conditions close to ideal for BFT spawning.

Other pelagic fish

A recent survey conducted just off the eastern coast of the Mallorca Islands found considerable numbers of billfish larvae (Alemany *et al.,* 2006). Other pelagic species that are also known to reproduce in summer around the Balearic Islands include albacore, common dolphinfish (*Coryphaena hippurus*), small tuna such as frigate tuna (*Auxis* sp.,), little tunny, skipjack tuna, Other large scombroids breeding in the area include Swordfish (*Xiphias gladius*) and *Tetrapturus* spp., (Alemany *et al.,* 2006). Small pelagic species spawning in these waters include anchovy (*Engraulis encrasicolus*) and round sardinella (*Sardinella aurita*).

Marine Mamals

In addition to species of marine mammals present throughout the year, such as the bottlenose dolphin, other marine mammals are sighted around the Balearic Islands and these waters may be important to them as possible feeding and mating ground.

The fin whale is the largest free-ranging predator found in the Mediterranean Sea. Recent studies (Cotté et al., 2009) suggest that fin whales have a year round presence to the North of the Balearic Islands with winter distribution patterns being more dispersed. It appears that whales were observed mostly within the mean cyclonic circulation in the northern part of the Western Mediterranean, limited to the north by the Northern Current and to the south by the North Balearic front (Rio et al., 2007). This species is known to favour upwelling and frontal zones with high zooplankton concentrations.

In the Mediterranean Sea, the sperm whale mostly inhabits the continental slope waters where mesopelagic cephalopods, the species' preferred prey, are most abundant (Reeves and Notarbartolo 2006). Buchan (2005) concluded that oceanographic parameters together with depth and topography were most relevant to sperm whale presence in Balearic waters. In the eastern Mediterranean, both solitary males and social units may remain in a limited area for more than a month, or may visit that area repeatedly during the same summer season, indicating that they stay in neighbouring waters (see Reeves and Notarbartolo 2006) Genetic data suggest that sperm whales in the Mediterranean constitute a separate population (see Drouot et al. (2004),

Marine Turtles

The Balearic Archipelago is an important developmental habitat for loggerhead turtles. The loggerhead turtle has a complex life cycle (Carreras et al., 2004). Large numbers of late juvenile loggerhead turtles occur all year round off the Balearic Islands (e.g. Mejías and Amengual, 2001) while juvenile loggerhead sea turtles from rookeries located in the eastern Mediterranean and the north-western Atlantic use feeding grounds in the Western Mediterranean (Carreras et al., 2006) but there they experience high levels of attrition due to long-line by-catch. A recent study of loggerhead feeding in those living near the Balearic Archipelago suggested that the bulk of the diet of turtles is represented by squid and the Mediterranean jelly, *Cotylorhiza tuberculata*. Jellyfish and squid are the staple food for immature loggerhead turtles off the Archipelago and longline bait is the most likely source of some prey species, explaining the high levels of turtle interaction with longline fisheries (Carreras et al., 2004; Revelles et al., 2007). In addition boat collision, debris ingestion, and pollution have been identified as potential threats to turtles at sea (Lutcavage et al., 1997). However available information suggests that fishing is the most important one, as some declining populations are known to have recovered once fishing mortality was reduced (NMFS-SEFSC 2001). Loggerhead by-catch off the Balearic archipelago is likely to have a detrimental effect on the numbers nesting on beaches elsewhere (Carreras et al., 2004).

Sharks

71 species of cartilaginous fishes live and breed in the Mediterranean and many of these are present in the Balearic region,(Cavanagh and Gibson 2007). For many species, there is very little information available.

Aggregations of basking shark (*Cetorhinus maximus*), have been observed in the northern Balearic region, (Walker *et al*. 2005). A strong correlation between the presence of *C. maximus*, chlorophyll concentration and prey abundance in these areas indicates that they are important feeding sites (Sims 2003; Sims *et al*. 2003).

3.5.3. Importance for threatened/endangered/declining species or habitats

Coralligenous algal beds

Protected species named in the annexes of BARCOM (1995)-SPAM and which have been recorded mainly on coralligenous beds at the Balearic seamounts include *Paramuricea clavata*, *P. macrospina*, *Anthias anthias*, *Muraena helena*, *Lappanella fasciata* and *Phycis phycis* (see Aguilar *et al.,* 2007). The carnivorous sponge *Asbestopluma hypogea* although first found in deep areas is not always associated with bio-concretions. Since the discovery of *A. hypogea*, in 1995 (Vacelet and Boury-Esnault, 1996), it has generally only been recorded in shallow caves in France and Croatia. A specimen found on Ausias Marc seamount was on a coralligenous bio-concretion at 100 meters depth (Bakran-Petricioli *et al.* (2007).

Bluefin Tuna

It is a well known fact the Atlantic bluefin tuna alarming decline (Block 2005) as presented before in section 3.4.1. However, it is considered as data deficient in the IUCN list.

Other relevant species considered

DOLPHINS				
Relevant specie	***Status***	***Features***	***Threaths***	***Source***
Delphinus delphis – *Common Dolphin* Mediterr. sub-population	EN	Widespread and abundant in much of the Mediterranean Sea until the late 1960s, and that their decline occurred relatively quickly. Dolphins remain relatively abundant in the western most portion of the basin, the Alboran Sea.	Bycatch, fisheries-related interactions, netting (past, present), Pollution (affecting habitat and/or species) Water pollution (ongoing) Global warming/oceanic warming (present, future), Changes in native species dynamics - Prey/food base (past, present).	Bearzi 2003
Bottlenose dolphin *Tursiops truncatus*	VU	Scattered throughout the Mediterranean and fragmented into small units. One unit is found around the Balearic Islands. Commonly regarded as coastal/inshore animals although regularly found near the continental slope in the Balearic seas. In the Balearic region there are a number of protected areas set up for cetaceans. Local subpopulations of bottlenose dolphins appear to be influenced by biogeographic and hydrographic features in relation to their distribution and movement patterns	The near-shore distribution of the species results in frequent interactions with trawlers. However Massutí (unpublished data) monitored 460 commercial trawling operations off Majorca from 2001 to 2004 without reporting a single incidental catch of bottlenose dolphins. Other threats include increased boat traffic and human presence during the summer tourist season.	Reeves and Notarbartolo di Sciara, 2006 Forcada *et al.,* 2004 Gonzalvo and Aguilar, 2004 Natoli *et al.* 2005 Forcada *et al.* 2004
Striped dolphin *Stenella coeruleoalba*	VU	Abundance estimates were made for the Balearic Sea for 1991 suggesting the presence of 5,826 animals (95%CI=2,193-15,476) (). The species has reference for highly productive, open waters beyond the continental shelf (e.g.). Status is still decreasing.	1990-92 epizootic due to morbillivirus infection affected Mediterranean population as a whole and resulted in many thousands of deaths PCBs and other organochlorine pollutants with potential for immunosuppression may have helped trigger the event and/or enhanced its spread and lethality Data from fishing activities are sparse but indicate that the species mortality from pelagic purse seines, longlines and gillnets is widespread and likely to be significant but no records exist for the Balearic area	Reeves and Notarbartolo 2006 Aguilar and Raga, 1993 Aguilar and Borrell, 1994 Forcada and Hammond, 1998 Gannier, 2005
PINNIPED				
Relevant specie	***Status***	***Features***	***Threaths***	***Source***
Monk seal *Monachus monachus*	CR	Only pinniped species present in the Mediterranean Sea and regarded as the world's most endangered pinniped The species has disappeared from most of its former range, including Balearic Islands.	Main threats are linked to human activities and include exploitation, bycatch and the increase of tourism causing significant disturbance to breeding colonies, as well as the risk of vessel accidents, spills, transmission of disease, and the discharge of pollutants and waste near the seals	IUCN 2000, UNEP-WCMC 2005 UNEP/MAP 1994, Aguilar 1998

NOTE: VU= Vulnerable, EN= Endangered, CR=Critically Endangered ; DD= Data deficient

Other relevant species considered (continued)

WHALES				
Relevant specie	***Status***	***Features***	***Threaths***	***Source***
Sperm whale *Physeter macrocephalus*	EN	Genetic data suggest that sperm whales in the Mediterranean constitute a separate sub-population from the Atlantic This subpopulation comprises fewer than 2,500 mature individuals and numbers of mature individuals continue to decline. No estimate of population numbers exists for the region but results from a survey in summer 2003 of a large portion of the western Med basin suggested that sperm whale numbers are significantly higher in the western basin than in the Ionian Sea	Entanglement in high seas swordfish driftnets, which has caused considerable mortality since the mid-1990s Ship strikes Noise pollution particularly linked to the intense maritime traffic but also from seismic testing equipment. Military operations, and illegal dynamite fishing	Reeves and Notarbartolo 2006 Drouot *et al.* 2004
Fin whale *Balaenoptera physalus*	DD	Estimated that there were 3,583 fin whales (S.E. 967, 95% C.I. 2,130-6,027) in a survey covering a large proportion of the western Mediterranean in 1991. Insufficient data exist to determine trends in abundance and of population-level threats		Forcada *et al.* 1996 Reeves and Notarbartolo di Sciara, 2006
CHONDRICHTHYANS (CARTILAGINOUS FISH)				
Relevant specie	***Status***	***Features***	***Threats***	***Source***
Blue shark *Prionauce glauca*	VU	Among the main commercially exploited species. It has recommended that a sustainable management programme	Fisheries either as a target species or as bycatch.	UNEP RAC/SPA
Angel shark *Squatina spp*	CR	All three European species are considered to be critically endangered by the IUCN. The low rate of exchange between isolated populations living in the waters around the Balearics, leaves them particularly to local depletion, given that recolonisation rates will be extremely low		Massutí and Moranta 2003
Rabbitfish *Chimaera monstrosa*	NT	Found at depths from 100m but is most abundant between 500–800m in depth. Several specimens have been reported from the Balearic Sea at depths of 650m No specific data on population trends over time are available.	its preferred depth exposes it to fishing activity while it also has a low reproductive capacity. When discarded it is expected to have a high mortality rate.	Sion *et al*. 2004 Baino *et al*. 2001
Great White Shark *Carcharodon carcharias*	VU global E Medit.	It is listed under Appendix II of the Bern Convention (Strictly Protected Fauna Species) and by the Barcelona Convention (Endangered or Threatened species). *C. carcharias* has a tendency to approach boats readily and to scavenge from fishing gear. This can result in accidental entrapment or in deliberate killing by commercial fishermen	Sport fishing, commercial trophy hunting or capture for human consumption. Offshore records in the Mediterranean show that white sharks in all size-classes are made by pelagic longlines, bottom trawls, driftnets and purse seines.	Fergusson *et al*. in prep Morey *et al.*, 2003 Fergusson *et al*., 2005
SEA TURTLES				
Relevant specie	***Status***	***Features***	***Threaths***	***Source***
Loggerhead turtle	EN	Satellite tracking studies have revealed that some 80% of young loggerhead turtles found in the central and southern Mediterranean Sea spend most of their time in the open ocean areas where the water is deeper than 1400m The remaining 20% visit the continental shelf on a regular basis and are likely to have access to benthic prey and fish discarded from bottom trawlers	Marine turtles in the Mediterranean are threatened by past overexploitation, by fishing activities, coastal development and tourism, shipping and pollution	IUCN, 2004 Cardona *et al*., 2005 Margaritoulis, 2003
Green Turtles	CR			
Leatherback turtles	CR			

NOTE: VU= Vulnerable, EN= Endangered, CR=Critically Endangered ; DD= Data deficient

Other relevant species considered (continued)

SEA BIRDS				
Relevant specie	***Status***	***Features***	***Threats***	***Source***
Balearic shearwater *Puffinus yelkouan mauretanicus*	CR	This is considered to be the most seriously threatened Mediterranean Seabird. Endemic to Balearic Islands, particularly Formentera Recent studies have estimated the population at 2,000 reproductive pairs.	Bycatch in longliner fisheries Overfishing of the main prey species Destruction of habitat Pollution and spillage Depredation by rats and feral cats Competition with *Calonectris diomedea* for breeding sites	Birdlife International, 2008, Aguilar 1991 Oro *et al.*, 2009 Arcos *et al.*, 2008; Mayol *et al.*, 2000 Rufino *et al.* 2009
Audouin´s gull (*Laurus audouinii)*	VU	the Cabrera archipelago southwest of Mallorca is one of the most important breeding grounds in the Mediterranean basin.	Disturbance of breeding colonies Overfishing leading to a decrease of prey species particularly during their breeding season Pollution and habitat destruction. Human settlements have dramatically reduced the availability of suitable breeding sites.	Oro and Muntaner, 2000 Oro *et al.*, 2003
European shag *Phalacrocorax aristotelis*	VU	The biggest reproductive colonies of this subspecies are located in the Balearic Islands although other dispersal breeding sites exist along the Spanish Mediterranean coast including small islands. In 2000, the reproductive population in the Balearic Islands was estimated at around 1.333 breeding pairs	The bycatch of juveniles in surface longline gear and driftnets, "soltas" and almadrabas is one important threat. (Guyot and Thibault, 1985; Guyot 1990). Other threats include the overexploitation of main fish resources reducing prey availability	Muntaner and Aguilar 1995 Paracuellos & Nevado, 2000 J. Muntaner, pers. comm.)

NOTE: VU= Vulnerable, EN= Endangered, CR=Critically Endangered, DD= Data deficient

3.5.4 Vulnerability, fragility, sensitivity or slow recovery

There are a large number of vulnerable habitats in the Southern Balearics that in addition can be considered as unique or rare. They were described in Numeral 3.3. and include the coralligenous communities found both in shallow waters and in the deep sea. Associated with these coralligenous communities are many species of high commercial value, for example, fish of the genera *Diplodus*, *Epinepheleus* and *Serranus*, large crustaceans and red coral (Ardizzone 2006).

Deep water corals grow very slowly (1.0-2.5 cm per year) and have an extremely long life span (Rogers 1999). These hard bottom communities are highly vulnerable to the mechanical destruction caused by bottom trawling which takes place in these waters. Such damage invariably reduces reef extent and causes a decline in biodiversity and in the density of associated organisms. Bottom trawling on nearby soft bottoms suspends sediments and settlement of these on reef areas can stress and even kill corals (Cartes *et al.,* 2004; Palanques *et al.,* 2004). The slow growth of these deep water organisms, coupled with commercial fisheries activity targeted at red shrimp species in waters up to 1000m depth, makes them highly vulnerable (Cartes *et al.,* 2004; Gianni 2004). Importantly trawl fisheries have been limited to 1000 m depth in the Mediterranean Sea (GFCM 2005) -. a precautionary ban that aims to protect still pristine and poorly understood deep-water ecosystems.

3.5.5 Biological productivity

Both, hydrodynamic forces in the area as well as the complex topographic features in the Balearics determine its productivity, as exposed in numeral 3.1.1 and 3.1. Particularly its southern part is a convergence area and therefore a strong retention zone where there is a high concentrations of nutrients due to the presence of fronts and mixing zones associated with reefs, canyons, seamounts and islands (Hyrenbach, 2000).

The Mallorca channel acts as a meeting point of the MAW and LAW water masses and the strong frontal systems generated along the northern side of Mallorca Island could explain the higher zooplankton biomass reported there (Cartes *et al.,* 2008). In addition, the Balearic Currents are also associated with the transport of nutrients accounting for the high concentrations of chlorophyll found in open sea waters off the Balearic Islands in summer (Jansá *et al.,* 2004; Sabatés *et al.,* 2007). Other relevant mechanisms that enhance the local productivity in the Mediterranean off the Balearics Islands are associated with changes in the slope orientation, the presence of canyons and shallow seamounts that interact with the currents creating upward vertical components typically upstream from these topographic features (Font *et al.,* 1990; Masó *et al.,* 1990). The existence of these mechanisms would explain the moderate levels of primary production recorded, especially in the western basin, as well as the relatively high fishery yield (Sabatés *et al.,* 2007).

Productivity occurs all along the water column, with seasonal variations. The upper layer of the water column shifts from well mixed water during autumn & winter to a strongly stratified one during spring and summer. The development of a thermocline in spring prevents vertical water mixing and nutrient supply to the surface waters is interrupted, causing a depletion of nutrients in the surface while deep chlorophyll maximum (DCM) can be found at the bottom of the photic zone (Estrada, 1985).

3.5.6 Biological diversity

Biological Hotspots

Most of the habitats considered as unique, vulnerable and productive, area also areas of biological diversity. Zones that are potentially considered as biodiversity hotspots include seamounts , Isidella elongate communities, crinoid beds and Maërl grounds.

Seamounts are recognized as zones with high biodiversity and high rates of endemism (Richer de Forges *et al.,* 2000; Matthiessen *et al.,* 2001; Santillo and Johnson, 2003; Morato and Pauly (eds), 2004). It has long been recognized that seamounts concentrate water currents and can have their own localized tides, eddies and upwellings (Santillo and Johnson 2003). It seems that the seamounts act as a foraging habitat for pelagic species (e.g. swordfish) which are attracted by the high concentrations of zooplankton and micronekton. The plankton biomass is often high over seamounts and this combined with the constant influx of prey organisms means they can attract large numbers of pelagic top predators (some commercially important) including marine mammals, sharks, tuna and cephalopods (Worm *et al.,* 2003) and even seabirds have been shown to be more abundant in surrounding shallow seamounts. In the Southern Balearics some impressive seamounts have been identified but for which the biodiversity values are still poorly known.

Deep-sea coral mounds are considered hotspot of Mediterranean biodiversity and can represent an essential fish habitat for many commercial species since its tree- or candelabra-like structures provides ecological niches to Mediterranean deep-sea species (SGMED, 2006). As presented in numeral 3.3.2. this habitat is found in the Southern Balearics. Some commercial fishes and like hake (*Merluccius merluccius)* and blue whiting (*Micromesistius poutassou)*, as well as decapods crustaceans *Parapenaeus longirostris* and *Aristaeomorpha foliacea* are more abundant in areas with live corals over this depth range. In contrast, the deep water red shrimps *Aristeus antennatus* one of the main commercial species on this facies, is more abundant in areas with dead corals. *Isidella elongata*, also constitutes a selected habitat for other commercial deep water shrimps the *Aristaeomorpha foliacea* (Maynou and Cartes 2006).

Leptometra beds (crinoids) enhance habitat heterogeneity and consistent species richness. According to results obtained during the trawl survey BALAR 0505, *Leptometra* beds (mainly represented by the species *Leptometra phalangium*) are mainly distributed on muddy-sand detritic bottoms of S and NE Mallorca and around Menorca, between 90 and 250m depth. High concentrations of epibenthic, suspensivorous organisms occur in these grounds as a result of the occurrence of bottom currents. In contrast with other deep shelf bottoms, these crinoid beds are characterised by higher biomass of invertebrates (mainly *Echinus spp*. and

Stichopus regalis). In addition, this can also act as essential fish habitat for many commercial species including *Merluccius merluccius, Micromesistius poutassou* and *Trisopterus minutus capelanus* (Maynou and Cartes 2006). Main concentrations of juveniles *Merluccius merluccius* are found S and NE Mallorca, where *Leptometra* beds are mainly distributed as well as large specimens of *Zeus faber* and *Raja clavata* seems to be related to *Leptometra* beds (Massuti and Ordinas, 2006).

Maërl beds have been described as areas of high diversity and ecological importance (Barberá *et al.,* 2003), being two of the most productive ecosystems in temperate regions (Martin *et al.,* 2007).

Ichthyoplankton diversity

Larvae of some large migratory species, e.g. T*hunnus thynnus, Thunnus alalunga or Coryphaena hippurus*, small tuna such as *Auxis* sp., *Euthynnus alleteratus, Sarda Sarda* or *Katsuwonus pelamy*s, or other large scombroids such as *Xiphias gladius* or *Tetrapturus* sp., also reproduce in summer around the Balearic Islands (Alemany 1997; Alemany *et al.,* 2006). This implies that during spring–summer there is high ichthyoplankton diversity.

3.5.7 Naturalness

The islands and coasts of the Mediterranean have highly populated for millennia and throughout history the Mediterranean and its marine life have played a major part in the lives and cultures of the people living there. Fishing and gathering seafood have been, and continue to be, of major importance to millions of people and some of the world's busiest shipping routes are to be found in the Mediterranean. Given the multiple ocean and land based anthropogenic drivers, it is unsurprising that the global map of human impact on marine impacts drawn up by Halpern and colleagues shows the Mediterranean to be an area of high human impact (Halpern et al. 2008). It would be hard to argue that this criterion is applicable to any area in the Mediterranean and certainly not in the Western Mediterranean; this of course does not mean that areas should not be selected for protection in the Mediterranean.

4. Sicilian Channel

4.1 Area description

The Sicilian Channel is the strait of the Sea located between the island of Sicily and Tunisia where Pantelleria (Italy), Pelagie Islands and Lampedusa (Italy), and Malta, Gozo and Comino Islands (Malta) are located. It plays an important role by dividing the Mediterranean Sea into two principal sub-basins, the eastern and the western Mediterranean. The complex topography and circulation scheme makes the Sicilian Channel a highly productive area and a biodiversity hotspot within the Mediterranean. Its location means that it hosts many species from both basins.

4.1.1 Main topographic features

This Sicilian Channel has complex bottom morphology comprising two sill systems separated by an internal deep basin (Figure 5). The eastern sill system is divided in the Malta plateau and Medina Bank and it has maximum depth of about 540m and connects the Sicilian Channel with the Ionian Basin. The western sill is divided in the large Adventure Bank and the Nameless Bank (Gasparini *et al.,* 2005). These large sill systems are separated by the narrow shelf in the central part. The shape of slope is extremely irregular, incised by many canyons, trenches and steep slopes (Fiorentino *et al.,* 2006)

According to Civile *et al.* (2008), neogene rifting caused the development of three major depressions, the Pantelleria (1317-m depth), Linosa (1529-m depth), and Malta (1731-m depth), located in the central basin of the channel. The Pantelleria Trough, southeast of Pantelleria Island, is one of three narrow, steep-walled, elongate NW–SE troughs in the

Channel. Pantelleria Trough has almost straight, fault-bounded slopes, over 100 km long and 28 km wide, with depths reaching 1314 m. The western end of Pantelleria Trough is cut by two fault valleys running parallel to the southwest and northeast coasts of Pantelleria Island.

The sea bottoms of the littoral zone of the northern Tunisian coast are mainly rocky, while those of the eastern (Hammamet Gulf) and southern (Gabès Gulf) coasts are sandy to sandy-muddy (Ben Mustapha *et al.* 2002b). The rocky bottoms of the northern coast offer the best substratum for colonization by very rich coralligenous assemblages (Ben Mustapha *et al.*2002a), while in “la petite Syrte” i.e the Gulf of Gabès *sensu lato*, and in several parts of the Hammamet Gulf, the *Posidonia* meadows show their maximum geographical distribution (e.g. Ben Mustapha *et al.* 1999).

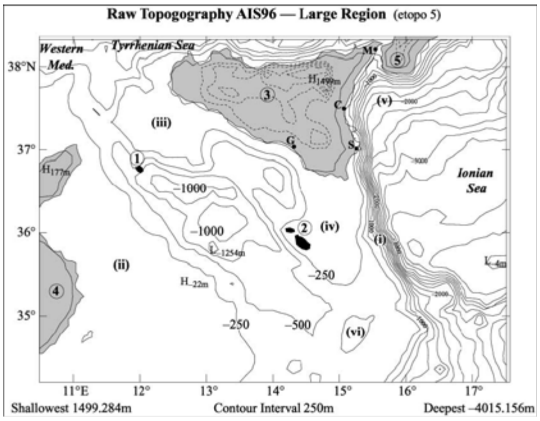


Fig. 5. Topography and geography of the Sicilian channel .

NOTE: The numbers indicate Pantelleria Island (1), Malta Island (2), Sicily (3), Tunisia (4) and Calabria (5). The (i)'s indicate topographic features (De Agostini, 1998): the Ionian slope (i), Tunisian shelf (ii), Adventure Bank (iii), Maltese plateau (iv), Messina Rise (v) and Medina Bank (vi). The letters indicate cities mentioned in the text: G for Gela, S for Siracusa, C for Catania and M for Messina.

SOURCE: *P.F.J. Lermusiaux, A.R. Robinson /Features of dominant mesoscale variability, circulation patterns and dynamics in the Strait of Sicily Deep-Sea Research I 48 (2001*)

4.1.2 Currents and nutrients circulation system

The Sicilian Channel is a high-energy site with a dynamic current system that exchanges the waters between western and eastern basins (Figure 6). Dynamically, the circulation in the Sicilian channel can be described as a two-layer exchange, the upper layer (about 200m thick) of Atlantic Water (AW) which flows eastward and the deep layer of Eastern Mediterranean Outflow Water (EOW) mainly composed of Levantine Intermediate Water (LIW here after) that flows in the opposite direction The AW splits into two branches at the entrance to the Sicilian Channel, one flowing to the Tyrrhenian Sea, the other into the Sicilian Channel. The second branch is composed by two streams, the Atlantic Ionian Stream (AIS) and the Atlantic Tunisian Current (ATC). In winter, the ATC is more pronounced. In summer, the AIS is associated with a number of well-known semi-permanent features including the intermittent northward extension of the AIS (NAIS) at the Ionian shelf break, which seems to be driven by the surface density contrast between waters of the Sicilian and the Ionian basins. (Beranger *et al.,* 2004).

In the subsurface layers the topography plays an important role. The LIW has a higher velocity due to the Bernoulli effect: LIW has a narrow area to flow in comparison the wide area available to AWAs consequence, it enables the upper layer of the Eastern Mediterranean Deep Water (EMDW) in the Ionian sea to reach the western basin (Gasparini *et al.,* 2005).

Upwelling along the eastern and southern costs of Sicily is a permanent feature. As explained by Beranger *et al.,* (2004), upwelling is governed by the south-eastward winds and by the inertia of the isopycnal domes of the AIS meanders and cyclonic vortices that can extend its influence far offshore due to the configuration of the circulation.

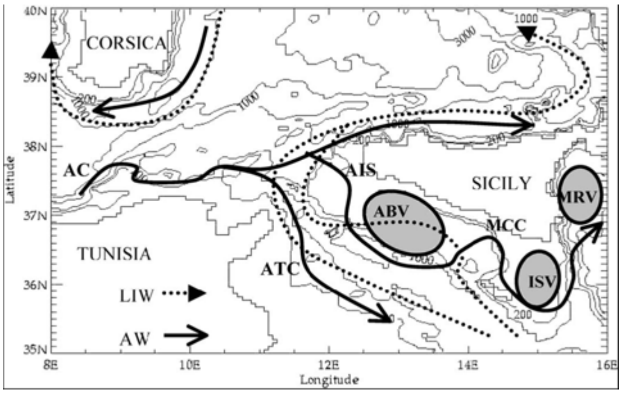


Fig. 6. Circulation of sea masses on the Sicilian channel .
NOTE: AC= Algerian Current AW= Atlantic Water; LIW= Levantine Intermediate Water; AIS=Atlantic Ionian Stream; ATC= Atlantic Tunisian Current
SOURCE: Beranger *et al.,* 2004

Many eddies of variable strength, shape and size (cyclonic and anticyclonic) are noticed in the Tunisian–Sicily region. According to Savini et al (2009 in press) between Adventure Bank and the Malta plateau, LIW forms a pair of subsurface eddies (one cyclonic, one anticyclonic) along the western flank of the Malta plateau and AIS forms a cyclonic vortex off Cape Passero.

4.2 Topographic Features of Remarkable Biological relevance

4.2.1. Seamounts

Seamounts are considered as highly productive and biodiversity hotspots, since they produce retention areas for phytoplankton and create the conditions that support a diversity of important habitat types. In the extension of the Sicilian continental shelf toward the Pantelleria Rift (Adventure Bank and Graham Bank plateaus), five volcanic seamounts have been recognized (Tetide, Anfitrite, Galatea, Cimotoe and Graham), three of which have been sampled. Two other much larger seamounts, Bannock and Nameless Bank (Banco Senza Nome), are located between the Malta and Pantelleria basins and close to the eastern border of the Nameless Bank respectively (Calanchi *et al.,* 1989).

4.2.2 Volcanic Islands and submerged volcanoes

Past volcanic activity in the Sicilian Channel has formed the islands of Pantelleria are Linosa. There is also volcanic activity underwater in the Graham Bank in the northwestern part of the channel. In the recent past, an eruption created the ephemeral Ferdinandea Island, with a diameter of about 600 m, constituted by a scoria cone that was rapidly eroded away. However, the underwater volcano, now known as a Graham Seamount or Empedocles Seamount is in fact part of a 3-km-long and 2-km-wide submerged edifice that rises from the sea-floor for about 180 m. Accordingly with Civile *et al.*(2008), at the base of the western slope, a 3-km-large and 1-km-long lava flow are recognizable and several fumaroles have been observed along the north eastern flank at depths ranging from −160 m to −50 m, following a roughly N–S direction. They are characterized by huge emissions that form well defined columns of bubble eruptions that can also be seen at the sea surface.

4.2.3 Slow-flux seeps

In research reported by Savini *et al. (*2009 *in press*) detailed acoustic mapping discovered more than 100 small-scale domes and peculiar ridges were a few miles offshore between 140 and 170 m water depth. Data collected suggest that both the domes and ridges are influenced by active slow-flux seeps. Mapped domes were found from 50 to 200 m wide and no more than 5 m high occurring on the seafloor, isolated or arranged in clusters. Ridges consisted of large tabular sub-elongated structures, elevated from 5 to 10 m from the surrounding seafloor, and had flat tops on which numerous close-set, small cones occurred, appearing in video observation as carbonate structures heavily colonized by gorgonians. There is evidence of past mud extrusion at the domes that is not longer evident and at the present time active degassing is the main process that controls the morphological and sedimentological expression of both the domes and ridges.

4.2.4 Pockmarks

Sea floor pockmarks are formed by gas discharge. They are features biologically relevant due the possible existence of unique chemosynthesis-based communities in the cold seep that are frequently found on them. According to Minisini *et al.,* (2007) structures that are interpreted as pockmarks have been found in the Sicilian Channel, at the West of the Gela Basin (the basin between Adventure Bank and the Malta Plateau).

4.3 Rare, vulnerable and highly productive habitats present on the Sicilian Channel

4.3.1 Deep coral communities

In the Sicilian Channel, there is a substantive variety of deep coral communities. The sessile benthos in the Sicilian Channel is dominated by the octocorals *Isidella elongata* and tall sea pen *(Funiculina quadrangularis*) as well as red coral (*Corallium rubrum)* (Freiwald *et al*., in press).

Areas that are difficult or impossible for sample trawling have been studied by Ragonese *et al.* (2003). According with this research, those hard bottoms are characterized by huge white coral assemblages produced by madrepores (*Madrepora oculata, Lophelia prolifera*) and barnacles (*Balanus* sp.). Another yellow coral, *Dendrophyllia cornigera* lives at higher depths (i.e. >500m), colonizing rocky substrates exposed to hydrodynamism.

Records of living colonies of white coral assemblage dominated by colonies of the scleractinian *Lophelia pertusa, Madrepora oculata* and *Dendrophyllia cornigera* were recently identified in the Linosa trough and in the nameless bank using ROV techniques as part of the recent research conducted under the HERMES project (Freiwald *et al*., in press). The most intense growth of *C. rubrum* was documented in the Linosa sample site, among the white coral habitats surveyed in the Sicilian Channel.

4.3.2 Cold seep communities

Cold seep communities are the home of unique chemosynthesis-based communities (not relying on photosynthetic production) dominated by bacterial mats and particular species of bivalves and tubeworms, that are associated with endosymbiotic (chemo-autotrophic) bacteria. The existence of pockmarks in the area points to the existence of these cold-seep type communities (Cartes *et al.,* 2004). The recent discovery of pockmarks (Minisini *et al.,* 2007) might points to the existence of these cold-seep type communities in the area. However, they have not been discovered yet and further research should be carried out to confirm the existence of these unique environments in this part of the Mediterranean deep sea.

4.4 Human activities and threats

4.4.1 Overfishing and impacts of fishing activities

Fishing Activity

The Sicilian Channel is one of the most important fishing areas of the Mediterranean Sea, where significant fleets operate with high fish production. Only in the Pelagie Islands the local fishery fleets consists of 164 fishing licenses (95 lines, 30 gillnets, 29 trawl net and 10 fish trap), In addition, the boats from the Sicilian and North African fleet are usually fishing in the Archipelago using trawl nets or purse seiners (Celoni et al., 2006). Both pelagic and demersal species are targeted.

Use of Destructive fishing techniques – Bottom Trawling

The Sicilian Channel is one of the most important demersal fishing grounds in the Mediterranean Sea and is commonly exploited by trawlers. In particular, the Mazara del Vallo trawl fishery (south-western Sicilian coast), is one of the most important in the Mediterranean Sea (about 180 trawl vessels). 21% of the trawl fleet operates in the Sicilian coastal waters with short fishing trips (1–2 days); the remaining 79% of the trawl fleet is characterised by boats that carry out deep-sea fishing and go out for long trips (21–25 days) in the Sicilian Channel (Gristina *et al.,* 2006). Some of main target species include hake *(Merluccius merluccius*), greater fork beard (*Phycis blennoides*), red mullet (*Mullus barbatus*) and anchovy (*Engraulis encrasicolus*) which have been heavily exploited in this area, causing their slow decline (Levi *et al.,* 1998, Garcia Lafuente *et al.,* 2002, Fiorentino *et al.,* 2003).

Trawling is known to have extremely marked direct impacts on the sea-bottom (Tudela 2004). Among the effects of intensive bottom-trawling is the reduction of the complexity of benthic habitats, affecting the epiflora and epifauna and reducing the availability of suitable habitats for predators and prey.

Ragonese *et al*., (2007) presented for the first time a map of the untrawlable bottoms, drawn on the basis of the not-valid hauls recorded over almost 20 years of scientific trawl surveying in the Sicilian Channel. Results showed that grasping events are concentrated in shallower areas, i.e. on the western banks, on the eastern platform and near the coast; on the contrary, net tearing and gear damages often occurred in deeper grounds, where the “white coral assemblages” are present.

Use of Destructive fishing techniques – Illegal Drift-netting

In the past, Italy had the largest driftnet fleet (in excess of 700 vessels during the 1990’s) operating throughout a significant portion of the central Mediterranean (Scovazzi 1998).Despite the fact that drift-netting is now prohibited, illegal drift-netting still occurs (Greenpeace 2008; WWF 2005).

Chondrichthyans most vulnerable and frequently caught with driftnets include blue shark *Prionace glauca*, common thresher *Alopias vulpinus*, shortfin mako *Isurus oxyrinchus*, porbeagle *Lamna nasus*, basking shark *Cetorhinus maximus*, giant devil ray *Mobula mobular*, pelagic stingray *Pteroplatytrygon violacea*, requiem sharks *Carcharhinus* spp. and hammerheads *Sphyrna* spp. (Tudela 2004; Walker *et al*. 2005).

Moreover, the entanglement in high seas swordfish driftnets has caused considerable mortality of the Mediterranean sperm whale subpopulation since the mid-1980s (Notarbartolo di Sciara 1990; International Whaling Commission 1994). It is worth noting that during the 1990´s Italy had the largest driftnet fleet (in excess of 700 vessels) operating throughout a significant portion of the central Mediterranean (Scovazzi 1998).

The large majority of the strandings in Italy and Mediterranean Spain were caused by entanglement in driftnets, as evident from the reported presence of net fragments or characteristic marks on the whales’ bodies (see Reeves and Notarbartolo, 2006 and references herein). Cagnolaro & Notarbartolo di Sciara (1992) reported that for 83% of 347 cetaceans stranded in Italy from 1986 to 1990 (inclusive), which included 56 sperm whales, the likely cause of death was related to entanglement. Despite international and national regulations banning driftnets from the Mediterranean, illegal or quasi-legal drift-netting continues in sperm whale habitat, in (e.g., in France, Italy, and Morocco).

Stocks in decline

There is evidence of overexplotation of there is evidence of overfishing for single target stocks (Levi *et al.,* 1998), but the impact of fishing on demersal fish communities in this area has hardly been investigated.

In the Sicilian Channel, demersal fishing ground overlaps with important spawning and nursery grounds and areas occupied by larvae and juveniles of some of the most commercial fish species (e.g. hake, red mullet, anchovy and great fork beard) (Fiorentino *et al.,* 2003, Garofalo *et al.,* 2004). For example, nursery areas are situated mainly between depths of 100 and 200 m for the hake and those for the greater fork beard were found at depths greater than 200 m (Fiorentino *et al.,* 2003).

BluefinTuna and Swordfish under threat

An important fishery in the area is the longline fishery targeting swordfish and tuna species and which has increased in effort over the past three decades (Di Natale, 2006; SCRS 2008).

Bycatch

Longline fisheries in the area pose a great threat to many species including large turtles (e.g. loggerhead (*Caretta caretta*) (Baez et al. 2007). Data of fishing interaction between marine turtles and fishing activities were recorded during 12 years of activity (1994 to 2005) and results showed drifting longline as the fishing gear with the highest local impact on sea turtles (95.7%). Its peak activity is in summer period, when fishers mostly work with drifting longlines targeting swordfish and loggerhead adult females come to the pocket beach "Pozzolana di Ponente" to lay their eggs. The artisanal fleet operating in the area is mainly composed of vessels employing drifting longlines. This kind of gear results in a high number of interactions, with a mean of 40 loggerheads being hooked per year and a total of 336 specimens found with one or more hooks embedded in their flesh (see Giacoma *et al.*, 2001, Piovano *et al.,* 2001, Nannarelli *et al.,* 2007). In addition, chondrichthyans are also being taken as bycatch in the longline fishery (Cavanagh and Claudine 2007).

Within the framework Life project *DelTa* (NAT/IT/000163) a dolphin-fishery interaction study has been conducted in the Archipelago of Pelagie Islands (south Sicily). Gillnets were identified as the gear for which fishermen were complaining frequent negative dolphin´s interaction in 83% of the cases. Results showed frequent interaction was complained by 72% of long line and 100% of trawler (Celoni *et al.,* 2006). Moreover, the study highlights the existence of what was called "operational competitive interaction" (Bearzi 2002) between bottlenose dolphin and fishermen. In fact, results showed a significant reduction of fishing catches for *Mullus surmuletus* when dolphins were present (Celoni *et al.,* 2006)

4.4.2. Pollution

Oil Spills

There is evidence that the area between Sicily and Malta is a pollution hotspot regarding oil spills in the Mediterranean Sea (UNEP/EEA 1999, EC Joint Research Centre/IPSC 2006).

Heavy metals and Persistent Organic Pollutants

Pollution by persistent organic pollutants (POPs *e.g.* PCBs and DDTs) and heavy metals has spread all over the world as evidenced by their detection both in humans and wildlife although their impact on offshore ecosystems has been poorly investigated. Large fish such shark, tuna and swordfish as well as marine mammals, sea turtles and seabirds, as species occupying the higher trophic levels in the pelagic food chain, may exhibit a high potential for the accumulation of pollutants (e.g. Stefanelli *et al.,* 2002,2004; Storelli *et al.*, 2003; Storelli and Marcotrigiano, 2006)

4.4.3. Alien Species

Non-native species invasions are currently of major global concern, they are considered to be the second largest threat to biodiversity, after habitat destruction. The invasion and survival of alien species in the Mediterranean is correlated with the general sea surface temperature increase, resulting in the replacement of local fauna with new species. Such changes affect not only local ecosystems, but also the activities of the international fishing fleet when commercial species are affected (Marine Board Position Paper, 2007). Accidentally introduced into the Mediterranean Sea in 1984, the tropical alga *Caulerpa taxifolia* has spread since then, reaching the Tunisian coast. Another variety of *Caulerpa racemosa* (*Caulerpa racemosa var occidentalis*) was discovered in Tunisia and qualified as invasive (Langar et al., 2003).

4.4.4 Tourism

The growing number of tourists presents a significant threat to many coastal habitats. In fact one of the main threats to the Pelagian Island turtle population is tourist activities in the nesting sites (Giacoma and Solinas, 2001).

4.4.5 Marine Traffic

Collisions of marine turtles with boats crossing the waters of the Sicilian Channel (between Sicily mainland and Pelagie Islands) have been recorded (Life NAT/IT/000163). In addition, the Mediterranean sperm whale subpopulation may be affected by disturbance from intense maritime traffic (development of 'highways of the sea') and collisions with vessels, including high-speed ferries. More than 6% (7) of 111 sperm whales stranded in Italy (1986-1999) had died after being struck by a vessel, and 6% of 51 photo-identified individuals (22 in Italy) bore wounds or scars that were clearly caused by a collision (Pesante *et al.* 2002).

4.5 Ecological characterisation against criteria

4.5.1 Uniqueness or rarity

Unique and rare habitats.

There are a considerable number of rare habitats in the Southern Balearics that were described in Numeral 4.3. It includes white-coral communities, *Isidella elongate* communities and *Funiculina quadrangularis* communities. It is also important to consider the Sicilian Channel topographic features of high ecological potential that require further research and that were described in numeral 4.2. They include two large seamounts (Nameless Bank, Bannock); the large graham/empedocles volcanic seamount and the volcanic Tetide, Anfitrite, Galatea, Cimotoe seamounts; and the pockmarks located on the Gela Basin.

Endemic and rare species

The Maltese skate (*Leucoraja melitensis*), a Mediterranean endemic species which main range now appears to be restricted to the Sicilian Channel. It inhabits waters of depths that coincide with that of trawling activity (Cavanagh and Gibson, 2007). The Mediterranean endemic scleractinian coral *Cladopsammia rolandi* is also present in the Sicilian Channel (Zibrowius 1980).

4.5.2 Special importance for life history stages

The Sicilian Channel is one of the most important demersal fishing grounds in the Mediterranean (Fiorentino *et al.,* 2003) and also an important area for life history stages of both demersal and pelagic species, including some of high commercial interest – see below.

Bluefin Tuna (Thunnus thynnus) spawning ground

As explained in numeral 3.4.2, the Mediterranean Sea is one of the main grounds where the BFT Atlantic stock reproduces. The Sicilian waters are one of the most important spawning sites in the Mediterranean, as confirmed by Piccinetti *et al*., (1996a, b) which shows that BFT larvae are mainly concentrated all around Sicily (the Sicilian Channel, southern Tyrrhenian and northern Ionian Seas). It is important to notice that the Sicilian Channel, as the Balearics, share the formation of important frontal systems, which may favour the feeding requirements of larval tuna.

Oray *et al.,* (2005) showed the results of a 2003 and 2004 fish egg and larval survey which encompasses the BFT spawning grounds off the southern Sicilian coasts. They reported high larvae catches in 2003 and relatively low catch in 2004. Importance as spawning ground is also confirmed by previous research reported by the same author has shown the area can be considered a rather important spawning ground for the species from the tuna fishery. However, recent larval surveys carried out off the Tunisian part of the Sicilian Channel within the TUNIS II project reported no BFT larvae catches.

Swordfish spawning and nursery ground

Swordfish (*Xiphias gladius*) is the second most important large pelagic species in the Mediterranean Sea. The ICCAT considers the existence of a single Mediterranean Stock. The Sicilian Channel seems to be one of the most important spawning grounds for the species along with others sites including the Balearic Isles & central Mediterranean (Di Natale, 2006).

The spawning activity of the Mediterranean swordfish appears more strictly related to climate and oceanographic features than for other pelagic species. Observations at sea confirms that having a surface layer at about 22°C or over is sometimes enough to induce spawning even for a short period and the hypothesis that swordfish spawn on multiple occasions during a single season is to be seriously taken into account (Di Natale 2006).

Although juvenile individuals are reported everywhere in the surface longline fishery, (Di Natale 2006), the major concentrations are linked to the availability of a plentiful supply of food either close to the coast or off-shore, and can change their geographical distribution substantially from one year to the other, according to oceanographic features. Juvenile swordfish is usually present along the entire Sicilian coast including small isles, the area around Malta as well as the Balearic Isles among others

Anchovy (Engraulis encrasicolus) spawning and nursery ground

Anchovy is a short-lived pelagic species, distributed all over the Mediterranean and one of the most important resources in this region. It ranks second in abundance to the sardine (*Sardina pilchardus*), but first in terms of economic importance. However, its distribution is not regular or wide-spread and rather comprises a set of independent populations. Such could be the case of the Sicilian Channel anchovy.

The dynamics of the biomass of the anchovy population in the Sicilian Channel were addressed by two European projects (Med 96-052 and Med 98-070). Results indicated that the NW region of the southern Sicilian coast (i.e. the area off Sciacca, on the Adventure Bank) gathers the most favourable conditions for the anchovy spawning grounds (Cuttita *et al.,* 2003). According to García Lafuente et al., (2002), distribution of anchovy early stages is highly dependent on surface water dynamics. Such study shows that the highest larval concentration is located off Cape Passero, (200 km downstream of the main spawning ground). The estimated averaged age of this population, based on the length of the larvae, is 8 to 10 days, which matches the time it takes larvae that has hatched from an egg spawned off Sciacca to get Cape Passero. The cyclonic circulation of water masses provides enrichment mechanisms for larvae growth and feeding, acting as main nursery ground.

Spawning and nursery grounds for demersal species of commercial interest.

Hake (*Merluccius merluccius*) is one of the most studied demersal species because of its great importance in Mediterranean fisheries although many aspects related to the spatial scale of its biology remain little known. Fiorentino and colleagues (2006) recently found that hake occurs at all life stages in two distinct geographic areas, the Adventure and Malta Banks, well separated by a wide area where hake abundance is very scarce. The two nurseries areas were identified at the eastern side of the Adventure Bank and Malta Bank, and in both nurseries grounds extended from about 100 m to the upper slope (approx. 200m). Moreover, juveniles inhabit preferentially the eastern side of the Banks and show seasonal differences with the highest concentration of juveniles located along the eastern boundary of Malta Bank in autumn, and in Adventure Bank during spring. Spawning aggregations were also found in the south-western break of both Adventure Bank and Malta Bank in autumn.

Red mullet *(Mullus barbatus)* is another of the most important Mediterranean demersal species, mainly caught by bottom trawling on continental shelves. On the Italian side of the Sicilian Channel, this species is mainly found at depth less than 200 m and spawns in spring, and the 0-group recruits in late summer (Levi *et al.*, 2003). A space-time analysis performed by Garofalo and colleagues (2004), indicated two clearly separate spawning grounds in the area, over two banks off the Adventure Bank and the Malta both at around 100 m depth. On the Adventure Bank the distribution is characterized by several patches, some of them being in coastal waters. In contrast, a large spawning area was identified close to the Maltese territorial waters. Although the recruits were rather widely distributed throughout Sicilian coastal waters, four areas of high concentrations were identified, between 20 m and 50 m depth, which were quite stable in location.

The greater fork beard (*Phycis blennoides*) is one of the most commercially important gadoids in the Mediterranean. Little is known of the spawning period. Reproduction occurs from late summer to early winter (Massutí *et al.,* 1996; Belcari and Biagi, 1999). Two extended areas of recruit concentration (i.e. stable nursery areas) were identified on the western and eastern side of the Adventure Bank, located between 200 and 400m deeper; other nurseries were found in the easternmost part of the Sicilian Channel. Different from hake, there is large interannual variability as to the nursery areas (Fiorentino *et al.,* 2003). Hydrology does not appear to play a role in explaining the position of the spawning fish and juveniles.

Other relevant species considered

Relevant specie	**Relevance for life history**	**Description**	**Source**
WHALES			
Fin whale (*Balaenoptera physalus*)	Feeding area	Fin whales are known to congregate in late February and early March in the coastal waters of the island of Lampedusa (Italy), Sicilian Channel, to feed on the euphausiid *Nyctiphanes couchii* Nevertheless, there is limited information on the presence and habitat use for this species They favour upwelling and frontal zones with high zooplankton concentrations.	Canese *et al., in press*. Hoyt 2005
SEA TURTLES			
Loggerhead turtle *Caretta caretta*	Nesting sites	Lampedusa and Linosa (two Natura 2000 sites) are among the last known nesting sites of Loggerhead in this part of the Mediterranean where this species can lay its eggs. In the last four years, a total of 11 nests have been found on the island of Linosa and between one and five nests on the island of Lampedusa. From 1995 Rescue Centre activity has marked more than 600 sea turtles and released in these years. During this period, it has been observed that one female turtle which was captured and marked in 1996 was observed nesting again in Linosa eight years later.	(Life NAT/IT/006271 "Urgent conservation measures of *Caretta caretta* in the Pelagian Islands" and Life NAT/IT/00184 "*Del.Ta*: Dolphins and Sea Turtles Protected).
SHARKS			
White shark *Carcharodon carcharias*	productive and nursery grounds	The fact that white shark reproduces in the central Mediterranean seems to be widely accepted. The Sicilian Channel apparently represent a productive and nursery grounds	Fergusson *et al*. (in prep)
SEABIRDS			
Cory´s shearwater *Calonectris diomedea diomedea*	Nesting sites	This species breeds on the rocky coasts and islands of the Mediterranean, with Europe constituting >75% of its global breeding range. Its European breeding population is large (>270,000 pairs), 15.000-18.000 (pairs) in Italy. However it underwent a large decline between 1970 and 1990. It has been suggested that colonies in the central Mediterranean (Linosa Island and southwestern Sardinia) and the Azores formed a panmictic population, with an estimated 4-19 individuals being exchanged among colonies per generation.	Birdlife 2009

4.5.3 Importance for threatened/endangered/declining species or habitats

Bluefin Tuna

It is a well known fact the Atlantic bluefin tuna alarming decline (Block 2005) as presented before in section 3.4.1. However, it is considered as data deficient in the IUCN list.

Other relevant species considered

Relevant specie	***Status***	***Features***	***Threaths***	***Source***
WHALES				
sperm whale (*Physeter macrocephalus*)	EN	No estimate of population size exists for the region	Bycatch in fishing gear and ship strikes Entanglement in highseas swordfish driftnets, which has caused considerable mortality since the mid-1980s Disturbance, particularly related to intense maritime traffic. It is suspected that a combination of these factors has led to decline (of unknown magnitude) over the last half century	Reeves and Notarbartolo di Sciara, 2006 Notarbartolo di Sciara 1990; International Whaling Commission 1994
DOLPHINS				
Bottlenose dolphin (*Tursiops truncatus*)	vu	Bottlenose dolphin have been recorded in waters around the Pelagie Islands Local subpopulations appear to be habitat-dependent, as biogeographic and hydrographic features influence their distribution and movement pattern Four possible ecological boundaries have been proposed for the species as follows: the Gibraltar strait, the Almerìa-Oran front, the Sicilian Channel and the Turkish Straits system. Nevertheless, information on the presence and habitat use for this species in the area is limited		(Reeves and Notarbartolo di Sciara, 2006) Natoli *et al*. 2005 Hoyt 2005
SEA TURTLES				
Loggerhead (*Caretta caretta*)	EN	The most frequent chelonian in the Italian Waters and Linosa is known as an important nesting site for this species. The activity in the Pelagie Islands is focused on loggerhead conservation but also includes observations to evaluate the impact of fisheries, in particular longline fishing, on loggerhead populations in the area. In this respect, an enduring collaboration was set with a number of fishermen that come from Sicily to the Pelagie Islands during the summer season for longline fishing (targeting swordfish).	The main threats to these turtles include pollution, being accidentally caught up in fishing gear and collisions with boats crossing the waters of the Sicilian Channel.	IUCN, 2004 data unpublished see Stefano Nannarelli *et al*
Green turtle *Chelonia mydas*	CR	they have only been recorded occasionally		IUCN 2004 Russo *et al*., 2003
Leatherback turtle *Dermochelys coriacea*	CR			

Other relevant species considered (continued)

CHONDRICHTHYANS (CARTILAGINOUS FISH)				
The Maltese skate (*Leucoraja melitensis*)	CR	Endemic species that is under imminent threat of extinction. Its main range now appears to be restricted to the Sicilian Channel which is subject to heavy trawling activity It is extremely rare, in broadscale surveys of the north Mediterranean coastline from 1995–1999, recorded in only 20 out of 6,336 hauls It is also now rare off Malta and rare or absent off Tunisia, where it was previously considered moderately common Although population data are lacking, given the small range of the remaining population the potential detrimental impact of trawl fisheries is likely to be significant. Further research is also needed on the exploitation, distribution, biology and ecology of this species, as well as trends in abundance	Trawl fisheries Very rapid population declines, which are estimated to exceed 80% in three generations. It was previously found over a relatively restricted area (about ¼ of the total area of the Mediterranean Sea) in the depth range where trawl fisheries routinely operate	Ungaro *et al*. 2006. Baino *et al*. 2001; Bertrand *et al*. 2000 Bradai 2000; Schembri *et al*. 2003
White shark (*Carcharodon carcharias*) Mediterranean population	E	Evidence of declines and the likely fishery pressures placed upon their apparent reproductive and nursery grounds in the Sicilian Channel Very little is known about seasonal movements or key elements of its population biology Fergusson suggest that efforts should focus upon the Sicilian Channel and its environment in order to implement a scheme of protective management in 'critical habitats', selected by interpreting biogeographical data.	In certain regions, such as Sicily, the white shark has traditionally been viewed negatively, as a costly interference to fisheries (Fergusson *et al*. in prep.). Declines of traditional regionally- important prey such as bluefin tuna alongside threats to other important prey, including small cetaceans (Morey *et al*. 2003) and other demersal and pelagic fishes, are suspected to have had a serious impact on white sharks in the Mediterranean	(Fergusson *et al*. in prep.). (Morey *et al*. 2003; Soldo and Dulcic 2005) (Fergusson pers. Comm see in Cavanagh and Gibson, 2007). (Fergusson 2002).
porbeagle (*Lamna nasus*)	CR		Unsustainable fisheries (target and bycatch, usually by longlines) are the main threats to these species	(Cavanagh and Gibson, 2007).
shortfin mako (*Isurus oxyrinchus)*	CR			
giant devilray (*Mobula mobular*)	E			
blue shark (*Prionace glauca*)	vu			

NOTE: VU= Vulnerable, EN= Endangered, CR=Critically Endangered ; DD= Data deficient

4.5.4 Vulnerability, fragility, sensitivity or slow recovery

White coral communities

Deep water white coral communities have a very low growth rate and a extremely long-life making these hard bottoms communities very vulnerable. Trawling may not only cause physical destruction of these reefs and the complex communities made up of many organisms associated with this habitat, but can also change the local hydrodynamic and sedimentary processes. A reduction of white coral reef always leads to a consequent decline in biodiversity and density of associated organisms. Bottom trawling on the nearby bottom produces suspension of sediments that can stress and even kill corals (Cartes *et al.,* 2004; Palanques *et al.,* 2004).

Recent mapping of the Sicilian Channel seafloor involving ROV techniques has discovered the presence of vulnerable living colonies of *Lophelia pertusa, Madrepora oculata* and *Dendrophyllia cornigera* as well as other species such as *Isidella elongate,* tall sea pen *(Funiculina quadrangularis*), red coral (*Corallium rubrum*) and other gorgonians sp. (see VI Biological diversity section) (Freiwald *et al.,* in press). The HERMES ROV dives on R/V *Meteor* cruise M70-1 demonstrated that white coral communities thrive over much wider geographic areas in the central Mediterranean; however, they are difficult to sample with conventional gear —and are therefore generally unrecognized because they live beneath bedrock overhangs on steeply inclined submarine walls and escarpments.

4.5.5 Biological productivity

Patti et Al (2004) show how the surface circulation of the two-way exchange flow through the Sicilian Channel and its complex topography makes the Sicilian Channel a high productivity and retention area. Accordingly with this author, AIS enters the channel by its west side to describe a large cyclonic meander, which embraces the Adventure Bank and then approaches the shore by the middle of the southern coast of Sicily and separates again when it encounters the shelf of Malta and then encircles a second cyclonic vortex, off Cape Passero . This circulation favours the existence of "permanent" upwelling to the left of the Stream. Coastal upwelling is believed to be the main source of nutrient pumping in the area (characterized by very low levels of river discharge).

This favours spawning activity and recruitment success processes, turning this area in a recognized spawning and nursery area for species of high commercial relevance such as bluefin tuna, swordfish, hake and greater fork beard. (e.g. Garcia Lafuente *et al.,* 2002, Garofalo *et al.,* 2004). (as seen in numeral 4.5.2). The area is also includes spawning grounds of red mullet (*Mullus barbatus*) (Garofalo *et al.,* 2004) and a relatively high abundance of rays, different from the remaining region (Garofalo *et al.,* 2003). According to Fiorentino *et al.,* 2003 the existence of a frontal zone precisely in the middle of the area, in fact, may offer an ideal situation for small predatory organisms such as squid paralarvae, due to the richness of food particles concentrating at the convergence front.

Levi et al. (2003) investigated the stock-recruitment relationship for red mullet in the Sicilian Channel, including environmental information in terms of sea surface temperature (SST) anomaly as a proxy for oceanographic processes affecting recruitment. Results showed that, for a given level of spawning stock, higher levels of recruitment corresponded to SST, being warmer than average during the early life stages.

4.5.6 Biological diversity

Biological Hotspots

Most of the habitats considered as unique, vulnerable and productive, area also areas of biological diversity. Topographic setting (seamount), hydrodynamic forcing (fronts, upwelling), and the biogeochemical characteristics of the deep-sea floor may play key roles in promoting and sustaining high biodiversity along the open slopes of continental margins (Freiwald *et al.,* 2009).

As explained in the case of the Balearic Island seamounts, this feature is recognized areas de potential high biodiversity and comparable islands as far as faunal biogeography is concerned and prone to endemism. In the Sicilian Channel a considerable number of seamounts have been identified, the Graham/Empedocles/Ferdinandea seamount being one of the better known. Investigations of seamounts and other submarine volcanic features in the Sicilian Channel have been mainly geological, with biological studies relatively neglected.

Last but not least, The *Adventure Bank* supports a large ichthyoplankton diversity which is consistent with favourable environmental and hydrographic conditions.

Mesopelagic diversity

Cuttia et al. (2004) are among the first scientists to investigate the mesopelagic fish species inhabiting the Sicilian Channel. They are the most common deep-water species and their larvae are common prey for many other species, including some that are commercially important, providing a link in the energy transfer from the deep sea and the higher layers of the water column. The distribution of mesopelagic fish larvae appears to be determined by hydrographic conditions. Generally found offshore, the researchers found some concentrations located in the shelf area between Mazara and Sciacca.

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Demersal diversity

Recently the diversity of demersal fish communities (Osteichthyes and Chondrichthyes) has been studied using trawl surveys under the international MEDITS program. The greatest diversity within these communities was found at the offshore bank on the western part of the south Sicilian shelf (Adventure Bank) with a high biomass of commercially important species such as hake and red mullet present. Detailed analysis of the catches from this area shows that 58 different fish species were present i.e. about 34% of the total number of fish species collected over the entire study area. The entire area delineated was inside the 100m isobath (Garofalo *et al.,* in press). The eastern sector of the Adventure Bank was found to be far less diverse as was the central sector of the Sicilian Channel. However these areas also showed high variability.

Interestingly, the areas showing the greatest inter-annual variability of diversity are located mainly along the shelf edge, where topographically induced upwelling may occur (Lermusiaux and Robinson, 2001), and particularly along the average trajectory of the AIS (Robinson *et al.,* 1991).

The area where the AIS approaches the Sicilian coast is known to be a permanent upwelling area (Lermusiaux and Robinson, 2001) and was identified in the MEDITS study as an area persistently characterized by low diversity values (Garofalo *et al.,* 2007).

White coral communities

Deep-water coral assemblage is dominated by colonies of the scleractinian *Lophelia pertusa, Madrepora oculata* and *Dendrophyllia cornigera*. The true extent of the white coral community in the Mediterranean Sea is poorly known and with relatively few verified records of live colonies. *Lophelia pertusa* and *M. oculata* exhibit a scattered distribution pattern.

As part of HERMES project, the R/V *Meteor* recently undertook an expedition using ROV techniques to determine the status of white coral communities in the Sicilian Channel and others sites in the central Mediterranean. The team investigated three escarpments within the Sicilian Channel and discovered living colonies of deep coral waters as well as other associated species (Freiwald *et al.,* 2009). Prior to this expedition, only Schembri et al. (2007) and Zibrowius and Taviani (2005) had documented the presence of living white corals in the region.

4.5.7 Naturalness

See section 3.5.7.

5. Recommendations

This study shows that both the high seas around the Balearic Islands and the Sicilian Channel meet the majority of criteria adopted by the CBD for identifying areas for protection and therefore should be considered as high priority areas in any future network to be developed for the region.

Although better studied than many ocean areas, including the eastern basin of the Mediterranean, there are still considerable gaps in our knowledge of the distribution of different habitats and communities living in both the waters around the Balearic Islands and the Sicilian Channel and in particular in the deeper waters. Lack of information should not be used as an excuse to differ protection – the existing information is sufficient to make valid decisions.

Given the high population and the degree of anthropogenic pressure throughout the Mediterranean it is hard to see how the naturalness criterion might be applied. While it is an obvious priority to ensure protection of near-pristine areas, any future protected area networks must be comprehensive and fully representative of the whole range of habitats and ecosystems and so impacted areas should not be excluded. Marine ecosystems have great powers of regeneration and such protection can bring about restoration with resulting benefits for both conservation and fisheries. Indeed, establishing large scale marine reserves around the Balearic Islands and the Sicilian Channel is likely to be a crucial step if we are ever to reverse the precipitous decline of the bluefin tuna in the Mediterranean.

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