



UNEP



**United Nations Environment Programme**

**MEDITERRANEAN ACTION PLAN**

**Regional Activity Centre for Specially Protected Areas**

## **Sicily Channel/Tunisian Plateau: Status of Cetaceans**

### ***Draft internal report***

**Draft to be used only to support the preparation of documents for the  
“Mediterranean Regional Workshop to Facilitate the Description of Ecologically or  
Biologically Significant Marine Areas. Malaga, Spain, 7-11 April 2014”**

February 2014

# Draft internal report not for distribution

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This report should be quoted as:

*UNEP-MAP-RAC/SPA*. 2014. Status and conservation of cetaceans in the Sicily Channel/Tunisian Plateau. By M. Aissi. Draft internal report for the purposes of the Mediterranean Regional Workshop to Facilitate the Description of Ecologically or Biologically Significant Marine Areas, Malaga, Spain, 7-11 April 2014.

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## 1. INTRODUCTION

The Mediterranean is a semi-enclosed marginal sea with sea-beds up to 5000 m deep (the maximum depth is 5121 m in the Matapan-Vavilov Deep, off the Southern coast of Greece, with an average depth of 2500 m). It harbours most of the same distinctive biodiversity key geomorphologic structures in other regions of the world such as submarine canyons, seamounts, mud volcanoes or deep trenches (WWF/IUCN, 2004).

The only relevant connection of the Mediterranean Sea with the world ocean is the Strait of Gibraltar, a narrow passage of hardly 14 km width at its narrowest section and a sill less than 300m depth. The Strait of Sicily, which is also a relatively constraining topographic feature, divides the Sea into two basins of comparable size, the Western ( $0.85 \cdot 10^6 \text{ km}^2$ ) and Eastern ( $1.65 \cdot 10^6 \text{ km}^2$ ) Mediterranean, which in turn are divided into smaller sub-basins.

The Strait is about 145 km wide and divides the Tyrrhenian Sea and the Western Mediterranean Sea from the eastern Mediterranean Sea. It has a high primary productivity with high values of biodiversity due: moderate depths (maximum depth is 320 m), peculiar hydrography and variety of habitat types. Most important human uses of the area are fishing, aquaculture, shipping and tourism. Other important uses are oil drilling and extraction, deployment of gas pipelines and communication cables, and construction of wind-mill farms.

Vessel activity in the Mediterranean has been rising steadily over the past 10 years. The largest vessels observed operating in this area are crude oil tankers (with an increase in size of 26 per cent over the past 10 years). Based on the Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea (REMPEC) report, vessel activity within the Mediterranean is expected to increase by 18 per cent whilst through transits are projected to rise by 23 per cent. The most significant increases will occur in the chemical, crude and LNG tanker sectors and also in container vessel movements (unnamed, 2008). The strait of Sicily is henceforth one of the areas within the ACCOBAMS region with the higher level of maritime traffic. The impact is prevalent mainly in the deep sea waters of the strait, especially along traffic routes, harbours and other important commercial coastal areas.

The Mediterranean Sea is considered one of the world's biodiversity hotspots (it hosts between 4% and 18% of all known marine species, many of them endemic, although it constitutes only 0.8% of global ocean surface) where the impact of those cited anthropogenic pressures together with climate change could be most devastating (Lejeusne et al., 2009; Coll et al., 2010).

Currently only 4% of the Mediterranean (less than 1% if we exclude the Pelagos sanctuary) is in Marine Protected and Managed areas and 75% of them are located along the basin's North-Western shore. In addition, their distribution is inconsistent with biodiversity attributes of fish species. Thus, although these areas included regions with high species diversity, high percentage of endemic species and of vulnerable species following the IUCN -International Union for Conservation of Nature - classification, they do not cover enough percentage of phylogenetic and functional diversity, which have also an important role in the conservation of other marine species and ecosystems.

The Convention on Biological Diversity (hereafter CBD) 2010 objective is set at 10%. By 2012, the CBD also has the objective to establish a coherent and ecologically representative network of MPAs in the Mediterranean. MPAs are effective tools for providing lasting protection, enabling restoration and ensuring careful use of this natural heritage. If they protect sensitive environments and threatened species, they also contribute to increasing the productivity of fishing areas, regulating the different uses of the sea, fostering sustainable tourism and creating new job-generating activities. A step beyond creating individual MPAs is to establish o a network of MPAs. Through interconnections and interdependencies, individual MPAs of this network contribute positively to each other's integrity by decreasing overall vulnerability (Abdulla et al., 2008).

What can be done to reverse the trend? New marine protected areas must be established particularly to protect the habitats that are not represented in the present network, notably, in the high seas and in the deep seas (as suggested Bernard CRESSENS, the Conservation Director of WWF- France). Consequently, this report outlines the marine mammal ecology of the Sicily Channel and Tunisian Plateau in order to guide the development of Marine Protected Areas in this area.

## 2. MARINE MAMMAL ECO-BIODIVERSITY IN THE MEDITERRANEAN SEA

All experts and marine mammal specialists confirm the possible occurrence of 26 cetacean species in the Mediterranean and Black Seas, at least 8 of them are considered common (Fin whale *Balaenoptera physalus*, Sperm whale *Physeter macrocephalus*, Striped dolphin *Stenella coeruleoalba*, Risso's dolphin *Grampus griseus*, long finned Pilot whale *Globicephala melas*, Bottlenose dolphin *Tursiops truncatus*, Common dolphin *Delphinus delphis*, Cuvier's beaked whale *Ziphius cavirostris*).

Moreover, 4 cetacean species are considered as occasional or have a small or local distribution area (as the strait of Gibraltar) (Minke whale *Balaenoptera acutorostrata*, Killer whale *Orcinus orca*, False killer whale *Pseudorca crassidens*, Rough toothed dolphin *Steno bredanensis*), and 6 accidental, alien to the Mediterranean, but occasionally sighted in the last 120 years (among them the Humpback whale *Megaptera novaeangliae*). Furthermore, we have to consider the presence of a small population of Harbour porpoise *Phocoena phocoena* in the Black Sea.

The Mediterranean Monk Seal (*Monachus monachus*) is the only pinniped to be found within the Mediterranean Sea. This species is actually very rare and listed as an endangered species. The only known colonies are in the Alboran Basin and in the Aegean Sea. Few sightings were reported occasionally from opportunistic boats, but an investigation study of the occurrence of this species in Libyan waters is still in course.

Cetacean population in the Mediterranean Sea are currently affected by the complex of threats deriving from a variety of human activities. Considering the various degrees of genetic isolation of the Mediterranean cetacean population from the Atlantic, these species are thus particularly vulnerable. As a consequence, conserving cetaceans has become an increasing challenge in present times.

Recent and ongoing studies carried out in the central Mediterranean Sea indicate that the higher species diversity is likely to occur within areas of special bottom topography. The spatial distribution of marine mammals is reflected particularly in three dissimilar morphological regions: submarine canyons (region 1), inter-canyons (region 2) and seamount areas (region 3) (Aïssi et al., 2012).

The ‘quantification’ of the seamounts influences on top predator distribution in the central Mediterranean Sea pointed out a seamount association for striped dolphins

and fin whales. Striped dolphin was significantly more abundant in the vicinity of some seamount summits (maximum effect at 20 nautical miles) than in other locations further away from these features (Morato et al., 2008; Aïssi et al., 2013a) (**Figure 1**). However sperm whales were significantly more abundant in the vicinity of some canyon areas than seamounts (**Figure 2**). Indeed, a relevant distinction of encounter rates was registered between these three zones characterized by different topography.

Moreover, the simulation of sperm whale distribution using Artificial Neural Network Model pointed out a relatively high predictive occurrence of sperm whales in the Tyrrhenian Sea beyond the borders of the Pelagos sanctuary (Eastern Sardinia). This spatial distribution is thought to be related to the special topographical bottom profile characterised by the presence of seamounts and submarine canyons (Aïssi et al., 2013b) (**Figure 3**).

Thus, we admit that cetaceans are not randomly wide-spread at sea and their distributions are directly or indirectly influenced by special topographic features like seamounts and submarine canyons (accelerators of primary production).

These extremely mobile and migratory top predators are able to travel rapidly from one area to another depending in trophic richness of a given area. In this synthesis, and looking to develop a conservation strategy of marine mammal at a large scale in the central Mediterranean Sea (characterized as a poorly studied area), we will based our analysis on available studies and surveys carried out in this zone and potential stranding data. A special focus on bottom topographical aspect possibly enhancing cetacean occurrence will be highlighted.

### **3. THE STRAIT OF SICILY**

#### **3.1. Ecology**

The strait of Sicily connects the western and eastern Mediterranean sub-basins. Its topography consists of shallow banks along the Sicilian and Tunisian coasts. There the water depth ranges from 50 to 200 m. The bank on the Tunisian side covers a substantial part of the surface area in the strait. Deeper channels with depths to around 1000 m exist between the shallow banks. Proceeding southeast from Sicily the depth changes from the 50 m range to around 600 in the shelf break region. There a steep drop occurs, to approximately 3 km, over a short distance.

Obviously, this topography plays a fundamental role in the dynamics of the Mediterranean general circulation pattern. The flow in this Channel is driven by direct forcing such as wind, and by thermohaline processes leading to density difference between the two sub-basins.

At first approximation, based on temperature and salinity distribution, we suggest the presence of seven water masses. From the surface downwards they are: Surface, Upper, Atlantic, Mixed, Fresh, Transition and Levantine. However, we admitted that the flow through the Sicily Channel can be considered merely as a two-layer system; surface layer and bottom-deep layer. A shear zone exists between these two systems (Robinson et al., 1999).

The surface layer is occupied by the relatively fresh Modified Atlantic Water (MAW). It is described as a broad homogeneous layer that undergoes progressive modifications becoming warmer and saltier as it spreads eastward toward the eastern Mediterranean basin. Its pathway is influenced by the topography, the surface forcing, the density gradient between both Mediterranean sub-basins, and mainly by advection within the Atlantic Ionian stream (AIS). It's identified by the salinity minimum. This surface circulation is characterized by meanders, semi-permanent cyclonic and anticyclonic gyres and eddies (Lermusiaux and Robinson, 2001).

Below the Atlantic layer, there is a mixed region where the salinity distribution tends to be linear and has a distinctive slope. It is a thin layer located between depths of about 100 and 200m. It has been associated to the Winter Intermediate Water, previously formed in the Western Mediterranean by surface cooling of MAW during the winter. At the bottom of this mixed layer, the salinity frequency of occurrence distribution shift to higher values (Sammari, et al., 1999).

The main complement to the surface exchange is the deep outflow. Waters coming at depth from the eastern Mediterranean cross the Sicily Strait with two streams determined by the presence of the ridge in the central part of the sill strait. Both streams are composed mainly of Levantine Intermediate Water (LIW) whose core can be found on both sides of the ridge, even though it is always present on the eastern narrower channel close to Sicily. Another water mass, much colder than LIW, is present at the bottom of the Tunisian side of the strait (Cretan Intermediate Water, CIW) (Robinson et al., 1991; Klein et al., 1999).

Weather patterns and associated winds can influence this internal dynamics. Variability occurs at several time and space scales and involves interactions of several water masses. The region contains active water mass modification processes and their mixing is important. It has been attributed mainly to turbulent mixing in high shear zones, atmospheric forcing, and mesoscale eddies and instabilities (Warn-Varnas et al., 1999).

In addition to the general circulation with its mesoscale variability, there are the wind driven currents on the shelf from local and remote storms (including the Sicilian coastal current) and upwelling off Sicily. Tides, inertial, gravity, surface, and continental shelf waves occur. The region contains a number of significant processes and phenomena. A recently emerging concept, which seems to have substantial explanatory power, addresses ocean triads. A series of comparative studies on the climatology and geography of known preferred spawning areas (Parrish et al., 1983; Cury and Roy, 1989; Bakun and Parrish, 1990; Durand et al., 1998) have served to identify three major classes of physical processes combining to yield favourable reproductive habitats for coastal pelagic fish as well as many other types of fish:

- enrichment processes (upwelling, mixing, etc.)
- concentration processes (convergence, frontal formation, water column stability)
- processes favouring retention within (or drift toward) appropriate habitats.

Bakun (1996) called these three elements the ‘fundamental triad’ of factors underlying favourable fish reproduction habitats. Subsequently, oceanic areas where the three elements exist in mutually supportive configurations are sometimes referred to as ocean triads (Bakun, 1998).

Winds blowing along the axis of an elongated basin (such as the Mediterranean) induce transport away from one coast. They thus cause a divergent flow which results in a ‘coastal upwelling’, while towards the opposite coast convergence and downwelling occur. Ekman Transport (Ekman, 1905) causes a water flow from the zone of upwelling and nutrient enrichment towards the area of convergence and downwelling, resulting in concentration (Franks, 1992) and retention, all together producing a natural ocean triad.

Mountainous coastal topography may offer sheltered locations where wind intensity can increase turbulent mixing-allowing processes, as for the concentration of

food for fish larvae. Inflows of less saline waters from rivers contribute to ocean triad configurations in the Mediterranean (Agostini and Bakun, 2002).

### **3.2. Biodiversity**

Biodiversity is not uniform throughout this channel but varies with depth in the water column and distance from the coast. Coastal regions and shallow waters have special features, and the western and eastern portions differ greatly in biodiversity richness. In fact, zooplankton distribution in this area reflected a mainly concentration in the north and off the southern tip of the Sicilian coast. An offshore transport of this plankton community was indicated due to the local circulation features.

The general circulation of the AIS generates cyclonic eddy in the north-western and north-eastern sides of its meander trajectory. These result in the formation of a series of anticyclonic vortexes off the eastern coast of Tunisia (south Lampedusa Island) and off Malta. The maintenance of cyclonic vortexes implies the existence of upwelling at its centre to counterbalance the effects of friction. This is a suitable condition for sustaining high rates of primary production. Convergence generated by anticyclonic eddies southeast of Cape Passero allows the herbivorous zooplankton to maintain its relative position in an area where retention also provides favourable conditions for feeding and growth. That's a typical oceanic triad situation.

Both, hydrodynamic forces in the area as well as the complex topographic features in the Sicily Channel determine its productivity. Particularly its southern part is a convergence area and therefore a strong retention zone where there is a high concentration of nutrients due to the presence of fronts and mixing zones associated with reefs, seamounts and islands (Bakun, 2006). Due to the persistence of the upwelling along the eastern and southern coasts of Sicily all year round, this area was be classified as a highly productive and considered as a biodiversity hotspot within the Mediterranean. Seamounts and deep-sea corals are found in the channel and the area is important to fin and sperm whales as well as the great white shark.

### **3.3. Cetacean fauna**

Data on the occurrence and distribution of cetacean species in the Mediterranean is non-homogenous. While the longstanding extensive research of countries on the European coast produced substantial published data for the Alboran, Ligurian, Tyrrhenian, Adriatic, Ionian and Aegean basins, very little is known about the central Mediterranean

Sea as the strait of Sicily (Notabartolo di Sciara and Birkun, 2010). Indeed, information on cetacean populations in this area still remains sporadic and scarce. Appropriate data arises generally from opportunistic surveys and limited in space and time dedicated surveys. The lack of adequate knowledge about the cetacean population in terms of distribution, size, and dynamics may dramatically limit the ability to develop strategies and policies for their conservation.

Several organisations and institutions developed various strategies to fill this gap of information through the cover or scanning coastal and surrounding pelagic waters using acoustic and/or visual techniques like during the first survey covering the whole coastal Tunisia waters in the framework of the cooperation between the ‘‘*Institut National des Sciences et Technologie de la Mer*’’ (INSTM) and the ‘‘Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic area’’ (ACCOBAMS) action.

The exclusive survey covering the greater part of the pelagic Tunisian plateau is financed also by ACCOBAMS focusing on cetacean observation from ferries along the strait of Sicily (between Tunisia and Sicily) and the channel of Sardinia (between Tunisia and Sardinia) (Figure 8). Preliminary results of this ongoing project may orientate a special attention to the canyon of Bizerte where sightings of large cetaceans occurred during fall season of 2013. This canyon extends over an area of about 1000 km<sup>2</sup> at an average depth of about 500 m, halfway from Tunisia, Sardinia and Sicily. This submarine valley is located in a key position, as connectivity area between the Alboran and Tyrrhenian Seas and offers potential link between the Western, the Central and the Eastern Mediterranean.

Similar coastal surveys were also conducted along the Pelagie’s archipelago southern of Sicily, especially around Lampedusa and Malta Islands. Land stations, dedicated vessels, opportunistic boats and aerial surveys were used to validate cetacean biodiversity and estimate marine mammal density in those areas (e.g. Vella and vella, 2012). All these studies focused mainly on coastal dolphin population and not any study raised the regular presence of large cetaceans.

International organizations have also been involved in the capacity building aspect and covered among others pelagic waters of the strait of Sicily such as the *International Fund for Animal Welfare* (IFAW) using the sailboat "Song of the Whale". (**Figure of effort**)

Moreover, cetaceans regularly strand along central Mediterranean coastline and information received on stranded animals may provide an accurate picture of what species are specifically found in this area and “speculate” local and/or seasonal distribution (Perrin and Geraci, 2002). This key biological information may be considered also useful pointers to the general health of the populations living in this key connectivity area. This provides also useful baseline data to help detect outbreaks of disease or unusual increases in mortality (Raga et al., 1997; Gibson et al., 1998; Jaber et al., 2006). This kind of data are often challenging because early historical accounts are difficult to access and scarce. Thus, this makes studies of historical and present occurrence particularly relevant.

Almost 26 cetacean species have been recorded in the Mediterranean Sea, nevertheless only eight have resident populations with various degrees of genetic isolation from the Atlantic as previously described.

### **3.3.1. Fin whale (*Balaenoptera physalus*)**

The fin whale is the largest free-ranging predator found in the Mediterranean Sea. Mediterranean fin whales are currently defined as a distinct subpopulation from those in the North Atlantic, perhaps extending out to southern Portugal (IWC 2009). Results from satellite tagged fin whales and stable isotope analysis from baleen plates suggest that a small proportion of Mediterranean fin whales migrate seasonally through the Strait of Gibraltar to feed in the Atlantic Ocean (Cotté et al., 2009); however, most individuals remain within the western basin during fall and winter (Bentaleb et al., 2011).

The hypothesized movement of Mediterranean whales into the North Atlantic is not fully supported by either the satellite tag or visual observation data. Few other population marker data are available by which to better evaluate the degree of isolation and current distribution limits of Mediterranean fin whales. As a result, the distribution limits and the relationship between North Atlantic and Mediterranean fin whales are still puzzling, and the identity of observed whales crossing the Strait of Gibraltar remains uncertain (Castellote et al., 2011).

The overall distribution of fin whale in the Mediterranean Sea has long been investigated resulting to the distribution map presented in **Figure 4**. Dedicated surveys pointed out the congregation of this species in late February and early March in the coastal waters surrounding Lampedusa Island to feed on the euphausiid *Nyctiphanes*

*couchii* (Canese et al. 2006; Aïssi et al., 2008). Here the fin whales were observed to spend their time in shallower waters than those in the Ligurian Sea. Indeed, during winter, fin whales disperse from the northern Mediterranean to a wider range within the Mediterranean, among them the southward direction. Certainly, the number of individuals sighted close to Lampedusa in winter was smaller than that estimated in the Ligurian Sea in summer.

Fin whale winter grounding in this part of the Mediterranean has been reported yearly since 2006. Moreover, the academic research project developed by the University of Malta since in 1996 has provided, over the years, an increasing knowledge of cetacean species presence, abundance and distribution in the central and southern part of the Mediterranean around the Maltese Islands. Fin whale sightings were recorded in coastal waters around the Maltese Islands between July and August 2007. Out of these, four sightings in July were of single Fin whales (spotted on different days, but appeared to be the same individual residing in the same area for at least a week) and one sighting in August included two individuals (sighted once as this was followed by days with strong winds) (Vella, 2010).

Analysis of the bottom topography of the strait of Sicily points out the existence of attractive top predators features, considered a likely suitable features to the Mediterranean fin whale sub-population during winter. This unique mysticete inhabiting the Mediterranean Sea uses a migratory corridor from the Pelagos Sanctuary to the Southern Mediterranean through the strait of Messina (Aïssi et al., 2008).

Fin whale presence in this area has been supported also by the stranding data accessible from the “*Mediterranean Database of Cetacean Strandings*” (MEDACES) and the Tunisian stranding network. Indeed, the overall analysis of stranding events points out a significant variability in species mortality. As illustrated, the most regularly identified species stranded along Tunisian coasts were not exclusively for small odontocete like bottlenose dolphin, (representing 51.7% of all stranding events), but also for large cetaceans like fin whale (25.3%) and sperm whale (10.3%). This unique mysticete regularly encountered in the Mediterranean Sea was registered mainly during winter.

In the Ligurian Sea, the known offshore preferences of fin whales coincides with the winter-spring presence of high levels of nutrients and upwelling currents in the centre of the basin, likely reflecting the distribution of Northern krill, *Meganictyphanes norvegica* (Relini et al., 1994). Nevertheless, inter-annual as well as seasonal

differences in prey biomass may be related to whale presence and aggregation behaviour in various areas. In the Gulf of Lions, in the Ligurian Sea and in the Tyrrhenian Sea, fin whales can occasionally be unusually sighted close to the coast (less than 2 km from shore, and often entering small bays and harbours), possibly as a consequence of prey aggregation due to a change in the circulation patterns. On the other hand, each year several fin whales specimens follow a less variable seasonal pattern, from January to the end of March, to exploit annual concentration of *Nictyphanes couchi* in the Sicily Channel shelf, around Lampedusa Island and its adjacent high seas (Aïssi et al., 2008; Canese et al., 2006).

Due to the endangered status of the fin whale world around, and not especially in the Mediterranean basin, this specie has been protected under both the Endangered Species Act (ESA) (as endangered) and the Marine Mammal Protection Act (MMPA). Although, it is listed as “endangered” by the IUCN and is listed in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (known as CITES). Thus, fin whale distribution in the Sicily Channel may underline the importance of these areas as having a special importance for life history of this specie.

### **3.3.2. Sperm whale (*Physeter macrocephalus*)**

The sperm whale, the most studied species, seems to be opportunistic in its habitat use, exploiting areas with steep slopes, as well as offshore waters featuring SST fronts. Juvenile and sub-adult sperm whales are thought to roam widely across the Mediterranean, but social unit seems to be quiet confined to some identified areas as Alboran Sea, Tyrrhenian Sea and Aegean Sea. Sperm whales spend more than 72% of their time in foraging dive cycles of 45 minutes interrupted by surface intervals lasting about 9 minutes. This behaviour makes passive acoustic study better than the visual survey. Indeed, this teutophageous species is considered particularly highly vocal.

The relatively common occurrence of sperm whale mortality events along the Tunisian coastline is quiet constant year round with highest relative frequencies during spring and summer. These events were mainly taking place in the western Mediterranean part exclusively for single individuals. No mass stranding were reported in this area and body lengths varied from 6 to 14 m.

Tunisian coastline belonging to the western Mediterranean basin is characterised by a strong topographic slope. This topographic feature is more likely preferred by sperm whales which appear to occur preferentially in deep continental slope waters where

mesopelagic cephalopods are most abundant. Nevertheless, due to the lack of regular monitoring effort in this area we cannot describe this area as suitable sperm whale habitat.

Although there are historical accounts of large groups of sperm whale in the strait of Sicily, recent visual and towed hydrophone surveys indicate rather low densities (Lewis et al., 2007). However, monitoring at the NEMO-ONDE neutrino detection array sited 20km off the east coast of Sicily had provided detections of sperm whales year round with a peak in April and October. Acoustic length measurement indicates that animals with a range of body lengths are present but none exceeded 15m, indicating an absence of the oldest male sperm whales. (See **detailed data in Aïssi et al., 2013 review** in Press)

### **3.3.3. Cuvier's beaked whale (*Ziphius cavirostris*)**

The Cuvier's beaked whale is the most common Ziphiid in the Mediterranean maintaining a resident sub-population in the Mediterranean that according to preliminary genetic analysis seems to be distinct (Dalebout et al., 2005). This poorly known species in the Mediterranean as elsewhere may be considered among the longest and deepest diving mammal. The visual observations are rare and furtive due to the unapproachable temperament of this animal. Its spatial distribution is restricted to some specific area of the Mediterranean, such as the Ligurian Sea and the Cretan edge. Visual observation has been reported solely in the South-Eastern of Sicily (Ionian Sicily).

This species appear to be prone to mass-strand in response to high-intensity sonar and seismic underwater air-gun arrays. Although mass stranding of this species are not usual, stranding events gleaned from the literature were reported from Sicily and Malta. However no strandings are known for Libya and Tunisia (Podestà et al., 2006). (**Figure stranding**)

Cuvier's beaked whale diet is composed exclusively of bathypelagic cephalopods from the Histioteuthidae and Ommastrephidae families. Altogether, *H. Bonnellii* and *H. reversa* constitute the main diet of this species. Indeed, these pelagic squids are the unique Histioteuthidae occurring in the Italian waters. These cephalopod species are by-caught by deep sea trawl fisheries off the Maltese Islands which may indicate possible presence of this deep-diving cephalopod predator.

Thus, this toothed whale prefers offshore areas containing submarine canyons, seamounts and escarpments, where it can feed on its preferred diet of deep-sea squid and some fish.

#### **3.3.4. Bottlenose dolphin (*Tursiops truncatus*)**

The bottlenose dolphin is one of the most frequently observed cetaceans in the Mediterranean (e.g. Gnone et al., 2011). They occur in most coastal waters of the basin and have been reliably reported in the waters of Tunisia, Sicily, Pantelleria, Malta and Lampedusa. They have been studied only in relatively small portions of the basin, and wide areas remain largely unexplored (Bearzi et al., 2008). The species was classified as Vulnerable and is also listed in the Annex II of the Habitats Directive (Council Directive 92/43/EEC), as a Species of Community Interest. (Reeves et al., 2006). The overall distribution of this species is detailed in Figure 6.

Aïssi and Daly Yahia (2011) detailed the common bottlenose dolphin (*Tursiops truncatus*) seasonal and spatial distribution, analyzing sighting data collected in fall seasons of 2008 and 2010 along the Bizerte coasts. This species are widely distributed throughout the Mediterranean Sea and occur in most coastal waters. They occur regularly around many of the region's offshore islands and archipelagos (Bearzi et al. 2008).

Moreover, Benmessaoud et al. (2012) covered the Eastern coastal zone (Cap Bon) revealing mainly the seasonal occurrence of bottlenose dolphins and especially the important presence of the short-beaked common dolphin. In fact, this endangered species suffers from marine habitat degradation these last decades. These small dolphins are found in both pelagic and neritic environments, occasionally sharing the former with striped dolphins and the latter with common bottlenose dolphins (Bearzi et al. 2003). Although common dolphins were considered relatively abundant in much of the Mediterranean until a few decades ago, large-scale population decline has occurred, and today they survive only in small portions of their former Mediterranean range. Indeed, these dolphins have become rare or are completely absent in some Mediterranean ex-suitable habitat.

Vella (2004) combined data from ship and aerial surveys conducted between 1997 to 2002, and obtained a density estimate of 0.135 common dolphins per km<sup>2</sup> (CV=0.28; 95% CI=0.066?0.290) in the area around the Maltese islands. Seasonal occurrence of this species seems to vary according to the time of year, with summer and autumn being

the seasons with greatest group sizes (Vella, 2004). Moreover, the overall distribution of sightings around the Maltese Islands indicates the preference for deep and offshore waters, except during the summer and autumn months when these dolphins may also be found closer to shore.

Though the bottlenose dolphin is one of the cetacean species mostly adapted to, and associated with shallow waters, its offshore relatives can spend most of their time in deeper waters and dive to over 400 m for their prey.

### **3.3.5. Striped dolphin (*Stenella coeruleoalba*)**

Striped dolphin in the Mediterranean is currently proposed to be listed on the IUCN Red List as Vulnerable. The Mediterranean population of striped dolphin is particularly exposed to high levels of chemicals and heavy metals, which have severe effects on their reproduction and immune system (Aguilar and Borrell, 1994). This subpopulation qualifies for listing as Vulnerable based on criterion A4 (Reeves et al., 2006). The overall distribution of this species is detailed in **Figure 5**.

These small cetaceans are found to distribute themselves close to submarine slopes and escarpments of the strait of Sicily. Indeed, sightings have been reported in the deep waters Northward and Eastward of Tunisia during the regular monitoring using ferries as platform of observation financed by ACCOBAMS. This study pointed out a similar habitat use (preference to open waters) as major Mediterranean areas where striped dolphins were spread over neritic and pelagic environments.

Although overall the Striped Dolphin is the most abundant cetacean in the Mediterranean, both in the eastern and the western basins, this ichthyo-teutophageous (fish and squid eater) species is not found at uniform densities.

MEDACES reported solely rare stranding of this along Tunisian coasts. Additional events were registered recently during May 2013 along the coast of Bizerte (North Tunisia) where two fresh dead striped dolphins beached. Unfortunately, cadavers were released to the water before our arrival.

### **3.3.6. Short-beaked common dolphin (*Delphinus delphis*)**

The short-beaked common dolphin is a small cetacean species with a wide distribution. In 2003 the Mediterranean common dolphin 'subpopulation' was listed as endangered in the IUCN Red List of Threatened Animals, based on criterion A2, which refers to a

50% decline in abundance over the last three generations, the causes of which ‘may not have ceased or may not be understood or may not be reversible’ (Bearzi et al., 2003). The species is present in the Sicily Channel (Cavalloni, 1988; Arcangeli et al., 1997) with larger groups being observed around Malta (Vella, 1998, 1999) and the Cap Bon area (Northern Tunisia) (Benmessaoud et al., 2012). In these two areas, the common dolphins reportedly associate with bluefin tuna *Thunnus thynnus*. Both shallow and deeper water habitats are utilized where it may be observed also in association with bottlenose dolphins or striped dolphins (Benmessaoud, pers. com). Indeed, the species is today relatively abundant in the Sicily channel around Malta and in the Cap Bon North-Eastern Tunisia.

Stranding data of this species in the strait of Sicily is quiet inexistent, however rare stranding events were mentioned along the Tunisian coastline.

### **3.3.7. Risso’s dolphin (*Grampus griseus*)**

Risso’s dolphins occur mainly in continental slope waters throughout the Mediterranean Sea as well as around many of the region’s offshore islands and archipelagos. Sightings have been consistently reported in the Western Mediterranean and Greece (Frantzis et al., 2003; Cañadas et al., 2005; Azzellino et al., 2008). This Mediterranean population is genetically differentiated from those in United Kingdom waters with limited gene flow between both areas (Gaspari et al., 2007).

Stranding records of Risso’s dolphin in the strait of Sicily are included in the MEDACES database belonging mainly to Tunisian coastline. Additional records were reported also in Malta (Vella, 1999) and Libya (Bearzi, 2006). Moreover, the species was rarely sighted off Tunisia (Ktari-Chakroun, 1980; Chakroun, 1994). Bearzi et al., (2011) suggested the possible occurrence of this species off Libya where research effort was low or nil. This cetacean species is found in the Sicily Channel especially in deeper waters, at times also sharing the area with striped dolphins (Vella and Vella 2012).

Risso’s dolphins seem to feed predominantly during the night to take advantage of the circadian vertical movements of their prey, with potential interaction with fishing boats using illuminated handlines for squid in some areas of the Mediterranean. This teutophageous dolphin has the most diverse diet composed of *Histioteuthis reversa*, *Histioteuthis bonnellii* and several other species with a great nutritional value.

Thus, this toothed whale may frequent in particular deep offshore waters, in particular those over steep shelf slopes and submarine canyons compared to other parts of the continental margin where mesopelagic squids may be predominant.

### **3.3.8. Long finned pilot whale (*Globicephala melas*)**

Long-finned pilot whales are among the largest members of the dolphin family, and are commonly seen in tight sociable groups. They feed offshore on deep-sea squid, other cephalopods and small pelagic fish using echolocation tactics to help them find food. Sightings and/or records of this deep diver species (over 600m) are very rare, the latter to date only records through stranding events.

These rare or infrequent records of such species in the strait of Sicily could be attributed to their association with pelagic waters overlying deep slopes, which habitat types are generally located in offshore marine waters on which very limited knowledge or data is currently available. Nevertheless, the lack of effort in this area does not exclude the possibility of presence of this species at least in key biodiversity areas such as seamounts or submarine canyons.

The main characteristic of the long-finned pilot whale diet was found to be the unique combination of mesopelagic prey and of prey living on, or close to, the bottom in neritic waters.

## **4. Conclusion**

Most previous studies about the influence of environmental factors on top predators' distribution have been performed. Relationships with water depth, temperature, salinity, sea floor relief, distance from land and various hydrological phenomena have been suggested. Nevertheless, neither was considered likely to have much influence, and all these environmental factors have been a secondary importance to the distribution of prey species.

In general, cetacean abundance is strongly dependent on the prey distribution and the diversity of cetacean feeding strategies is reflected in the significant differences in their habitats. Studies have suggested that odontocetes, for example sperm whales, feeding mainly on deep-squids, are commonly associated with topographic structures such as canyons and submarine mountains (Aïssi et al., 2013; David, 2000), while mysticetes, e.g. fin whales, feeding on plankton, aggregate on thermal fronts or convergent structures rich in zooplankton.

Vella and Vella (2012) suggested that the strait of Sicily hosts various cetaceans species associated with deep waters and also to prey on species found in deep waters. Thus, it is recommended when planning protected areas or management programmes for long-term conservation of cetacean species to establish the locations and sizes of home ranges, the extent of seasonality in home range use, and the extent of fidelity to any migration paths taken by the species between areas used. This central area of the Mediterranean Sea plays a fundamental role in large cetacean migration. This corridor between Tunisia and Sicily includes Pelagic Islands (Lampedusa and Pantelleria as well as the Malta islands) and adjacent high seas where wintering habitat of fin whale has been highlighted.

Within this context, the ‘Toothed Whales’ in the strait of Sicily are deemed to be represented mainly by the striped dolphin (*Stenella coeruleoalba*), the common dolphin (*Delphinus delphis*) and the bottlenose dolphin (*Tursiops truncatus*). These three species are relatively frequently reported in the Tunisian plateau and waters surrounding Italian Islands. Available records suggest the presence of resident populations is highly likely. Moreover, the unique mysticete in the Mediterranean Sea (fin whales) frequents this central area especially during winter, characterising it as a wintering feeding ground. Small resident population may exist in this particular area (south-eastern of Sicily) of the Mediterranean. Those “discrete” populations may be studied through tagging and sightings studies. Stranding data may reflect lack of suitable beaked whale habitat (i.e., deep water or presence of canyons), or may be accounted to a relative lack of reporting or effort in the strait of Sicily.

Bottlenose Dolphins in the Mediterranean are often regarded as predominantly ‘coastal’ or ‘inshore’ animals but this designation may be misleading as they can be encountered in continental shelf and shallow plateaux waters at any distance from the coast (Bearzi et al. 2008). They inhabit a wide variety of habitats including continental shelf waters, lagoons and enclosed seas, and the waters surrounding islands and archipelagos (Bearzi et al. 2008). Bearzi (2012) reported that about a hundred national Marine Protected Areas (MPAs) of different types, sizes and purposes have been established in different Mediterranean. However, due to their opportunistic behaviour and predominantly coastal occurrence, these dolphins are at risk of entanglement in many types of fishing gear. In addition to incidental mortality, depredation and damage caused by dolphins to fishing gear may result in animals being shot or harassed in retaliation (Di Natale and Notarbartolo di Sciara 1994).

Associations of short-beaked common dolphins with other cetaceans in areas where these associations exist also need consideration (e.g. Cap Bon, Maltese waters), since cetacean monitoring should whenever possible be considered holistically, due to the resources required in time, human effort, equipment, and funds to sustain such vital assessments. Occasional associations, including possible competition, with offshore bottlenose, striped and Risso's dolphins, and sperm whales may need further study (Vella, 2004).

Moreover, based on the regression of short-beaked common dolphin habitat in the Mediterranean Sea and the rarity of observation of this small dolphin, the Northern Tunisian coast (Cap Bon), the strait of Sicily and the waters surrounding Malta seems to be a suitable habitat for this small dolphin. These dolphins are otherwise rare in, or completely absent from other Mediterranean areas.

Vella (2004) during her long monitoring inside the Maltese waters suggests that the common dolphins in this region appear to show large home ranges, with a marked increase in group sizes and abundance close to the Maltese Islands during the September and October period. During this period, common dolphins are also observed to travel closer to land than is typical of the species at other times of the year in this region. Thus the Maltese Islands may either be positioned in the middle of the travel path of common dolphins during these months, or due to its position on a continental shelf, they may be situated at an important location for the species during the summer/autumn period of the year.

Cetacean conservation should be designed based on an understanding of their residency patterns and their movements from different suitable habitat. Bottlenose dolphins and short-beaked common dolphin communities in the Mediterranean are good conservation targets for MPAs, as they are known to show very high levels of site fidelity (although some individuals may travel over long distances, e.g. see Dhermain et al., 1999). This means that a properly designed network of MPAs may represent a solid strategy to protect these coastal and largely "resident" animals, as long as the creation of a few small MPAs is no excuse for forgetting other management goals within the wider region (Bearzi et al., 2003).

Given the lack of detailed information on the prey concentration, additional parameters have had to be used for estimating the cetacean distribution. The habitat preference of top predators, when they are in their feeding grounds, mostly depends upon the

distribution of their prey, and this last is highly time-space heterogeneous in its correlation with ocean dynamics.

The Ninth Conference of the Parties (COP9) to the Convention on Biological Diversity (CBD) adopted seven scientific criteria (known as the CBD EBSA criteria), to identify Ecologically and Biologically Significant Areas (EBSA) in the marine environment, as well as guidance for designing representative networks of marine protected areas: 1) Uniqueness or rarity, 2) Special importance for life history of species, 3) Importance for threatened, endangered or declining species and/or habitats, 4) Vulnerability, fragility, sensitivity, slow recovery, 5) Biological productivity, 6) Biological diversity and 7) Naturalness. To be identified as EBSA is first of the five properties required to establish a representative network of MPAs, which are: representativity, connectivity, replicated ecological features, adequate and viable sites. Taking into account traditional MPA criteria, the CBD EBSA criteria are specially designed to apply to open ocean and deep seabed areas including marine areas beyond national jurisdiction.

The COP9 further urged Parties and invited other Governments and relevant organisations to apply the criteria and guidance as well as to implement conservation and management measures, including the establishment of representative networks of marine protected areas in accordance with international law (CBD Decision IX/20).

In respect of this last aspect, it could be useful to identify a number of critical habitats within a larger pelagic MPA or even create a network of smaller MPAs. In this way it would be possible to carry out improved protection of more sensitive areas, e.g. “stepping stones”, such as identified breeding, spawning and feeding grounds for vulnerable species. This may be more effective if the MPAs are set to cover the entire distribution ranges of a particular species.

Many Mediterranean pelagic species undertake very wide migrations, inside and outside the Strait of Gibraltar. A MPA network must take into account this aspect of the species' biology. If a migration route is interrupted by natural events or causes of anthropic origin, the migrating species can change its conservative behaviour, leaving the migration routes forever. The more obvious consequence is that one or more MPA areas within the network could be abandoned. For many species moving throughout the entire Mediterranean Sea (i.e. bluefin tuna, swordfish, turtles, sharks and cetaceans), protection of migratory corridors could be as essential as protecting their feeding and spawning areas.

The above-considered areas of the Central Mediterranean Sea play an important and specific role in the fin whales' life history. They are fundamental too for the biological productivity of the entire Mediterranean pelagic ecosystem. Moreover, being used by the same specimens seasonally as feeding grounds, these areas show a highly connectivity, thus fit the application of two EBSA criteria and almost one of the CBD criteria needed to establish a representative MPA network.

Considering these aspects, however, it must be also highlighted that protecting an area by means of fixed boundaries can be useful to mitigate and even solve certain problems deriving from human activities, as long as there are no changes in the system (which could drive protected species far from the protected area). In all ecosystems a great part of threats are mediated by physical-chemical and biological processes, frequently originating far from the area in which they occur. Because of pelagic ecosystem dynamics, it is not surprising that, in a next future, a more effective approach for realistic protection of a given species or a given habitat will need of new MPA paradigm.

A MPA network, if it is designed on a static basis, could not properly correspond to ecosystem approach principles. Considering it impossible to protect the entire Mediterranean Sea area, since the main characteristic of its pelagic environment is high variability, the instruments for its protection must also be flexible enough to adapt quickly to a new situation. Moreover, protection carried out by area is limited to the evidence on the surface of the sea. Frequently what is visible is the result of processes linked to water masses, which may not be restricted to the water column exactly below the protected area. In the Mediterranean Sea, cyclonic circulation affects the productivity of the two basins and upwelling areas in their northern parts are strictly linked to convergence in the south. What is done in the north returns to the north with a contribution from the southern coast, through west-east and south-north cycles?

For these reasons, the aspect related to water mass protection and bottom topography features seem to be crucial for future application of the ecosystem approach to pelagic habitat conservation, even if it is not yet considered as a priority. It is recommended to consider active seamounts and/or submarine canyons as the main attractive areas for biodiversity and top predators aggregation.

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