UNITED NATIONS

EP

UNEP(DEPI)/MED WG.408/Inf.19

UNEP

UNITED NATIONS
ENVIRONMENT PROGRAMME
MEDITERRANEAN ACTION PLAN

April 2015
Original: English

Twelfth Meeting of Focal Points for Specially Protected Areas

Athens, Greece, 25-29 May 2015

Agenda item 10: Marine and Coastal Protected Areas, including in the open seas and deep seas

10.2. Regional Working Programme for the Coastal and Marine Protected Areas in the Mediterranean Sea including the High Seas

10.2.1. Activities for the identification and creation of SPAMIs in the open seas, including the deep seas

Sicily Channel /Tunisian Plateau: Status and conservation of Cetaceans

UNEP/MAP
RAC/SPA - Tunis, 2015

Note:
The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of RAC/SPA and UNEP concerning the legal status of any State, Territory, city or area, or of its authorities, or concerning the delimitation of their frontiers or boundaries.

Regional Activity Centre for Specially Protected Areas (RAC/SPA)
Boulevard du Leader Yasser Arafat
B.P. 337 - 1080 Tunis Cedex - Tunisia
E-mail: car-asp@rac-spa.org

The original version of this document was prepared for the Regional Activity Centre for Specially Protected Areas (RAC/SPA) by: Mehdi AÏSSI and Adriana VELLA, RAC/SPA Consultants.

Table of Contents

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).

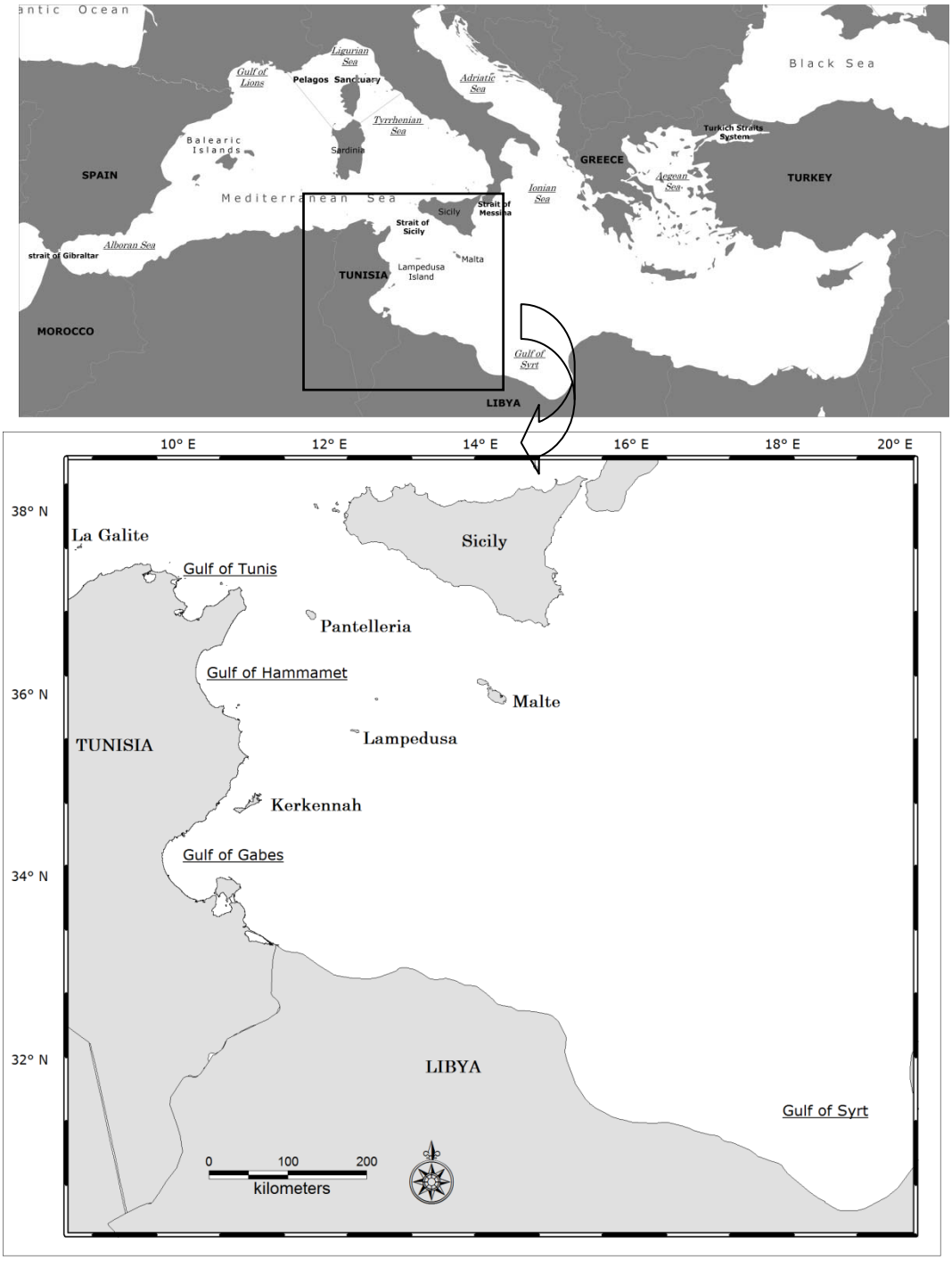


Figure 1: Geographical location of the strait of Sicily area within the Mediterranean including main geographic locations cited in the text.

The only relevant connection of the Mediterranean 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 (0.85 106 km^2) and Eastern (1.65 106 km^2) Mediterranean, which in turn are divided into smaller sub-basins (Figure 1).

The Sicily Channel is about 145 km wide and divides the Tyrrhenian Sea and the Western Mediterranean from the Eastern Mediterranean. 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. Major 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 (REMPEC) report, vessel activity within the Mediterranean is expected to increase by a maximum of 18 per cent whilst through transits are projected to rise by 23 per cent. The most significant increase will occur in the chemical, crude and LNG tanker sectors and also in container vessel movements (REMPEC, several 2008 sources). In general, the strait of Sicily is an intensively used area in terms of maritime transport and henceforth one of the areas within the ACCOBAMS region with the higher level of maritime traffic.

Environmental pressure as a result of the intensive maritime traffic (and corresponding collision risk / accident risk) in the area is relatively high. Shipping produces constantly acoustic pollution, which may affect large areas. Sound travels five times faster in water than in air since the density of water transmits acoustic energy much more efficiently.

The complex topography and circulation scheme makes the Strait of Sicily a highly productive area and a biodiversity hotspot within the Mediterranean. Indeed, in the extension of the Sicilian continental shelf toward the Pantelleria Rift, various important bottom topographic features have been recognised like banks (Adventure Bank and Graham Bank plateaus), seamounts and mud and volcanoes seamounts (Tetide, Anfitrite, Galatea, Cimotoe and Graham) (see details in Würtz et al., Atlantis of seamounts in the Mediterranean Sea, In Press). These geological structures are considered highly productive and they are biodiversity hotspots as well, since they produce retention areas for phytoplankton and create the conditions that support a diversity of important habitat types.

It is not uncommon for marine protected areas (hereafter MPAs) to be designated with the protection of a particular species or group of species in mind. There are MPAs for many commercially valuable fish species as well as for sharks or sea birds or corals. Although many MPAs in the Mediterranean contain suitable habitat for marine mammals, only a handful of these were established with the declared intent of protecting one or more marine mammal populations. 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.

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).

This report outlines the distribution areas of marine mammal in the Sicily Channel and Tunisian Plateau gathered from bibliography in order to a suggest likely suitable habitat and to guide the development of Marine Protected Areas in this area.

2. Marine mammal eco-biodiversity in the Mediterranean

All experts and marine mammal specialists confirm the possible occurrence of 26 cetacean species in the Mediterranean and Black Sea, 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*) (Figure 2).

Figure 2: Common cetacean species inhabiting the Mediterranean.

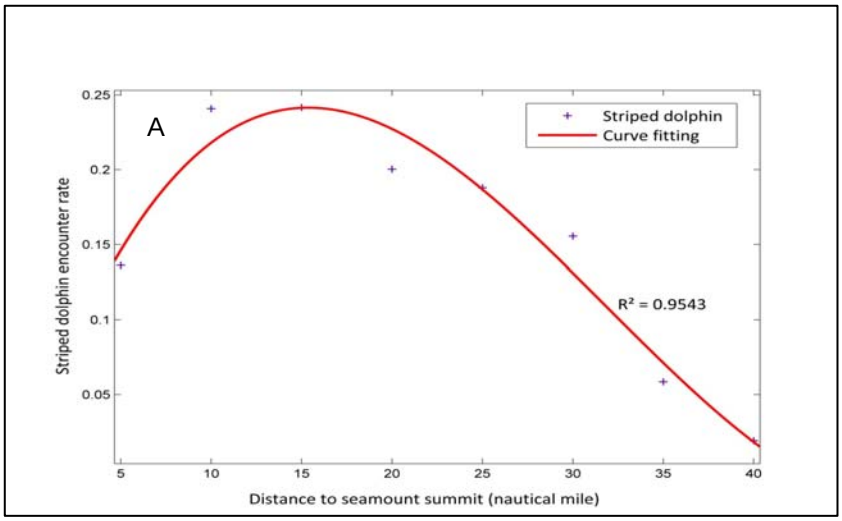
Moreover, 4 cetacean species are considered as occasional or have a small or local distribution area (as the Strait of Gibraltar) (Minke whale *Balaenoptera acutorostrata*, Killer whale *Orcinus orca*, False killer whale *Pseudorca crassidens*, Rough toothed dolphin *Steno bredanesis*), and 6 accidental, 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. This species is actually very rare and listed as an endangered species. The main known colonies are in the Levantine Basin and in the Aegean and Ionian Seas. 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 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 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 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 3). However sperm whales were significantly more abundant in the vicinity of some canyon areas than seamounts (Figure 4). Indeed, a relevant distinction of encounter rates was registered between these three zones characterized by different topography.



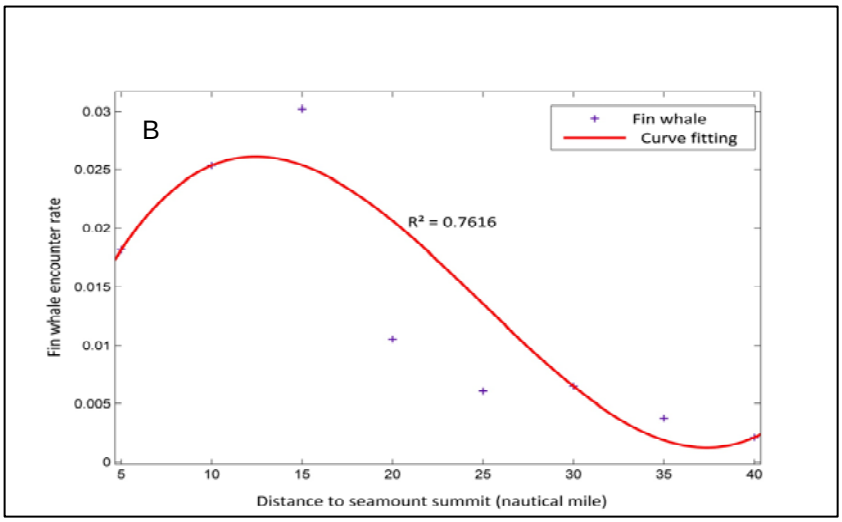


Figure 3: The relationship between encounter rate and distance from the nearest seamount summit in the Central Mediterranean; (A) case of striped dolphin, (B) case of fin whale (Aïssi et al., 2013a).

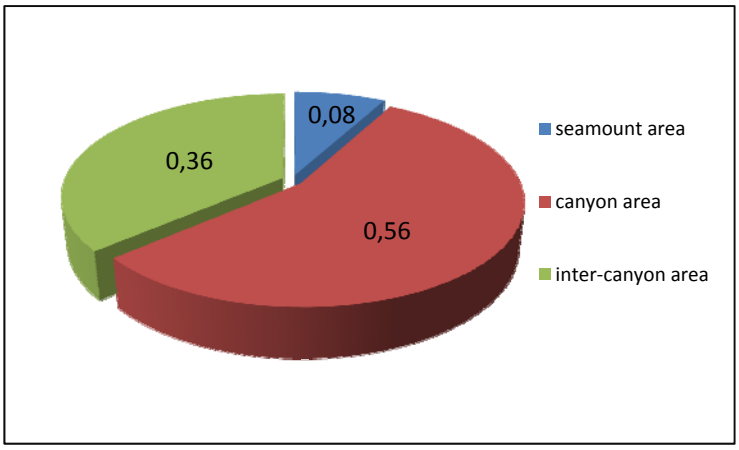


Figure 4: Cumulative percentage of sperm whale occurrence in areas with different physiographic features (canyon, inter-canyon and seamount areas) (Aïssi et al., 2013b).

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 5).

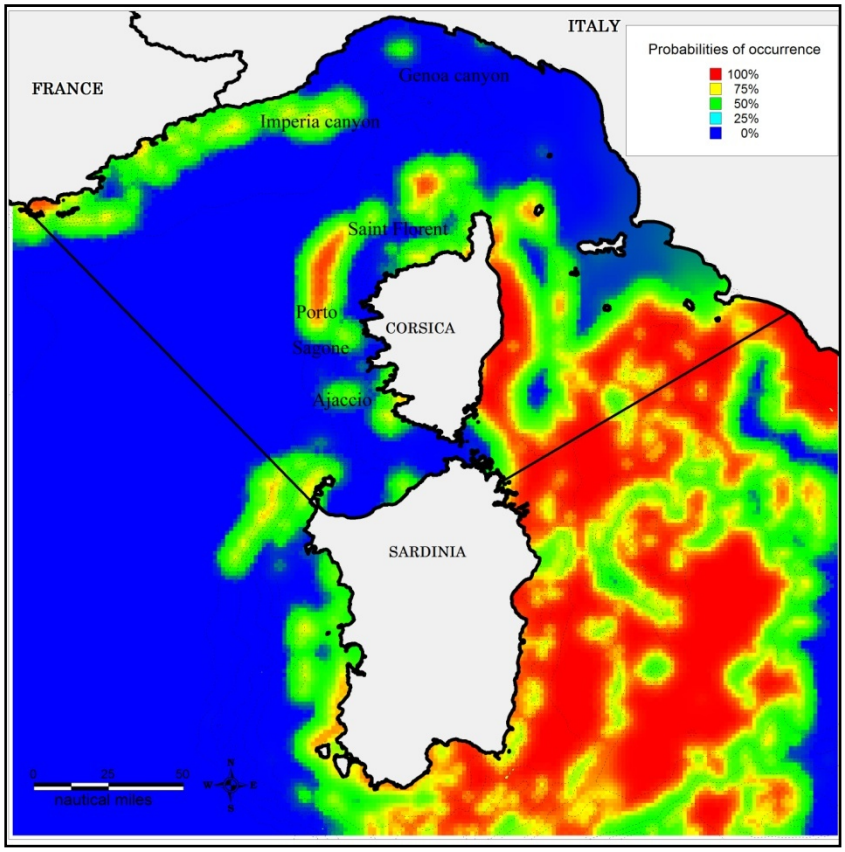


Figure 5: Spatial prediction map of sperm whale relative presence probability in the central Mediterranean obtained by the Artificial Neural Network kriging technique (Aïssi et al., 2013b).

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 on 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 (characterized as a poorly studied area), we will base 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 Sicily Channel

3.1. Ecology

The Sicily Channel connects the western and eastern Mediterranean sub-basins. Its topography consists of shallow banks along the Sicilian and Tunisian coasts. 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. 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 forces 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 admit 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) (Figure 6a).

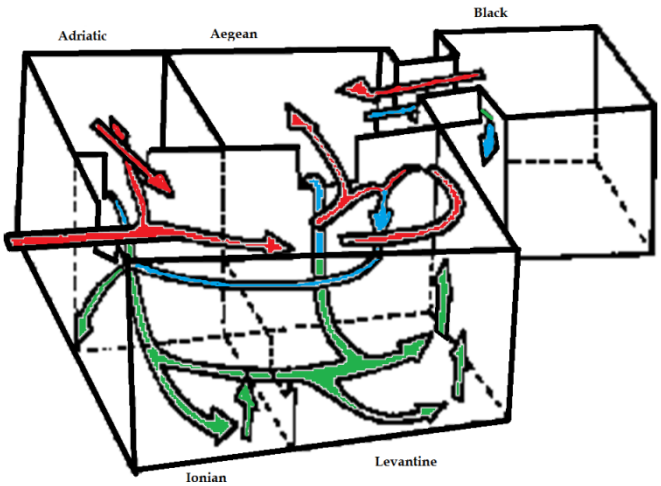


Figure 6a: Water masses flow in the Eastern Mediterranean basin (Red: Surface waters; Blue: Intermediate waters; Green: Deep waters) (elaborated from Malanotte-Rizzoli and Hetch, 1988) Malanotte-Rizzoli, P. and Hecht, A. (1988). Large-scale properties of the Eastern Mediterranean: a review. Oceanologica Acta, 11(4):323-335.

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) (Figure 6b).

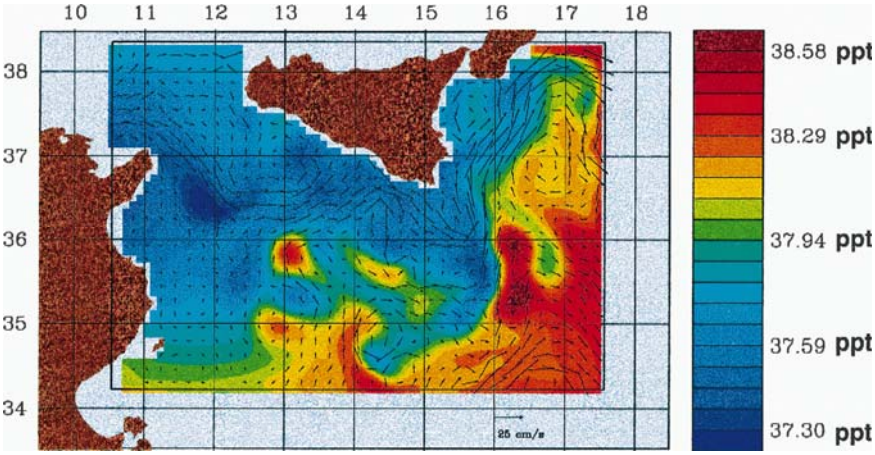


Figure 6b: Surface current inflow in the strait of Sicily on a salinity background (Warn-Varnas et al., 1999). Warn-varnas A, Sellschopp J, Haley PJ, Ward-Geiger L, Lozano CJ. 1999. Strait of Sicily water masses. *Dynamics of Atmospheres and Oceans* **29**: 437–469.

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 Channel 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 channel (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 (Figure 7).

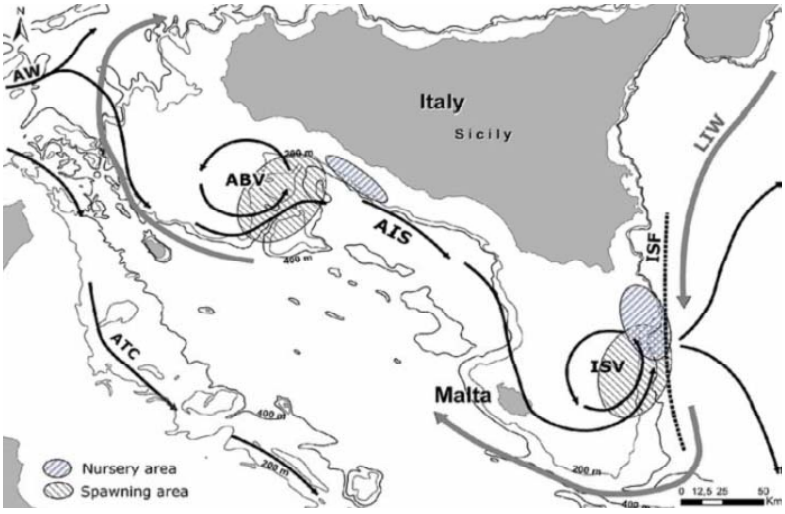


Figure 7: Water circulations and nursery and spawning areas of deep-water rose shrimp in the Strait of Sicily.

Source: Fortibuoni et al., 2010, Nursery and spawning areas of deep-water rose shrimp, Parapenaeus longirostris (Decapoda Penaeidae), in the Strait of Sicily (Central Mediterranean Sea). Journal of Crustacean Biology 30: 167-174

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. An overview of the importance of this region for conservation was also produced by Vella et al. 2011 while other overviews also focus on cetacean species Vella 1998; 2004; 2011; 2014.

3.3. Cetacean fauna

Data on the occurrence and distribution of cetacean species in the Mediterranean is non-homogenous. Taking into consideration efforts deployed by different researchers, government bodies operating in those areas and ACCOBAMS partners, various strategies were developed to fill the gap of information.

Several organisations covered or scanned 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 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 km² 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). Some of these studies focused mainly on coastal dolphin population and not any study raised the regular presence of large cetaceans. The Maltese study area studied all cetacean species from the smallest to the largest recorded during ongoing long-term research in both coastal and offshore parts of the study area.

The Conservation Biology Research Group at the University of Malta (CBRG-UoM) together with volunteers from the NGO Biological Conservation Research Foundation (Hereafter BICREF) have sustained long-term commitment to research, monitoring and local awareness work in relation to cetacean conservation in the Central Southern Mediterranean Region. A research area of 120,000 km² around the Maltese Islands (Figure 8) has been and still is the subject of year-round marine research since 1997 (Vella 1998, 1999, 2000, 2001, 2002, 2005, 2006, 2008, 2009, 2010, Vella & Vella 2011, Vella & Vella 2012; Vella 2014). All cetacean species in the area have been studied and are monitored year-round annually using aerial strip-transect survey techniques, side-by-side with marine surveys, allowing for various aspects of cetacean species spatial-temporal associations to be analyzed.

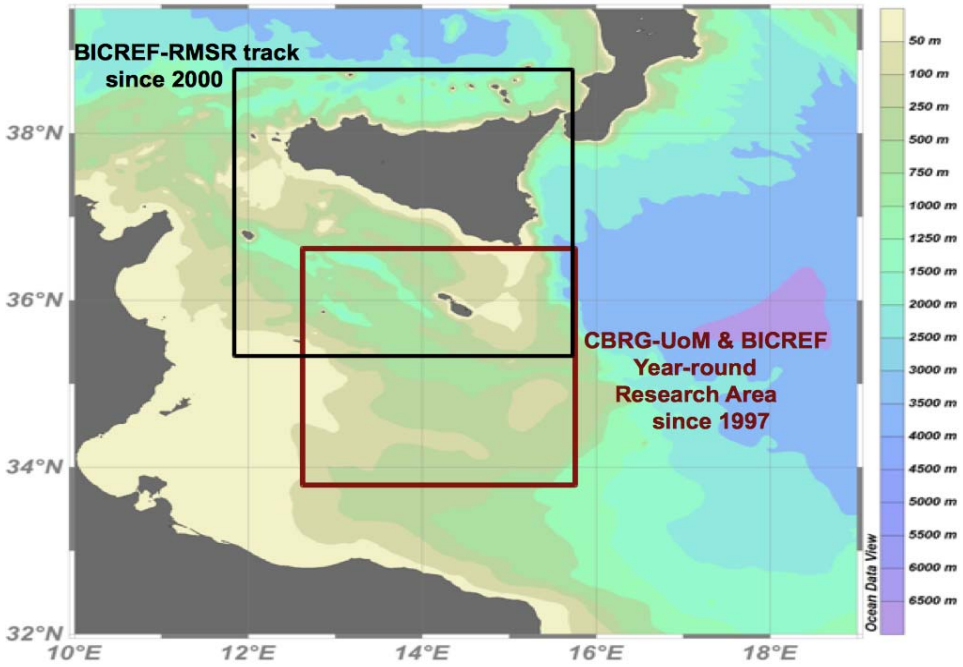


Figure 8: Long-term and year-round Maltese cetacean study in areas of interest elaborated by the University of Malta and the BICREF.

The area around the island of Sicily includes the path traversed by the sailing vessels of the Rolex Middle Sea Race every year in autumn. Through a collaborative project the CBRG and BICREF have undertaken a citizen science project using fill-in form and cameras for all the participating boats to fill in their sightings every year since 2000. This project has greatly contributed to local, regional and global awareness of cetaceans in this region.

The data collected around the island of Sicily in the framework of a collaborative project with the CBRG and BICREF provided valuable insights not only in autumn when little to no research is undertaken, but a valuable case study to analyse the appropriateness of various modelling techniques and analyses for of cetacean abundance and distribution in this region.

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 9)

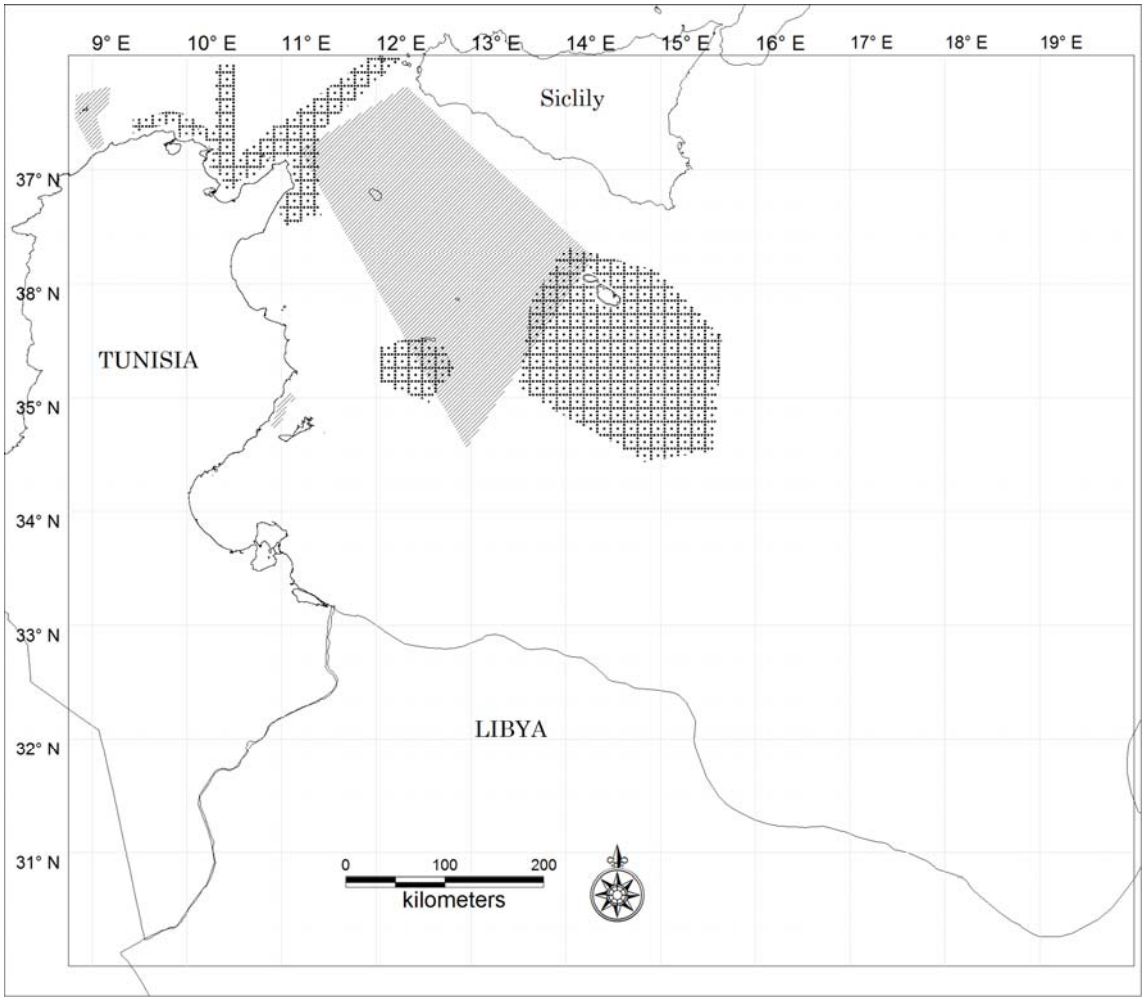


Figure 9: Map of the effort deployed in the strait of Sicily dedicated to cetacean monitoring. (Dotted area: regular monitoring; hatched area: occasional survey elaborated utmost twice).

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, 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. 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).

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 whales have been spotted in the central-southern Mediterranean in the long term research undertaken in the Maltese study area by CBRG-UoM and BICREF. Since 2007 coastal presence of this mysticete has been recorded regularly in coastal waters too. The academic research project developed by the University of Malta since in 1996-97 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, 2010a,b) (Figure 10).

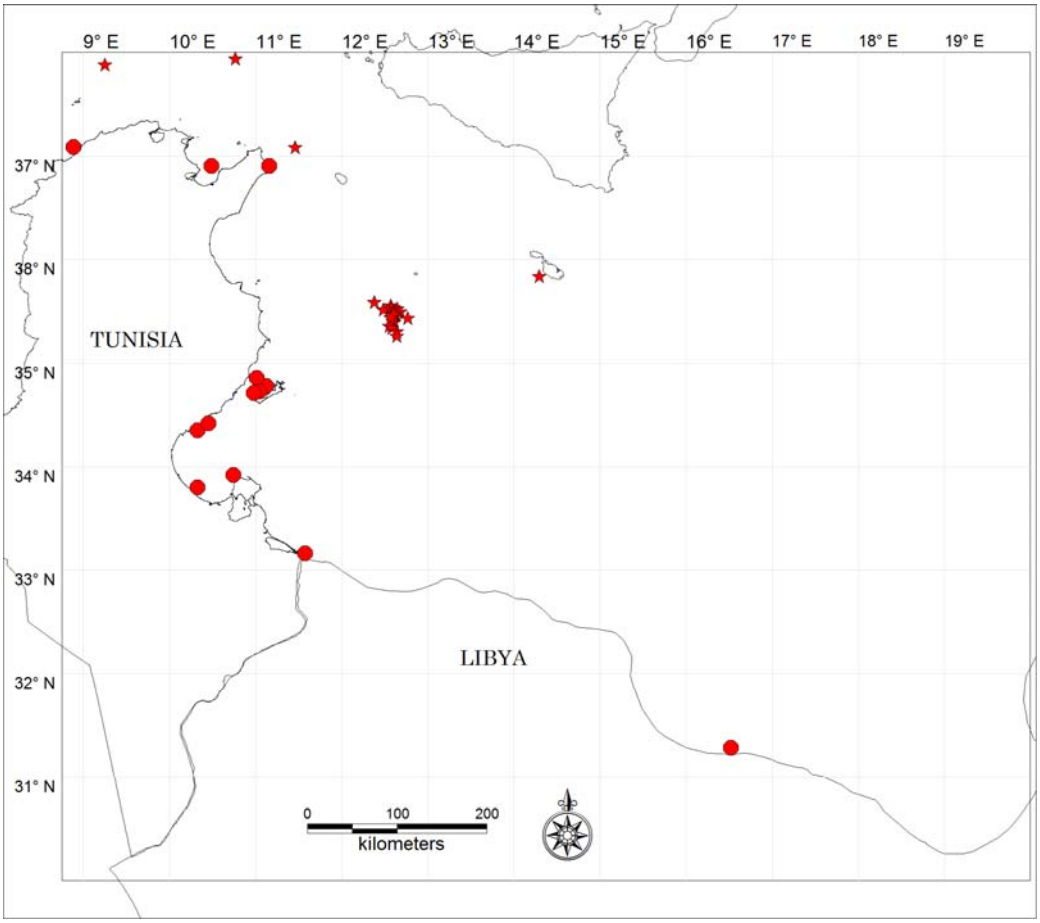


Figure 10: Sighting position of fin whale in the strait of Sicily reported from bibliography (dots: stranding events; stars: visual sighting from dedicated or opportunistic surveys)

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 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 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.

Sperm whale observation in the strait of Sicily is restricted to few occasions during the monitoring of this area throw ferries (Figure 11). 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.

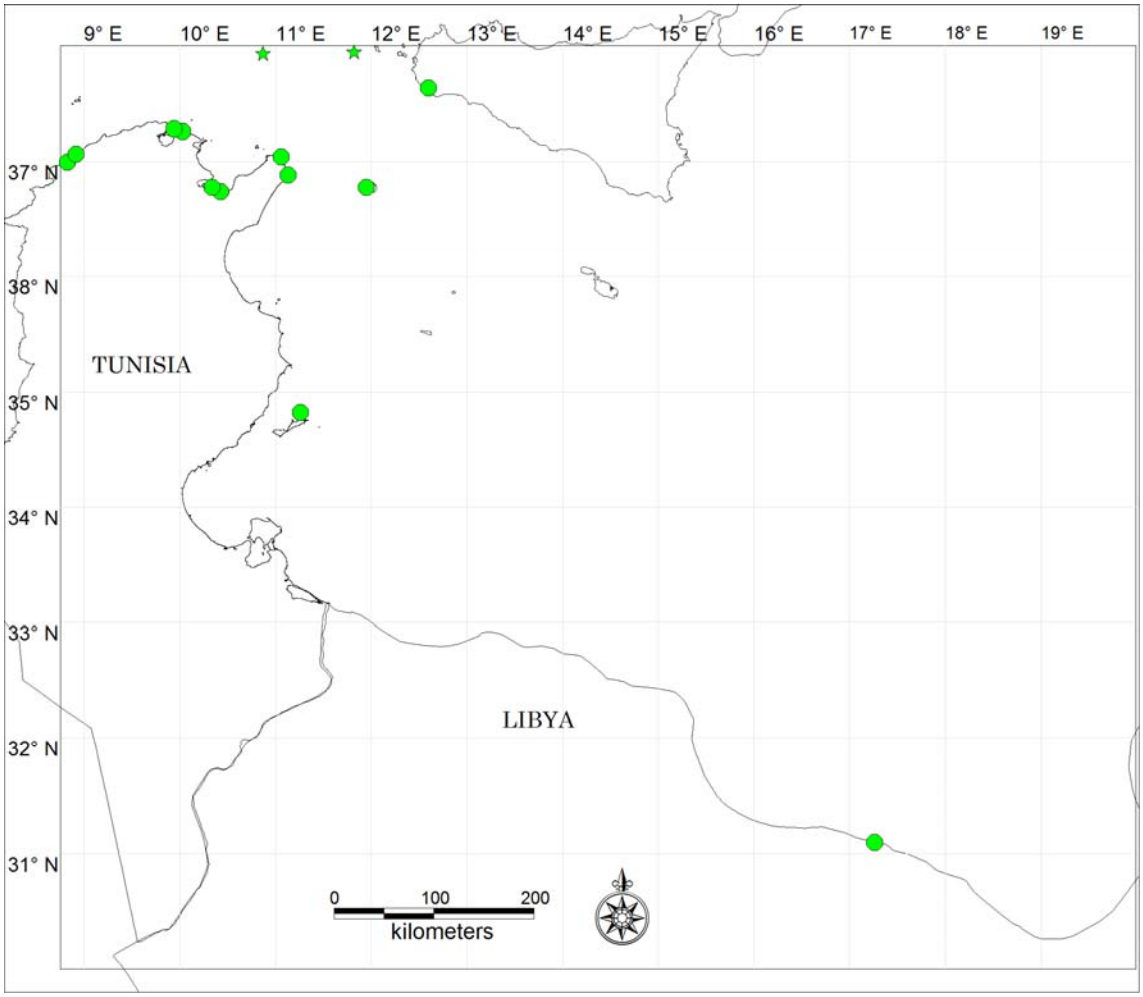


Figure 11: Sighting position of sperm whale in the strait of Sicily reported from bibliography (dots: stranding events; stars: visual sighting from dedicated or opportunistic surveys).

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.

Sperm whales have been spotted in the central-southern Mediterranean in the long term research undertaken in the Maltese study area by CBRG-UoM & BICREF using both aerial and marine surveys, but also through collaborative work with sea-users in the areas of research interest (Vella 2014).

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 12).

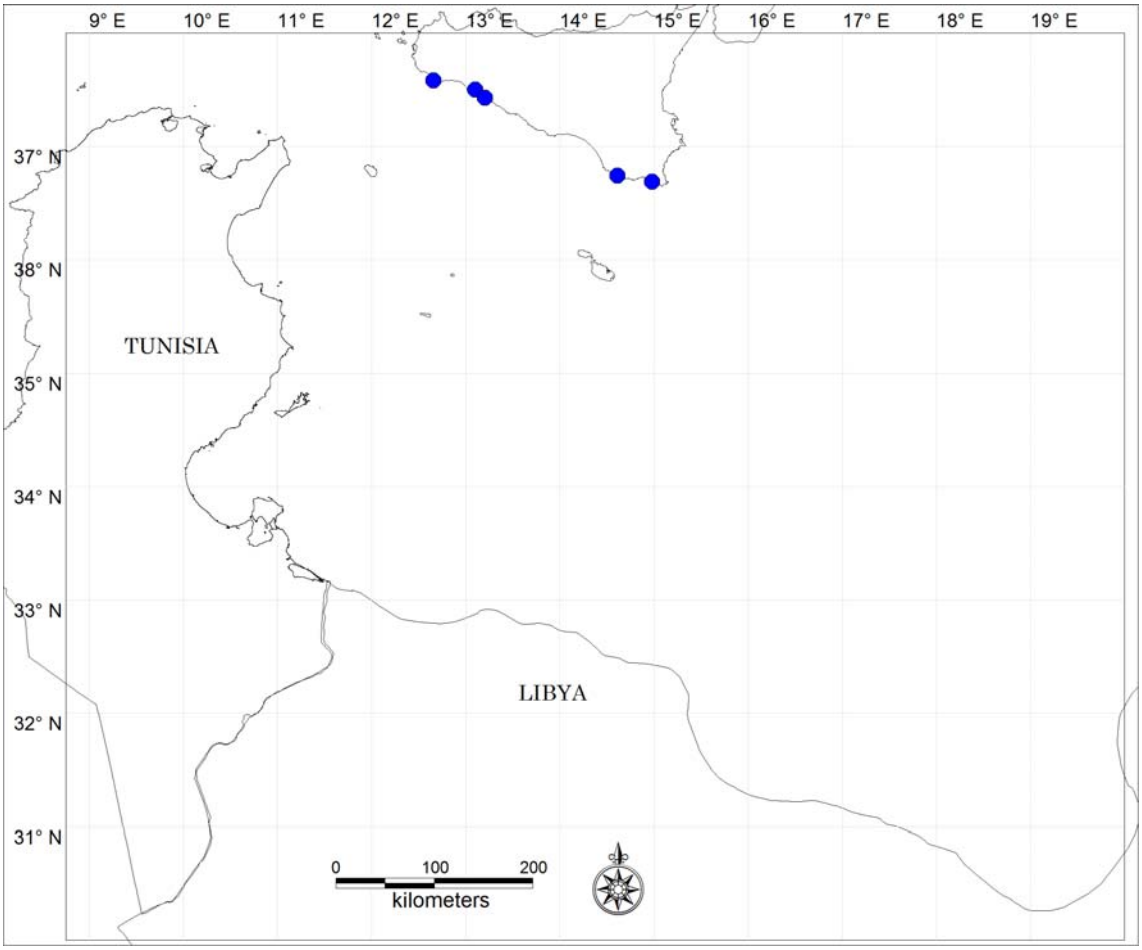


Figure 12: Stranding position of Cuvier's beaked whale in the strait of Sicily reported from bibliography.

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 (Figure 13).

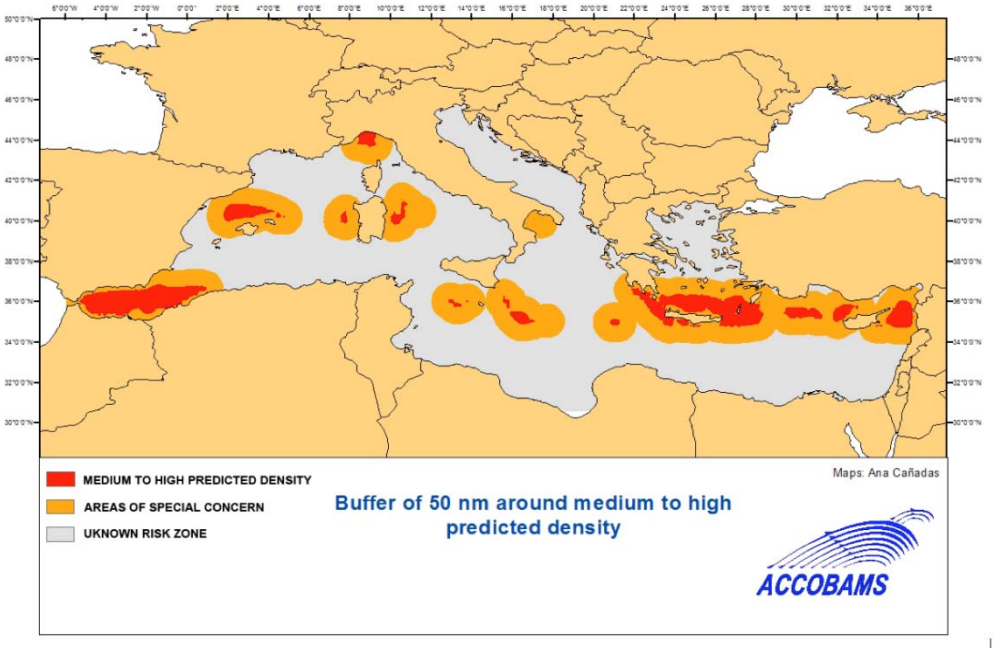


Figure 13: Map of the predicted suitable habitat of the Cuvier's beaked whale in th Mediterranean Sea.

Stranding records of this species have been recorded by ongoing cetacean research by the Conservation Biology Research Group at the University of Malta.

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 and occur in most coastal waters. They occur regularly around many of the region's offshore islands and archipelagos (Bearzi et al. 2008) (Figure 14).

Vella 1998 gives first detailed estimates from both aerial and marine Distance transect surveys with estimates of around 700 to 800 bottlenose dolphins in the whole Maltese study area (C=0.34-41, 95%CI: 350-1900). Abundance and distribution studies together with Photo ID are some of the main

long-term efforts undertaken by the CBRG-UoM assisted by BICREF. The importance of studying these species in relation to human activities was considered high in the Maltese study and thus from the very start bottlenose dolphin interactions with human activities and vessels in coastal waters and with fisheries from coastal to offshore have been integrated (Vella, 1998; 2006). Associations between cetacean distributions and other species are part of the studies to understand relationships between species in various parts of the study area. The latter is also important when trying to find the best areas for conservation such as the preliminary set of MPA suggested to ACCOBAMS (Vella, 2004).

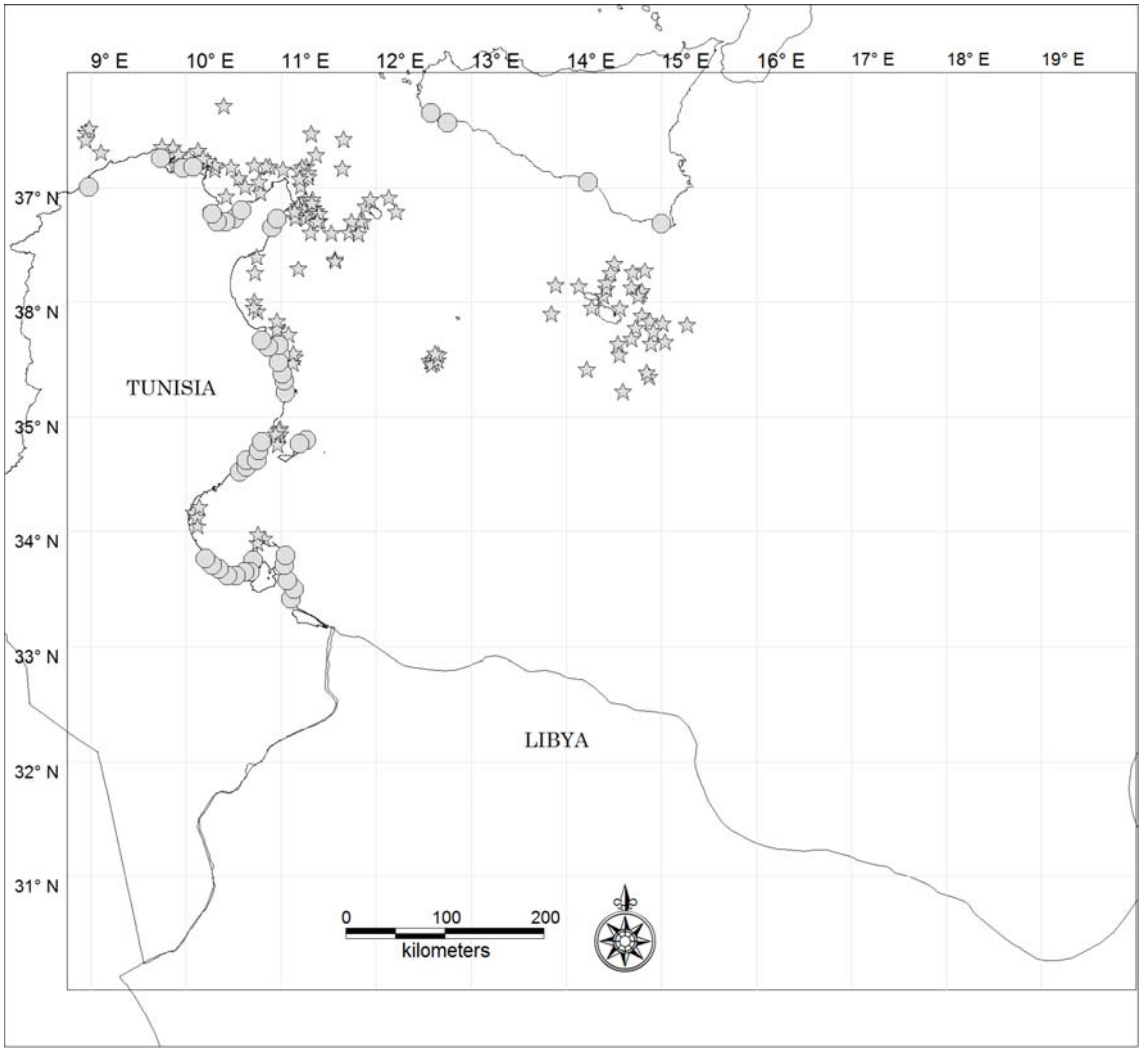


Figure 14: Sighting position of bottlenose dolphin in the strait of Sicily reported from bibliography (dots: stranding events; stars: visual sighting from dedicated or opportunistic surveys).

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 km² (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.

Stranding events of this species is very common in the strait of Sicily. Indeed, bottlenose dolphin is the most regularly identified species stranded along the Tunisian coasts.

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).

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 (Figure 15).

Aerial surveys apart from marine surveys (Vella 1998; 2014) have allowed for accurate numbers and spread of the individuals of striped dolphins sighted to be recorded thus allowing a detailed account of the presence of this species in the Maltese study area at different times of the year and from year to year.

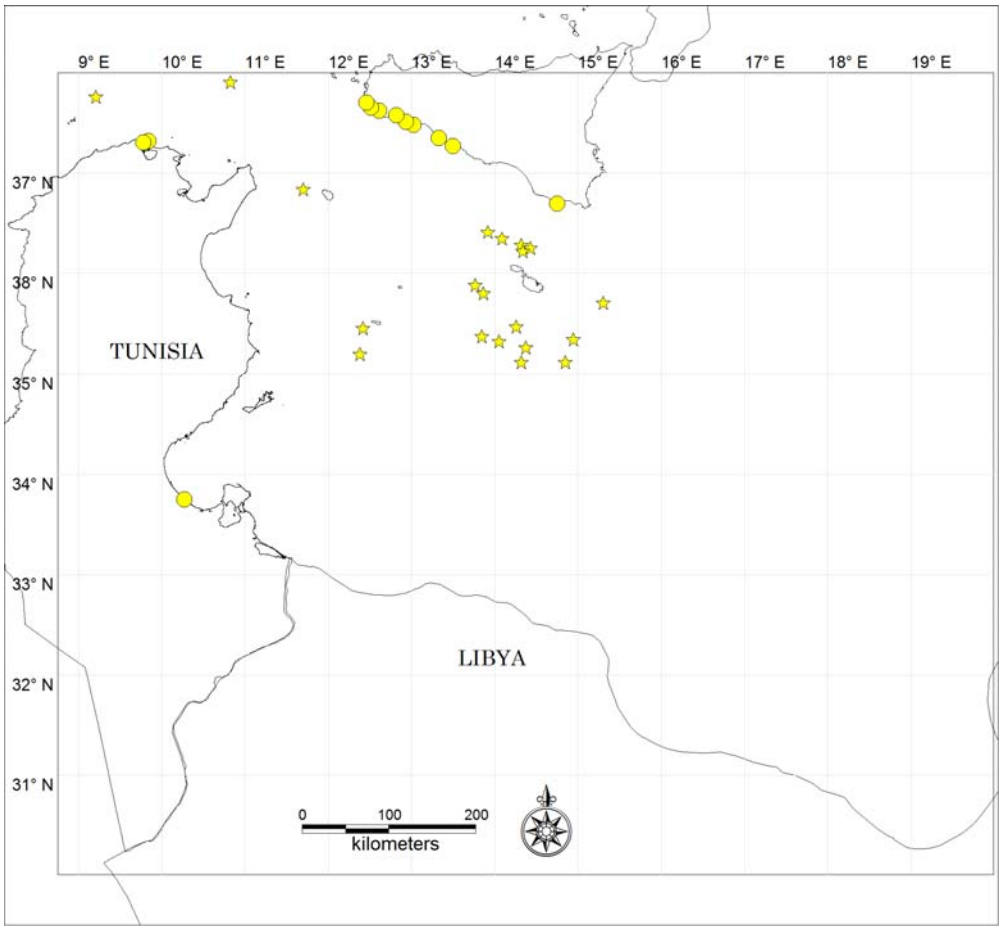


Figure 15: Sighting position of striped dolphin in the strait of Sicily reported from bibliography (dots: stranding events; stars: visual sighting from dedicated or opportunistic surveys)

Although overall the striped Dolphin is the most abundant cetacean in the Mediterranean, both in the eastern and the western basins, this ichtyo-teutophageous (fish and squid eater) species is considered covering major of pelagic waters in this area.

MEDACES reported solely rare stranding of this along Tunisian coasts. Additional events were registered recently during May 2013 along the coast of Bizerte (Northern 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 (Figure 16).

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 0.140 common dolphins (*Delphinus delphis*) per km² (CV=0.295; 95% CI=0.068-0.295) 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 in shallower waters.

Standing data of this species in the strait of Sicily is rather inexistent, however rare stranding events were recorded along the Tunisian (Karaa, 2009) and Maltese coastline (Vella, 2005).

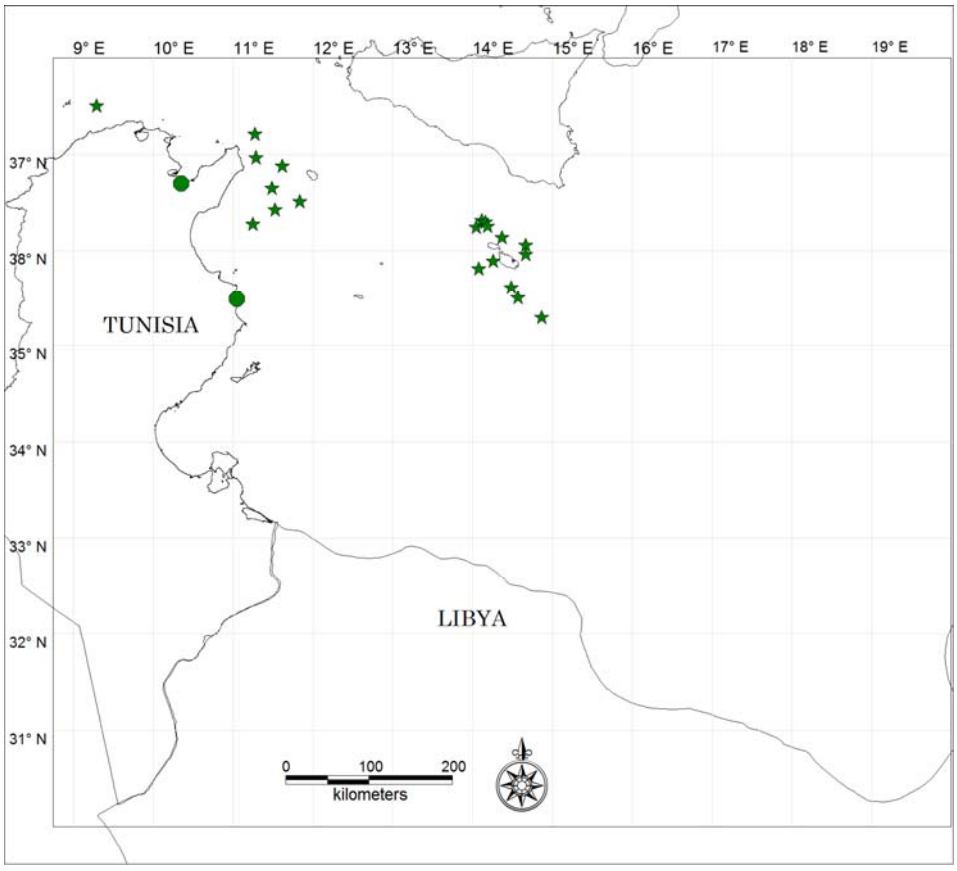


Figure 16: Sighting position of common dolphin in the strait of Sicily reported from bibliography (dots: stranding events; stars: visual sighting from dedicated or opportunistic surveys).

3.3.7. Risso's dolphin (Grampus griseus)

Risso's dolphins occur mainly in continental slope waters throughout the Mediterranean 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) (Figure 17 shows only few of the various data points available for the Maltese Study area, Vella 2014).

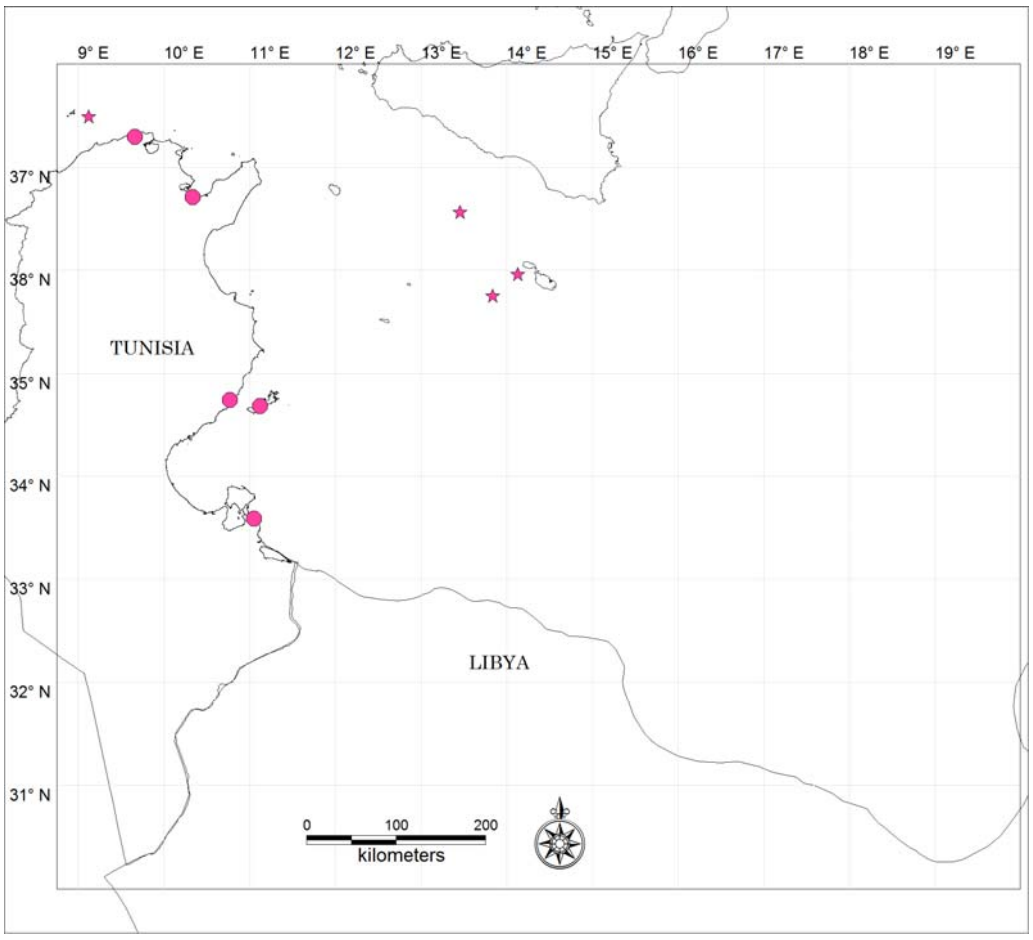


Figure 17: Sighting position of Risso's dolphin in the strait of Sicily reported from bibliography (dots: stranding events; stars: visual sighting from dedicated or opportunistic surveys)

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.

Figure 18: Photo of the ''rare '' mature long-finned pilot whale stranding in the coast of Bizerte (Northern Tunisia) on 23 February 2014. © Photo of Mehdi Aïssi

Solely two stranding events were recorded in this area (Northern Tunisian coasts). The latest one was reported by ATUTAX (Association Tunisienne de Taxonomie) for a single adult specimen reaching 5.22 m (Figure 18). 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 (Figure 19).

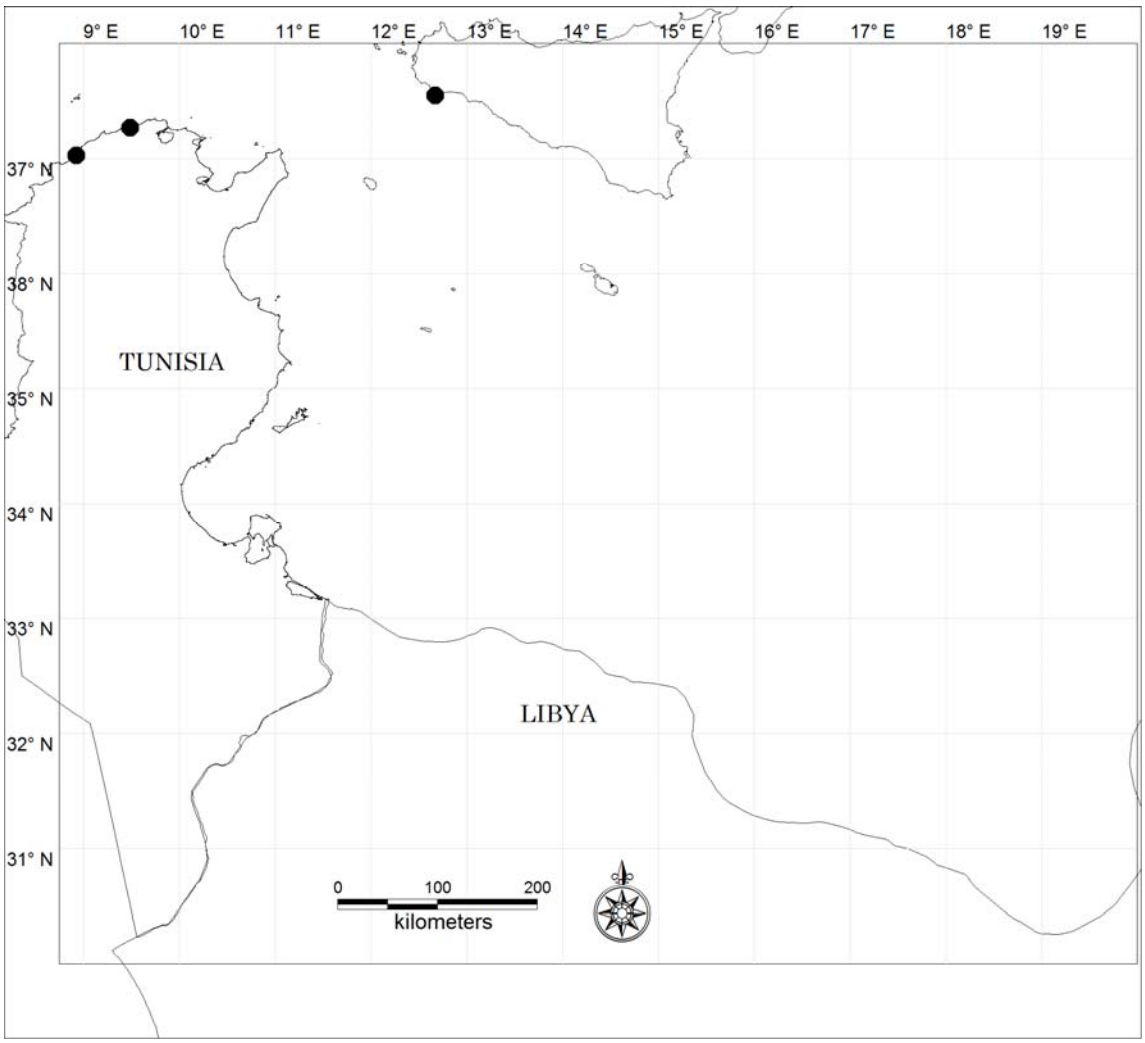


Figure 19: Stranding position of long-finned pilot whale in the strait of Sicily reported from bibliography.

It's assumed that long finned pilot whale lives in stable social groups and forms matrilineal kinship groups. Within such groups all individuals are genetically related with the oldest female and mating occurs between individuals from different groups. Long-finned pilot whales are the most common species to mass stranding and it has long been assumed this tendency was related to the species' social organization. Thus, stranding events for a single individual in this area may indicate the presence of this species in such area. 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 plays a fundamental role in large cetacean migration as the case of fin whale.

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 (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 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 long-term and ongoing research and monitoring in the Maltese research area suggests that the common dolphins 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. Through the years more detailed information has been gathered on all cetacean and pelagic species in this Maltese study area therefore fine-tuning the seasonal and annual distributions of these species in the central-southern Mediterranean (Vella, 2014). Long-data sets are essential for reliable management, strategic planning, modelling and designation of any marine protected areas for any cetacean species. Unfortunately few Mediterranean countries do have such important information collected year-round as in the Maltese research area. Analyses of such data sets are producing important conservation information which would feed into projects such as this one.

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. In order to establish a representative network of MPAs, including open ocean waters and deep sea habitats, the COP9 adopted a scientific guidance with the following network properties and components: EBSAs, representatively, 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 (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 collaborative programme established since 2007 to monitor cetacean and other macro-fauna species along fixed transect using ferries as research platform may be a good opportunity to enhance the ability for better contribution to the understanding of the marine ecosystem complexity in this area (Figure 20).

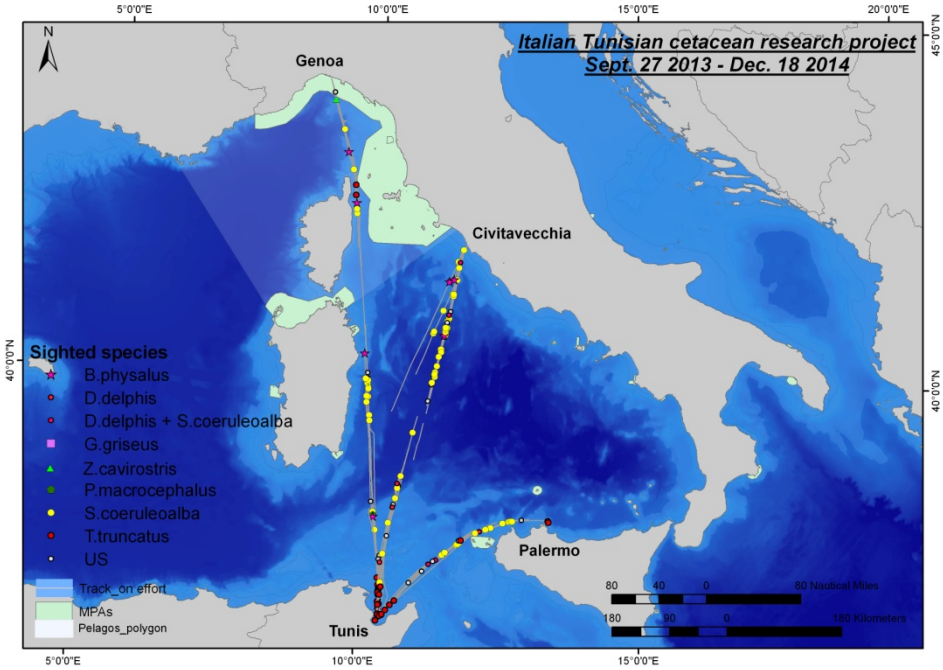


Figure 20: Map of cetacean species observed in the central Mediterranean area collected from ferries between 2013 to 2014. (Project financed by ACCOBAMS)

The above-considered areas of the Central Mediterranean 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 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, 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.

5. References

Agostini VN, Bakun A. 2002. `Ocean triads' in the Mediterranean: physical mechanisms potentially structuring reproductive habitat suitability (with example application to European anchovy, Engraulis encrasicolus). *Fisheries Oceanography* **11**: 129–142.

Aguilar a, Borrell a. 1994. Abnormally high polychlorinated biphenyl levels in striped dolphins (*Stenella coeruleoalba*) affected by the 1990-1992 Mediterranean epizootic. *The Science of the total environment* **154**: 237–47.

Aïssi M, Daly Yahia MN. 2011. Bottlenose dolphin seasonal occurrence in the Bizerte lagoon. *Revue de la société des sciences naturelles de la Tunisie* **38**: 7–14.

Aïssi M, Celona A, Comparetto G, Mangano R, Würtz M, Moulins A. 2008. Large-scale seasonal distribution of fin whales (*Balaenoptera physalus*) in the Central Mediterranean. *Journal of the Marine Biological Association of the United Kingdom* **88**: 1253–1261.

Aïssi M, Fiori C, Alessi J. 2012. Mediterranean submarine canyons as stepping stones for pelagic top predators: the case of sperm whale. In *Mediterranean Submarine Canyons: Ecology and Governance*, Würtz M (ed). Gland, Switzerland and Malaga, Spain; 99–104.

Aïssi M, Alessi J, Fiori C. 2013a. PROMETEOS Project: Evidence of seamount and submarine canyons effects on cetacean aggregation in the central Mediterranean. In *27th Conference of the European Cetacean Society* Setubal; 249–250.

Aïssi M, Ouammi A, Fiori C, Alessi J. 2013b. Modelling predicted sperm whale habitat in the central Mediterranean: requirement for protection beyond the Pelagos Sanctuary boundaries. *Aquatic Conservation: Marine and Freshwater Ecosystems*: n/a–n/a.

Aïssi M, de Stephanis R, Alessi J, David L, Fiori C, Frantzis A, Gannier A, Lewis T, Mussi B, Notabartolo Di Sciara G, et al. 2013c. Sperm whales in the Mediterranean. *Aquatic Conservation: Marine and Freshwater Ecosystems*: n/a–n/a.

Arcangeli A, Caltavuturo G, Marini L, Salvati E, Trincali M, Valentini T, Villetti G. 1997. Avvistamenti invernali di cetacei nel Canale di Sicilia. In *Atti del Terzo Convegno Nazionale sui Cetacei*, Borri M, Cagnolaro L, Podestà M, Renieri T (eds). Napoli; 5–9.

Azzellino A, Gaspari S, Airoldi S, Nani B. 2008. Habitat use and preferences of cetaceans along the continental slope and the adjacent pelagic waters in the western Ligurian Sea. *Deep-Sea Research* **55**: 296–323.

Bakun A. 1996. *Patterns in the Ocean: Ocean Processes and Marine Population Dynamics*. California, USA.

Bakun A. 1998. Ocean triads and radical interdecadal variation: bane and boon to scientific fisheries management. In *Reinventing Fisheries Management*, Pitcher T., Hart PJ., Pauly D (eds). London; 331–358.

Bakun A. 2006. Wasp-waist populations and marine ecosystem dynamics: Navigating the "predator pit" topographies. *Progress in Oceanography* **68**: 271–288.

Bakun A, Parrish RH. 1990. Comparative studies of coastal pelagic fish reproductive habitats: the Brazilian sardine (*Sardinella aurita*). *Journal du Conseil international pour l'Exploration de la Mer* **46**: 269–283.

Bearzi G. 2006. Action plan for the conservation of cetaceans in Libya. Regional Activity Centre for Specially Protected Areas (RAC/SPA), Libya's Environment General Authority and Marine Biology Research Center. 50pp.

Bearzi G, Reeves RR, Notarbatolo di Sciara G, Politi E, Canadas A, Frantzis A, Mussi B. 2003. Ecology, status and conservation of short-beaked common dolphins *Delphinus delphis* in the Mediterranean. *Mammal Review* **33**: 224–252.

Bearzi G, Fortuna CM, Reeves RR. 2008. Ecology and conservation of common bottlenose dolphinsTursiops truncatus in the Mediterranean. *Mammal Review* **39**: 92–123.

Bearzi G, Costa M, Politi E, Agazzi S, Pierantonio N, Tonini D, Bastianini M. 2009. cetacean records and encounter rates in the northern adriatic sea during 1988-2007. *annales series historia naturalis*: 145–150.

Bearzi G, Reeves RR, Remonato E, Pierantonio N, Airoldi S. 2011. Risso's dolphin *Grampus griseus* in the Mediterranean. *Mammalian Biology - Zeitschrift für Säugetierkunde* **76**: 385–400.

Bearzi M. 2012. Cetaceans and MPAs should go hand in hand: A case study in Santa Monica Bay, California. *Ocean & Coastal Management* **60**: 56–59.

Benmessaoud R, Chérif M, Bradai MN, Bejaoui N. 2012. Distribution of bottlenose dolphin around Kelibia (Northeastern of Tunisia). *Asian Journal of Contemporary Sciences* **1**: 1–11.

Bentaleb I, Martin C, Vrac M, Mate B, Mayzaud P, Siret D, De Stephanis R, Guinet C. 2011. Foraging ecology of Mediterranean fin whales in a changing environment elucidated by satellite tracking and baleen plate stable isotopes. *Marine Ecology Progress Series* **438**: 285–302.

Cañadas A, Sagarminaga R, de Stephanis R, Urquiola E, Hammond PS. 2005. Habitat preference modelling as a conservation tool: proposals for marine protected areas for cetaceans in southern Spanish waters. *Aquatic Conservation: Marine and Freshwater Ecosystems* **15**: 495–521.

Canese S, Cardinali A, Fortuna CM, Giusti M, Lauriano G, Salvati E, Greco S. 2006. The first identified winter feeding ground of fin whales (*Balaenoptera physalus*) in the Mediterranean. *Journal of the Marine Biological Association of the United Kingdom* **86**: 903–907.

Castellote M, Clark CW, Lammers MO. 2012. Fin whale (*Balaenoptera physalus*) population identity in the western Mediterranean. *Marine Mammal Science* **28**: 325–344.

Cavalloni B. 1988. Aspetti dell'ecologia dei Cetacei del Mediterraneo centro-orientale. University of Padova, Italy.

Chakroun F. 1994. Status of cetaceans in Tunisian marine waters. In *Proceedings of the eighth annual conference of the european cetacean society* Montpellier, France; 107.

Cotté C, Guinet C, Taupier-Letage I, Mate BR, Petiau E. 2009. Scale-dependent habitat use by a large free-ranging predator, the Mediterranean fin whale. *Deep-Sea Research I*.

Cury P, Roy C. 1989. Optimal environmental window and pelagic fish recruitment success in upwelling areas. *Canadian Journal of Fisheries and Aquatic Sciences* **46**: 670–680.

Dalebout ML, Robertson KM, Frantzis A, Engelhaupt D, Mignucci-Giannoni AA, Rosario-Delestre RJ, Baker CS. 2005. Worldwide structure of mtDNA diversity among Cuvier's beaked whales (*Ziphius cavirostris*): implications for threatened populations. *Molecular Ecology* **14**: 3353–3371.

David L. 2000. Rôle et importance des canyons sous-marins dans le talus continental sur la distribution des cétacés en période estivale en Méditerranée nord-occidentale. Ecole Pratique des Hautes Etudes, Montpellier.

Dhermain F, Ripoll T, Bompar J-M, David L, Di Meglio N. 1999. First evidence of the movement of a bottle□nosed dolphin Tursiops truncatus between Corsica and Hyères archipelago, south□eastern France. *European Researcch on Cetacean* **13**: 306–311.

Di Natale A, Notarbartolo di Sciara G. 1994. A review of the passive fishing nets and trap fisheries in the Mediterranean and of cetacean by-catch. *Report of the International Whaling CommissionInternational Whaling Commission*: 189–202.

Durand M., Cury P, Mendelssohn R, Roy C, Bakun A, Pauly D. 1998. *Global Versus Local Changes in Upwelling Systems*. Paris.

Ekman VW. 1905. On the influence of the earth's rotation on ocean current. *Arkiv för Matematik, astronomi och fysik* **2**: 1–55.

Franks P. 1992. Sink or swim, accumulation of biomass at fronts. *Marine Ecology Progress Series* **82**: 1–12.

Frantzis A, Alexiadou P, Paximadis G, Politi E, Gannier A, Corsini-Foka M. 2003. Current knowledge of the cetacean fauna of the Greek Seas. *Journal du Conseil international pour l'Exploration de la Mer* **5**: 219–232.

Gaspari S, Airoldi S, Hoelzel AR. 2007. Risso's dolphins (*Grampus griseus*) in UK waters are differentiated from a population in the Mediterranean and genetically less diverse . *Conservation Genetics* **8**: 727–732.

Gibson DI, Harris EA, Bray RA, Jepson PD, Kuiken T, Baker JR, Simpson VR. 1998. A survey of the helminth parasites of cetaceans stranded on the coast of England and Wales during the period 1990–1994. *Journal of Zoology* **244**: 563–574.

Gnone G, Bellingeri M, Dhermain F, Dupraz F, Nuti S, Bedocchi D, Moulins A, Rosso M, Alessi J, McCrea RS, et al. 2011. Distribution, abundance, and movements of the bottlenose dolphin (*Tursiops truncatus*) in the Pelagos Sanctuary MPA (north-west Mediterranean). *Aquatic Conservation: Marine and Freshwater Ecosystems* **21**: 372–388.

IWC. 2009. Report of the First Inter-sessional RMP Workshop on North Atlantic Fin Whales. *Journal of Cetacean Research and Management* **11**: 425–452.

Jaber JR, Pérez J, Arbelo M, Zafra R, Fernández A. 2006. Pathological and inmunohistochemical study of gastrointestinal lesions in dolphins stranded in the Canary Islands. *Veterinary Record* **159**: 410–414.

Klein B, Roether W, Manca BB, Bregant D, Beitzel V, Kovacevic V, Luchetta A. 1999. The large deep water transient in the Eastern Mediterranean. *Deep-Sea Research I* **46**: 371–414.

Ktari-Chakroun F. 1980. Les cétacés des côtes tunisiennes. *Bulletin de l'Institut National Scientifique et Technique d'Océanographie et de Pêche de Salammbô* **7**: 139–149.

Lermusiaux PFJ, Robinson a. R. 2001. Features of dominant mesoscale variability, circulation patterns and dynamics in the Strait of Sicily. *Deep Sea Research Part I: Oceanographic Research Papers* **48**: 1953–1997.

Lewis TIM, Matthews J, Boisseau O, Danbolt M, Gillespie D, Lacey C, Leaper R, Mclanaghan R, Moscrop A. 2007. Abundance estimates for sperm whales in the south western and eastern Mediterranean from acoustic line-transect surveys. In *The 6th International Workshop on Detection, Classification, Localization, & Density Estimation of Marine Mammals using Passive Acoustics* St Andrew, UK; 11.

Morato T, Varkey DA, Damaso C, Machete M, Santos M, Prieto R, Santos RS, Pitcher TJ. 2008. Evidence of a seamount effect on aggregating visitors. *Marine Ecology Progress Series* **357**: 23–32.

Notabartolo Di Sciara G, Birkun AJ. 2010. Conserving whales and dolphins in the Mediterranean and Black seas., Monaco.

Parrish RH., Bakun A, Husby D., Nelson C. 1983. Comparative climatology of selected environmental processes in relation to eastern boundary current pelagic fish reproduction. *FAO Fisheries Report* **291**: 731–778.

Perrin WF, Geraci JR. 2002. *Stranding* (WF Perrin, B Würsig, and JGM Thewissen, Eds). Academic Press, San Diego, .

Podestà M, D'Amico A, Pavan G, Drougas A, Komnenou A, Portunato N. 2006. A review of Cuvier's beaked whale strandings in the Mediterranean. *Journal of Cetacean Research and Management* **7**: 251–261.

Raga JA, Balbuena JA, Aznar J, Fernández M. 1997. The impact of parasites on marine mammals: a review. *Parasitologia* **394**: 293–296.

Reeves RR, Notarbartolo Di Sciara G. 2006. The status and distribution of cetaceans in the Black sea and Mediterranean. The World Conservation Union (IUCN) Centre for Mediterranean Cooperation, Monaco.

Relini G, Relini LO, Cima C. 1994. *Meganyctiphanes norvegica* and fin whales in the ligurian sea: new seasonal patterns. In *proceedings of the eighth annual conference of the european cetacean society 2-5 March 1994*, EVANS PGH (ed). Montpellier, France; 179–182.

Robinson A., Golnaraghi M, Leslie W., Artegiani A, Hecht A, Lazzoni E, Michelato A, Sansone E, Theocharis A, Unluata U. 1991. The Eastern Mediterranean general circulation: features, structure and variability. *Dynamics of Atmospheres and Oceans* **15**: 215–240.

Robinson AR, Sellschopp J, Warner-Varnas A, Leslie WG, Lozano CJ, Haley PJ, Anderson LA, Lermusiaux PFJ. 1999. The Atlantic Ionian stream. *Journal of Marine Systems* **20**: 129–156.

Sammari C, Millot C, Taupier-Letage I, Stefani a, Brahim M. 1999. Hydrological characteristics in the Tunisia–Sardinia–Sicily area during spring 1995. *Deep Sea Research Part I: Oceanographic Research Papers* **46**: 1671–1703.

Unnamed. 2008. Study of Maritime Traffic Flows in the Mediterranean. A report prepared for the Regional Marine Pollution Emergency Response Centre for the Mediterranean (REMPEC) by Lloyd's Marine Intelligence Unit under Task 2.3 O of Activity 2 of the European Union financed MEDA regional project "Euromed co-operation. 40pp.

Vella, A. (1998) 'Cetacean Research Surveys around the Maltese Islands and Maltese Sea-User Cetacean questionnaire study' Presented at the First World Marine Mammal Conference in Monaco with paper publication in proceedings: European Research on Cetaceans – No. 12 Eds. Evans, and Parsons.

Vella, A. 1999 "Conservation research of Bottlenose dolphins, Tursiops truncatus around the Maltese Islands (Central and Southern Mediterranean region)" at the 13th Annual meeting of the European Cetacean Society held in Valencia, Spain. Abstract in Proceedings of the European Research on Cetacean – No. 13 Eds. Evans, Cruz and Raga.

Vella, A. 2000. 'Cetacean Research and Conservation around the Maltese Islands and in the Central/Southern Mediterranean Region' in Monitoring and conservation of birds, mammals and sea-turtles of the Mediterranean and the Black Sea. (MEDMARAVIS Symposium). Proceedings of the Pan-Mediterranean Marine Wildlife Symposium (29th September to 3rd October 1998). Published by the Environment Protection Department, Malta 2000.

Vella A. 2001. Fisheries Exploitation and Cetacean Survival in the Central-Southern Mediterranean Region, at the Marine Mammal Science Conference in Vancouver, Canada in November. Included in the Abstract Proceedings of the 14th Biennial conference on the Biology of Marine Mammals – Nov-Dec 2001, Vancouver, B.C. Canada. Society for Marine Mammalogy.

Vella A. 2002. Delphinus delphis, (Common Dolphins) status in Central/Southern Mediterranean around the Maltese Islands – presented at the European Cetacean Conference in Liege, Belgium. Publication in proceedings ECS no 16. (This paper was also utilized by Bearzi, G., et al (2003) Ecology, status and conservation of short-beaked common dolphins (Delphinus delphis) in the Mediterranean Sea. Mammal Review 33(3):224-252).

Vella, A. 2004: Report for the Scientific Committee of ACCOBAMS on the Marine Protected Areas for Cetaceans at both Local & Regional level.

Vella, A. 2005: Common dolphins (Delphinus delphis) status in the central and southern Mediterranean around the Maltese Islands, in Common dolphins: Current Research, threats and issues. Eds: K. Stockin, A. Vella, & P. Evans. ECS newsletter no. 45 - special issue July 2005.

Vella, A. 2006: Human Impacts on coastal Cetaceans around the Maltese Islands. ECS 20th Annual Conference in Gdynia, Poland – in the 20th ECS conference Proceedings.

Vella, A. 2008: Pelagic species diversity in the Central-Southern Mediterranean: overview from long-term field research presented at the World Conference on Marine Biodiversity held in November 2008 in Valencia, Spain.

Vella A. 2009: Sustainable Fisheries in the Mediterranean. Study and Publication commissioned by the Regional Activity Centre for Cleaner Production (CP/RAC), Barcelona, Spain. (available from: http://www.cprac.org/en/downloads/ documents/sector-studies).

Vella A., 2010a. First Research Sightings of Fin Whales (Balaenoptera physalus) Coastal waters of the Maltese Islands, Central-Southern Mediterranean. Rapp. Comm. Int. Mer Medit. Vol. 39 - page 693.

Vella, A., 2010b. Scientific considerations for Conservation Marine Area/s in the Central Mediterranean Region around the Maltese Islands. Brief report and presentation at the CIESM workshop no 41: Science for peace – proposing International coast-to-coast Marine Parks in the Mediterranean - Syracusa, Sicily 18-20 November 2010.

Vella, A., Mazzola, S., Notarbartolo di Sciara G., Rais C., and Wurtz M., 2011. Scientific rationale for the proposed CIESM Pelagian Sea Marine Peace Park. In Marine Peace Parks in the Mediterranean – a CIESM proposal. No 41 pg 51-53 - CIESM Workshop Monographs (F. Briand Ed.), 128 pp, Monaco.

Vella A., 2011. Cetacean Species Diversity and Conservation in the Central Southern Mediterranean around the Maltese Islands: review of 14 years of marine and aerial research. Abstract proceedings of oral presentations at the World Conference on Marine Biodiversity in Scotland September 2011. 19/0917.

Vella A. Vella J. 2012. Central-southern Mediterranean submarine canyons and steep slopes: role played in the distribution of cetaceans, bluefin tunas and elasmobranchs. Mediterranean Submarine Canyons: Ecology and Governance. (Ed.) Wurtz M. (2012) Gland, Switzerland and Malaga, Spain: IUCN. 216pp.

Vella A. 2013. Cetacean, Turtle and Pelagic Species and Associations in the Central-Southern Mediterranean Sea: Implications for Conservation Action. Rapp. Comm. Int. Mer Medit. Vol. 40.

Vella A. 2014. Long-term research: essential for understanding how cetaceans are indicators of a changing environment in the Central-Southern Mediterranean Sea at the 28th European Cetacean Society Conference in Liege 5th-9th April - oral presentation.

Warn-varnas A, Sellschopp J, Haley PJ, Ward-Geiger L, Lozano CJ. 1999. Strait of Sicily water masses. *Dynamics of Atmospheres and Oceans* **29**: 437–469.

WWF/IUCN. 2004. *The Mediterranean deep-sea ecosystems deep-sea ecosystems An overview of their diversity, structure, functioning and anthropogenic impacts, with a proposal for their conservation*. Malaga.