

Summer Distribution, Relative Abundance and Encounter Rates of Cetaceans in the Mediterranean Waters off Southern Italy (Western Ionian Sea and Southern Tyrrhenian Sea)

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Abstract

During the summers of 2010 and 2011, weekly cetacean surveys were undertaken in “passing mode”, using ferries as platforms of opportunity, along the “fixed line transect” between Catania and Civitavecchia (southern Italy). Of the 20 species of cetaceans confirmed for the Mediterranean Sea, eight were sighted within the survey period, of which seven species represented by Mediterranean subpopulations (*Balaenoptera physalus*, *Physeter macrocephalus*, *Stenella coeruleoalba*, *Delphinus delphis*, *Grampus griseus*, *Tursiops truncatus* and *Ziphius cavirostris*) and one is considered a visitor (*Steno bredanensis*). A total of 220 sightings were effected during 2010 and a total of 240 sightings in 2011. The most frequently recorded species was *S. coeruleoalba*. By comparing the data from the two sampling seasons, a significant increase of *D. delphis* sightings and a decrease of sightings of *B. physalus* and *P. macrocephalus* were observed. While all the other species were observed in both sampling seasons, *Z. cavirostris* and *Steno bredanensis* were observed only during 2011. The presence of mixed groups of odontocetes was also documented: groups composed of pairs of species were *S. coeruleoalba* and *D. delphis*, *S. coeruleoalba* and *T. truncatus*, and *S. coeruleoalba* and *G. griseus*. The results of this research add useful information on cetacean species in a very poorly known area and highlight the need to standardize large-scale and long-term monitoring programs in order to detect variation in presence, abundance and distribution of cetaceans populations and understand the effect of anthropogenic factors.

Keywords: Cetaceans, distribution, relative abundance, central Mediterranean Sea, mixed groups.

Introduction

Cetacean fauna in the Mediterranean Sea can be considered as a group of the north Atlantic fauna. Of the approximately 20 species of cetaceans that have been cited in the Mediterranean Sea, only eight are considered Mediterranean subpopulations (Reeves & Notarbartolo di Sciara, 2006): *Balaenoptera physalus* (fin whale), *Physeter macrocephalus* (sperm whale), *Ziphius cavirostris* (Cuvier's beaked whale), *Globicephala melas* (pilot whale), *Grampus griseus* (Risso's dolphin), *Delphinus delphis* (common dolphin), *Stenella coeruleoalba* (stripped dolphin) and *Tursiops truncatus* (bottlenose dolphin), while *Steno bredanensis* (rough-toothed dolphin) is considered only an occasional species for the Mediterranean Sea. All cetaceans are long-lived vertebrates located in the highest levels of the marine trophic webs; they are also characterized by a very low reproductive rate and are thus particularly vulnerable to threats deriving from human activities, especially in the semi-enclosed basin of the Mediterranean Sea that supports a high human density in the coastal zones. As has been demonstrated for the

short-beaked common dolphin (*Delphinus delphis*) and other cetaceans (Bearzi *et al.*, 2003; Bellante *et al.*, 2012; Fossi *et al.*, 2013), these threats may lead to declining populations of some Mediterranean species. Therefore, it is necessary to implement conservation measures especially in this basin. Information on spatial and temporal variations in cetacean abundance, as well as other taxa, is essential to determine both whether management actions are necessary and to assess the effectiveness of any actions that are taken (Evans & Hammond, 2004). Obtaining abundance estimates is, then, a priority in order to assess the status of the different cetacean species in the Mediterranean Sea and to evaluate the impact that human threats may have on these populations. Monitoring cetacean presence, and distribution and migration patterns is an effective indicator to detect environmental changes and habitat degradation and to recommend appropriate conservation planning. However, distribution and abundance data on cetaceans, particularly those occurring predominantly offshore, are generally difficult to collect (Notarbartolo di Sciara *et al.*, 1993; Kiszka *et al.*, 2007). The cost of dedicated surveys on chartered research ves-

sels is generally prohibitive in terms of carrying out regular surveys. For this reason, vessels of opportunity has been widely used for opportunistic surveying of cetaceans (Northridge *et al.*, 1995; Pollock *et al.*, 1997; Berrow *et al.*, 2001; Reid *et al.*, 2003; Evans & Hammond, 2004; O'Cadhla *et al.*, 2004; Wall *et al.*, 2006; Arcangeli *et al.*, 2013). In particular, ferries allow for repetitive surveys along a fixed transect which can be conducted regularly over progressive years within a particular area of interest (MacLeod *et al.*, 2007). This method has been accepted by the Joint Nature Conservation Committee for regular conservation assessments of cetaceans in the UK (Brereton *et al.*, 2000). Between 1989 and 1991, in the central Tyrrhenian Sea, dedicated surveys along a fixed transect were carried out twice a week using passenger ferries as opportunity research platforms for cetaceans sightings between Civitavecchia (Lazio) and Golfo Aranci (Sardinia) (Marini *et al.*, 1996). For the first time, this project engaged a species census of cetaceans, their distributions and sighting frequency in the Mediterranean. In 2007 the Accademia del Leviatano in partnership with ISPRA (Istituto Superiore per la Protezione e Ricerca Ambientale, Italy) resurrected the project, under the same protocol and the same supervision. In 2008 this project became organic and systematic monitoring of cetaceans in all the western Mediterranean across five transects began: Catania – Civitavecchia; Civitavecchia – Golfo Aranci; Livorno – Bastia; Savona – Bastia; Nizza – Calvi.

In this paper the results of weekly observations during the summers 2010 and 2011 are presented, along the western Ionian and the southern Tyrrhenian seas, in the ferry transect between Catania (Sicily) and Civitavecchia (Lazio). The main goal of this study was to provide preliminary information on the presence, the distribution, the encounter rates, and habitat characteristics of cetaceans in the central-southern Tyrrhenian and western Ionian seas. We focused our attention also on the presence of mixed groups. These results could be used for further conservation applications for cetacean Mediterranean populations.

Materials and Methods

Study area

The survey area covers three different marine geographical regions: western Ionian Sea, Messina Strait and southern Tyrrhenian Sea (Fig. 1). Calabria, together with Sicily and the Tunisian coast, divides the Mediterranean Sea into western and eastern parts, often characterized by different biological communities (Nicolaidou *et al.*, 2012; Sperone *et al.*, 2012; Bilecenoglu *et al.*, 2013). The Tyrrhenian side of the study area lies in the western Mediterranean, while the Ionian side lies in the eastern Mediterranean. The Ionian Sea is included among the Sicilian, Calabrian and Apulian coasts on the western

side, and Albanian and Greek coasts on the eastern side. The Ionian continental shelf is not particularly wide, and the depth along the Sicilian coast drops suddenly and reaches -2000 m within few miles from the coast. The backdrop is bumpy and irregular, often characterized by canyon formations. In particular, the Gulf of Catania is characterized by important upwellings that develop interesting and delicate ecosystems. The Messina Strait is very important from a geological and an oceanographic point of view, because together with the Sicily-Tunisian Ridge it is one of the two conjunction points between the western and eastern basins of the Mediterranean Sea. The sea floor of this basin could be considered a mount-like formation and its top is named "Sella" (from -80 to -120 m under sea level). Sella Mountain divides the strait into two parts: the northern side lies in the Tyrrhenian and it has gentle slopes, reaching -2000 m bathymetric near the Aeolian islands; the southern side lies in the Ionian and it has steep slopes, quickly reaching -500 m near Messina. The two basins have different chemical and physical characteristics of the sea water and give origin to particular tides and currents. The Tyrrhenian Sea is located on the west Italian coast, encompassing Sicily, Sardinia and Corsica. The continental slope is well-developed along the western Sicilian, Campanian, Sardinian and Corsican coasts, while along the Calabrian and northern Sicilian coasts it is almost absent with considerable depths reached near the coastline. The abyssal plane within 3000 m under the sea level is located in the central-southern part of the basins, but it is often interrupted by mountains like the Marsili volcano and the Mavilov mount.

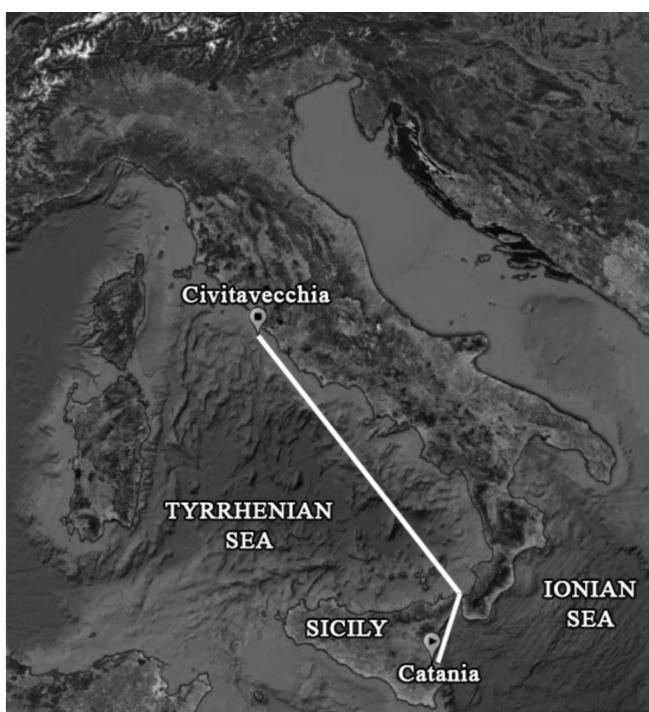


Fig. 1: Location of the study area.

Data collection

Between July and October 2010 and July and September 2011, weekly observation were undertaken in “passing mode”, using ferries as platforms of opportunity for dedicated surveys (see Donovan, 2005), along the “fixed line transect” between Catania harbor (Sicily, 37.50 N; 15.50 E) and Civitavecchia harbor (Lazio, 42.08 N; 11.8 E). The stretch is 358.5 nautical miles (nm) of which 120-170 were covered during night time and 210-230 nm during the day time. Cruising speed was approximately 20 knots and the average time of runs was approximately 19 hours. Two observers were located on the two sides of the command deck of the ferry, each observer focused primarily on an 90° arc ahead of the ship and continuously scanned area by naked eye and occasionally with binoculars (according to Marini *et al.*, 1996 and Arcangeli *et al.*, 2013). Observations were undertaken under fine weather condition (Beaufort wind-strength ≤ 3) during the day time. At the moment of sighting, data on species, group size, swim direction, distance between the detected group and the track line were collected on dedicated data sheets. Sighting bearings were measured using an angle board and distances were estimated with the aid of measuring stick. Sighting positions were also recorded using the GPS (Global Positioning System) of the ship. Environmental data were noted every hour. Sightings were reported on geo-referenced map using Google Earth software. Where species identification could not be confirmed, sightings were placed as unidentified small cetaceans (NISC) or unidentified big cetaceans (NIBC). According to Cañadas *et al.* (2002), group size was considered to be a group of animals seen at the same time, showing similar behavioral characteristics and < 1000 m from each other.

Data analysis

All collected data were organized using MS Excel, in the Ketos Database. Presence, relative abundance and distribution of the species were all analyzed. However, due to variation in visibility during the survey, observations were not continuous and differed according to the run. For this reason and due to the fact that along the transect sighting could be considered an event and not a state, the relative abundance was measured using Encounter Rate (ER): i.e., numbers of sightings per hour of observation (Evans & Hammond, 2004; Wall *et al.*, 2006). Data from the two investigated periods were compared with the Mann-Whitney (MW) test. To test whether differences occurred in inter-annual and intra-annual observations, yearly and monthly analyses were performed only on the most commonly sighted species, i.e., *S. coeruleoalba*, *D. delphis* and *T. truncatus*.

Results

Of the 20 species of cetaceans regularly present in the Mediterranean sea, eight were sighted within the

survey period: seven species represented by Mediterranean subpopulations (*B. physalus*, *P. macrocephalus*, *S. coeruleoalba*, *D. delphis*, *G. griseus*, *T. truncatus* and *Z. cavirostris*) and one was considered only as occasional (*S. bredanensis*). A total of 220 sightings were made during 2010 and 240 sightings in 2011. The sightings distribution for all species is given in Figure 2. The seasonal Encounter Rate for summer 2010 was 0.94 ± 0.60 , while for summer 2011 was 1.11 ± 0.94 . From both seasons the most frequent species seen was *S. coeruleoalba*, which represented 34% of sightings of 2010 and the 48% of 2011. The overall sighting relative frequencies and numbers of sightings observed are given in Table 1. In 30% of the sightings, species could not be determined. While all the other species were observed in both sampling seasons, *Z. cavirostris* (two individuals) and *Steno bredanensis* (five individuals) were observed only during 2011 near the Pontine Islands. By comparison of the data from the two sampling seasons, a significant increase of *D. delphis* sightings could be observed: only 37 individuals were encountered in 2010, but 289 individuals in 2011 ($\chi^2_{Yates} = 112,69$; $df = 1$; $P < 0.0001$). On the other hand, a decrease in sightings of *B. physalus* and *P. macrocephalus* was observed: in fact, in 2011 both species were sighted just once. During the two sampling seasons many groups of mixed species were observed (Fig. 3). The most frequent association was that between *S. coeruleoalba* and *D. delphis* with two sightings in 2010 and five in 2011. In the case of associations between *S. coeruleoalba* and *G. griseus* and between *S. coeruleoalba* and *T. truncatus*, only one sighting was registered for each year.

Cetacean sightings frequency reflects regional differences, so the entire study area may be subdivided into two distinct categories: regions where the overall cetacean sightings frequency is high (Campanian-Latium sea; Aeolian sea- Strait of Messina -Gulf of Catania) and regions in which is low (southern Tyrrhenian sea). In this latter region only *S. coeruleoalba* and *D. delphis* were

Table 1. Overall sighting encounter rates, numbers of sightings, and number of specimens for each species.

Species	Encounter rates		Number of sightings	
	2010	2011	2010	2011
<i>Balaenoptera physalus</i>	0,02	0,01	7	2
<i>Physeter macrocephalus</i>	0,04	0,01	6	1
<i>Stenella coeruleoalba</i>	0,34	0,56	74	94
<i>Delphinus delphis</i>	0,03	0,11	4	15
<i>Grampus griseus</i>	0,05	0,01	7	1
<i>Tursiops truncatus</i>	0,03	0,05	9	8
<i>Steno bredanensis</i>	0	0,01	0	1
<i>Ziphius cavirostris</i>	0	0,01	0	1
Total			107	123

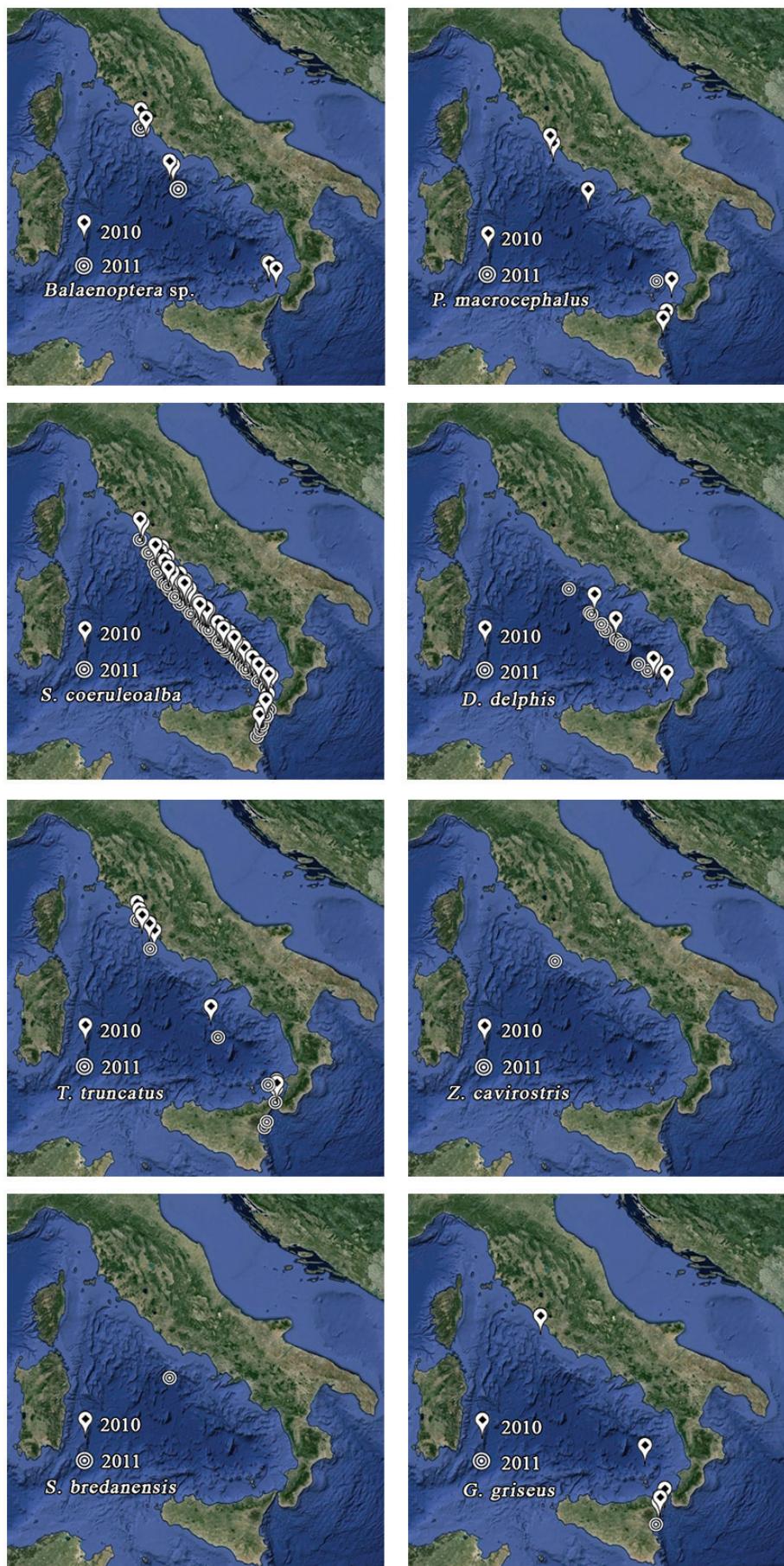


Fig. 2: Sightings of cetaceans in the study area during the study periods.



Fig. 3: Sightings of mixed groups.

observed, while all the other species were sighted in the regions with high frequency.

For *B. physalus* a decrease was registered in the numbers of sightings, indeed, the ER is 0.02 in 2010 and only 0.01 in 2011. Sightings were recorded along the continental slope, near Civitavecchia harbor, Pontino archipelago and in the Strait of Messina. Even for *P. macrocephalus* a decrease of sightings and abundance were recorded: in the 2010 seasonal ER was 0.04 with 8 individuals, while in 2011 it was only 0.01, with one sighted specimen. All the sightings were recorded in the area with the highest frequency of sightings, corresponding to the location of the continental slope. An increase of frequency of sightings for *S. coeruleoalba* was recorded: the seasonal ER was 0.34 in 2010 and 0.56 in 2011. In both years the higher monthly values were observed in July and in September. Sightings of this species were all recorded in deep water. An increase of frequency of *D. delphis* was observed in the two years of investigation: the seasonal ER was 0.03 in 2010 and 0.11 in 2011. All sightings were recorded beyond the continental slope, in deep waters between the Aeolian arch and the Pontino archipelago. *Tursiops truncatus* seasonal ER values were 0.03 in 2010 and 0.05 in 2011 while the abundance of this species was approximately the same: in fact, 64 individuals were counted in 2010 and 68 in 2011, and all sight-

ings were recorded along the continental platform. For *G. griseus* a decrease in frequency and abundance was recorded. Only one sighting with three individuals was recorded in 2011 summer, in spite of the seven sightings of 2010 with a total 41 individuals. Seasonal ER values were 0.05 for the 2010 and 0.01 for 2011. Most sightings were recorded along the Sicilian continental platform.

Group size descriptive statistics are shown in Table 2. In 2010 the species with the greatest mean group size (20.08) was *S. coeruleoalba*. *Delphinus delphis* had the second largest mean group size (9.25), followed by *T. truncatus* (7.1) and *G. griseus* (5.85). The two largest species, *B. physalus* and *P. macrocephalus*, had a mean group size of 1.43 and 1.3 respectively. In 2011 the spe-

Table 2. Group size statistics.

Species	Mean group size	
	2010	2011
<i>Balaenoptera physalus</i>	1.43	1.00
<i>Physeter macrocephalus</i>	1.30	1.00
<i>Stenella coeruleoalba</i>	20.08	14.87
<i>Delphinus delphis</i>	9.25	19.86
<i>Grampus griseus</i>	5.85	3.00
<i>Tursiops truncatus</i>	7.10	8.50
<i>Steno bredanensis</i>	0	5.00
<i>Ziphius cavirostris</i>	0	2.00

cies with the greatest mean group size was *D. delphis* (19.86). *Stenella coeruleoalba* had the second largest mean group size (14.87), followed by *T. truncatus* (8.5) and *G. griseus* (3). The two largest species, *B. physalus* and *P. macrocephalus*, had a mean group size of 1.

Discussion

This work represents the first attempt to compare the distribution and relative abundance of cetaceans between two regions of the sea surrounding southern Italy. Data analysis underlined some differences in the abundance of species and within their area of distribution, probably in relation to the sea bed characteristics, the chemical and physical water parameters, the vessel traffic and the trophic availability (Hui, 1979). The observed sightings and frequencies of cetacean species warrant discussions on their significance.

The sightings of *B. physalus* were mainly located in the central-northern part of the transect along the continental slope: this distribution could be related to the detection of a new feeding zone in the central Tyrrhenian Sea (Arcangeli *et al.*, 2014) where the species seems to concentrate during summer. On the other hand, the sightings of *B. physalus* in the area of the Strait of Messina confirmed the importance of this area as seasonal feeding ground and for the migration patterns of this species through different marine geographical regions in the Mediterranean (Aissi *et al.*, 2008). The absence of sightings in the southern part of the transect could be linked to a different seasonal use of this area but more investigation is needed to confirm this data.

Physeter macrocephalus is the most pelagic of the odontocetes (Notarbartolo di Sciara *et al.*, 1993): in fact, this species was sighted only in pelagic waters, where its preys (mesopelagic squids) are common. The low number of sightings for this species could be linked to a general decrease of the species in the Mediterranean basin where it is listed as Endangered by the IUCN Red List criteria (Notarbartolo di Sciara, 2013) and by the fact that visual surveys can, in general, affect the sighting's probability for long-diving species such as the sperm whale.

Stenella coeruleoalba was the most frequently recorded and abundant species, confirming the general pattern described for the Mediterranean Sea (Notarbartolo di Sciara *et al.*, 1993; Gomez de Segura *et al.*, 2006; Panigada *et al.*, 2011). These sightings were all recorded in the deep waters of the transect between the Aeolian Arc and the Latium continental shelf: this confirmed that *S. coeruleoalba* is an almost exclusively pelagic species (Forcada *et al.*, 1994). Most sightings were recorded along the Sicilian coast, between Messina and Catania, in relationship with the high trophic availability of the area, as a consequence of the local upwelling currents.

Delphinus delphis is considered extremely rare in

Mediterranean, with some relict groups in the south-eastern Tyrrhenian around the Cuma canyon (Bearzi *et al.*, 2003), but we documented the presence and an increment of sightings and abundance of the species along the transect investigated. Sightings were all recorded along the deeper waters between the Messina Strait and Civitavecchia, in accordance with the habits of *D. delphis* recorded in the western Mediterranean and in the Alboran Sea (Cañadas *et al.*, 2002; Cañadas & Hammond, 2008).

Tursiops truncatus was sighted mainly in neritic water, along the continental shelf near Civitavecchia and Catania and in the Strait of Messina, agreeing well with the species' coastal habits already documented for the Mediterranean (Notarbartolo di Sciara *et al.*, 1993). In 2010 we recorded only one sighting of *T. truncatus* in deep waters, along the continental slope, confirming the observations of Notarbartolo di Sciara *et al.* (1993) that the species can be rarely observed also in pelagic waters.

Most of sightings of *G. griseus* were recorded in the Catania Gulf, along continental shelf, where coastline and continental slope are closer, in relationship with their prey habits (Bearzi *et al.*, 2011).

Interesting, the only sighting of *Z. cavirostris* was recorded in 2011 in the Latium pelagic waters, in the area that is known to host the species since the beginning of the 1990s (Marini *et al.*, 1996) and where its presence has been confirmed in recent years (Arcangeli *et al.*, 2012).

Steno bredanensis is considered an accidental species in the Mediterranean (Notarbartolo di Sciara, 1994): for this reason the sighting of the five specimens in the pelagic waters off Latium should be considered an interesting datum.

During our surveys, the presence of mixed groups of odontocetes were documented: groups composed of *S. coeruleoalba* and *D. delphis*, of *S. coeruleoalba* and *T. truncatus*, and of *S. coeruleoalba* and *G. griseus* were recorded. Mixed groups of *S. coeruleoalba* and *D. delphis* were known in the western tropical Pacific Ocean (Reilly, 1990) and this aggregation was explained as a consequence of the similar habitat shared by both species. In the Mediterranean, the association between *S. coeruleoalba* and *D. delphis* are common only in the Alboran Sea and in the Gulf of Corinth (Frantzis & Herzing, 2002). In particular, in the Alboran Sea, 17% of *D. delphis* sightings were recorded in association with *S. coeruleoalba* (Garcia *et al.*, 2000). Frantzis & Herzing (2002) documented that *D. delphis* sightings in mixed groups represented approximately 25% of all sightings of this species in the Pontine archipelago, an area in which the species abundance is lower than in the Alboran Sea. Very little is known about the associations between *S. coeruleoalba* / *T. truncatus* and *S. coeruleoalba* / *G. griseus*, so that this could be a potential indication of particular conditions in the area that deserve further investigation.

The results of this research add useful information on cetacean species in a very poorly known area and high-

light the need to standardize large-scale and long-term monitoring programs in order to detect variation in presence, abundance and distribution of cetacean populations and to understand the effect of anthropogenic factors. If used as a standardized protocol, ferries could be an efficient and low cost platform of observation for longer and larger cetacean monitoring programs.

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