Journal of the Marine Biological Association of the United Kingdom, 2018, 98(5), 1003–1009.
doi:10.1017/S0025315416001892

Two live sightings of Sowerby's beaked whale (*Mesoplodon bidens*) from the western Mediterranean (Tyrrhenian Sea)

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*Sowerby's beaked whale (*Mesoplodon bidens*) was previously known in the Mediterranean Sea from a single live stranding of two individuals in the French Riviera. We report here on two live sightings in the western Mediterranean, central-western Tyrrhenian Sea off eastern Corsica (Montecristo Trough) and off eastern Sardinia (Caprera Canyon) in 2010 and 2012, respectively. In both cases single individuals, possibly the same individual, occurred within groups of Cuvier's beaked whales (*Ziphius cavirostris*) suggesting inter-specific interactions. Based on our close observations of mixed-species groups of Sowerby's and Cuvier's beaked whales, we hypothesize that some previous long-distance sightings of beaked whales in the Mediterranean may not be reliably attributed to* Z. cavirostris. *The present sightings and previous live stranding indicate that the western Mediterranean Sea is the easternmost marginal area of* M. bidens *within the North Atlantic geographic range. Notes on behaviour are also provided.*

Keywords: Marine biodiversity, Ziphiidae, cetaceans inter-specific interactions, Caprera Canyon, biogeography

Submitted 19 July 2015; accepted 12 December 2016; first published online 23 January 2017

INTRODUCTION

Eight of the 12 new cetacean species described in the last century belong to the family Ziphiidae, mostly to the genus *Mesoplodon* Gervais, 1850 (Mead, 1989; Dalebout *et al.*, 2002; Perrin, 2015). At the surface, the beaked whales' morpho-traits do not allow equally easy identification and require a close observation of the head (Barlow *et al.*, 2006; Jefferson *et al.*, 2015). Little is known of most of the Ziphiidae, due to their cryptic, shy and elusive behaviour. Their prolonged dives, small group size, and inconspicuous surface activity showing only small body portions for very short durations, increase the poor detectability. The lack of beaked whales abundance estimates, together with the geographic variation of sighting rates could be related to difficulties in their visual detection and identification at sea, mainly due to the need for very good sea state and wind (Douglas and Beaufort scales = 0–1), to observers' experience in detecting beaked whales at sea, and to a scant research effort in large pelagic areas (Barlow *et al.*, 2006). In particular, the genus *Mesoplodon* is also frequently misidentified at sea for its anatomical similarities, especially for juveniles and females (Pitman, 2009).

Four *Mesoplodon* species inhabit the North Atlantic, i.e. Gervais' beaked whale *Mesoplodon europaeus* (Gervais, 1855), Blainville's beaked whale *Mesoplodon densirostris* (Blainville, 1817), True's beaked whale *Mesoplodon mirus* True, 1913, and the endemic Sowerby's beaked whale *Mesoplodon bidens* (Sowerby, 1804) (Mead, 1989; MacLeod, 2000; MacLeod *et al.*, 2006). They are sympatric, at a large scale, in the North Atlantic warm-temperate zone (MacLeod, 2000).

Mesoplodon bidens is characterized by the northernmost distribution (Figure 1A), whereas *M. densirostris, M. mirus* and *M. europaeus* generally occur further south with an almost certainly cross-equatorial geographic range (MacLeod, 2000). The northernmost live sighting of *M. bidens* occurred in the polar Norwegian Sea (Carlström *et al.*, 1997) while the majority of stranding records occurred in the European Atlantic Coast (MacLeod *et al.*, 2006) (Figure 1A), where it is also the most commonly stranded species among mesoplodonts (Bachara *et al.*, 2014). Regular sightings of *M. bidens* off the Azores (MacLeod & Mitchell, 2000; Visser, 2012; Villa, personal communication) along with many strandings (Reiner, 1986; Reiner *et al.*, 1993; Pereira *et al.*, 2011; Bachara *et al.*, 2014) and sightings off the Madeira Archipelago (Maul & Sergeant, 1977; Freitas *et al.*, 2012) highlight that these areas may represent the south-eastern parts of its geographic range, with the latter recent live sightings probably related to the increase in local cetological research. Stranding records of *M. bidens* were also reported as extralimital in the Canary Archipelago (Lanzarote) by Martín *et al.* (2011), and from the southern Spanish Atlantic coast, near Cádiz (Bellido *et al.*, 2008) ~100 km away from the Gibraltar Strait (Figure 1A).

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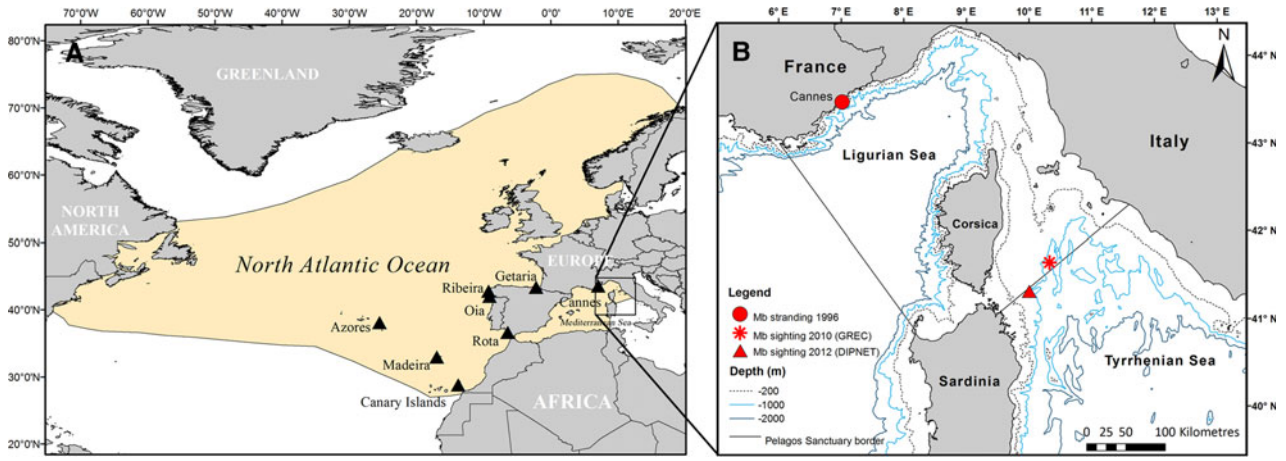

Fig. 1. (A) *Mesoplodon bidens*. North Atlantic geographic range (shaded area) (modified from MacLeod *et al.*, 2006; IUCN, 2008) with the area of potential occurrence in the Mediterranean Sea. Stranding records (black triangles) in the southernmost North-eastern Atlantic Ocean and western Mediterranean Sea, during 1941–2012 (N = ind. num.). Getaria, Spain, 2006, N = 1 (Bachara *et al.*, 2014); Ribeira, Spain, 2012, N = 1 (Covelo *et al.*, 2016); Oia, Spain, 2013, N = 1 (Covelo *et al.*, 2016); Rota, Spain, 2007, N = 2 (Bellido *et al.*, 2008); Lanzarote, Canary Archipelago, Spain, 2007, N = 1 (Martín *et al.*, 2011); Madeira Archipelago, Portugal, 1941–2012, N = 4 (Maul & Sergeant, 1977; Freitas *et al.*, 2012); Azores Archipelago, Portugal, 1981–2009, N = 23 (Reiner, 1986; Reiner *et al.*, 1993; Bachara *et al.*, 2014). (B) Sighting positions recorded in the Mediterranean Sea by GREC (asterisk) in 2010 and by DIPNET (triangle) in 2012 and stranding site (circle) in Lérins Islands (see Table 1). The International Pelagos Sanctuary is indicated by black lines.

However, the south-westernmost stranding, maybe extra-limital, occurred in Brazil in 1983 and was only recently identified as *M. bidens* (Bachara *et al.*, 2014).

There is no evidence of the regular occurrence of mesoplodonts in the Mediterranean (MacLeod *et al.*, 2006), while Cuvier's beaked whale *Ziphius cavirostris* Cuvier, 1823 is thought to be the only regularly occurring ziphiid (Notarbartolo di Sciara, 2002; Notarbartolo di Sciara & Demma, 2004). Only five mesoplodont specimens in four reliable strandings are known in the Mediterranean Sea, with just one referred to a live stranding event (Table 1). A specimen reported as female *M. bidens* stranded in 1927 on the western coast of Italy (Brunelli & Fasella, 1928) but samples were neither preserved, nor any clear morphological description was given to provide a less doubtful identification (Podestà *et al.*, 2006). The ascription to the genus *Mesoplodon* by the authors was based on the teeth position ('not on the tip of the lower jaw, but significantly distant', Brunelli & Fasella, 1928). Although the description is detailed enough to conclude that it was not a Cuvier's beaked whale, it is insufficient for a reliable identification at species level. The Gervais' beaked whale (*M. europaeus*) stranded in Italy in 2001 represents the first Mediterranean record of this species (Podestà *et al.*, 2005).

Only a single Mediterranean record (live stranding) may be clearly referred to *M. bidens* on the basis of photographic data (Van Canneyt *et al.*, 1998; Bompar, 2000; Notarbartolo di Sciara, 2002; Dhermain, 2004; Reeves & Notarbartolo di Sciara, 2006), when two subadults *M. bidens* were rescued and refloated in the Lérins Islands (Cannes, Ligurian Sea), without collecting any tissue samples to confirm, on a genetic basis, the species identity (Bompar, 2000). Podestà *et al.* (2009) stated that all these strandings indicate the presence of the genus *Mesoplodon* in the Mediterranean Sea, but until then no live sighting data were available. Although stranding records actually provided much of the available information on the beaked whales, geographic range can be better assessed when regular sightings occur.

The debate as to whether the Sowerby's beaked whale inhabits the Mediterranean Sea is still open. Here we report two live sightings of *M. bidens* from the western Mediterranean Sea, along the south-eastern border of the International Pelagos Sanctuary for the protection of Mediterranean marine mammals.

MATERIALS AND METHODS

Sighting No. 1 was part of a GREC dedicated programme on *Z. cavirostris* during visual and acoustic boat surveys, carried out in sea state Douglas 0–1 (i.e. Beaufort wind force scale 0–1) by three experienced observers. The survey focused on natural behaviour, therefore groups were not approached and the sail boat was stopped at a distance of 100–200 m away from the whales. Photographs were taken using digital cameras. For all GPS positions, depth was then determined using GEBCO Atlas (IOC–IHO–BODC, 2003); see Gannier (2011) for full description of field protocol.

Table 1. Genus *Mesoplodon*. Records of stranded beaked whales in the Mediterranean Sea.

Species	Date	Location	Length (cm)	No. of animals	References
M. bidens	9/11/1927	Nettuno (Roma, Italy)	–	1	Brunelli & Fasella (1928)
M. bidens	15/8/1996	Îles de Lérins (Cannes, France)	–	2	Bompar (2000, personal communication)
M. densirostris	17/2/1980	Alcossebre (Spain)	421	1	Casinos & Filella (1981)
M. europaeus	9/8/2001	Castiglioncello (Livorno, Italy)	450	1	Podestà *et al.* (2005)

https://doi.org/10.1017/S0025315416001892 Published online by Cambridge University Press

Sighting No. 2 was part of a DIPNET – University of Sassari research programme focused on pelagic cetaceans (Bittau & Manconi, 2011; Bittau, 2014). Visual observation and photo-identification were carried out during an opportunistic boat survey (whale watching) by means of a power catamaran in sea state Douglas scale 0–2 (i.e. Beaufort wind force scale 0–3). Photographs of the animals were collected using digital cameras. For all GPS positions, depth was then determined by ISMAR–CNR depth data using Geographic Information System (GIS) ESRI ArcGIS 9.3. SST was recorded during all tracking by a Garmin transducer (GPS nav 540s) positioned on the boat's hull. See Bittau & Manconi (2016) for a full description of the field protocol.

Species identification was based on the photographic and behavioural data analysis of diagnostic traits of the two animals *vs* the other species of *Mesoplodon* expected to occur in the North Atlantic (Leatherwood & Reeves, 1983; Heyning, 1989; Mead, 1989; MacLeod, 2000; Jefferson *et al.*, 2015).

RESULTS

Sighting offshore the Corsica Island

Sighting No. 1 is the northernmost of the two records (Figure 1B), and occurred on 9 August 2010, 72.2 km offshore eastern Corsica, in the Montecristo Trough area (41°42.467′N 10°16.550′E; time 17:47 UTC+1) at a depth of 1280 m on sighting position, with Douglas and Beaufort 0–1, calm sea and cloudy weather. At first, a beaked whale group was visually detected, at a distance of ~0.93 km while cruising at 5 knots.

A group size of eight beaked whales was initially estimated, but later it appeared to be structured in two subgroups of three and five individuals. A single individual was initially observed repeatedly breaching, up to four times in a row, displaying belly flop leaps and showing flippers, hence not showing its full body length (Figure 2A) and staying not less than 100 m away. The subgroup of three, apparently including all juveniles, approached the boat at less than 10 m, were photographed at close distance and identified with certainty as Cuvier's beaked whales, due to their head shape (Figure 2B). The general behaviour was initially social and mobile, with the two subgroups that joined and split, thus showing a variable size, at times performing short dives, but with always at least two individuals at the surface. This uncoordinated behaviour finished when all eight animals dived. Some clicks were recorded after this dive and thereafter. After a 29 min dive, one whale was spotted at the surface and 3 min later three individuals, presumably juveniles, were visible, but they were never approached. The sighting was concluded when clicks were no longer recorded and beaked whales were not visible anymore. The total sighting duration was 96 min, including 31 min during which the entire group was generally visible, and 65 min when most individuals performed a deep dive. This sighting was immediately qualified as unusual, because of both group size and surface activity.

All whales sighted in 2010 offshore eastern Corsica were initially recorded as *Z. cavirostris*. However, one individual

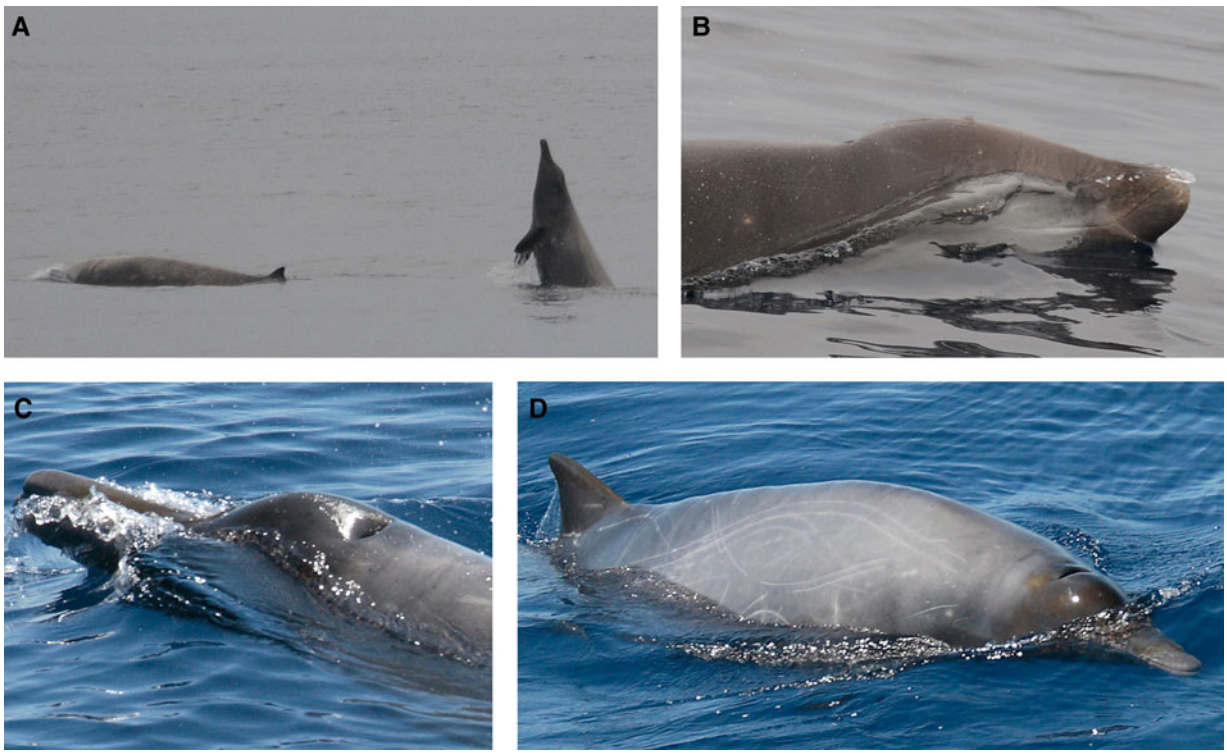

Fig. 2. *Mesoplodon bidens* in the western Mediterranean Sea. (A) The *M. bidens* associated with *Ziphius cavirostris* sighted offshore E Corsica (August 2010), during the breaching series, showing long pointed beak and prominent bulge. (B) Head of *Z. cavirostris* recorded during the same sighting of (A). (C and D) The *M. bidens* sighted offshore NE Sardinia (June 2012). (C) Head details of the animal showing dark colour, long beak, prominent bulge and concave shape between the forehead and the beak; (D) the same animal as in (C) showing its long beak, pale blaze and closely spaced parallel scars on body side. Photo credits: (A and B), Adrien Gannier; (C and D), Paolo Curto.

https://doi.org/10.1017/S0025315416001892 Published online by Cambridge University Press

in the subgroup of five, showing its forebody during the breaching series, was distinguished by a highly distinctive long and thin beak compared with the rest of the group (Figure 2A and B). At that time this unusual head shape was associated with its lean body, perhaps characteristic of an emaciated individual. Two years later, despite the long distance observation and poor quality photographs, the final identification of this individual as a Cuvier's beaked whale was reviewed after the sighting of a mesoplodont, carried out offshore Sardinia by DIPNET. The more detailed photographic analysis allowed us to also identify the 2010 animal as a mesoplodont. Six sightings of *Z. cavirostris* were recorded by GREC in the study area, offshore eastern Corsica from 2010–2012, in 787 km of effective effort (0.76 group per 100 km). Gannier & Epinat (2008) reported a sighting rate of 0.1 group per 100 km for Cuvier's beaked whale in the northern Tyrrhenian Sea, and Gannier (2011) obtained 19 primary sightings with an effective effort of 907 km in 2007–2008, giving a mean sighting rate of 1.88 group per 100 km.

Sighting offshore Sardinia Island

Sighting No. 2, the southernmost of the two records, is located to the east of the Bonifacio Strait (Figure 1B). It occurred on 17 June 2012, 44.5 km offshore north-eastern Sardinia, in the Caprera Canyon area (41°23.075′N 9°57.672′E; time 12:50 UTC+1; Figure 1B) at a depth of 950 m and sea surface temperature of 21.8 °C on sighting position. Sea and weather conditions were wind Beaufort 1, good sea state (Douglas 1) and visibility >10 km. Total time with the animals was 9 min.

A group of four individuals was first identified as Cuvier's beaked whales, when observed from a distance. During the approach, an animal was identified as an adult male *Z. cavirostris* showing a white, odd-shaped head with a deformed beak, which seemed to have suffered a previous fracture. The colour pattern showed ochre–yellowish patchiness, presumably because of diatoms and distinct body scarring, with some fresh rake marks on the head, consistent with a mature male (according to Rosso *et al.*, 2011). The second animal was identified as an adult female *Z. cavirostris*, with greyish colour and poor body scarring, showing only some white patches. The third animal was a juvenile *Z. cavirostris*, due to its typical, totally brownish head and poor scarring pattern.

Field identification of the fourth, 4–5 m long, animal was not so clear. This beaked whale approached the boat to less than 100 m and displayed morphological and behavioural traits typical of some *Mesoplodon* species such as a long and thin beak, and a prominent bulge on the forehead. Early in the observation, the beaked whale performed one breach, where the whole body, except the flukes, left the water. Then it surfaced to breathe at a steep angle, displaying its long beak way out of the water. Observations of the head in close-up photos seem to show that there were no teeth in the lower jaw (Figure 2C and D). Also, it was a very lean animal, as seen from frontal observation. Moreover, the colour pattern of this animal showed a dark head and a pale blaze across the back, in front of the dorsal fin.

Fifteen parallel, double linear scars ~1–2 m in length on both sides of the animal, mostly located on the right flank, were highlighted by photographs (Figure 2D). Scars were mainly closely parallel, and ranging from fine- to medium-scrape, with estimated size ranging from a thickness ≤1 cm (fine scrape) to 1–3 cm (medium scrape), following Cuvier's beaked whale mark description (Rosso *et al.*, 2011). Almost all pairs of linear marks on both sides showed a narrow width and a lighter grey colour, compared with the colour of the surrounding skin. Few single fine and medium scrapes (not paired) were observed on both sides of the animal, below and behind the dorsal fin. Three small, not recent, oval scars were observed on the left side of the body, below the dorsal fin, and several more on the right, behind the eye. These may be 'attachments' similar to *Z. cavirostris* natural marking (Rosso *et al.*, 2011) and related to sea lampreys (*Petromyzon* sp.) or scars from cookie cutter shark bites (*Isistius* sp.), a pelagic squaloid never recorded in the Mediterranean Sea (Di Natale *et al.*, 2013). During a DIPNET survey in 2011, a sea lamprey (*Petromyzon* sp.) was sighted by the authors at the surface in the Caprera Canyon area, attached to a live pelagic stingray *Pteroplatytrygon violacea* (Bonaparte, 1832). Other smaller white dots may be due to previous settlement of epizoic copepods as the single probable *Pennella* sp., settled behind the dorsal fin, on the left side back of the observed mesoplodont. Total effort offshore Sardinia in 2011–2013 made by DIPNET–University of Sassari was 11,700 km, 3537 km of which were run on-effort, searching for cetaceans. A total number of 64 Cuvier's beaked whale groups were sighted in this time, with a mean sighting rate of 1.89 group per 100 km (Bittau & Manconi, 2016).

DISCUSSION

The animals described here clearly matched morphological and behavioural traits of the genus *Mesoplodon* (Mead, 1989). Photographs of both animals highlighted the Sowerby's beaked whale *Mesoplodon bidens* diagnostic traits (Leatherwood & Reeves, 1983; Jefferson *et al.*, 2015) as a beak longer and thinner than other mesoplodonts occurring in the North Atlantic, a melon with prominent bulge on the forehead, a concave shape between the forehead and the beak, a small triangular dorsal fin and laterally compressed body shape.

The comparative analysis (see Leatherwood & Reeves, 1983; Mead, 1989; Jefferson *et al.*, 2015) highlighted that the beak observed in each of the two sightings was too long to belong to Gervais', Blainville's or True's beaked whales. The long beak observed in 2012, projected at a 45° angle from the water before the rest of the head (Figure 2C) is a typical Sowerby's beaked whale surfacing behaviour (Hooker & Baird, 1999; Jefferson *et al.*, 2015). The later photographic analysis of the individual sighted in 2010 showed the typical long beaked-head profile, displayed during the breaching series and definitely identified it as *M. bidens*.

Although *M. bidens* colouration is not well known, and does not appear to be distinctive, the colour pattern evident in the 2012 sighting (Figure 2D) seems quite usual in *M. bidens* and consistent with the dark head, lighter grey blaze on the sides, and pale back extended just behind the dorsal fin, as described by Jefferson *et al.* (2015).

Adult male *M. bidens* have two teeth on the lower jaw, about two-thirds from the beak tip (Mead, 2002), generally producing single scars, not paired (Jefferson *et al.*, 2015).

https://doi.org/10.1017/S0025315416001892 Published online by Cambridge University Press

Scarring tends to be numerous on adult males (Heyning, 1984; Mead, 1989). However, the long, close-spaced parallel scars along both flanks of the *M. bidens* sighted in 2012 (Figure 2D) seem left by an adult male of a different beaked whale species bearing terminal teeth at the tip of the lower jaw, according to McCann (1974); Heyning (1984) and J. Mead (personal communication). The close-spaced parallel scars are typically related to males *Z. cavirostris* or *M. mirus*, both with apical teeth on the lower jaw (McCann, 1974; Heyning, 1984), the former rather common in the Caprera Canyon area (Bittau *et al.*, 2013b, a; Bittau & Manconi, 2016).

The apparent lack of teeth in this individual could mean that they had not erupted yet, or they were not yet clearly visible, as in subadult males. However, this animal may have already fought with different males, as clearly shown by the extensive linear scars of different thickness. Both present sightings of *M. bidens* in the Mediterranean Sea occurred in association with groups of *Z. cavirostris*, whose males may have inflicted these wounds, due to inter-species interactions. There are few data on inter-species interactions among beaked whales (Allen *et al.*, 2011). The extensive scars on the mesoplodont sighted in 2012 raise further questions on how long it had been wandering in the Mediterranean and whether both records involved the same individual. These new records confirm that *M. bidens* may occur occasionally in the Mediterranean Sea.

Photographic matching between the two mesoplodonts did not allow us to conclude that both the *M. bidens* were the same individual, due to the poor quality photographs of the 2010 animal, although the mutual distance (44.4 km), and the occurrence of both Sowerby's in mixed groups with Cuvier's beaked whales, might suggest this hypothesis. A further photographic comparison of the 2012 Tyrrhenian mesoplodont *vs* North East Atlantic Sowerby's beaked whale catalogues should be made.

Both present sightings occurred in the central–western Tyrrhenian (western Mediterranean Sea) in an area previously identified as a favourable habitat for *Z. cavirostris* (Gannier & Epinat, 2008; Gannier, 2011). The two single mesoplodonts encountered offshore Corsica and Sardinia were in both cases associated with a *Z. cavirostris* group and represent very unusual sightings, even in areas where members of both genera co-occur. Finally, a matching was attempted between the *Z. cavirostris* individuals associated with *M. bidens* in 2010 *vs* those in 2012, but the poor quality of the first sighting photographs did not allow us to determine whether the two groups of Cuvier's beaked whales shared some individuals. *Mesoplodon bidens* and *Z. cavirostris* seem to have a different diet and probably occupy a separate ecological niche (MacLeod *et al.*, 2003). The dietary plasticity of *M. bidens* argued by Pereira *et al.* (2011) may partly explain its association, in the medium term, with *Z. cavirostris*. However it is unclear how the two beaked whale species may share different foraging habits and relative dive depths, in the case of a prolonged association (years) in a mixed species group. Stomach contents of *M. bidens* stranded in the Azores revealed a diet composed primarily of small, mid-water fish inhabiting depths of 0–750 m, confirming that this species is mainly a fish eater (Pereira *et al.*, 2011) as in MacLeod *et al.* (2003), Pitman (2009) and Spitz *et al.* (2011). On the other hand Cuvier's beaked whale has a highly specialized diet, feeding mainly on larger prey, as oceanic (meso- to bathy-pelagic) cephalopods, although some authors also found remains of oceanic fish and crustaceans (Blanco & Raga, 2000; Santos *et al.*, 2001).

The current literature data (e.g. MacLeod *et al.*, 2006) indicate that Sowerby's beaked whale in the Mediterranean Sea could be considered as a stray. In the past, Cuvier's beaked whale *Z. cavirostris* was also regarded as an accidental species (Tortonese, 1957). It was only after mass strandings since the 1960s (Tortonese, 1963; Podestà *et al.*, 2006) and along with the increase of sightings since the 1980s that this species has been considered common in the western and eastern Mediterranean basins.

Based on the initial misidentification of the *M. bidens* sighting in 2010, it cannot be excluded that some mesoplodonts encountered in the past may have been misidentified as Cuvier's beaked whales and missed because of the underlying assumptions that all individuals in a group, or distant sightings, belong to a single species. However their occurrence may be more common than we currently know. We suggest that species identification of some previous beaked whale sightings should be carefully dealt with or revisited by photographic analysis of datasets, in order to investigate the possible co-occurrence of mixed species groups. Present records might confirm the *M. bidens* occasional occurrence in the Mediterranean Sea.

The sightings described here are until now the only records, supported by photographic documentation, of free-ranging Sowerby's beaked whales in the Mediterranean Sea. The present data contribute to increase information on *M. bidens* presently categorized as 'Data Deficient' at a global level in the IUCN Red List of Threatened Species (Taylor *et al.*, 2008).

The co-occurrence with *Z. cavirostris* could indicate the need to be associated with another deep-feeder beaked whale to forage efficiently and/or the need of protection against predators.

If both sightings involved the same individual it would mean that one *M. bidens* has survived for at least two years and the scars may have been inflicted during the time spent in the Mediterranean basin. On the basis of the present sightings and previous live stranding, we hypothesize that the western Mediterranean Sea is a marginal area of the *M. bidens* North Atlantic geographic range. More likely, *M. bidens* in the Mediterranean could still be considered strays from the nearby North Atlantic cetacean community.

Further research effort focused on beaked whales might help to confirm the *M. bidens* occasional occurrence in other Mediterranean areas as well, or even lead to investigations with regard to the presence of a potential small population in this enclosed basin.

ACKNOWLEDGEMENTS

Fieldwork would not have been possible without the collaboration and support of Corrado Azzali and Whale Watching Sardinia team. We thank Marco Frenquellucci for the kind support. We are grateful to Natacha Aguilar de Soto, Wojtek Bachara, Jean Michel Bompar, Leigh Hickmott, James Mead, Colin McLeod, Giuseppe Notarbartolo di Sciara, Robert Pitman, Massimiliano Rosso and Dylan Walker for the useful discussions and expert opinion on species identification. We are also grateful to Marzia Rovere and Fabiano Gamberi, ISMAR–CNR Bologna, for providing

depth data. Special thanks to all the students and volunteers who contributed with their work to this research. We are also grateful to Paolo Curto for providing his photos and to Mario de Luca and Paolo Pan for the collaboration. We also thank the referees for helpful suggestions about how to improve the manuscript.

FINANCIAL SUPPORT

This work was supported by the La Maddalena National Park, Fondazione Banco di Sardegna, CAR/ASP–UNEP, DELL Company, and in part by the Regione Autonoma della Sardegna (RAS/L.7/2007), INTERREG–EU, and Italian Ministero dell'Università e della Ricerca Scientifica e Tecnologica (MIUR−PRIN).

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https://doi.org/10.1017/S0025315416001892 Published online by Cambridge University Press